BANK CAPITAL, BANK CREDIT, AND UNEMPLOYMENT

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Abstract

Since the worst employment slumps follow periods of high household debt and almost all household debt is provided by banks, we theoretically investigate whether bank regulation can play a role in stimulating employment. Using a competitive search model, we find that levered households suffer from a debt overhang problem that distorts their preferences, making them demand high wages. In general equilibrium, firms internalize these preferences and post high wages but few vacancies. This *vacancy-posting effect* implies that high household debt leads to high unemployment. Unemployed households default on their debt. In equilibrium, the level of household debt is inefficiently high due to a *household-debt externality*—banks fail to internalize the effect that household leverage has on household default probabilities via the vacancy-posting effect. As a result, household debt levels are inefficiently high. Our results suggest that a combination of loan-to-value caps for households and capital requirements for banks can improve efficiency, providing an alternative to monetary policy for labor market intervention.

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> People ... were poor not because they were stupid or lazy ... they were poor because the financial institutions in the country did not help them widen the economic base.
>
> Muhammed Yunus, *Banker to the Poor: Micro-lending and the Battle Against World Poverty*

1 Introduction

An interesting stylized fact that connects labor and credit markets is that the worst employment slumps follow the largest expansions of household debt. For example, in the U.S., household debt as a percentage of GDP climbed from below fifty percent in 1980 to almost one hundred percent by 2006, and the Great Recession that accompanied the 2007–09 subprime crisis saw the U.S. economy shed over eight million jobs. Ng and Wright (2013) note that the increase in leverage prior to the Great Recession was more pronounced for households than for firms. And Mian and Sufi (forthcoming) document that counties in the U.S. that were the most highly levered had the sharpest drop in employment. The connection between increases in household debt and spikes in unemployment is *not* a unique feature of the last recession—it is rather commonplace in recessions associated with financial crises.[1]

Almost all household debt is created by consumer loans made by banks. So the lending decisions of banks influence aggregate household debt, and those lending decisions, in turn, are affected by bank regulation. This raises an interesting question: can a central bank stimulate employment through bank regulation? This is the central question we address in this paper.

Based on our analysis, the short answer to this question is yes. The central mechanism at work in our model relies on a two-way bridge between the labor and credit markets. Higher household debt induces workers to demand higher wages, and firms respond by posting fewer job vacancies, causing unemployment to go up. Higher unemployment elevates default rates, but households and individual banks fail to internalize this negative labor-market-driven externality of increasing consumer credit, leading to excessive lending to households. We show that a central bank, in its role as a prudential regulator, can diminish this inefficiency and boost employment with a *combination* of capital requirements on banks and caps on household leverage.

[1] See, for example, Reinhart and Rogoff (2009) and Schularick and Taylor (2012).

This approach to dealing with unemployment generated by the interaction of frictions in the labor and credit markets is in sharp contrast to the approach in the previous research, which relies on monetary policy. Specifically, the focus has been on the interest rate set by the central bank as the policy variable through which it influences labor market outcomes. The setting is one in which credit market shocks are transmitted to the labor market via the aggregate demand channel.[2] When credit tightens for consumers, it reduces demand for goods, leading to falling prices for goods, which causes firms to cut production and hire fewer workers, increasing unemployment. A lowering of bank interest rates by the central bank can ease credit and eliminate the negative employment effect engendered by the initial credit tightening.

We take a different, yet complementary, approach in which we develop a general equilibrium model of household borrowing, bank lending, and the labor market. We focus on the most ubiquitous frictions in these markets: banks face adverse selection frictions when lending to households and households face search frictions when looking for jobs. Households are risk-averse, live for two dates, and come in two types, good and bad. Good types have a labor endowment at the late date, whereas bad types have no labor endowment. At the late date, good households (and only good households) may find employment in a competitive search market. To smooth consumption, households borrow from competitive banks at the early date. Good and bad households are ex ante observationally identical to banks, generating an adverse-selection friction. Banks cope with this friction by screening households, which permits the observation of a noisy signal about borrower types before lending. This information allows banks to avoid lending to bad households, who never repay debt because they have no labor endowment at the late date. The precision of each bank's signal is determined by the bank's private investment in a costly screening technology. Household debt and the level of employment are both endogenously determined in equilibrium.

Analysis of this model produces the following four main results. First, increasing household debt raises the equilibrium unemployment rate. Second, households fail to internalize the effect of their borrowing on unemployment, thus generating an externality on the labor market, which induces inefficiently high household debt. Third, there is a feedback effect between household borrowing and employment that generates a multiplicity of equilibria. There is a high-debt, low-employment equilibrium and a low-debt, high-employment equilibrium. Fourth, a combination of high capital requirements for banks and a cap on household leverage can both eliminate the equilibrium involving low employment and increase employment even above the laissez-faire level

[2] See Eggertsson and Krugman (2012), Guerrieri and Lorenzoni (2011), Mian and Sufi (forthcoming), Midrigan and Philippon (2011), and Mishkin (1978, 1978).

in the high-employment equilibrium.

We now explain each of these results in sequence, beginning with the first result, that increasing household debt raises the equilibrium unemployment rate. Conditional on finding employment, highly-indebted households must pay a substantial portion of their wages to their creditors and, therefore, attach lower value to finding employment. Hence, highly indebted households are relatively more sensitive to wages than to the probability of finding employment. Competitive firms recognize these household preferences when posting vacancies to attract workers. This results in firms posting fewer vacancies, but at higher wages, as household debt increases. We refer to this as the *vacancy-posting effect* of household debt and it emanates from the fact that leverage distorts household preferences.

We now turn to the second result, that the level of household debt is *inefficiently high* in equilibrium. Each bank is small compared to the whole economy, so it fails to internalize the vacancy-posting effect that results from the loan that it grants. Thus, the vacancy-posting effect of households generates a negative *household-debt externality* on the labor market.

Consider next the third main result, that there is a feedback effect between household borrowing and employment. Due to the vacancy-posting effect, an increase in debt decreases employment. But, since unemployed households default on their debts, the lower employment rate leads to a lower probability that households will repay their loans. As a result, banks demand higher face values of debt to compensate for this increase in default probability. This closes the feedback loop by which increases in household debt lead to further increases in household debt. See Figure 1 for an illustration of the feedback loop.

In conjunction with the household debt externality, the feedback effect results in a multiplicity of equilibria. Since banks take the employment rate—and thus households' repayment probability—as given when they determine the face value of debt, beliefs are self-fulfilling. There is one equilibrium in which banks believe that employment will be low and, as a result, they demand high face values of debt. There is another equilibrium in which banks believe that employment will be high and, as a result, they demand low face values of debt.

Output is proportional to employment in our economy because all firms that are matched with workers produce the same output. Therefore, output is high when employment is high, and the high-employment equilibrium is more efficient from the point of view of GDP. However, the inefficiency generated by the household debt externality does not vanish altogether in the high-employment equilibrium. Hence, we ask whether banks' screening of borrowers can reduce this inefficiency by lowering the interests rates

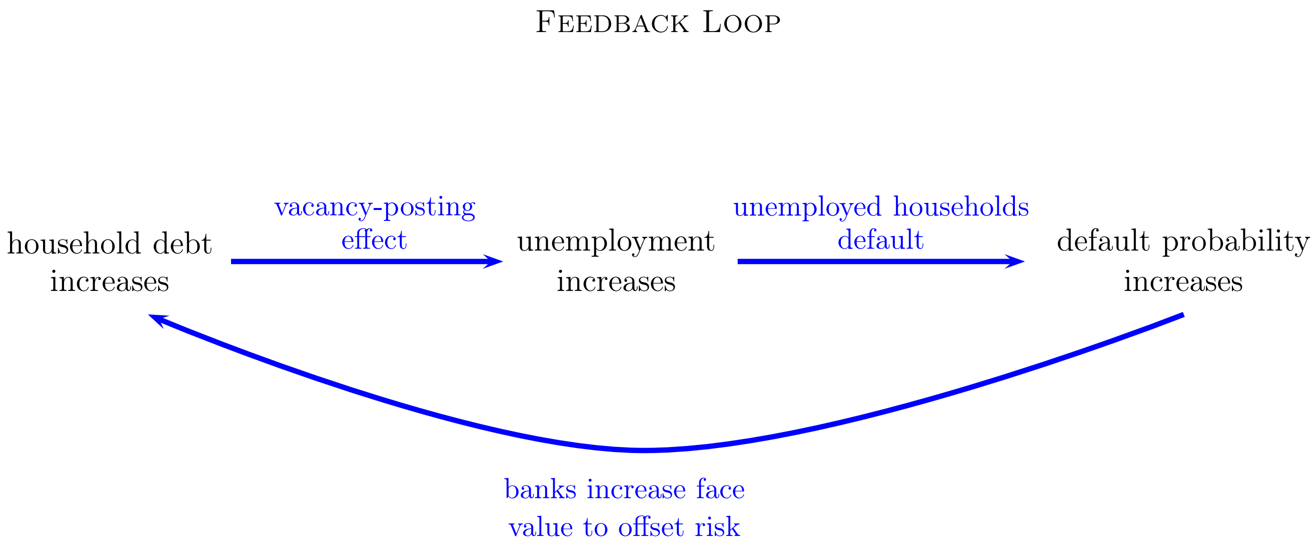

Figure 1: A representation of the feedback loop between household debt and unemployment.

charged on household debt. We find that the answer is yes. In the high-employment equilibrium, increasing bank screening increases employment. With more precise screening, banks reduce the likelihood of lending to bad households and, therefore, charge good households a lower interest rate—good households have to compensate banks less for the failed loans they make to bad households.

This intuition for why increased screening leads to lower face values of household debt does not carry over to the low-employment equilibrium. Increasing screening precision has in fact two countervailing effects on the interest rate of debt—not only the direct effect described above which leads banks to demand lower interest rates, but also a belief-driven indirect effect that leads banks to demand higher interest rates. In the low-employment equilibrium, this indirect effect dominates, leading banks to demand *higher* face values as they increase screening precision.

Finally, let us turn to the fourth result. We analyze bank capital structure and ask whether regulating bank capital structure can increase employment and improve welfare. We show that banks raise all new capital via debt and do not issue equity. The reason for this in our model differs from the usual culprits for which banks like high leverage such as taxes, safety nets and the like. Rather, in our model, high leverage serves as a commitment device for banks to *not* screen loans too intensely. Banks that are somewhat lax in screening are attractive to borrowers who then face a lower risk of being denied credit. Borrowers are impatient and therefore place high value on the probability of receiving credit today. Thus, high leverage serves as a commitment device for competitive banks to offer easy credit and attract more borrowers. Given that banks in the model have an incentive to lever up and over-lend, we now ask whether a bank regulator can improve welfare by imposing capital requirements to curb this tendency.

Increasing bank equity has a direct positive effect on bank screening. Better-capitalized banks screen loans more intensely. But this higher screening has the effect of lowering interest rates for households *only* in the high-employment equilibrium; in fact, it has a perverse effect in the low-employment equilibrium. Thus, a bank regulator has a delicate task. The regulator should increase capital requirements, but only after having implemented policies that prevent the economy from ending up in the low-employment equilibrium. Fortunately, the regulator can eliminate the low-employment equilibrium with a simple policy that regulates household borrowing: capping household loan interest rates.[3] [4] If the regulator caps the interest rates that banks can charge households, the unique equilibrium is the high-employment equilibrium of the model without regulation. The reason is that if banks are not allowed to charge high interest rates, then the interest rate in the low-employment equilibrium becomes infeasible, and the amount of debt each household can take on will be consequently limited. Thus, our results suggest that capital regulation is valuable, but should not be implemented in isolation. Rather, capital requirements should be implemented in conjunction with limits on household debt. Put a bit differently, bank regulators ought to be concerned with minimum capital requirements *for household as well as for banks*.[5]

We model the labor market within a competitive search framework (Moen (1997), Shimer (1996)). See Rogerson, Shimer, and Wright (2005) for a survey of this literature. Our contribution is to incorporate the provision of household credit by banks into this setting. The only other paper that we know of that embeds a household credit market in a search model of the labor market is Bethune, Rocheteau, and Rupert (2015), which focuses on self-enforcing contracts for unsecured credit (i.e. credit card loans) in a dynamic environment with limited enforcement. However, in that paper there are no banks and there is no default in equilibrium.

Various other papers have examined the consequences of the interaction between credit and labor markets. Acemoglu (2001) argues that failures of the credit market to channel funds to socially valuable projects can increase unemployment, and that the

[3]In the model, households always borrow the same amount in equilibrium. As a result caps, on interest rates and caps on household leverage will be equivalent in the model.

[4]Such caps have been implemented in several countries in recent years, see, for example, Borio and Shim (2007), Crowe, Dell'Ariccia, Igan, and Rabanal (2011) and Ono, Uchida, Udell, and Uesugi (2014).

[5]Note that we focus only on the effect of bank capital on screening loans and we abstract from other effects that bank capital requirements may have. For discussion and analysis of these other effects, see Opp, Opp, and Harris (2014) and Thakor (forthcoming).

persistence of high unemployment in Europe, relative to in the US, may be explicable on this basis. Adams (2005) suggests that the ability of households to repay their loans depends on the likelihood of remaining employed, which means that lenders can predict default likelihood by looking at the labor market. Adams, Einav, and Levin (2009) document that automobile demand in the US increases sharply during the rebate season, and that household default rates rise with loan size, indicating the possible desirability of loan caps.[6] Buera, Fattal-Jaef, and Shin (2014) develop a theoretical model in which a credit crunch leads to a big drop in employment for small, young firms and a lesser drop for large, old firms. Boeri, Garibaldi, and Moen (2012) develop a model and provide evidence that more highly-leveraged sectors in the economy are associated with higher employment-to-output elasticities during banking crises. Kocherlakota (2012) develops an incomplete labor market model with an exogenous interest rate to show that a decline in the price of land can cause a reduction in employment if the real interest rate remains constant. Koskela and Stenbacka (2003) develop a model in which increased credit market competition leads to lower unemployment under certain conditions related to labor force mobility, whereas Gatti, Rault, and Vaubourg (2012) document that reduced banking concentration can lead to lower unemployment, but only under some labor market conditions.

What distinguishes our paper from this earlier research is our focus on the two-way interaction between the level of household debt in the credit market and equilibrium unemployment in the labor market, and the mediating role of bank capital in this interaction. This also enables us to examine how bank regulatory policy can be crafted to deal with the potential inefficiencies arising from the interaction of labor and credit market frictions. Specifically, we study how a regulator can mitigate the adverse effects of the lack of coordination among households that leads to household debt choices that impose a negative externality on the labor market. In other words, our analysis suggests how a central bank can affect labor market outcomes through bank regulation.[7]

Our paper also relates to the literature on bank capital regulation. In the wake of the financial crisis of 2008–09, there has been active debate about the costs and benefits of high bank capital requirements. For example Admati, DeMarzo, Hellwig, and Pfleiderer (2013) advocate higher capital requirements for banks, and Berger and Bouwman (2013) document that higher capital enhances bank performance during financial crisis. See Thakor (forthcoming) for an extensive review of this literature. The papers in this literature that are most related to our work study the effects of increasing bank equity

[6]The optimality of capping household loan-size is also an implication that arises in our analysis.

[7]The relevance of this is underscored by the fact that controlling unemployment is one of the goals of central banks like the Federal Reserve in the US.

in a general equilibrium framework. For example, Opp, Opp, and Harris (2014) show that increasing equity has a non-monotonic effect on welfare. When banks face competition from outside investors, increasing capital requirements can lead banks to take on excessive risk and destroy value. Furthermore, Nguyen (2014) shows that increasing capital requirements can produce welfare gains.

The rest of the paper is organized in four remaining sections. In Section 2 we develop the model and in Section 3 we solve it. Section 4 discusses the role of key assumptions in the analysis. Section 5 contains a welfare analysis and discusses policy interventions. Section 6 discusses the robustness of our results to the following three extensions: (i) modeling the labor market with a random matching framework, instead of a directed search framework; (ii) including a penalty for defaulting households; and (iii) using a more general specification of household utility than we use to solve the full model. Section 7 concludes. The Appendix contains all formal proofs as well as a glossary of notations.

2 Model

This section describes the model, which has two dates, Date 0 and Date 1. There are five types of players: savers, banks, firms, and two types of workers, good workers and bad workers. The good and bad workers are ex ante identical. Firms have capital and good workers have labor; they meet in a directed search market at Date 1. Banks borrow from savers and lend to workers. They use a noisy screening technology to screen out bad workers. Savers and workers consume at both Date 0 and Date 1, whereas banks and firms maximize only expected Date 1 profits.

2.1 Preferences and Action Spaces of Players

In summarizing the preference and action spaces of the players in the mode, we use the terms "savers" and "depositors" interchangeably. Likewise, the words "workers," "households," and "borrowers" all refer to the same type of player. Which word we use depends mainly on the context.

2.1.1 Savers/Depositors

There is a unit continuum of risk-neutral savers with discount factor one, each with wealth $I - e$. They cannot lend directly to workers, because they lack the technology to distinguish between good workers (who are creditworthy) and bad workers (who are not creditworthy).[8] They can deposit their capital in a bank for the promised gross return R or consume at Date 0. The deposit market is competitive, so depositors' expected return just satisfies their participation constraint.

2.1.2 Workers/Households

There is a unit continuum of impatient, risk-averse workers. Workers can be either good $\tau = g$ or bad $\tau = b$; g-workers have a unit labor endowment at Date 1, whereas b-workers have no labor endowment. Let $\theta \in (0, 1)$ be the prior probability that the worker is $\tau = g$. Workers consume c_0 at Date 0 and c_1 at Date 1. They have utility $U(c_0, c_1) = u(c_0) + \delta u(c_1)$. Below we will assume that u is piecewise linear (Subsection 4), which will enable us to solve the model. Because workers are risk-averse, they want to smooth consumption. Since they have endowments only at Date 1, they can achieve this by borrowing from banks at Date 0. The risk aversion of workers is what creates a rational for the bank to step in and supply credit to enable consumption smoothie.

2.1.3 Banks

There is a unit continuum of risk-neutral banks with discount factor one. Each bank has initial equity e and raises an amount D in debt and an amount Δ in equity from a depositor at Date 0; the one-period gross interest rate on debt is R and the equity stake granted to outsiders is $1 - \beta$. Therefore, the Date 0 asset value of the bank is $e + \Delta + D = E + D$, where $E := e + \Delta$ denotes the total value of bank equity. At Date 0, the bank can lend an amount B to a worker in exchange for the worker's promise to repay face value F at Date 1. The credit market is competitive, so each bank earns an expected rate of return equal to the (zero) riskless interest rate.

Banks have a noisy screening technology that enables them to screen out b-type workers. Each bank observes a signal $s \in \{s_g, s_b\}$ about the worker it will potentially lend to. Whenever a worker is g-type, the bank observes the signal s_g. In contrast, when the worker is b-type, the bank observes the signal s_b with probability σ and the signal s_g with probability $1 - \sigma$. Symbolically,

$$\mathbb{P}\left[s = s_g \,|\, \tau = g\right] = 1 \tag{1}$$

and

$$\mathbb{P}\left[s = s_b \,|\, \tau = b\right] =: \sigma. \tag{2}$$

[8]In Subsection 2.1.1 we relax this assumption and show the the equilibrium is unaffected (Lemma 3).

We refer to $\sigma \in [0, 1]$ as the bank's *screening precision.* Note that $\sigma = 0$ yields a completely uninformative signal—the bank always observes the signal s_g, regardless of the true type of the worker. In this case the bank's posterior belief about borrower quality coincides with its prior belief. In contrast, $\sigma = 1$ yields a fully informative signal. In this case, the bank observes s_g exactly when the borrower is type g and s_b exactly when the borrower is type b. (See Figure 2 for a pictorial representation.) Increasing the screening precision σ allows the bank to reduce the probability of lending to b-type workers, but increasing σ is costly for the bank. Specifically, the bank can pay cost $c(s) = \gamma\sigma^2/2$ to achieve screening precision σ.

Pictorial Representation of the Signal Structure

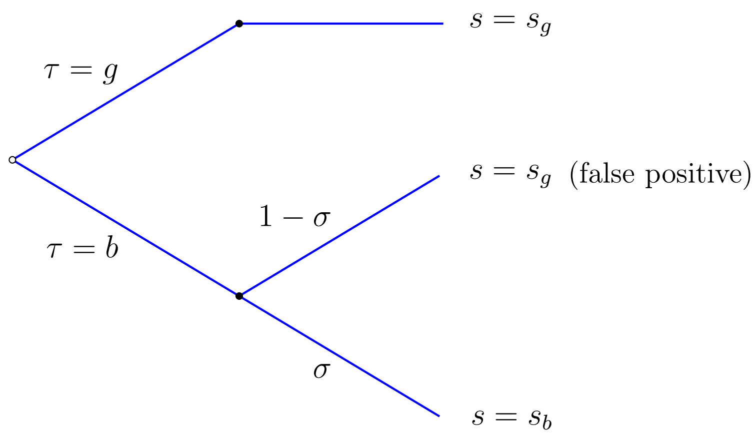

Figure 2: A pictorial representation of the signal structure. g-type workers always generate signal s_g, whereas b-type workers generate signal s_b with probability equal to the screening precision and signal s_g complementary probability.

Note that banks never receive negative signals about g-type workers (thereby precluding type I errors), but sometimes receive positive signals about b-type workers (thereby admitting type II errors). This implies that screening workers can help the bank to deny credit to b-type workers, but not to extend more credit to g-type workers—screening reduces type II errors. Not only do we find this assumption realistic, but we also find it useful for technical reasons. This is because this asymmetric signal means that all g-type workers generate the same signal s_g at Date 0. Therefore, banks treat all g-type workers the same way at Date 0, leading them to all have the same amount of debt when they search in the labor market at Date 1. This allows us to abstract from worker heterogeneity in the labor market, which is a major simplification.[9]

2.1.4 Firms

There is a measure of firms significantly greater than one.[10] Each has a unit of capital, which, in conjunction with a unit of labor, produces output y. Firms pay search cost k to post wages w. Since only g-workers search for work, firms either find a g-worker or remain unmatched. Firms make revenue y if they find a worker in the labor market and zero if they remain unmatched. Firms are competitive and will receive zero expected profit in equilibrium.

2.2 Labor Market

We model the labor market with a one-shot version of a standard competitive search model. In our model, firms post wages w and workers direct their search at a given wage. If the measure of firms posting w is ν_w and the measure of workers directing their search at wage w is μ_w, then the ratio of firms to workers for each w is

$$q_w := \frac{\mu_w}{\nu_w},$$

which is called the *queue length* for wage w (this is the reciprocal of the so-called tightness of submarket w). We assume that for each wage w, workers are matched with firms with intensity $\alpha(q_w)$ and firms are matched with workers with intensity $q_w\alpha(q_w)$. α is decreasing and convex, $q\alpha$ is increasing and concave, and all matches are one-to-one. In general, these properties follow from standard assumptions on a constant-returns-to-scale matching function.

2.2.1 Contracts

In this subsection we clarify different contractual relationships that exist in the model. There are three types of contracts in the model: (i) the labor contract between workers and firms, (ii) the borrowing contract between workers and banks, and (iii) the bank

[9] Modeling worker heterogeneity in the labor market may be interesting in its own right in future research, especially if employers condition hiring decisions in the labor market on the information they glean from the credit-extension decisions made by banks that specialize in screening loan applicants.

[10] The reason that we assume that this measure is greater than one, which is the measure of workers, is to eliminate the possibility that *all* firms post vacancies. In order to ensure an interior solution in the sense that some firms stay out of the market, we assume that there are many more firms than workers searching for employment.

funding contract between banks and depositors. The bank funding contract is an optimal mix of debt and equity. We discuss these three types of contracts here to introduce notation and to discuss the amount of commitment that contracts provide. The full details of the contractual relationships are formalized by the game form described in Subsection 2.3 below.

The labor contract between workers and firms is defined entirely by a wage w, which is paid at the end of Date 1, after production. Firms post the wage at the beginning of Date 1 and, if a worker is matched with the firm, he receives w in exchange for devoting his unit of labor toward production.

The borrowing contract between a worker and his bank is defined by the amount B borrowed by the worker and his promised repayment F. We denote this debt contract by (B, F). We assume that contracts are enforceable but that workers are protected by limited liability, so workers repay whenever they are employed (and have sufficient income), but workers are not punished beyond the loss of their income when they default.[11] Since there are only two outcomes ("employed" and "unemployed") and the cash flow to the worker is zero when he is unemployed, attention can be restricted to to debt contracts without loss of generality.

Now turn to the funding contract between the bank and the depositor. The bank raises an amount D via debt upon which it promises to repay RD and it raises an amount Δ of equity in exchange for an equity stake that promises a proportion $1-\beta$ of the bank's cash flows after debt repayments. We denote this contract by $\big((D, R), (\Delta, \beta)\big)$.

2.3 Timing

The sequence of moves is as follows. At Date 0, each bank raises capital, is matched with a worker, invests in a screening technology and observes a signal about the worker's type. Each bank funds itself via an optimal mix of debt and equity, which it raises from competitive depositors. Then, each bank proceeds to lend to a worker. This allows the risk-averse worker to smooth his consumption over the two dates. At Date 1, good workers match with firms in a decentralized labor market. Next, if firms are matched with workers, they produce output and pay wages. Finally, employed workers repay their debts and banks repay their depositors.

Below we specify the timing more formally. The markets for deposits, loans, and workers are competitive. We capture competition via the free entry of banks, depositors,

[11]Our results would be robust to the inclusion of default penalties as long as the default penalties are bounded from above by a pre-specified maximum.

and firms. Note that the only matching frictions are in the labor market.

Date 0 0.1 Each bank competitively posts a contract (B, F) to lend to workers and a contract $\big((D, R), (\Delta, \beta)\big)$ to raise capital from a random depositor.

- Depositors accept or reject banks' offers.

0.2 Each worker directs its search at its preferred contract and is matched with a bank.[12]

0.3 Each bank chooses its screening precision σ and observes the signal s about the type of the worker it is matched with.

- Contingent upon the signal, the bank either agrees to lend B to the worker in exchange for the promise to repay F or does not lend.

0.4 Depositors and workers consume.

Date 1 1.1 Each firm either pays k to post wage w or stays out.

1.2 Each g-type worker directs his search at a wage w and matches take place (see Subsection 2.2).

1.3 Each worker who has borrowed either repays F to his bank or defaults.

1.4 Each bank either repays RD to its depositor or defaults. The residual cash flows are split among equity holders.

1.5 Depositors and workers consume. Firms and banks record profits.

See Figure 3 for a timeline representation of the sequence of moves.

2.4 Solution Concept

The solution concept is symmetric perfect Bayesian equilibrium.

2.5 Assumptions

In this section we impose several restrictions on functional forms and parameters. Specifically, we assume functional forms for the workers' utility and the firm-worker matching function to make the model tractable and we restrict the model's parameters to focus on the cases that we think are economically most important.

[12] To focus on adverse selection frictions in the credit market and search frictions only in the labor market, we assume that these matches in the credit market are frictionless. Formally, this corresponds to a Leontief matching technology. Note that the contract at which the worker directs its search is $\big((B, F), \big((D, R), (\Delta, \beta)\big)\big)$—i.e., the worker takes the bank's capital structure into account when searching. The reason that this matters is that the bank's capital structure will affect the bank's screening precision and therefore the worker's probability of being granted a loan.

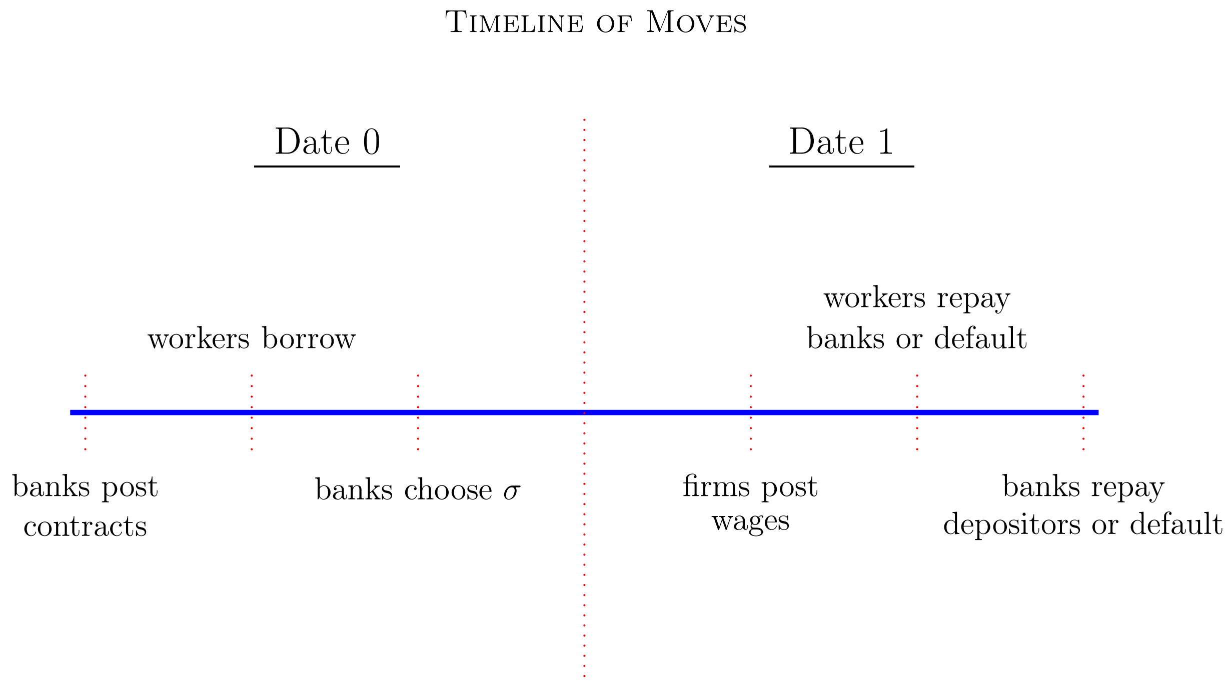

Figure 3: A timeline representation of sequence of moves described in Subsection 2.3.

Acemoglu and Shimer (1999) allow workers to be risk-averse in a labor model with directed search, but Rogerson, Shimer, and Wright (2005) note that this "means it is no longer possible to solve the model explicitly" (p. 976). We avoid this difficulty by assuming that workers' utility functions are piecewise linear. Workers are risk averse globally, giving them the incentive to smooth consumption, but risk-neutral locally, allowing us to solve the Date 1 search model as if they have linear utility. See Chassang (2013) and Dang, Gorton, Holmström, and Ordonez (2014) for a similar assumption on preferences.

Assumption 1.

$$u(c) = \begin{cases} c & \text{if } c \leq I, \\ I & \text{otherwise.} \end{cases} \tag{3}$$

We assume a form for the matching probability α that enables us to solve the model in closed form.

Assumption 2. *The matching function is homogenous and the probability that a worker is employed if he queues at a firm with queue length q is*

$$\alpha(q) = \frac{a}{\sqrt{q}}. \tag{4}$$

This probability satisfies the properties induced by standard matching functions in the literature—the probability α that a worker matches with a firm is decreasing and convex in the queue length, whereas the probability $q\alpha$ that a firm matches with a worker is increasing and concave in the queue length.

We must ensure that these matching probabilities are between zero and one in equilibrium, namely that for the equilibrium queue lengths $\alpha, q\alpha \in [0,1]$ or

$$a^2 < q < \frac{1}{a^2}. \tag{5}$$

a being sufficiently small suffices for this to hold in equilibrium. Instead we impose the following tighter restriction on primitives.

Assumption 3.

$$a^2 \left(y + \sqrt{y^2 - 4\Gamma_{\min}} \right) < 4k < y + \sqrt{y^2 - 4\Gamma_{\min}} \tag{6}$$

where

$$\Gamma_{\min} := \frac{2k}{a^2\theta} \left(1 - \frac{(1-\theta)^2 I^2}{2\gamma} \right). \tag{7}$$

Appendix A.10 demonstrates the sufficiency of these bounds for $\alpha, q\alpha \in [0,1]$.

The worker's utility function is flat whenever consumption is greater than the level I, at which point there is a kink. Therefore, in order to ensure we have an interior solution for workers' wages, it must be that workers' consumption is less than I. Since employed workers repay their debts before consuming, this condition corresponds to $w - F < I$. A sufficient condition for this to hold is given in terms of primitives in the next assumption, that firm output y is not too large relative to the kink parameter I.

Assumption 4.

$$2I > y. \tag{8}$$

Appendix A.11 demonstrates the sufficiency of this assumption for the maintained hypothesis that $0 < w - F < I$.

Finally, we state one hypothesis that we maintain throughout and verify ex post. It says that banks maintains positive equity value even if they does not lend. We show that this assumption holds in equilibrium in Appendix A.12.

Maintained Hypothesis 1.

$$I > RD. \tag{9}$$

3 Results

The analysis of the model is presented in this section. We look for a symmetric equilibrium in which all workers' loans have the same face value F. We first solve the labor market in terms of F and then proceed by backward induction to find the equilibrium in the credit markets.

3.1 Labor Market

The solution to the directed search model in the labor market is mostly standard,[13] but there is the twist that in our model workers have debt with face value F. In this section we take the face value F as given; we solve for it in Subsection 3.2 below. Note that we are assuming for now that all g-type workers have the same level of debt. Later, we will verify that this is the case in equilibrium (see Proposition 4).

The key insight for the solution procedure is that each firm posts a wage that makes workers indifferent between directing their search at that wage and directing their search at the most attractive other wage available. If this were not the case, a firm could profitably deviate by posting a slightly lower wage and attracting all the workers. This observation allows us to take as given the worker's utility U from directing his/her search toward the most attractive other wage, and then maximize the firm's profit over the wage it posts. To find the equilibrium queue length, we use the firm's zero-profit condition.

Throughout this section we assume that workers' wages are such that $w - F < I$, and thus workers have linear utility locally, and, further, that $w > F$ so that workers do not default if they are employed. Appendix A.11 demonstrates that these conditions indeed hold in equilibrium given Assumption 4.

We solve the problem for an individual firm; all firms will offer identical wages in equilibrium. Taking v as the workers' Date 1 indirect utility from searching at the most attractive other firm, the firm posts wages w. Note that the workers' outside option is zero if he is unemployed, which occurs with probability $1 - \alpha$, so the worker's utility is just the probability of being employed times the wage minus the worker's debt repayment. Thus,

$$v = \alpha(w - F). \tag{10}$$

[13]See Rogerson, Shimer, and Wright (2005).

We can solve this equation to write the wage in terms of v,

$$w = F + \frac{v}{\alpha}, \tag{11}$$

which in turn will allow us to express the firm's profits in terms of the workers' outside option. The firm pays cost k to post wages w and attract workers with probability $q\alpha$, in which case it generates revenue y. Its expected profit is thus

$$\begin{aligned} \Pi &= q\alpha(y - w) - k \\ &= q\alpha(y - F) - qv - k, \end{aligned} \tag{12}$$

having substituted for w in terms of U from above. The objective is smooth and concave, so the first-order condition defines the global maximum:

$$v = \alpha(y - F) + q\alpha'(y - F), \tag{13}$$

which immediately leads to an expression for the wage w from equation (14):

$$w = y + \frac{q\alpha'(y - F)}{\alpha}. \tag{14}$$

To find the equilibrium queue length and, thus to characterize the equilibrium of the labor market in terms of the face value F of household debt, we substitute this wage into the firm's zero profit condition $\Pi = 0$ or

$$\begin{aligned} k &= q\alpha(y - w) \\ &= -q^2\alpha'(y - F) \end{aligned} \tag{15}$$

or

$$q^2\alpha' = -\frac{k}{y - F}. \tag{16}$$

Proposition 1. *The equilibrium queue length and wage are*

$$\sqrt{q} = \frac{2k}{a(y - F)}, \tag{17}$$

and

$$w = \frac{y + F}{2}. \tag{18}$$

The equilibrium queue length allows us to find the equilibrium matching probabilities. Unmatched workers are unemployed and, thus, α equals the employment rate.

Corollary 1. *The employment rate α is decreasing in the amount of household debt F.*

Corollary 1 above says that household debt has a negative affect on the labor market. The reason is that in equilibrium firms must pay higher wages when they employ more-highly-indebted workers. Therefore, firms' willingness to post vacancies decreases as household debt increases, and unemployment increases. The reason that wages are increasing in household debt is that, while workers' payoff from unemployment is constant (equal to zero), their payoff from employment (equal to $w - F$) is decreasing in F. To explain this in more detail, we calculate the sensitivity of the worker's utility to the employment rate α and the face value of worker debt F. First, recall that the worker's utility is

$$U = \alpha(w - F).$$

So we have that

$$\frac{\partial}{\partial F}\left(\frac{\partial U}{\partial \alpha}\right) = -1,$$

whereas

$$\frac{\partial}{\partial F}\left(\frac{\partial U}{\partial w}\right) = 0.$$

Observe that the sensitivity of U to w is independent of F, but the sensitivity of U to α is decreasing in F. Thus, the higher F is, the less workers value employment relative to unemployment. Firms recognize these household preferences and post high wages to attract indebted households. But, then, firms can employ fewer workers.

3.2 Credit Markets

We now turn to the two credit markets in the model, namely the market in which workers borrow from banks and the market in which banks borrow from savers. Our main results are about the connection between the labor market and the market in which workers borrow. First, we examine the feedback loop between the face value of worker debt and the unemployment rate, and then we analyze the effect of banks' equity on their screening precision and the face value of worker debt. This section proceeds with solving the game backward. We first solve for screening precision, then for the face value of worker debt, and then for the interest rate that depositors charge banks.

In this section, it will be useful to have notation to refer to the Date-1 asset value of a bank. If the worker repays his debt F, the bank's assets are simply this face value, whereas if the worker defaults, the bank's assets are zero. Furthermore, if the bank does not lend, its asset value is simply its initial value of its assets $E + D$. Formally, let V denote the (random) Date 1 value of a bank's assets:

$$V := \begin{cases} F & \text{if } \tau = g \text{ and the worker is employed,} \\ D + E & \text{if bank does not lend,} \\ 0 & \text{otherwise.} \end{cases}$$

3.2.1 The Level of Worker Debt

Before we turn to our main results of this section, we state a lemma that will simplify the analysis. The lemma pins down the amount that banks and workers will borrow at Date 0. Specifically, workers borrow exactly up to the kink in their utility functions, $B = I$. The reason that they do not borrow more is that their utility function is flat above the kink, so their marginal benefit from consuming above the kink at Date 0 is zero. The reason they do not borrow less is that they are impatient (their discount factor δ is relatively small), so they have a strong incentive to move consumption forward. Thus, the amount of credit a worker demands from his bank is exactly I. Since each bank is matched with at most one worker, and the only alternative to lending is riskless storage, a bank has no incentive to hold assets in excess of I at Date 0. Therefore, a bank borrows $D = I - E$ so that its entire cash holdings at Date 0 are I. The result of this argument is stated formally in the next lemma.

Lemma 1. *In equilibrium, banks borrow $D = I - E$ and workers borrow $B = I$.*

3.2.2 Bank Screening

Each bank chooses its screening precision σ to maximize its expected Date-1 equity value net of screening costs. The bank will invest in costly screening of the borrower only if the information acquired affects its decision to lend. Since a negative signal s_b indicates a worker is type b with certainty, a bank never extends credit after observing s_b. If a bank lends, it will only be after it observes signal s_g. In other words, there are three possibilities: either (i) a bank does not screen ($\sigma = 0$) and always lends to its loan applicant, (ii) a banks screens ($\sigma > 0$) and lends only when it observes s_g, or (iii) a bank does not screen and does not extend credit. Here we focus only on case (ii). We will see below that Maintained Hypothesis 1 implies that banks will always screen in equilibrium, so case (i) will never obtain. Case (iii) would involve no lending to workers and, therefore, a violation of depositors' participation constraint (equation (32) below) unless the deposits were riskless. Thus, case (iii) is the case of no economic activity.

When $RD < I$, the bank's shareholders have an incentive to screen in order to avoid lending to b-type borrowers. The benefit of screening in this case is that by not lending the bank preserves the equity value $I - RD > 0$. The bank now chooses its screening precision σ to maximize the expected value of its Date-1 equity net of screening costs. Recall that, conditional on its choosing to screen, the bank lends only when it observes the positive signal s_g. Thus, the terms in the bank's objective function (which is written in full in equation (22) below) are as follows. It lends exactly when it observes a positive signal, which occurs with probability

$$\mathbb{P}\left[s = s_g\right] = \theta + (1-\theta)(1-\sigma). \tag{19}$$

Conditional on lending, it receives the repayment F exactly when both of two events occur. The first event is that the worker is indeed type g, which occurs with conditional probability

$$\mathbb{P}\left[\tau = g \,|\, s = s_g\right] = \frac{\theta}{\theta + (1-\theta)(1-\sigma)} \tag{20}$$

and the second event is that the worker is employed, which occurs with probability α, where α is the employment rate. When the bank receives repayment F, it must repay its creditors RD, so its equity value, given its borrower's repayment, is $F - RD$. That summarizes the bank's expected payoff when it observes the signal s_g. Alternatively, the bank may observe the negative signal s_b. This occurs with probability

$$\mathbb{P}\left[s = s_b\right] = (1-\theta)\sigma. \tag{21}$$

In this event the bank simply keeps its Date-0 assets in place and has asset value I from which it still repays depositors RD. Its equity value is $I - RD$. Finally, the bank bears the screening cost $c(\sigma) = \gamma\sigma^2/2$. Thus, the objective function of the bank is given by

$$\begin{aligned} &\mathbb{P}\left[s = s_g\right]\mathbb{P}\left[\tau = g \,|\, s = s_g\right]\alpha\left(F - RD\right) + \mathbb{P}\left[s = s_b\right]\left(I - RD\right) - c(\sigma) \\ &\qquad = \theta\alpha\left(F - RD\right) + (1-\theta)\sigma(I - RD) - \frac{\gamma\sigma^2}{2}. \end{aligned} \tag{22}$$

Maximizing this objective gives the bank's equilibrium choice of screening precision, as summarized in Proposition 2 below.

Proposition 2. *Banks screen with precision*

$$\sigma = \begin{cases} \dfrac{1}{\gamma}(1-\theta)(I - RD) & \text{if} \quad 0 < I - RD < \dfrac{\gamma}{1-\theta}, \\ 1 & \qquad I - RD > \dfrac{\gamma}{1-\theta} \end{cases} \tag{23}$$

The expression for σ in Proposition 2 above allows us to perform comparative statics on the screening precision as a function of bank leverage. In particular, we see that more highly levered banks screen less. The reason is that screening only prevents banks from lending to bad borrowers and, when banks are levered, the cost of these loans to bad borrowers is borne by the bank's creditors, not by the shareholders who determine screening precision. In the next corollary we look at how changes in D and R affect σ.

COROLLARY 2. *Screening precision is decreasing in bank leverage and deposit rates. In particular,*

$$\frac{\partial \sigma}{\partial D} = -\frac{(1-\theta)R}{\gamma} < 0$$

and

$$\frac{\partial \sigma}{\partial R} = -\frac{(1-\theta)D}{\gamma} < 0$$

whenever $0 < I - RD < \gamma/(1-\theta)$*, and otherwise the derivatives is zero or undefined.*

Note that the corollary above takes into account only the direct effects of D and R on σ. In other words, it summarizes the direct effects of bank debt and deposit rates taking the other variable as given. This corresponds to studying what would happen in the abbreviated version of our model that takes bank capital structure as exogenous. In the full model, capital structure is endogenous. In Subsection 3.2.3 below, we will analyze a bank's optimal mix of debt and equity funding. To find the optimum we will have to consider not only the direct effect of an increase in debt D on screening precision σ that we calculate above, but also its indirect effect on screening intensity through a change in the deposit interest rate. In particular, we will have to study the total derivative

$$\frac{d\sigma}{dD} = \frac{\partial \sigma}{\partial D} + \frac{\partial \sigma}{\partial R}\frac{\partial R}{\partial D}. \tag{24}$$

Note that Corollary 2 suggests that the direct effects of increasing D and R on σ are negative. In the proof of Proposition 3 below, we show that this intuition carries through to this total derivative, and it is indeed negative.

3.2.3 Bank Capital Structure

In this subsection, we find the optimal capital structure for banks. We write down the bank's problem to set its borrowing and lending contracts as a constrained maximization program. The constraints are determined by competition. In particular, banks and depositors are competitive, so they break even in expectation. The objective function in the program is the expected utility of the worker. The reason is that in order to be able to make a loan, a bank must appeal to workers who want to borrow. Only banks whose contracts maximize the workers' expected utility receive any loan applications, because these are the only banks at which workers direct their search. Precisely, the bank must maximize the expected utility of a worker subject to four constraints. They are as follows: (1) old shareholders break even; (2) new shareholders break even; (3) depositors break even; and (4) amount of deposits available satiesfies the depositor's wealth constraint. The program is thus

$$\text{Maximize } \big(\theta + (1-\theta)(1-\sigma)\big)I + \delta\theta\alpha(w - F) \tag{25}$$

subject to

$$\beta\Big(\theta\alpha(F - RD) + (1-\theta)\sigma(I - RD) - c(\sigma)\Big) = e, \tag{26}$$

$$(1-\beta)\Big(\theta\alpha(F - RD) + (1-\theta)\sigma(I - RD) - c(\sigma)\Big) = \Delta, \tag{27}$$

$$\Big(\theta\alpha + (1-\theta)\sigma\Big)RD = D, \tag{28}$$

$$e + \Delta + D = I \tag{29}$$

over F, β, Δ, R, and D, where σ is as in Proposition 2. We now have:

PROPOSITION 3. *In equilibrium, banks raise capital only via debt, i.e.* $\Delta = 0$ *and* $D = I - e$.

The intuition is as follows. Increasing bank leverage decreases the bank's incentives to screen, i.e. decreases σ, as we discusses earlier (see Corollary 2). This increases the probability that the worker is granted a loan at Date 0 and, therefore, the probability that the worker consumes early. Since workers are impatient, they place a high value on this early consumption and are willing to repay more tomorrow in order to be able to borrow today—they are willing to compensate banks for lending to bad borrowers. Since the only mechanism banks have at their disposal to commit not to screen out bad borrowers is leverage on their own balance sheet, a highly levered bank can appeal more to workers in search of loans. This explanation is, of course, only partial. It omits the effect of the program's constraints, and does not fully explicate the effects of bank leverage on the face value F of worker debt in the objective function. The subtleties in the proof come from taking these effects into account. However, the proof shows that the intuition we present here is robust.

3.2.4 The Face Value of Worker Debt

We are now in a position to compute the face value of debt that a bank will post. Banks and depositors are both competitive and therefore break even on average, i.e.

the expected value of a bank's Date 1 equity net of screening costs equals its equity E,

$$\mathbb{E}\left[\max\left\{V - RD, 0\right\} \mid \sigma\right] - c(\sigma) = E, \tag{30}$$

and the expected repayment that the bank's depositors receive equals the initial capital D that they provide,

$$\mathbb{E}\left[\min\left\{V, RD\right\} \mid \sigma\right] = D. \tag{31}$$

Recall that the bank's total Date 0 capital is I (Lemma 1), so summing the break-even conditions for the bank's equity and the claims of its depositors gives

$$\mathbb{E}\left[V \mid \sigma\right] - c(\sigma) = E + D = I. \tag{32}$$

From now on we will work with this condition to determine the face value F as a function of the interest rate R that depositors charge the bank. After having determined F, we can use the depositors' break-even condition to find R.

The final equation above (equation (32)) is the combined break-even condition for all of the bank's claimants. We now decompose the expectation of the bank's total asset value on the left-hand side. There are two terms in the expression. The first term is the probability that the bank receives a good signal—and hence it lends—multiplied by the expected repayment conditional on a good signal. The second term is the probability that the bank receives a bad signal—and therefore does not lend—multiplied by the Date-0 asset value I. Thus,

$$\mathbb{E}\left[V \mid \sigma\right] = \theta\alpha F + (1-\theta)\sigma I, \tag{33}$$

where σ is as given in Proposition 2. Thus, the break-even condition expressed in equation (32) gives an expression for the face value F that the bank chooses,

$$F = \frac{\big(1 - (1-\theta)\sigma\big)I + c(\sigma)}{\theta\alpha}. \tag{34}$$

Now observe from the equation (34) above that the face value F depends on the employment rate (in the denominator on the right-hand side). Recall that the employment rate α depends on the face value of debt that workers have when they enter the labor market (see equation (54)). Thus, the face value F that the bank chooses depends on the face value that the bank believes the other banks are offering, through its dependence on the employment rate. To make the distinction between the face value determined by the bank's zero-profit condition and the face value that the bank believes (or "conjectures") that other banks are offering, denote this conjectured face value by $\hat{F}$. Therefore, when a bank posts the face value F, it acts as if other banks are offering face value $\hat{F}$. So the conjectured employment rate—and therefore the conjectured repayment probability—is given by

$$\alpha = \frac{a^2}{2k}\big(y - \hat{F}\big).$$

Thus, for a face value F to be an equilibrium face value, it must satisfy two conditions. The first is the bank's zero-profit condition:

$$F = \frac{2k}{a^2\theta\big(y - \hat{F}\big)}\Big(\big(1 - (1-\theta)\sigma\big)I + c(\sigma)\Big), \tag{35}$$

where we have substituted in for α in equation (34). The second is the rational expectations condition

$$F = \hat{F}. \tag{36}$$

Combining these conditions yields a quadratic equation in F:

$$(y - F)F = \Gamma_D \tag{37}$$

where the function Γ_D is independent of F and defined as follows:

$$\begin{aligned}
\Gamma_D &:= \frac{2k}{a^2\theta}\Big(\big(1 - (1-\theta)\sigma\big)I + c(\sigma)\Big) \\
&= \begin{cases} \dfrac{2k}{a^2\theta}\left(I - \dfrac{\big(1-\theta\big)^2\big(I^2 - R^2D^2\big)}{2\gamma}\right) & \text{if } 0 < I - RD < \dfrac{\gamma}{1-\theta}, \\[2ex] \dfrac{2k}{a^2\theta}\left(\theta I + \dfrac{\gamma}{2}\right) & \text{otherwise.} \end{cases}
\end{aligned}$$

Because of *the self-fulfilling beliefs of banks about future employment*, the quadratic in equation (37) has two solutions. When banks believe that the rate of employment will be high—and therefore that worker default is unlikely—banks demand low face values and employment is indeed high. Likewise, when banks believe that the rate of employment will be low—and therefore that worker default is likely—banks demand high face values and unemployment is indeed high. The self-fulfilling prophecy results from the externality that household debt imposes on the labor market. Because high household indebtedness leads to low employment, banks' beliefs (or conjectures) have a critical impact on employment. The face values determined by the two solutions of the quadratic equation (37) are summarized in the next proposition.

PROPOSITION 4. *There are two equilibrium face values,*

$$F_- = \frac{1}{2}\Big(y - \sqrt{y^2 - 4\Gamma_D}\Big) \tag{38}$$

and

$$F_+ = \frac{1}{2}\Big(y + \sqrt{y^2 - 4\Gamma_D}\Big), \tag{39}$$

so long as the discriminant above is positive.

3.2.5 The Effect of Bank Leverage on the Face Value of Worker Debt

In this subsection we analyze the effect of bank leverage on the face value of worker debt. We will show that the two equilibria—the equilibrium associated with face value F_- and the equilibrium associated with face value F_+—have very different comparative statics properties. In particular, in equilibrium a decrease in the bank debt D leads to a increase in F_- but an decrease in F_+.

Before analyzing the specific effects of changing bank leverage on worker indebtness, we first study how changes in the face value of worker debt F affect bank loan values. Observe that the bank loan values are first increasing and then decreasing in the face value F (see Figure 4). The reason is that there are two effects of increasing the face value of debt, a *direct effect* and an *indirect effect*. The direct effect of an increase in the face value is that the amount that a bank is repaid is higher. This higher repayment increases the value of a banks' loans. The indirect effect comes via the externality in the labor market. Increasing the face value of worker debt decreases employment and hence the probability of repayment. In the F_- equilibrium, the direct effect is stronger than the indirect effect, so increasing face values increases asset values. In the F_+ equilibrium, in contrast, the indirect effect is stronger than the direct effect, so increasing face values decreases loan values.

We now explain how these contrasting effects of a marginal increase in the face value of a worker's loan translate into contrasting effects of changes in bank leverage on the loan face value itself. First recall that a decrease in bank debt increases bank screening, causing it to make fewer loans to bad workers and a higher proportion of loans to good workers. A decrease in debt, therefore, decreases the losses the bank makes from lending to bad workers, so, the bank can lower the borrower's obligation on the loans that it does make and still break even. In other words, when the bank has lower leverage in its capital structure, those who receive loans are the beneficiaries of the losses the bank avoids by eliminating loans to bad borrowers. But we have seen that issuing a loan with a lower value corresponds to a lower face value in the F_- equilibrium but to a higher face value in the F_+ equilibrium. This is stated formally in the proposition below.[14]

Proposition 5. *F_- is increasing in bank leverage,*

$$\frac{dF_-}{dD} \geq 0,$$

whereas F_+ is decreasing in bank leverage,

$$\frac{dF_+}{dD} \leq 0.$$

Illustration of Comparative Statics of F

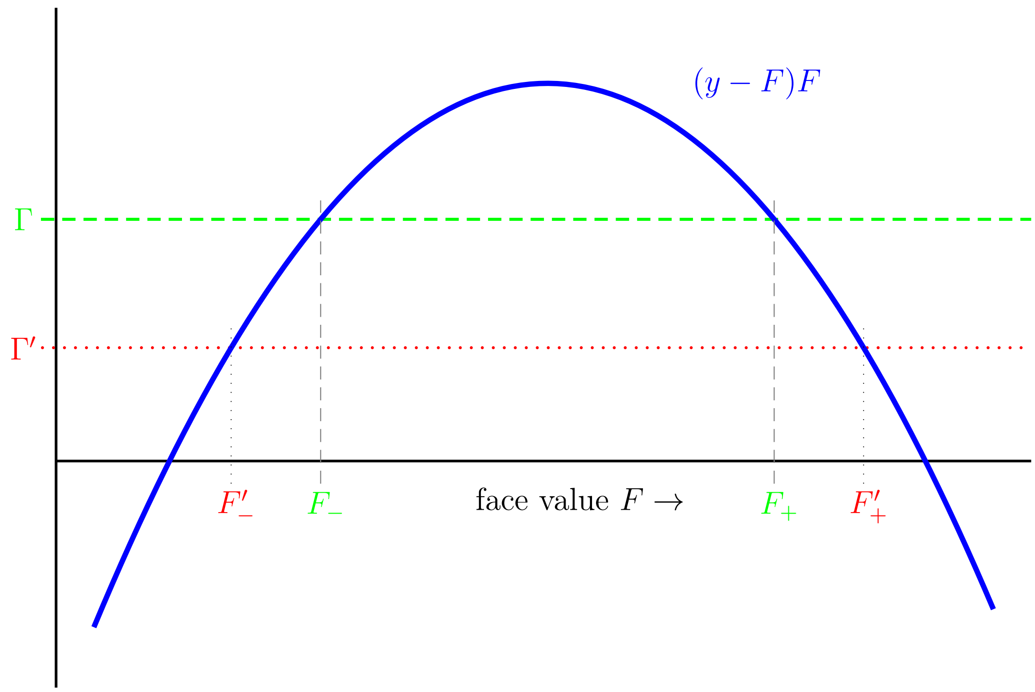

Figure 4: An illustration of how the solution to the equation $(y - F)F = \Gamma$ changes as Γ changes. The primed solutions F'_- and F'_+ correspond to Γ'; the unprimed solutions F_- and F_+ correspond to Γ. If Γ decreases to $\Gamma' < \Gamma$, then F_- decreases to F'_-, whereas F_+ increases to F'_+.

[14]Note that in the proposition we use the "total derivative" notation to emphasize the dependence of R on D in equilibrium.

3.2.6 The Equilibrium Deposit Rate

In this section we briefly discuss the equilibrium deposit rate R. Our main analysis centers around the connections between household debt, employment, and bank capitalization, but not bank deposit rates. Here we derive the polynomial equation that defines R implicitly. We do this more to close the model than to derive further results.

The equilibrium deposit rate is the one that makes the depositors' break-even condition (in equation (31)) bind. Since, by Maintained Hypothesis 1, $I > RD$, the bank defaults only when it lends and its worker defaults, which occurs with probability $(1-\theta)(1-\sigma)$. The equation for R thus reads

$$\theta\alpha RD + (1-\theta)\sigma RD = D. \tag{40}$$

Recall that α is both the employment rate and repayment rate, as conjectured when R is posted at Date 0. Replacing α in the equation above with the expression in terms of the conjectured face value of debt $\hat{F}$, we have

$$\frac{\theta a^2}{2k}\big(y-\hat{F}\big) + (1-\theta)\sigma = \frac{1}{R}. \tag{41}$$

This reveals immediately that the equilibrium deposit rate also depends on banks' belief about the equilibrium they will be in. The next lemma summarizes how the deposit rate depends on whether the economy is in an equilibrium associated with F_- or an equilibrium associated with F_+. Note that we express the next lemma in terms of Γ_D, even though when $I - RD > \gamma/(1-\theta)$, Γ_D depends on R.

LEMMA 2. *If the economy is in an equilibrium associated with F_-, then the deposit rate R_- solves*

$$\frac{\theta a^2}{4k}\Big(y+\sqrt{y^2-4\Gamma_D}\Big)R + \frac{1}{\gamma}(1-\theta)^2(I-RD)R = 1 \tag{42}$$

If the economy is in an equilibrium associated with F_+, then the deposit rate R_+ solves

$$\frac{\theta a^2}{4k}\Big(y-\sqrt{y^2-4\Gamma_D}\Big)R + \frac{1}{\gamma}(1-\theta)^2(I-RD)R = 1. \tag{43}$$

3.2.7 Depositors Do Not Lend Directly to Workers

The depositors in the model have been largely in the background, funding banks via deposits. We have not explained why banks intermediate between depositors and workers, namely why depositors do not lend to workers directly. To address this potential concern about the *raison d'être* of banks, we demonstrate that if we allow depositors to lend directly to workers, they still prefer to invest in banks. The reason is two-fold. First, banks have a screening technology that increases the surplus from lending. Second, banks are competitive, so they pass the savings on to workers in equilibrium. Therefore, to lend to a worker, a depositor must offer the worker better terms than he can obtain from a bank, making the loan at best zero NPV from the depositor's point of view.

LEMMA 3. *In equilibrium, depositors are weakly better off investing via banks than they would be lending directly to workers.*

Further, there cannot be an equilibrium in which depositors lend directly to workers rather than depositing in banks.

4 Discussion of Key Simplifying Assumptions

Because our model has both directed search in the labor market and endogenous information acquisition by banks, it inherits the complexities of both types of models. Nonetheless, it remains tractable. The tractability of our model relies on several useful, but stark, assumptions. We would now like to bring two of these assumptions to the foreground, both because they are useful in solving the model and because they may appear non-standard.

The first assumption is that households' utility is piecewise linear. This is a reduced-form way to capture households' risk aversion. The local risk neutrality implied by this assumption allows us to solve the directed search model of the labor market (see the discussion in Rogerson, Shimer, and Wright (2005)). But the *global* risk aversion of households implied by this assumption gives them the incentive to borrow.

The second assumption is that the banks' screening technology delivers asymmetric signals. Regardless of its precision, the signal is never wrong about good borrowers, but greater signal precision reduces the probability of a "false positive", i.e., mistakenly identifying a bad borrower as good. This allows us to solve for *symmetric* equilibria in which all households have the same amount of debt when they enter the labor market. If banks' noisy screening led them to sometimes make the mistake of denying credit to good workers at the early date, then both the good workers with debt and the good workers without debt would search in the labor market at the late date, leading to worker heterogeneity in the labor market, and adding substantial complexity.

5 Welfare and Policy Implications

5.1 Welfare

In this section we analyze welfare in the economy. Banks, depositors, and firms all break even in equilibrium, so the welfare analysis revolves around the utility of workers. Our first result of this section says that if two equilibria of the model are associated with different face values of household debt, then the equilibrium associated with the lower face value corresponds to higher employment and output than the equilibrium associated with the higher face value.

PROPOSITION 6. *Employment and output are higher in the equilibrium associated with F_- than in the equilibrium associated with F_+.*

This proposition follows from the observation that lower household debt means a diminished externality of debt on unemployment. Thus, the equilibria are efficiency-ranked from the point of view of GDP. Simply the common belief that banks will offer low interest rates can arrest a drop in employment and prevent a recession. What is especially novel about our result is that it points to a role for a financial regulator to intervene to restore efficiency in the labor market. We explore such possible interventions in the next section.

5.2 Policy Implications

A bank regulator may wish to implement policies that eliminate the low-employment equilibrium. Suppose we have a bank regulator in this economy who wishes to increase employment. To do this, his first task is to implement policies that prevent the economy from ending up in the equilibrium with high debt and low employment. His second task is to increase the rate of employment, given that the economy is in the equilibrium with low debt and high employment.

Since the low-employment equilibrium depends on a high face value of worker debt—i.e., high household interest rates—a bank regulator can step in and eliminate this equilibrium by either prohibiting banks from demanding such high repayments or by directly capping household debt. Given this restriction on the face values of household loans, there will only be one feasible equilibrium face value, the lower face value F_- associated with the high-employment equilibrium. We summarize this in the next proposition.

Proposition 7. *If banks are restricted to offer workers debt with face values below a cap $\bar{F} \in (F_-, F_+)$, then the unique equilibrium of the model is the high-employment equilibrium of the model without the cap.*

We now turn to the effect of regulating bank equity on the economy. We perform comparative statics on banks' equity E to represent regulatory capital requirements. Our final main result is that increasing bank equity increases employment, provided that the face value of household debt is capped to ensure the economy is in the high-employment equilibrium.[15]

Proposition 8. *As long as banks's initial equity e is not too small, if banks are restricted to offer workers debt with face values below a cap $\bar{F} \in (F_-, F_+)$, then increasing banks' equity E increases the rate of employment α,*

$$\frac{d\alpha}{dE} > 0. \tag{44}$$

Our analysis thus shows that increasing bank equity increases employment. However, we have also shown that increasing bank equity can be detrimental when the economy is in the low-employment equilibrium. Thus, a regulator must use capital requirements *in conjunction* with other regulations that prevent the economy from ending up in the bad equilibrium. In particular, if the regulator caps household debt, he can eliminate the bad equilibrium, so that capital requirements unambiguously increase employment.

6 Extensions

6.1 The Effect of Directed Search rather than Random Matching

There are two main paradigms of search models in the theory literature in labor economics. They are the directed search framework we employ in our model and the Diamond–Mortensen–Pisarides random matching framework. In this section we explain briefly how our results would differ if we used the random matching framework to model labor market search in our model. The main point of the section is that our results about the effects of household debt on employment are robust to the specification of the matching model. We proceed by outlining a random matching analogue of our labor market search model in which households have debt F. We then explain why

[15]This shows an additional and previously unexplored beneficial effect of bank capital that goes beyond the role of bank capital in promoting financial stability, as discussed, for example in Thakor (forthcoming).

higher household debt leads to lower employment via the free entry condition. Finally, we comment on the effects on wages.

With random search, firms and households divide the surplus generated from their match according to a generalized Nash bargaining rule. This implies that there is a proportion β of the surplus that the household gets and a proportion $1-\beta$ that the firm gets. Since our model is a one-shot model, all outside options are zero. The total surplus to be shared between the household and the firm is $y-F$, the total output generated by the match minus the amount that must be paid to a third party, namely the household's creditor. Thus, the firm's expected profit from entering the market is

$$\Pi = q\alpha(1-\beta)(y-F) - k, \tag{45}$$

where, as in the baseline model, $q\alpha$ is the probability a firm is matched with a household (although here it depends only on the aggregate number of firms entering, not on any submarket), and k is the cost of posting vacancies. Imposing the zero-profit condition $\Pi = 0$ as a result of free entry and rearranging gives

$$q\alpha = \frac{k}{(1-\beta)(y-F)}. \tag{46}$$

This equation says that as F increases $q\alpha$ must increase. Since this probability $q\alpha$ is increasing in the queue length, this means that queues must be longer for firms to enter when households are more indebted. Longer queues are tantamount to fewer vacancies. Thus, as household debt increases there are fewer vacancies. In other words, *the vacancy-posting effect of household debt is robust to the specification of the matching model.*

Note, however, that our predictions about the connection between wages and household debt are sensitive to our specification of the matching model. In the directed search set-up, wages increase as household debt increases. In the random matching model, the wage is just a mechanism to divide the surplus, so the wage equals the household's share of the surplus $\beta(y-F)$ or, $w = \beta(y-F)$. This is decreasing in household indebtedness F.

6.2 Allowing for a Default Penalty

In this section, we discuss the effect of the inclusion of a default penalty on our results. We show that our main results are robust to the inclusion of default penalties, i.e. that as long as the default penalty is capped at a maximum amount, the vacancy-posting effect of household debt will still be at work in the economy. Further, we show that higher default penalties attenuate the vacancy-posting effect. Specifically, for a given level of debt F, higher default penalties lead to higher employment rates.

We now suppose that a household that defaults on its debt suffers a penalty $-d$.[16] Thus, if a household has debt F before searching in the labor market, its expected Date 1 utility is

$$v = \alpha(w - F) + (1 - \alpha)(-d) \tag{47}$$

$$= \alpha\big(w - (F - d)\big) - d. \tag{48}$$

The last term $-d$ is an additive constant and therefore does not affect household behavior. Comparison with equation (10) reveals that a household with debt F that will suffer a penalty $-d$ in the event of default has equivalent preferences to a household with debt $F' := F - d$ that will suffer no penalty in the event of default. Thus, *the vacancy-posting effect is robust to the inclusion of default penalties* (as long as they are bounded) and we view the zero default penalty in the model as just a normalisation of default penalties to zero. In addition, higher default penalties attenuate the vacancy posting effect. The reason is that the preference distortion due the debt overhang problem of debt is mitigated by the default penalty—the effect of $-d$ on preferences is exactly countervailing to the effect of F on preferences. We think that this observation gives a novel cross-sectional prediction of the model: geographical regions with weaker default penalties should have deeper employment slumps following periods of high household leverage, all else equal.

6.3 Robustness to the Functional Form of Utility

In this section we argue that our main results are robust to different assumptions than ours about functional forms. We do this by demonstrating that the main mechanism behind the vacancy-posting effect would only be amplified if we were to use a more traditional utility function that was strictly increasing and concave everywhere.

Consider the utility of a household with debt F searching in the labor market at Date 1. Its expected utility is given by

$$v = \alpha u(w - F) + (1 - \alpha)u(0), \tag{49}$$

where, as in the main model, the household receives $w - F$ if employed (which occurs

[16] This penalty is in utility terms, which, due to our utility specification, is tantamount to consumption terms as long as consumption is less than I, since the household is risk-neutral before the kink at the point I in its utility function.

with probability α) and zero otherwise (which occurs with probability $1-\alpha$). Above we used the functional form $u(c) = \min\{I, c\}$ and recovered equation (10). There we solved for the equilibrium of the search model and found the vacancy-posting effect of household debt, as expressed in Corollary 1. We explained that this is due to a household debt-overhang problem: as households become more indebted, their expected utilities v become more sensitive to wages w relative to the probability α of being employed. To see that this holds true even with a more general utility, differentiate equation (49) with respect to w and α without specifying a specific form for u, but just assuming it is smooth, increasing, and concave. We find that

$$\frac{\partial v}{\partial w} = \alpha u'(w - F), \tag{50}$$

which is increasing in F, i.e.

$$\frac{\partial^2 v}{\partial F \partial w} = -\alpha u''(w - F) > 0. \tag{51}$$

And we find that

$$\frac{\partial v}{\partial \alpha} = u(w - F) - u(0), \tag{52}$$

which is decreasing in F, i.e.

$$\frac{\partial^2 v}{\partial F \partial \alpha} = -u'(w - F) < 0. \tag{53}$$

Thus, increasing F increases the marginal value of higher wages, but decreases the marginal value of a higher probability of employment. This is exactly the mechanism behind the vacancy-posting effect induced by household debt-overhang. As a result, we conclude that we expect that *the vacancy-posting effect of household debt is robust to more general utility specifications.*

7 Conclusion

This paper examines how the credit and labor markets interact and how this interaction is influenced by bank capital. The analysis shows that household debt is inefficiently high in an unregulated equilibrium, and this contributes to lower employment. The feedback effect between the labor and credit markets generates multiple equilibria, one with higher household indebtedness and lower employment than the other. A combination of high capital requirements for banks and a cap on household leverage can both eliminate the low-employment equilibrium and even increase employment above the laissez-faire level in the high-employment equilibrium.

This role of bank capital requirements, used in conjunction with limits on household debt, in promoting employment is novel. It shows that a well-capitalized banking system not only can contribute to a reduction in financial fragility, as is well recognized, but it can also foster a reduction in unemployment. This role of prudential bank regulation seems significant in light of persistently undercapitalized banks and stubbornly-high unemployment in some parts of the world, e.g., Europe.

Future research may be directed at additional considerations related to the effects of interbank competition and competition between banks and markets on unemployment in the real sector. We know from the theories of relationship banking that these factors affect both the nature and level of relationship lending (e.g., Boot and Thakor (2000)) and there is empirical evidence that banking concentration can affect unemployment (e.g., Gatti, Rault, and Vaubourg (2012)). These insights may be joined to explore a host of additional issues that have potentially rich regulatory implications. One of these is the potential interaction between unemployment insurance, unemployment, consumer indebtedness and bank capital in a general equilibrium setting.

A Appendix

A.1 Proof of Proposition 1

The result follows immediately from substituting $\alpha(q) = a/\sqrt{q}$ into equations (14) and (16). $\square$

A.2 Proof of Corollary 1

Substituting in for the equilibrium q from Proposition 1 gives the employment rate

$$\alpha(q) = \frac{a^2(y - F)}{2k}, \tag{54}$$

which is decreasing in F. $\square$

A.3 Proof of Proposition 2

The objective function in equation (22) is a negative quadratic polynomial in σ, so the first-order condition determines the global maximum, i.e., whenever there is an interior solution $\sigma \in (0, 1)$, the optimal screening precision solves

$$(1 - \theta)(I - RD) - \gamma\sigma = 0. \tag{55}$$

When the global maximizer is to the right of the boundary at $\sigma = 1$, $\sigma = 1$ maximizes the quadratic on the domain $[0, 1]$. In contrast, we can see immediately from the first-order condition for $\sigma > 0$ whenever $I > RD$—there is never a corner solution at zero. $\square$

A.4 Proof of Proposition 3

To prove that $\Delta = 0$ in equilibrium, we suppose an interior solution $\Delta \in (0, I - e)$ and then show that changing D (equivalent to changing Δ) is a profitable deviation for the bank. As a result, it must be that the program has a corner solution. There are two possible corner solutions, $D = 0$ and $D = I - e$. We compare these directly and show that $D = I - e$ corresponds to a higher value of the objective than $D = 0$, so leverage is maximal in equilibrium.

We divide the proof into four steps. In Step 1, we eliminate the variables that appear linearly in the constraints to simplify the program. In Step 2, we consider a marginal change in leverage. We do this by differentiating the objective along the surface defined by the binding constraints. In Step 3, we prove that the program must have a corner solution, so $D \in \{0, I-e\}$. Finally, in Step 4, we compare the values of the objective at these two candidate solutions directly and show that it must be that $D = I - e$ in equilibrium.

Step 1: Reducing the program. We begin the proof by rewriting the bank's program from equations (25)–(29), having substituted for the equilibrium value of screening intensity σ: maximize

$$\left(1 - \frac{(1-\theta)^2}{\gamma}\big(I - RD\big)\right) I + \delta\theta\alpha(w - F) \tag{56}$$

subject to

$$\beta\left(\theta\alpha(F - RD) + \frac{(1-\theta)^2}{2\gamma}\big(I - RD\big)^2\right) = e, \tag{57}$$

$$(1-\beta)\left(\theta\alpha(F - RD) + \frac{(1-\theta)^2}{2\gamma}\big(I - RD\big)^2\right) = \Delta, \tag{58}$$

$$\theta\alpha RD + \frac{(1-\theta)^2}{\gamma}\big(I - RD\big)RD = D, \tag{59}$$

$$e + \Delta + D = I \tag{60}$$

over F, β, Δ, R, and D. Now, observe that the system is linear in the variables β, e, and Δ that appear in the constraints. Thus, we can collapse the three equations (57), (58), and (60) into a single equation, which we then add to equation (59), to eliminate these three variables to rewrite the program again: maximize

$$\left(1 - \frac{(1-\theta)^2}{\gamma}\big(I - RD\big)\right) I + \delta\theta\alpha(w - F) \tag{61}$$

subject to

$$\theta\alpha F + \frac{(1-\theta)^2}{2\gamma}\big(I^2 - R^2D^2\big) = I, \tag{62}$$

$$\theta\alpha R + \frac{(1-\theta)^2}{\gamma}\big(I - RD\big)R = 1. \tag{63}$$

Step 2: The effect of an incremental change in D on the objective. Now suppose that $\Delta > 0$ or, equivalently, $D < I - e$ and consider a marginal increase in D. First, we solve for $\partial F/\partial D$ by differentiating the first constraint (as expressed in equation (62)).

This gives

$$\theta\alpha\frac{\partial F}{\partial D} - \frac{(1-\theta)^2 RD}{\gamma}\frac{\partial}{\partial D}(RD) = 0. \tag{64}$$

We now differentiate the objective and substitute for $\partial F/\partial D$ from the equation above:

$$\frac{(1-\theta)^2 I}{\gamma}\frac{\partial}{\partial D}(RD) - \delta\theta\alpha\frac{\partial F}{\partial D} = \frac{(1-\theta)^2}{\gamma}\big(I - \delta RD\big)\frac{\partial}{\partial D}(RD). \tag{65}$$

Since $\delta < 1$, $I - \delta RD > I - RD$, which is positive by Maintained Hypothesis 1. Thus, a necessary and sufficient condition for the objective to be increasing in D is for RD to be increasing in D. We will now use the second constraint (equation 63) to show that this condition is satisfied.

Step 3: Showing the program has a corner solution. Differentiating the second constraint (as expressed in equation (63)) with respect to D gives

$$\left(\theta\alpha + \frac{(1-\theta)^2}{\gamma}\big(I - RD\big)\right)\frac{\partial R}{\partial D} - \frac{(1-\theta)^2}{\gamma}R\frac{\partial}{\partial D}(RD) = 0. \tag{66}$$

We now simplify this equation using the fact that

$$\frac{\partial}{\partial D}(RD) = R + D\frac{\partial R}{\partial D}, \tag{67}$$

to recover

$$\frac{\partial R}{\partial D} = \frac{(1-\theta)^2 R^2}{\theta\alpha\gamma + (1-\theta)^2(I - 2RD)}. \tag{68}$$

Now turn to the condition established above—i.e. that RD is increasing in D—and substitute for $\partial R/\partial D$ from the last equation above (equation (68)) to see exactly when it is satisfied:

$$\begin{aligned}
\frac{\partial}{\partial D}(RD) &= R + D\frac{\partial R}{\partial D} && (69)\\
&= R + \frac{(1-\theta)^2 R^2 D}{\theta\alpha\gamma + (1-\theta)^2(I - 2RD)} && (70)\\
&= \left(\frac{\theta\alpha\gamma + (1-\theta)^2(I - 2RD) + (1-\theta)^2 RD}{\theta\alpha\gamma + (1-\theta)^2(I - 2RD)}\right)R && (71)\\
&= \left(\frac{\theta\alpha\gamma + (1-\theta)^2(I - RD)}{\theta\alpha\gamma + (1-\theta)^2(I - 2RD)}\right)R. && (72)
\end{aligned}$$

Maintained Hypothesis 1 (that $I > RD$) implies that the numerator is always positive and the derivative above is never zero. Since RD is always strictly increasing or strictly decrease in D, we know from Step 2 above that the objective is either strictly increasing or strictly decreasing in D. This implies that the program has a corner solution, either

$D = 0$ or $D = I - e$. Specifically, if RD is increasing in D, then $D = I - e$ and if RD is decreasing in D then $D = 0$.

Step 4: Comparing $D = 0$ and $D = I - e$.

Here we evaluate the objective function from equation (61),

$$\text{objective}\,\Big|_{R,D} := \left(1 - \frac{(1-\theta)^2}{\gamma}\big(I - RD\big)\right) I + \delta\theta\alpha\big(w - F\big) \tag{73}$$

where, from equation (62), F is determined by

$$\theta\alpha F = I - \frac{(1-\theta)^2}{2\gamma}\big(I^2 - R^2D^2\big). \tag{74}$$

Now we compute the difference between the objective at the $D = I - e$ corner and the $D = 0$ corner. The computation uses the fact that $\delta < 1$.

$$\begin{aligned}
\text{objective}\,\Big|_{R,D=I-e} - \text{ objective}\,\Big|_{R,D=0} &= \frac{(1-\theta)^2}{\gamma}R(I-e)I - \frac{\delta(1-\theta)^2}{2\gamma}R^2(I-e)^2 \\
&= \frac{(1-\theta)^2}{2\gamma}\Big(2I - \delta R(I-e)\Big)R(I-e) \\
&> \frac{(1-\theta)^2}{2\gamma}\Big(I - R(I-e)\Big)R(I-e) \\
&> 0,
\end{aligned}$$

since $I - R(I-e) = I - RD > 0$ by Maintained Hypothesis 1. □

A.5 Proof of Proposition 4

Immediate from applying the quadratic formula to equation (37). □

A.6 Proof of Proposition 5

We begin the proof by computing the derivative of Γ_D with respect to RD, denoted Γ'_D, whenever it exists:

$$\Gamma'_D = \begin{cases} \dfrac{2k(1-\theta)^2RD}{\gamma a^2\theta} & \text{if } 0 < I - RD < \dfrac{\gamma}{1-\theta}, \\[2ex] 0 & \text{otherwise,} \end{cases} \tag{75}$$

so $\Gamma'_D \geq 0$. Also recall from Appendix A.4 that $\partial(RD)/\partial D \geq 0$, so

$$\frac{d\Gamma_D}{dD} = \Gamma'_D \frac{\partial(RD)}{\partial D} \geq 0. \tag{76}$$

Turning to the face value of household debt, we have

$$\frac{dF_-}{dD} = \frac{\partial(RD)}{\partial D} \frac{\Gamma'_D}{\sqrt{y^2 - 4\Gamma_D}} \geq 0 \tag{77}$$

and

$$\frac{dF_+}{dD} = -\frac{\partial(RD)}{\partial D} \frac{\Gamma'_D}{\sqrt{y^2 - 4\Gamma_D}} \leq 0. \tag{78}$$

To complete the argument, note that it is easy to see from the definition of Γ_D that Γ_D is decreasing in D about the kinks, where it is not differentiable. $\square$

A.7 Proof of Lemma 2

The statement follows immediately from inserting the expression for σ from Proposition 2 and the expressions for F_- and F_+ from Proposition 4 into equation (41). $\square$

A.8 Proof of Lemma 3

In order for depositors to lend directly to workers it must be incentive compatible for both workers to borrow directly from depositors and for depositors to lend directly to workers rather than to lend to workers via banks. Denoting by R_s the rate at which the depositor lends to the worker, the incentive compatibility constraint for the worker to borrow from the depositor is

$$R_s I < F.$$

In other words, the depositor must prefer to borrow $R_s I$ from the depositor than F from the bank.

The incentive compatibility constraint for the depositor is

$$\theta \alpha R_s > \theta \alpha R + (1 - \theta)\sigma R.$$

In other words, he must prefer to lend I at rate R_s to his worker (regardless of his type) and get back $R_s I$ if the worker is good and employed, than to lend I at rate R to a bank. If he lends to a bank he gets repaid in two cases: either if the worker is good and employed or if the bank screens, does not lend to a bad worker and does not default.

The incentive compatibility constraints are satisfied if

$$R_s \in \left(\frac{\theta\alpha R + (1-\theta)\sigma R}{\theta\alpha}, \frac{F}{I} \right).$$

Such a rate exists when the interval above is non-empty. Thus, if

$$\frac{F}{I} < \frac{\theta\alpha R + (1-\theta)\sigma R}{\theta\alpha},$$

then there is no R_s that satisfies the constraints.

Since $\theta\alpha R + (1-\theta)\sigma R = 1$, the equation above can be re-written as

$$\theta\alpha F < I.$$

Plugging in for F from equation (34), this can be re-written as

$$\frac{(1-(1-\theta)\sigma)I + c(\sigma)}{I} < 1. \tag{79}$$

As a result of the bank's maximization of the objective in equation (22), the left-hand-side in the above equation is minimized in equilibrium. Thus, it is always smaller than it's value at $\sigma = 1$:

$$\frac{(1-(1-\theta)\sigma)I + c(\sigma)}{I} < \left. \frac{(1-(1-\theta)\sigma)I + c(\sigma)}{I} \right|_{\sigma=1} = 1.$$

This implies that inequality (79) is always satisfied and R_s does not exist. $\square$

A.9 Proof of Proposition 8

For this proof, we simply compute the total derivative of α with respect to D directly, given that the face value of debt is

$$F_- = \frac{1}{2}\big(y - \sqrt{y^2 - 4\Gamma_D}\big).$$

Note that α depends on F_- which, in turn, depends on Γ_D. For $I - RD > \gamma/(1-\theta)$, Γ_D does not depend on D. For $I - RD < \gamma/(1-\theta)$, Γ_D depends on D directly and indirectly, via R. Thus,

$$\frac{d\alpha}{dD} = -\frac{a^2}{2k\sqrt{y^2 - 4\Gamma_D}} \left(\frac{d\Gamma_D}{dD} + \frac{\partial \Gamma_D}{\partial R}\frac{\partial R}{\partial D} \right).$$

We know that $I - RD > \gamma/(1-\theta)$ we have that $d\alpha/dD = 0$, so we can focus on the case in which $I - RD < \gamma/(1-\theta)$. First note that

$$\frac{\partial \Gamma_D}{\partial D} = \frac{2kI(1-\theta)^2 R^2 D}{a^2 \theta \gamma} > 0,$$

and

$$\frac{\partial \Gamma_D}{\partial R} = \frac{2kI(1-\theta)^2 R D^2}{a^2 \theta \gamma} > 0.$$

As a result, a sufficient condition for $d\alpha/dD$ to be negative is that $\partial R/\partial D$ is positive.

Now, recall that R is defined implicitly by the following equation

$$\frac{\theta a^2}{4k}\left(y + \sqrt{y^2 - 4\Gamma_D}\right) R + \frac{1}{\gamma}(1-\theta)^2 (I - RD) R = 1. \tag{80}$$

So we use the implicit function theorem to determine the sign of $\partial R/\partial D$. Below, we refer to $\partial R/\partial D$ as R'. Implicitly differentiating the equation above we find

$$\frac{\theta a^2}{4k}\left(y + \sqrt{y^2 - 4\Gamma_D}\right) R' - \frac{\theta a^2 R}{2k\sqrt{y^2 - 4\Gamma_D}}\left(\frac{\partial \Gamma_D}{\partial R} R' + \frac{\partial \Gamma_D}{\partial D}\right) + \\ + \frac{1}{\gamma}(1-\theta)^2 \left[IR' - R^2 - 2RDR'\right] = 0$$

or

$$\left[\frac{\theta a^2}{4k}\left(y + \sqrt{y^2 - 4\Gamma_D}\right) + \frac{1}{\gamma}(1-\theta)^2 (I - RD) - \frac{(1-\theta^2)RD}{\gamma}\left(\frac{IRD}{\sqrt{y^2 - 4\Gamma_D}} + 1\right)\right] R' = \\ = \frac{(1-\theta)^2 R^2}{\gamma}\left(\frac{IRD}{\sqrt{y^2 - 4\Gamma_D}} + 1\right).$$

Thus, R' is positive as long as

$$\frac{\theta a^2}{4k}\left(y + \sqrt{y^2 - 4\Gamma_D}\right) + \frac{1}{\gamma}(1-\theta)^2 (I - RD) - \frac{(1-\theta^2)RD}{\gamma}\left(\frac{IRD}{\sqrt{y^2 - 4\Gamma_D}} + 1\right) > 0,$$

which holds as long as D is not too large. Since $D = I - e$ in equilibrium, this holds as long as e is not too small. Thus, whenever the bank's initial equity e is not too small, $d\alpha/dD < 0$ or $d\alpha/dE > 0$ as desired. $\square$

A.10 Sufficiency of Bounds in Assumption 3

Here we show the sufficiency of the bounds stated in Assumption 3 for the matching probabilities to be well-defined. Substituting the equilibrium q from Proposition 1 and the equilibrium F from Proposition 4, we can rewrite the condition in equation (5) as

$$a^2(y - F) < 2k < (y - F).$$

Plugging in for for the smallest F, i.e., F_-, in the left-hand-side of the equation and for the largest F, i.e., F_+, in the right hand side of the equation we obtain sufficient conditions for the inequality above to hold, namely

$$a^2\left(y + \sqrt{y^2 - 4\Gamma_D}\right) < 4k < y - \sqrt{y^2 - 4\Gamma_D}.$$

These bounds are tightest when Γ_D is smallest. Thus, we minimize Γ_D over all possible σ. We do this by minimizing the expression[17]

$$\Gamma_D = \frac{2k}{a^2\theta}\Big(\big(1 - (1-\theta)\sigma\big)I + c(\sigma)\Big) \tag{81}$$

and replacing σ with the minimizer

$$\sigma = \frac{(1-\theta)I}{\gamma} \tag{82}$$

to find the expression for $\Gamma_{\min}$ in the statement of the assumption. □

A.11 Verification that $0 < w - F < I$

In Subsection 3.1 we solved the model under the hypothesis that $0 < w - F < I$. Here we show that given the equilibrium values of w and F, Assumption 4 suffices for the hypothesis to hold. Substituting in for w from Proposition 1 gives the necessary and sufficient condition

$$F < y < 2I + F. \tag{83}$$

The expressions for F in Proposition 4 show that $0 < F < y$, so Assumption 4 that $y < 2I$ suffices.

[17]The expression is a negative quadratic, so the first-order condition suffices to find the global minimizer.

A.12 Verification of Maintained Hypothesis $I - RD > 0$

We use the equation

$$\theta\alpha RD + \frac{(1-\theta)^2}{\gamma}(I - RD)RD = D \tag{84}$$

which follows from plugging in for the equilibrium σ in equation (40) to show that the hypothesis $I > RD$ (Maintained Hypothesis 1) holds in equilibrium. This equation says that

$$I - RD = \frac{\gamma(1-\theta\alpha R)}{(1-\theta)^2 R}. \tag{85}$$

Therefore $I > RD$ exactly when

$$1 > \theta\alpha R. \tag{86}$$

This holds by equation (84) since $I - RD > 0$ by hypothesis.

Notice that this argument is (appropriately) circular. When $I > RD$, banks anticipate that they can recover the value $I - RD$ from avoiding lending to a bad borrower. This induces them to invest in a positive screening precision in equilibrium (Proposition 2). Because the screening precision is positive, depositors get repaid with probability higher than $\theta\alpha$. Thus they demand an interest rate strictly lower than $(\theta\alpha)^{-1}$. $\square$

A.13 Table of Notations

	Labor Market
q_w	the queue length in the submarket associated with wage w
q	the equilibrium queue length
α	probability that a worker is matched with a firm
$q\alpha$	probability that a firm is matched with a worker
	Workers
U	workers' lifetime utility function
u	workers' single date utility ("felicity") function
I	workers' utility parameter—i.e. the point of the kink in workers' utility
c_t	workers' consumption at Date t
δ	workers' discount factor
$\tau \in \{g, b\}$	worker type
	Banks
$s \in \{s_g, s_b\}$	signal about worker type
σ	banks' screening precision
$c(\sigma)$	banks' cost of screening
γ	cost function parameter
V	banks' total assets
e	banks' initial equity
Γ_D	shorthand notation in banks' asset value
	Firms
y	firms' output
k	firms' search cost
Π	firms' profit
	Contracts
B	the amount workers' borrow from banks
F	the face value of worker debt
F_-, F_+	the two possible equilibrium face values of worker debt
D	the amount banks borrow from depositors via debt
R	the interest rate on bank deposits
Δ	the amount banks raise from depositors via equity
β	the proportion of equity retained by initial equity holders
w	the wage firms pay workers

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