Financial markets and unemployment.*

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Abstract  

We study the importance of financial markets for (un)employment fluctuations in a model with searching and matching frictions where firms issue debt under limited enforcement. Higher debt allows employers to bargain lower wages which in turn increases the incentive to create jobs. The transmission mechanism of ‘credit shocks’ is fundamentally different from the typical credit channel and the model can explain why firms cut hiring after a credit contraction even if they have not shortage of funds for hiring workers. The theoretical predictions are consistent with the estimation of a structural VAR whose identifying restrictions are derived from the theoretical model.

Keywords: Limited enforcement, wage bargaining, unemployment, credit shocks.

JEL classification: E24, E32, E44.

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1 Introduction

The recent financial turmoil has been associated with a severe increase in unemployment. In the United States the number of unemployed workers jumped from 5.5 percent of the labor force to about 10 percent and continues to stay close 9 percent despite more than three years have passed since the beginning of the recession. Because the financial sector has been at the center stage of the recent crisis and the volume of credit has dropped significantly, many believe that the contraction of credit is an important driving force of the unemployment hike. According to this view, employers are forced to cut investment and employment because they have difficulties raising funds. This is the typical ‘credit channel’ described in Bernanke and Gertler (1989) and Kiyotaki and Moore (1997).

Although there is some compelling evidence in support of the view that the credit channel has played an important role at the beginning of the crisis when the volume of credit contracted sharply and the liquidity in the business sector dried up, this channel appears less important for explaining the sluggish recovery of the labor market after the initial drop in employment. As shown in the top panel of Figure 1, the liquidity held by US businesses contracted in the first stage of the crisis, consistent with the view of a credit crunch. However, after the initial drop, the liquidity of nonfinancial businesses quickly rebounded and shortly after the crisis firms have completely rebuilt their liquidity. Therefore, in spite of the credit contraction (see bottom panel of Figure 1) firms seem to have enough resources to finance investment and hiring. This poses some doubts that the standard credit channel is the primary explanation for the sluggish recovery of the labor market after the initial stage of the crisis.

Should we then conclude that the credit contraction is irrelevant for the sluggish recovery of employment? In this paper we argue that, even if firms have enough funds to support their hiring plans, a credit contraction can still generate a cut in employment that is very persistent. The reason lower debt reduces employment is not because it impairs the hiring ability of firms but because it allows workers to bargain higher wages. Therefore, availability of credit affects the ‘willingness’, not (necessarily) the ‘ability’ to hire.

The theoretical framework shares the basic ingredients of the models studied in Pissarides (1987) and Mortensen and Pissarides (1994) where firms are created through the random matching of job vacancies and workers. We extend the basic structure of these models in two directions. First, we al-
Liquid assets/GDP

Debt/GDP

Figure 1: Liquidity and debt in the US nonfinancial business sector. *Liquidity* is the sum of foreign deposits, checkable deposits and currency, time and savings deposits. *Debt* is defined as credit markets instruments. Data is from the Flows of Funds Accounts.
low firms to issue debt under limited enforcement. Second, we introduce an additional source of business cycle fluctuations which affects directly the enforcement constraint of borrowers and the availability of credit.

Because of the matching frictions and the wage determination process based on bargaining, firms prefer to issue debt even if there is no fixed or working capital that needs to be financed. The preference for debt derives exclusively from the wage determination process, that is, bargaining, whose empirical relevance is shown in Hall and Krueger (2010). When wages are determined through bargaining, higher debt reduces the net bargaining surplus which in turn reduces the wages paid to workers. This creates an incentive for the employer to borrow until the borrowing limit binds. The goal is to study how exogenous or endogenous changes in this limit affect the dynamics of the labor market.

Central to our mechanism is the firm’s capital structure as a bargaining tool in the wage determination process. Both anecdotal and statistical evidence point to this channel. Consider the anecdotal evidence first. An illustrative example is provided by the case of the New York Metro Transit Authority. In 2004 the company realized an unexpected 1 billion dollars surplus, largely from a real estate boom. The Union, however, claimed rights to the surplus demanding a 24 percent pay raise over three years.\footnote{From The New York Times, Transit Strike Deadline: How extra Money Complicates Transit Pay Negotiations, 12/15/2005: “The unexpected windfall was supposed to be a boom[...] but has instead become a liability[...] How, union leaders have asked, can the authority boast of such a surplus and not offer raises of more than 3 percent a year? Why aren’t wages going up more?” In a similar vein: “The magnitude of the surplus [...] has set this year’s negotiations apart from prior ones, said John E. Zuccotti, a former first deputy mayor. It’s a much weaker position than the position the M.T.A. is normally in: We’re broke and we haven’t gotten any money [...] The playing field is somewhat different. They haven’t got that defense”.

Another example comes from Delta Airlines. The company weathered the 9/11 airline crisis but its excess of liquidity allegedly reduced the need to cut costs. This hurt the firm’s bargaining position with workers and three years after 9/11 it faced severe financial challenges.\footnote{From The Wall Street Journal, Cross Winds: How Delta’s Cash Cushion Pushed It Onto Wrong Course, 10/29/2004: “In hindsight, it is clear now that Delta’s pile of cash and position as the strongest carrier after 9/11 lured the company’s pilots and top managers onto a dire course. Delta’s focus on boosting liquidity turned out to be its greatest blessing and curse, helping the company survive 9/11 relatively unscathed but also putting off badly needed overhauls to cut costs”.

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The idea that debt allows employers to improve their bargaining position is supported by several empirical studies in corporate finance literature. Bronars and Deere (1991) document a positive correlation between leverage and labor bargaining power, proxied by the degree of unionization. Matsa (2010) finds that firms with greater exposure to (union) bargaining power have a capital structure more skewed towards debt. Atanassov and Kim (2009) find that strong union laws are less effective in preventing large-scale layoffs when firms have higher financial leverage. Gorton and Schmid (2004) study the impact of German co-determination laws on firms’ labor decisions. They show that firms that are subject to these laws also exhibit greater leverage ratios. Chen, Chen and Liao (2011) show that labor union strength relates positively to bond yield spreads.

All the aforementioned studies suggest that firms may use financial leverage strategically in order to contrast the bargaining power of workers. Although there are theoretical studies in the micro-corporate literature that investigates this mechanism (see Perotti and Spier (1993)), the implications for employment dynamics at the macroeconomic level have not been explored. With this paper we provide some new insights. In particular, we study the response of the labor market to a shock that affects directly the availability of credit for employers. These shocks resemble the ‘credit shocks’ studied in Jermann and Quadrini (2009) but the transmission mechanism is fundamentally different. While in Jermann and Quadrini credit shocks are transmitted through the standard credit channel (higher cost of financing employment), in our paper the financing cost does not change over time. More specifically, a credit contraction forces firms to cut on borrowing, placing them on a less favorable position in the bargaining of wages. As a result, fewer jobs are created.

Credit shocks can generate sizable employment fluctuations in our model. Furthermore, as long as the credit contraction is persistent—a robust feature of the data—the impact on the labor market is long-lasting. In this vein, the properties of the model are consistent with recent findings that recessions associated with financial crisis are more persistent than recessions associated with systemic financial difficulties. See IMF (2009), Claessens, Kose, and Terrones (2008), Reinhart and Rogoff (2009). Models with the standard credit channel such as Jermann and Quadrini (2009) are capable of generating a severe drop in employment but cannot easily generate the persistence.

Chugh (2009) and Petrosky-Nadeau (2009) have also embedded credit market frictions in search and matching models of the labor market. How-
ever, the transmission mechanism is still based on the typical credit channel. More specifically, since firms could be financially constrained, the cost of financing new vacancies plays a central role in the transmission of shocks. Also related is Wasmer and Weil (2004). They consider an environment in which bargaining is not between workers and firms but between entrepreneurs and financiers. In this model financiers are needed to finance the cost of posting a vacancy and the higher surplus extracted by financiers is similar to a higher cost of financing investments. Thus, the mechanism is still of the credit channel type.

In order to assess the empirical relevance of credit shocks for employed fluctuations, we estimate a structural VAR with both productivity and credit shocks. The two shocks are identified using short-term restrictions derived from the theoretical model. We find that the response of employment (and unemployment) to credit shocks is statistically significant and economically sizable.

The structure of the paper is as follows. Section 2 presents the theoretical model and Section 3 provides analytical intuitions for employment response to shocks. After presenting the quantitative analysis in Section 4, the next Section 5 proposes an extension of the baseline model capable of improving the dynamics of wages. Section 6 conducts the empirical analysis based on a structural VAR and Section 7 concludes.

2 Model

There is a continuum of agents of total mass 1 with lifetime utility $E_0 \sum_{t=0}^{\infty} \beta^t c_t$. At any point in time agents can be employed or unemployed. They save in two types of assets: shares of firms and bonds. Risk neutrality implies that the expected return from both assets is equal to $1/\beta - 1$. Therefore, the net interest rate is constant and equal to $r = 1/\beta - 1$.

Firms: Firms are created through the matching of a posted vacancy and a worker. Starting in the next period, a new firm produces output $z_t$ until the match is separated. Separation arises with probability $\lambda$. An unemployed worker cannot be self-employed but needs to search (costlessly) for a job. The number of matches is determined by the function $m(v_t, u_t)$, where $v_t$ is the number of vacancies posted during the period and $u_t$ is the number of unemployed workers. The probability that a vacancy is filled is $q_t =$
$m(v_t, u_t)/v_t$ and the probability that an unemployed worker finds a job is $p_t = m(v_t, u_t)/u_t$.

At any point in time firms are characterized by three states: a productivity $z_t$, an indicator of the financial conditions $\phi_t$ that will be described below, and a stock of debt $b_t$. The productivity $z_t$ and the financial state $\phi_t$ are exogenous stochastic variables, common to all firms (aggregate shocks). The stock of debt $b_t$ is chosen endogenously. Although firms could choose different levels of debt, in equilibrium they all choose the same $b_t$.

The dividend paid to the owners of the firm (shareholders) is defined by the budget constraint

$$d_t = z_t - w_t - b_t + \frac{b_{t+1}}{R},$$

where $R$ is the gross interest rate charged on the debt. As we will see, $R$ is different from $1 + r$ because of the possibility of default when the match is separated.

**Timing**: If a vacancy is filled, a new firm is created. The new firm starts producing in the next period, and therefore, there is no wage bargaining in the current period. However, before entering the next period, the newly created firm chooses the debt $b_{t+1}$ and pays the dividend $d_t = b_{t+1}/R_t$ (the initial debt $b_t$ is zero). There is not separation until the next period. Once the new firm enters the next period, it becomes an incumbent firm.

An incumbent firm starts with a stock of debt $b_t$ inherited from the previous period. In addition, it knows the current productivity $z_t$ and the financial variable $\phi_t$. Given the states, the firm bargains the wage $w_t$ with the worker and output $z_t$ is produced. The choice of the new debt $b_{t+1}$ and the payment of dividends arise after wage bargaining. After the payments of dividends and wages, and after contracting the new debt, the firm observes whether the match is separated. It is at this point that the firm chooses whether to default. Therefore, each period can be divided in three sequential steps: (i) wage bargaining, (ii) financial decision, (iii) default. These sequential steps are illustrated in figure 2.

**Remarks on timing**: We would like to clarify the importance of the timing assumptions. Although this will become clear later, it will be helpful to stress the relevance of our assumptions here. First, the sequential timing
of decisions for an *incumbent* firm is irrelevant for the dynamic properties of equilibrium employment. For example, the alternative assumption that incumbent firms choose the new debt before or jointly with the bargaining of wages will not affect the dynamics of employment. For *new* firms, instead, the assumption that the debt is chosen in the current period while the first bargaining takes place in the next period is crucial for the results. As an alternative, we could assume that bargaining takes place in the same period in which a vacancy is filled as long as the choice of debt is made before going to the bargaining table with the new worker. For presentation purposes, we assumed that the debt is raised after matching with a worker (but before bargaining the wage). Alternatively, we could assume that the debt is raised before posting a vacancy and this would not affect the results. What is crucial is that the debt of a new firm is raised before bargaining for the first time with the new worker. Second, the assumption that wages continue to be bargained in every period is not important. We adopted this assumption in order to stay as close as possible to the standard matching model (Pissarides 1987)). In Section 5 we show that the employment dynamics do not change if we make different assumptions about the frequency of bargaining. All we need is that there is bargaining when a new worker is hired.

Financial contract and borrowing limit: We assume that lending is done by competitive intermediaries who pool a large number of loans. We
refer to these intermediaries as *lenders*. The amount of borrowing is constrained by limited enforcement. After the payments of dividends and wages, and after contracting the new debt, the firm observes whether the match is separated. It is at this point that the firm chooses whether to default. In the event of default the lender will be able to recover only a fraction $\chi_t$ of the firm’s value.

Denote by $J_t(b_t)$ the equity value of the firm at the beginning of the period, which is equal to the discounted expected value of dividends for shareholders. This function depends on the individual stock of debt $b_t$. Obviously, higher is the debt and lower is the equity value. It also depends on the aggregate states $s_t = (z_t, \phi_t, B_t, N_t)$, where $z_t$ and $\phi_t$ are exogenous aggregate states (see more below), $B_t$ is the aggregate stock of debt and $N_t = 1 - u_t$ is employment. We distinguish aggregate debt from individual debt since we have to allow for out-of-equilibrium deviations in order to derive the equilibrium. We use the time subscript $t$ to capture the dependence of the value function from the aggregate states, that is, we write $J_t(b_t)$ instead of $J(z_t, \phi_t, B_t, N_t; b_t)$. We will use this notational convention throughout the paper.

We begin by considering the possibility of default when the match is separated. In this case the value of the firm is zero. The lender anticipates that the recovery value is zero in the event of separation and the debt will not be repaid. Therefore, in order to break-even, the lender imposes a borrowing limit insuring that the firm does not default when the match is not separated and charges an interest rate premium to cover the losses realized when the match is separated.

If the match is not separated, the value of the firm’s equity is $\beta E_t J_{t+1}(b_{t+1})$, that is, the next period expected value of equity discounted to the current period. Adding the present value of debt, $b_{t+1}/(1 + r)$, we obtain the total value of the firm. If the firm defaults, the lender recovers only a fraction $\chi_t$ of the total value of the firm. Therefore, the lender is willing to lend as long as the following constraint is satisfied

$$\chi_t \left[ \frac{b_{t+1}}{1 + r} + \beta E_t J_{t+1}(b_{t+1}) \right] \geq \frac{b_{t+1}}{1 + r}.$$ 

The variable $\chi_t$ is stochastic and affects the borrowing capacity of the firm. Henceforth, we will refer to unexpected changes in $\chi_t$ as ‘credit shocks’.

By collecting the term $b_{t+1}/(1 + r)$ and using the fact that $\beta(1 + r) = 1$,
we can rewrite the enforcement constraint more compactly as

$$\phi_t \mathbb{E}_t J_{t+1}(b_{t+1}) \geq b_{t+1},$$

(1)

where $$\phi_t \equiv \chi_t/(1 - \chi_t)$$. We can then think of credit shocks as unexpected innovations to the variable $$\phi_t$$. This is the exogenous state variable included in the set of aggregate states $$s_t$$.

We now have all the elements to determine the actual interest rate that lenders charge to firms. Since the loan is made before knowing whether the match is separated, the interest rate charged by the lender takes into account that the repayment arises only with probability $$1 - \lambda$$. Assuming that financial markets are competitive, the zero-profit condition requires that the gross interest rate $$R$$ satisfies

$$R(1 - \lambda) = 1 + r.$$  

(2)

The left-hand side of (2) is the lender’s expected income per unit of debt. The right-hand side is the lender’s opportunity cost of funds (per unit of debt). Therefore, the firm receives $$b_{t+1}/R$$ at time $$t$$ and, if the match is not separated, it repays $$b_{t+1}$$ at time $$t + 1$$. Because of risk neutrality, the interest rate is always constant, and therefore, $$r$$ and $$R$$ bear no time subscript.

**Firm’s value:** Central to the characterization of the properties of the model is the wage determination process which is based on bargaining. Before describing the bargaining problem, we define the value of the firm recursively taking as given the wage bargaining outcome. This is denote by $$w_t = g_t(b_t)$$. The recursive structure of the problem implies that the wage is fully determined by the states at the beginning of the period.

The equity value of the firm can be written recursively as

$$J_t(b_t) = \max_{b_{t+1}} \left\{ z_t - g_t(b_t) - b_t + \frac{b_{t+1}}{R} + \beta(1 - \lambda)\mathbb{E}_t J_{t+1}(b_{t+1}) \right\}$$

(3)

subject to

$$\phi_t \mathbb{E}_t J_{t+1}(b_{t+1}) \geq b_{t+1}.$$  

Notice that the only choice variable in this problem is the debt $$b_{t+1}$$. Also notice that the firm takes the current wage as given but it fully internalizes that the choice of debt $$b_{t+1}$$ affects future wages.
Because of the additive structure of the objective function, the optimal choice of $b_{t+1}$ does not depend neither on the current wage $w_t = g_t(b_t)$ nor on the current liabilities $b_t$.

**Lemma 1** The new debt $b_{t+1}$ chosen by the firm depends neither on the current wage $w_t = g_t(b_t)$ nor on the current debt $b_t$.

**Proof 1** Since $w_t$ and $b_t$ enter the objective function additively and they do not affect neither the next period value of the firm’s equity nor the enforcement constraint, the choice of $b_{t+1}$ is independent of $w_t$ and $b_t$.

As we will see, this property greatly simplifies the wage bargaining problem we will describe below.

**Worker’s values:** In order to set up the bargaining problem, we define the worker’s values ignoring the capital incomes earned from the ownership of bonds and firms (interests and dividends). Since agents are risk neutral and the change in the dividend of an individual firm is negligible for an individual worker, we can ignore these incomes in the derivation of wages.

When employed, the worker’s value is

$$W_t(b_t) = g_t(b_t) + \beta E_t \left[ (1 - \lambda)W_{t+1}(b_{t+1}) + \lambda U_{t+1} \right],$$

which is defined once we know the wage function $w_t = g_t(b_t)$. The function $U_{t+1}$ is the value of being unemployed and is defined recursively as

$$U_t = a + \beta E_t \left[ p_t W_{t+1}(B_{t+1}) + (1 - p_t)U_{t+1} \right],$$

where $p_t$ is the probability that an unemployed worker finds a job and $a$ is the flow utility for an unemployed worker.

While the value of an employed worker depends on the aggregate states and the individual debt $b_t$, the value of being unemployed depends only on the aggregate states since all firms choose the same level of debt in equilibrium. Thus, if an unemployed worker finds a job in the next period, the value of being employed is $W_{t+1}(B_{t+1})$. 

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**Bargaining problem:** Let’s first define the functions

\[
\hat{J}_t(b_t, w_t) = \max_{b_{t+1}} \left\{ z_t - w_t - b_t + \frac{b_{t+1}}{R} + \beta(1 - \lambda)\mathbb{E}_tJ_{t+1}(b_{t+1}) \right\}
\]

(5)

\[
\hat{W}_t(b_t, w_t) = w_t + \beta\mathbb{E}_t\left[ (1 - \lambda)W_{t+1}(b_{t+1}) + \lambda U_{t+1} \right].
\]

(6)

These are the values of a firm and an employed worker, respectively, given an arbitrary wage \(w_t\) paid in the current period and future wages determined by the function \(g_{t+1}(b_{t+1})\). The functions \(J_t(b_t)\) and \(W_t(b_t)\) were defined in (3) and (4) for a particular wage equation \(g_t(b_t)\).

Given the relative bargaining power of workers \(\eta \in (0, 1)\), the current wage is the solution to the problem

\[
\max_{w_t} \hat{J}_t(b_t, w_t)^{1-\eta}\left[ \hat{W}_t(b_t, w_t) - U_t \right]^{\eta}.
\]

(7)

Let \(w_t = \psi_t(g; b_t)\) be the solution. We made explicit the dependence on the function \(g\) determining future wages. The rational expectation solution to the bargaining problem is the fixed-point to the condition \(g_t(b_t) = \psi_t(g; b_t)\).

We can now see the importance of Lemma 1. Since the optimal debt chosen by the firm after the wage bargaining does not depend on the wage, in solving the optimization problem (7) we do not have to consider how the choice of \(w_t\) affects \(b_{t+1}\). Therefore, we can derive the first order condition taking \(b_{t+1}\) as given. After some re-arrangement this can be written as

\[
J_t(b_t) = (1 - \eta)S_t(b_t),
\]

(8)

\[
W_t(b_t) - U_t = \eta S_t(b_t),
\]

(9)

where \(S_t(b_t) = J_t(b_t) + W_t(b_t) - U_t\) is the bargaining surplus. As it is typical in search models with Nash bargaining, the surplus is split between the contractual parties proportionally to their relative bargaining power.

**Choice of debt:** Let’s first rewrite the bargaining surplus as

\[
S_t(b_t) = z_t - a - b_t + \frac{b_{t+1}}{R} + (1 - \lambda)\beta\mathbb{E}_tS_{t+1}(b_{t+1}) - \eta\beta p_t\mathbb{E}_tS_{t+1}(B_{t+1}).
\]

(10)
Notice that the next period surplus enters twice but with different state variables. In the first term the state variable is the individual debt $b_{t+1}$ while in the second is the aggregate debt $B_{t+1}$. The reason is because the value of being unemployed today depends on the value of being employed in the next period in a firm with the aggregate value of debt $B_{t+1}$. Instead, the value of being employed today also depends on the value of being employed next period in the same firm. Since the current employer is allowed to choose a level of debt that differs from the debt chosen by other firms, the individual state next period, $b_{t+1}$, could be different from $B_{t+1}$. Although in equilibrium $b_{t+1} = B_{t+1}$, in deriving the optimal policy we have to allow the firm to deviate from the aggregate policy.

Because the choice of the new debt $b_{t+1}$ does not depend on the existing debt $b_t$ (see Lemma 1), we have

$$
\frac{\partial S_t(b_t)}{\partial b_t} = -1.
$$

(11)

Before using this property, we rewrite the firm’s problem (3) as

$$
J_t = \max_{b_{t+1}} \left\{ z_t - g_t(b_t) - b_t + \frac{b_{t+1}}{R} + \beta(1 - \lambda)(1 - \eta) \mathbb{E}_t S_{t+1}(b_{t+1}) \right\}
$$

(12)

subject to

$$(1 - \eta) \phi_t \mathbb{E}_t S_{t+1}(b_{t+1}) \geq b_{t+1},$$

where we used $W_{t+1}(b_{t+1}) - U_{t+1} = \eta S_{t+1}(b_{t+1})$ from (8) and the surplus is defined in (10).

Denoting by $\mu_t$ the Lagrange multiplier associated with the enforcement constraint, the first order condition is

$$
\eta - \left[ 1 + (1 - \eta) \phi_t \right] \mu_t = 0.
$$

(13)

In deriving this expression we used (11) and $\beta R(1 - \lambda) = \beta(1 + r) = 1$. We can then establish the following result.

**Lemma 2.** The enforcement constraint is binding ($\mu_t > 0$) if $\eta \in (0, 1)$.
A key implication of Lemma 2 is that, provided that workers have some bargaining power, the firm always chooses to maximize the debt and the borrowing limit binds. To gather some intuition about the economic interpretation of the multiplier $\mu_t$, it will be convenient to re-arrange the first order condition as

$$\mu_t = \left( \frac{1}{1 + (1 - \eta)\phi_t} \right) \times \left( \frac{1}{R} - \frac{1 - \eta}{R} \right).$$

The multiplier results from the product of two terms. The first term is the change in next period liabilities $b_{t+1}$ allowed by a marginal relaxation of the enforcement constraint, that is, $b_{t+1} = \phi_t(1 - \eta)E_tS(z_{t+1}, B_{t+1}, b_{t+1}) + \bar{a}$, where $\bar{a} = 0$ is a constant. This is obtained by marginally changing $\bar{a}$. In fact, using the implicit function theorem, we obtain

$$\frac{\partial b_{t+1}}{\partial a} = \frac{1}{1 + (1 - \eta)\phi_t},$$

which is the first term.

The second term is the net gain, actualized, from increasing the next period liabilities $b_{t+1}$ by one unit (marginal change). If the firm increases $b_{t+1}$ by one unit, it receives $1/R$ units of consumption today, which can be paid as dividends. Next period this unit has to be repaid. The effective cost, however, is lower than 1. In fact, a higher level of debt allows the firm to reduce the next period wage by $\eta$, that is, the part of the surplus going to the worker. Therefore, the effective repayment incurred by the firm is $1 - \eta$. This cost is discounted by $R = (1 + r)/(1 - \lambda)$ because the debt is repaid only if the matched is not separated which happens with probability $1 - \lambda$. Therefore, the multiplier $\mu_t$ is equal to the total change in debt (first term) multiplied by the gain from a marginal increase in borrowing (second term).

It is interesting to observe that the effective cost of the debt decreases with $\eta$: the higher the bargaining power of workers, the higher the firm’s incentive to borrow. When the bargaining power is zero, the firm does not gain from borrowing and $\mu_t = 0$.

### 2.1 Firm entry and general equilibrium

So far we have defined the problem solved by incumbent firms. We now consider more explicitly the problem solved by new firms. In this setup
new firms are created when a posted vacancy is filled by a searching worker. Because of the matching frictions, a posted vacancy will be filled only with probability $q_t = m(v_t, u_t)/v_t$. Since posting a vacancy requires a fixed cost $\kappa$, vacancies will be posted only if the value of posting a vacancy is not smaller than the cost.

We start with the definition of the value of a filled vacancy. When a vacancy is filled, the newly created firm starts producing and pays wages in the next period. The only decision made in the current period is the debt $b_{t+1}$. The funds raised by borrowing are distributed to shareholders. Therefore, the value of a vacancy filled with a worker is

$$Q_t = \max_{b_{t+1}} \left\{ \frac{b_{t+1}}{1 + r} + \beta (1 - \eta) \mathbb{E}_t S_{t+1}(b_{t+1}) \right\}$$

subject to

$$\phi_t (1 - \eta) \mathbb{E}_t S_{t+1}(b_{t+1}) \geq b_{t+1}.$$  

Since the new firm becomes an incumbent starting in the next period, $S_{t+1}(b_{t+1})$ is the surplus of an incumbent firm defined in (10).

As far as the choice of $b_{t+1}$ is concerned, a new firm faces a similar problem as incumbent firms (see problem (12)). Even if the new firm has no initial debt and it does not pay wages, it will choose the same stock of debt $b_{t+1}$ as incumbent firms. This is because the new firm faces the same enforcement constraint and the choice of $b_{t+1}$ is not affected by $b_t$ and $w_t$ as established in Lemma 1. This allows us to work with a 'representative' firm.

We are now ready to define the value of posting a vacancy. This is equal to $V_t = q_t Q_t - \kappa$. As long as the value of a vacancy is positive, more vacancies will be posted. Thus, in equilibrium we must have $V_t = 0$ and the free entry condition can be written as

$$q_t Q_t = \kappa.$$  

In a general equilibrium all firms choose the same level of debt. Therefore, $b_t = B_t$. Furthermore, assuming that the bargaining power of workers is positive, firms always borrow up to the limit, that is, $B_{t+1} = \phi_t (1 - \eta) \mathbb{E}_t S_{t+1}(B_{t+1})$. Together with the free entry condition (15), we derive in
Appendix A the wage equation

\[ w_t = (1 - \eta)a + \eta(z_t - b_t) + \frac{\eta[p_t + (1 - \lambda)\phi_t]\kappa}{q_t(1 + \phi_t)}. \tag{16} \]

This expression makes clear that the initial debt \( b_t \) acts like a reduction in output in the determination of wages. Instead of getting a fraction \( \eta \) of the output, the worker gets a fraction \( \eta \) of the output 'net' of debt. Thus, for a given bargaining power \( \eta \), the larger is the debt and the lower is the wage received by the worker.

### 3. Response to shocks

In this section we investigate how the value of a filled vacancy \( Q_t \) is affected by a credit shock (change in \( \phi_t \)) and by a productivity shock (change in \( z_t \)). Through the free entry condition \( q_t Q_t = \kappa \), we can then infer the impact on job creation. More specifically, if the value of a filled vacancy \( Q_t \) increases, the probability of filling a vacancy \( q_t = m(v_t, u_t)/v_t \) must decline. Since the number of searching workers \( u_t \) is given in the current period, this requires an increase in the number of posted vacancies. Thus, more jobs are created.

#### 3.1 Credit shocks

To derive some intuition we consider a temporary shock that affects only a single firm. In this way we can abstract from general equilibrium effects. Starting from a steady state equilibrium, suppose that there is one firm with a newly filled vacancy for which the value of \( \phi_t \) increases. The increase is purely temporary and it reverts back to the steady state value starting in the next period. We stress that the change involves only one firm so that we can ignore the general equilibrium consequences of the change.

The derivative of \( Q_t \) with respect to \( \phi_t \) is

\[ \frac{\partial Q_t}{\partial \phi_t} = \left[ \frac{1}{1 + r} + \beta(1 - \eta)\frac{\partial E_t S_{t+1}(b_{t+1})}{\partial b_{t+1}} \right] \frac{\partial b_{t+1}}{\partial \phi_t}. \]

Applying the implicit function theorem to the enforcement constraint holding with equality, \( b_{t+1} = \phi_t(1 - \eta)E S_{t+1}(b_{t+1}) \), we can rewrite the derivative as

\[ \frac{\partial b_{t+1}}{\partial \phi_t} = \frac{(1 - \eta)E_t S_{t+1}(b_{t+1})}{1 - (1 - \eta)\phi_t E_t \frac{\partial S_{t+1}(b_{t+1})}{\partial b_{t+1}}}. \]
Substituting $\partial E_t S_{t+1}(b_{t+1})/\partial b_{t+1} = -1$ (see equation (11)) we obtain

$$
\frac{\partial Q_t}{\partial \phi_t} = \frac{\eta(1 - \eta)\beta E_t S_{t+1}(b_{t+1})}{1 + (1 - \eta)\phi_t},
$$

(17)

where we have used $\beta = 1/(1 + r)$.

This expression allows us to assess the effect of a credit shock on the value of a newly created firm, which is summarized in the next proposition.

**Proposition 1** Consider a positive credit shock for a newly created firm. If $\eta \in (0, 1)$, the rise in $\phi_t$ increases the value of the firm $Q_t$.

**Proof 3** It follows directly from (17) since $\phi_t$ and $E_t S_{t+1}(b_{t+1})$ are positive.

Therefore, an increase in $\phi_t$ raises the value of a newly filled vacancy $Q_t$, provided that the worker has some bargaining power. The intuition for the above proposition is straightforward. If the new firm can increase its debt in the current period, the firm can pay more dividends now and less dividends in the future. However, the reduction in future dividends needed to repay the debt is smaller than the increase in the current dividends because the higher debt allows the firm to reduce the next period wages. Effectively, part of the debt will be repaid by the worker, increasing the firm’s value today.

In deriving this result we assumed that the change in $\phi_t$ was only for one firm so that we could ignore the general equilibrium effects induced by this change. However, since $\phi_t$ is an aggregate variable, this change increases the value of a vacancy for all firms and more vacancies will be posted. The higher job creation will have some general equilibrium effects that cannot be characterized analytically. The full general equilibrium response will be shown numerically in the next section.

### 3.2 Productivity shocks

Although the main focus of the paper is on credit shocks, we also investigate how the ability to borrow affects the propagation of productivity shocks since most of the literature has focused on this type of shocks.

In general, productivity shocks generate an employment expansion because the value of a filled vacancy increases. This would arise even if the level of debt is constant. If we further normalize the constant debt to zero,
we would revert to the standard matching model. However, if the debt is not constrained to be constant but changes endogenously, then the impact of productivity shocks on employment could be amplified. To derive some analytical intuitions about the amplification mechanism, we consider a productivity shock that affects only one newly created firm. As in the case of the credit shock, this allows us to abstract from general equilibrium effects.

Starting from a steady state equilibrium, suppose that there is one newly created firm for which the value of $z_t$ increases. We further assume that the productivity shock is persistent. For example, it could follow a first order autoregressive process. The persistence implies that the new firm will be more productive also in the next period when it starts producing. If the increase in $z_t$ was purely temporary, the change would not have any effect.

The derivative of $Q_t$ with respect to $z_t$ is

$$
\frac{\partial Q_t}{\partial z_t} = \beta(1 - \eta) \frac{\partial E_t S_{t+1}(b_{t+1})}{\partial z_t} + \left[ \frac{1}{1 + r} + \beta(1 - \eta) \frac{\partial E_t S_{t+1}(b_{t+1})}{\partial b_{t+1}} \right] \frac{\partial b_{t+1}}{\partial z_t}.
$$

Applying the implicit function theorem to the enforcement constraint $b_{t+1} = (1 - \eta) \phi_t E_t S_{t+1}(b_{t+1})$, we obtain

$$
\frac{\partial b_{t+1}}{\partial z_t} = \frac{(1 - \eta) \phi_t E_t \frac{\partial S_{t+1}(b_{t+1})}{\partial z_t}}{1 - (1 - \eta) \phi_t E_t \frac{\partial S_{t+1}(b_{t+1})}{\partial b_{t+1}}}.
$$

Since $\partial E_t S_{t+1}(b_{t+1})/\partial b_{t+1} = -1$ (see equation (11)), substituting in the derivative of the firm’s value $Q_t$ and using $\beta = 1/(1 + r)$ we obtain

$$
\frac{\partial Q_t}{\partial z_t} = \beta(1 - \eta) \frac{\partial E_t S_{t+1}(b_{t+1})}{\partial z_t} + \frac{(1 - \eta) \phi_t \beta}{1 + (1 - \eta) \phi_t} \frac{\partial E_t S_{t+1}(b_{t+1})}{\partial z_t}.
$$

Comparing (18) to (19), we can see that when the borrowing limit is endogenous, there is an extra term in the derivative of $Q_t$ with respect to $z_t$. More specifically, we replace the enforcement constraint (1) with the borrowing limit $b_{t+1} \leq \bar{b}$ where $\bar{b}$ is constant. Under this constraint we have that $\partial b_{t+1}/\partial z_t = 0$. Therefore,

$$
\frac{\partial Q_t}{\partial z_t} = \beta(1 - \eta) \frac{\partial E_t S_{t+1}(b_{t+1})}{\partial z_t}.
$$

Comparing (18) to (19), we can see that when the borrowing limit is endogenous, there is an extra term in the derivative of $Q_t$ with respect to $z_t$. More specifically, we replace the enforcement constraint (1) with the borrowing limit $b_{t+1} \leq \bar{b}$ where $\bar{b}$ is constant. Under this constraint we have that $\partial b_{t+1}/\partial z_t = 0$. Therefore,
This term is positive if $\eta > 0$. Therefore, the change in the value of a filled vacancy in response to a productivity improvement is bigger when the borrowing limit is endogenous. Intuitively, the increase in productivity raises the value of the firm. This allows for more debt which in turn increases the value of a filled vacancy $Q_t$.

4 Simulation

In this section we present some quantitative results based on the numerical simulation of the model. We first simulate the baseline model described so far. We will see that the model can generate quantitatively interesting dynamics of employment and financial flows. However, the dynamics of wages may appear less appealing. Because of this, in the next section we will consider an extension of the model that generates similar dynamics in employment and financial flows but also generate cyclical properties of wages that is more in line with empirical observations.

4.1 Calibration

We think of a period in the model to be a quarter and set the discount factor to $\beta = 0.99$. The matching function takes the typical Cobb-Douglas form $m(v, u) = \xi v^\alpha u^{1-\alpha}$ where $\xi$ is a constant. We set the matching parameter $\alpha = 0.7$. This is in the range of estimates conducted in the literature. For example, Petrongolo and Pissarides (2001) report that the range of estimates based on aggregate data on total hires is $0.6 - 0.7$. Using JOLTS data for 2000 and 2002, Hall estimates $\alpha = 0.765$. We should also acknowledge, however, that there are estimates with lower numbers like in Shimer (2005). Different values of $\alpha$ do not affect the qualitative response of employment although it changes the magnitude. For the bargaining parameter $\eta$ we follow the common practice of setting it to 0.5 in absence of direct evidence.

After normalizing the steady state value of productivity to 1, we turn our attention to the following five parameters: the steady state value of the enforcement variable $\bar{\phi}$, the utility flow for unemployed workers $a$, the separation rate $\lambda$, the cost to create a vacancy $\kappa$, and the constant in front of the matching function $\xi$. These five parameters are calibrated using the following conditions: (i) the steady state debt-to-output ratio is 0.1; (ii) the utility flow for unemployed workers $a$ is 75% the steady-state value of wages; (iii) the steady state unemployment rate is 10 percent based on a broad
definition of unemployment; \((iv)\) the probability of filling a vacancy is 0.7; 
\((v)\) the probability of an unemployed worker to find a job is 0.93.

The choice of the target for the debt-to-output ratio requires some explanation. Strictly speaking, this is much smaller than in the data. Typically, if we look at business debt over the value added of the business sector, a reasonable number is \(B/Y = 2\) (when \(Y\) is measured quarterly). However, in our model we do not have physical capital while in the real economy physical capital is an important collateral for debt. Therefore, the debt we consider in the model is only the debt that is guaranteed by (lifetime) profits in excess of the opportunity cost of capital. Based on this observation, the stock of debt in the model should be relatively small. This justifies the 0.1 number.\(^3\)

At this point we are only left with the parameters that characterize the stochastic process for the two shocks, credit and productivity. Assuming that the logarithm of \(\phi_t\) and \(z_t\) follow independent first order autoregressive processes, we need to assign the persistence parameters, \(p_\phi\) and \(p_z\), and the standard deviations \(\sigma_\phi\) and \(\sigma_z\). For the productivity shock we set \(p_z = 0.95\) and \(\sigma_z = 0.01\), which are standard in the literature. For the parametrization of the credit shock, instead, we use the empirical properties of debt. Since the dynamic properties of debt in the model are mostly driven by the credit shock and since in the data the stock of debt is very persistent, we set \(p_\phi = 0.95\). Then we set \(\sigma_\phi = 0.3\) so that the change in debt over GDP is similar to the data. More specifically we target the volatility of \((B' - B)/Y\).

We would like to stress that the volatility of debt is crucial for evaluating the performance of the model. We can generate any volatility of employment by choosing the volatility of the credit shock. However, by imposing that the volatility of debt generated by the model cannot be at odd with the data, we remove this degree of freedom. The full set of parameter values are reported in Table 1.

4.2 Responses to credit shocks

Figure 4.2 plots the responses of several variables to a negative credit shock: change in debt, employment, output and wages. Since the model is solved by linearizing around the steady state, the response to a positive credit shock

\(^3\)To see this more clearly, suppose that we add physical capital \(\bar{K}\) to the model, which for simplicity is assumed to be fixed. Suppose also that in case of liquidation the residual value of physical capital is \(\zeta\bar{K}\). Then the enforcement constraint would be \(b_{t+1} \leq \zeta\bar{K} + E_t J_{t+1}(b_{t+1})\). Thus, what we call debt in our model is the term \(b_{t+1} - \zeta\bar{K}\).
Table 1: List of parameters

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount factor for entrepreneurs, $\beta$</td>
<td>0.990</td>
</tr>
<tr>
<td>Relative bargaining power, $\eta$</td>
<td>0.500</td>
</tr>
<tr>
<td>Matching parameter, $\alpha$</td>
<td>0.700</td>
</tr>
<tr>
<td>Matching parameter, $\xi$</td>
<td>0.762</td>
</tr>
<tr>
<td>Probability of separation, $\lambda$</td>
<td>0.103</td>
</tr>
<tr>
<td>Cost of posting vacancy, $\kappa$</td>
<td>0.298</td>
</tr>
<tr>
<td>Utility flow unemployed, $a$</td>
<td>0.714</td>
</tr>
<tr>
<td>Average productivity, $\bar{z}$</td>
<td>1.000</td>
</tr>
<tr>
<td>Productivity shock persistence, $\rho_z$</td>
<td>0.950</td>
</tr>
<tr>
<td>Productivity shock volatility, $\sigma_z$</td>
<td>0.010</td>
</tr>
<tr>
<td>Enforcement parameter, $\bar{\phi}$</td>
<td>0.868</td>
</tr>
<tr>
<td>Credit shock persistence, $\rho_\phi$</td>
<td>0.950</td>
</tr>
<tr>
<td>Credit shock volatility, $\sigma_\phi$</td>
<td>0.300</td>
</tr>
</tbody>
</table>

will have the same shape with the opposite sign. The numbers are percent deviation from the steady state.

As can be seen from the figure, the response of employment is sizable and quite persistent, reflecting the persistence of the shock. The mechanism that generates this dynamics should be clear by now. Since firms are forced to cut their debt, workers are able to extract higher future wages which in turn discourages job creation. In fact, as can be seen from the last panel, even if the wage falls at impact, it raises above the steady state value starting from the next period. Since the value of a new firm depends on future wages, the fact that wages increase above the steady state starting in the next period discourages the creation of jobs.

The initial drop in the wage of incumbent workers can be explained as follow. All bargaining parties understand that, starting from the next period wages are going to increase. Since bargaining conducted immediately after the shock is conducted before changing the debt, the total surplus has not changed either (besides some general equilibrium effects). This means that the values received by both parties remain the same as they split the surplus according to the share $\eta$. But then, if the value received by workers does not change but there is the expectation that they will receive higher wages in the future, the current wage has to decline.
It is interesting to observe that the credit shock does not affect the value received by ‘incumbent’ workers and firms (besides, again, for minor general equilibrium effects). So it may appear counterintuitive why the firm chooses to borrow up to the limit if, effectively, this does not change the surplus and the division of the surplus. The reason is because there is a time inconsistency problem. Since the new debt is chosen unilaterally by the firm after bargaining on the wage, the firm prefers higher debt to reduce future wages. However, since the firm cannot credibly commit, workers demand higher wages today in anticipation of higher debt, and therefore, lower future wages. If the firm could credibly commit before bargaining the wage, it would agree not to raise the debt. This mechanism has some similarities with the model studied by Barro and Gordon (1983): since workers anticipate that the central bank inflates ex-post, they demand higher nominal wages today. Differently from that model, however, here there is not real costs from deviating. As long as new firms can choose the debt before bargaining with
new workers, what happens once the firm becomes incumbent is irrelevant for the dynamics of employment.

More on the dynamics of wages Although the model generates a sizable dynamics of employment, the dynamics of wages may seem at odd with the data. Typically, wages tend to be pro-cyclical. For new hired workers, instead, the model predicts the opposite. For incumbent workers the model predicts a pro-cyclical response at impact but it reverts immediately after. This also implies that the wages paid by incumbent firms are very volatile contrary to the data. In Section 5 we enrich the model in ways that also allow for plausible dynamics of wages.

4.3 Responses to productivity shocks

Figure 4.3 plots the impulse responses to a negative productivity shock. We also report the response when the debt limit is exogenously fixed to the steady state value. More specifically, we impose the borrowing constraint \( b_{t+1} \leq \bar{\phi} \bar{J} \), where \( \bar{\phi} \) and \( \bar{J} \) are the steady state values of the financial variable \( \phi_t \) and the firm’s value \( J_t(b_t) \).

Productivity shocks are amplified somewhat when the borrowing limit is endogenous. However, the magnitude of the amplification is small. The main reason is because the productivity shock does not generate a large change in the value of the firm. Thus, as can be seen from the first panel, the change in debt is not large.

In general, the response of the economy to productivity shocks is similar to the standard matching model. This is not surprising since the version of the model with exogenous borrowing is essentially the standard matching model. Employment moves in the right direction but the size of the movement is small. Thus, most of the movements in output are (counter-factually) driven by productivity, not employment.

5 Monopolistic producers and infrequent negotiation

We extend the model in two directions. First we assume that each firm produces a differentiated good that is used as an input in the production of final goods. Therefore, we have monopolistic competition which is becoming a popular assumption in many macroeconomic models. The second assumption is that, after the initial hiring, wages are not re-bargained in
every quarter. Obviously this is a more plausible assumption independently of whether we think of wage negotiation as conducted by individual workers or unions. As we will see, the new features will have very minor implications for the dynamics.

5.1 Monopolistic competition

We now assume that each firm is a monopolistic producer of a differentiated good. Before describing the technical details of the extension, we would like to clarify why monopolistic competition could affect the response of wages to credit shocks.

A well known feature of models with monopolistic competition is that the demand of each firm and its profits are increasing functions of aggregate demand (production). In our model with equilibrium unemployment aggregate production depends on how many workers are employed. We will then
be able to show that, to capture the structure of monopolistic competition, all we have to do is to replace the firm level output $z_t$ with

$$\pi = \tilde{z}_t N_t^\nu.$$  \hspace{1cm} (20)

The variable $\tilde{z}_t$ is a monotone transformation of productivity and $N_t$ is aggregate employment taken as given by an individual firm. We call this term net surplus flow instead of output for reasons that will become clear below.

Thanks to the dependence of the surplus flow from aggregate employment, a positive credit shock has two effects on the wages of new hired workers. On the one hand, the higher leverage allows firms to pay lower wages. On the other hand, the increase in employment raises firms’ profits which, through the bargaining of the surplus, increases wages. Therefore, whether a credit shock is associated with an increase or decrease in the wages paid to new hires depends on the relative importance of these two effects. We will show that the second effect could dominate for reasonable calibrations of the model.

We are now ready to describe the derivation the surplus function (20). Each firm, indexed by $i$, produces an intermediate good used in the production of final goods. The production function for final goods is

$$Y = \left( \int_0^N y_i^\varepsilon \, di \right)^{1/\varepsilon}.$$  \hspace{1cm}

Notice that the integral is over the interval $[0, N]$ since there are $N$ producers equivalent to the number of employed workers. The inverse demand function is $P_i = Y^{1-\varepsilon}y_i^{\varepsilon-1}$, where $P_i$ is the price of the intermediate good and $1/(1 - \varepsilon)$ is the elasticity of demand.

To make the monopolist structure relevant, we need to introduce some margin along which the firm can change the quantity of intermediate goods produced. One way to do this is to assume that there is also an intensive margin in the use of labor. Suppose that each matched worker supplies hours $l_i$ and individual production is equal to $y_i = zl_i$. The intensive margin involves the disutility cost $Al_i^{1+\varphi}/(1 + \varphi)$ for the worker.

The monopoly revenue is $P_i y_i$, that is, the price multiplied by output. Substituting the demand and production functions, the revenue can be written as $Y^{1-\varepsilon}(zl_i)^\varepsilon$. The optimal input of labor $l_i$ solves the problem

$$\max_{l_i} \left\{ Y^{1-\varepsilon}(zl_i)^\varepsilon - \frac{A l_i^{1+\varphi}}{1 + \varphi} \right\},$$  \hspace{1cm} (21)
with first order condition $\varepsilon Y^{1-\varepsilon} z L^{\varepsilon - 1} = A l_i^{\phi \varepsilon}$.

We can now impose the equilibrium condition $l_i = L$ and individual production is $y_i = zL$. Aggregate production is equal to $Y = zLN^{\frac{1}{\phi \varepsilon}}$ and the price intermediate goods is $P_i = P = N^{\frac{1-\varepsilon}{\phi \varepsilon}}$ units of consumption goods. Finally, the individual revenue is equal to $zLN^{\frac{1-\varepsilon}{\phi \varepsilon}}$.

Using these results in the first order condition for the intensive margin, we can solve for the input $L = (\varepsilon z A)^{\frac{1}{\phi \varepsilon}} N^{\frac{1-\varepsilon}{\phi \varepsilon}}$. Then substituting in (21) and re-arranging, the revenue net of the disutility from working (net surplus flow) can be written as

$$\pi = \left[ \left( \frac{\varepsilon}{A} \right)^{\frac{1}{\phi \varepsilon}} \left( 1 - \frac{\varepsilon}{1 + \varphi} \right) \right] z L^{\frac{1+\varphi}{\phi \varepsilon}} N^{\frac{(1-\varepsilon)(1+\varphi)}{\phi \varepsilon}}. \quad (22)$$

It is now easy to see the equivalence between this function and the reduced net surplus flow reported in (20). If we set $z^{\frac{1+\varphi}{\phi \varepsilon}} = \tilde{z}$ and we choose the parameters of the model to satisfy $\left[ \left( \frac{\varepsilon}{A} \right)^{\frac{1}{\phi \varepsilon}} \left( 1 - \frac{\varepsilon}{1 + \varphi} \right) \right] = 1$ and $\frac{(1-\varepsilon)(1+\varphi)}{\phi \varepsilon} = \nu$, the surplus flow defined in (22) is exactly equal to (20). A further advantage of this approach is that we can now show also the performance of the model in terms of extensive and intensive margins.

### 5.2 Optimal labor contracts and infrequent negotiation

Although it is common in the searching and matching literature to assume that wages are re-bargained every period, in general there is not a theoretical or empirical justification for making this assumption. An alternative approach is to think in terms of optimal contracting. Then, after characterizing the optimal contract, we can think of possible ways of implementing the optimal contract.

Suppose that, when the worker is first hired, the parties bargain an optimal long-term contract. The optimal contract chooses the sequence wages that the firm pays to the worker at any point in time, contingent on all possible states that affect the firm directly. The state-contingent sequence of wages maximizes the total surplus subject to the condition that the parties divide the surplus according to the relative bargaining weight $\eta$. Furthermore, the sequence of wages has to satisfy the participation constraints for the firm and the worker at any point in time. What this means is that the value of the firm cannot be negative and the value for the worker cannot be smaller than being unemployed, at any point in time.
It turns out that the sequence of wages that characterizes the optimal contract is not unique. The intuition is simple. Since production does not depend on wages, choosing a different sequence of wages does not change the surplus. For example, the firm could pay slightly lower wages at the beginning and slightly higher wages later. This is also an optimal contract as long as the worker’s value is the same and the participation constraints are not violated. This is typically the case if \( \eta \) is not too close to 0 or 1 and there are only bounded aggregate shocks. The multiplicity depends on the assumption that both agents have linear utility. With concave utility of at least one of the parties, like in Michelacci and Quadrini (2009), the solution would be unique.

Given the multiplicity, we have different ways of implementing the optimal contract. One possibility is to choose a sequence of state-contingent wages that is equal to the sequence obtained when the wage is re-bargained with some probability \( \psi \). As long as this sequence does not violate the participation constraints, it also implements the optimal contract. Another way of thinking is that, when the firm and the worker meet, they decide not only the division of the surplus (through bargaining) but also the frequency with which they renew the contract. The parties are essentially indifferent on the frequency. Thus, we could choose a frequency that seems more relevant empirically. Although this choice is arbitrary from a theoretical point of view, it cannot be dismissed on the ground that it is suboptimal.

Appendix B defines the key equations under the assumption that wage contracts are renegotiated with probability \( \psi \) and wages stay constant until they are renegotiated. The net surplus generated by a match \( S_t(b_t) \) is still given by (10) while the net value of an employed worker when the contract is renegotiated is equal to

\[
W_t(b_t) - U_t = \eta S_t(b_t) = \frac{w_t - a}{1 - \beta(1 - \lambda)(1 - \psi)} + \Omega_t(b_t),
\]

with the function \( \Omega_t(b_t) \) defined recursively as

\[
\Omega_t(b_t) = \eta \beta [(1 - \lambda)\psi - p_t] E_t S_{t+1}(b_{t+1}) + \beta (1 - \lambda)(1 - \psi) E_t \Omega_{t+1}(b_{t+1}).
\]

We can see from equation (23) that the value of the worker has two components. The first component captures the value under contingencies in which the contract is not renegotiated. The second component captures the value under contingencies in which the contract is renegotiated. We are now ready to study the quantitative properties of the extended model.
5.3 Quantitative results

For the parameters that are also present in the baseline model we use the same calibration targets as described in Section 4.1. The parameter $a$ is also set so that the flow utility from unemployment is equal to 75% the utility flow from employment. In the baseline model this implies that $a$ is 75% the steady state wage. In the extended model, however, $a$ is a smaller percentage of the wage because part of the wage compensates the worker for the dis-utility of working.

The new parameters we need to calibrate are the frequency of negotiation, $\psi$, the price mark-up, $1/\varepsilon$, and the elasticity of labor supply, $1/\varphi$. The frequency of negotiation is set to one year, that is, $\psi = 0.25$. The parameter $\varphi$ is set to 0.8, implying a price mark-up of $1/\varepsilon = 0.25$. Finally, the parameter $\varphi$ is set to 1 implying an elasticity of labor of 1.

Figure 5.3 plots the impulse responses to a credit shock. We first notice that the responses of debt and employment are not very different from the

Figure 5: Impulse responses to a negative credit shock - Extended model.

Figure 5.3 plots the impulse responses to a credit shock. We first notice that the responses of debt and employment are not very different from the
baseline model. The dynamics of wages, however, is very different. First, wages are much less volatile. Second, and more importantly, the wages of new hired workers fall in response to a negative credit shocks. Furthermore, average wages fall in response to the shock not only at impact but they stay below the steady state for a prolonged period of time. Therefore, the consideration of monopolistic competition and infrequent bargaining allows the model to generate a dynamics of wages that is more in line with the general pattern of wages in the data.

6 Empirical analysis

The theoretical analysis suggests that shocks to the ability of borrowing could be important for employment fluctuations. In this section we investigate this mechanism empirically using a structural VAR where the identifying restrictions are derived from the theoretical model studied in the previous sections.

We use a three dimensional VAR in the growth rates of TFP, Credit to the Private Sector, Employment. The inclusion of the TFP series is motivated by the need to separate the credit expansion induced by productivity shocks from credit expansions driven by other shocks. As we have seen in the theoretical model, productivity shocks have two effects on employment. In addition to the direct impact, productivity shocks are amplified through the expansion of credit that is made possible by the endogeneity of the borrowing limit. The explicit inclusion of the TFP series should separate the credit expansion induced by productivity shocks from the credit expansion induced by other perturbations. We refer to these other perturbations as ‘credit shocks’.

The identification of the structural shocks is done through the imposition of zero short-term restrictions. To illustrate the identification assumptions it will be convenient to write down explicitly the VAR system as

\[
(I - A_1 L - A_2 L^2 - \ldots - A_n L^n) \begin{pmatrix} z_t \\ b_t \\ e_t \end{pmatrix} = P \begin{pmatrix} \epsilon_{z,t} \\ \epsilon_{b,t} \\ \epsilon_{e,t} \end{pmatrix},
\]

where \( L \) is the lag operator and \( n \) is the number of lags included in the VAR.

The vector \((z_t, b_t, e_t)\) is the observed data. It includes the growth rate of TFP, the growth rate of private credit, and the growth rate of employment. A more detailed description of the data is provided below.
The vector \((\epsilon_{z,t}, \epsilon_{b,t}, \epsilon_{e,t})\) contains the orthogonalized disturbances. In order to assign a particular economic interpretation to these shocks, we impose that some of the elements of the matrix \(P\) are equal to zero. To be more specific, let’s write the matrix in extensive form as

\[
P = \begin{pmatrix}
p_{zz} & p_{zb} & p_{ze} \\
p_{bz} & p_{bb} & p_{be} \\
p_{ez} & p_{eb} & p_{ee}
\end{pmatrix}.
\]

By imposing that some of the elements of \(P\) are zero, we are assuming that some of the orthogonalized disturbances cannot have an immediate impact on some of the variables included in the system. For example, if we set \(p_{eb} = 0\), the shock \(\epsilon_{b,t}\) does not have an immediate impact on employment \(e_t\). Since the identification of a three dimensional system requires at least three restrictions, we have to impose that at least three elements of the matrix \(P\) are zero. Thus, we start with the following restrictions:

1. Since TFP evolves exogenously in the model, credit shocks cannot affect TFP. Therefore, we set \(p_{zb} = 0\).

2. Since an improvement in productivity affects employment with one period lag (due to the matching frictions), innovations to productivity cannot affect employment at impact. This requires \(p_{ez} = 0\).

3. The same logic applies to credit shocks, that is, they also affect employment with one period lag. Therefore, innovations to the availability of credit cannot affect employment at impact, which requires \(p_{eb} = 0\).

With these restrictions we can interpret \(\epsilon_{z,t}\) as innovations to TFP, \(\epsilon_{b,t}\) as innovations to the availability of credit, and \(\epsilon_{e,t}\) as residual disturbances.\(^4\)

**Data:** The estimation uses quarterly data over the period 1984.1-2009.3. The TFP growth is constructed using the utilization-adjusted TFP series constructed by John Fernald (2009). The growth in private credit is constructed using data from the Flow of Funds. Specifically, we use new borrowing (financial market instruments) for households and nonfinancial businesses dividend

\(^4\)An alternative way to generate a just-identified system is to assume (i) \(p_{zb} = 0\), (ii) \(p_{ez} = 0\), and (iii) \(p_{eb} = 0\). Results based on this alternative identification scheme are similar and are available upon request.
by the stock of debt (again, financial market instruments). For employment we have three series. The first series includes all civilian employment from the BLS. The second series includes all employees in private industries, also from the BLS. The third series includes all employees in the nonfarm sector, from the Current Employment Statistics survey.

**Impulse responses:** We first estimate the VAR system with $e_t$ measured by ‘employment in the private sector’ and five lags ($n = 5$). Results using the other two definitions of employment (not reported) are similar.

The impulse response functions of Private Credit and Employment to credit and TFP shocks are plotted in Figure 6. As far as the credit shock is concerned, we see that this generates an expansion in the growth rate of private credit that lasts for many quarters. Therefore, these shocks tend to generate long credit cycles. Credit shocks generate an expansion in the growth rate of employment that is statistically significant for four quarters.

TFP shocks also generate an expansion in the growth rate of private credit but the impact is much less persistent. The growth rate of employment goes up but the overall impact is smaller than the impact of credit shocks.

Overall, the results presented in Figure 6 are consistent with the properties of the theoretical model. In particular, we see that credit shocks have a statistical significant impact on employment and TFP shocks lead to a credit expansion. As long as a credit expansion allows for more job creation, the financial mechanism allows for some amplification of productivity shocks.

As an alternative to using employment as a measure of labor market performance, we could use the rate of unemployment. We re-estimate the VAR with the growth rate of TFP, Private Credit and Unemployment. For unemployment we use the measure provided by the BLS. The impulse responses to financial and productivity shocks are plotted in Figure 7. Also in this case we find that productivity shocks have a statistically significant impact on the growth rate of private credit and unemployment.

**Adding wages:** Since wages plays a central role in the transmission of credit shocks, we now expand the VAR model by including wages. Wages are measured as Average Hourly Earnings for Total Private Industries from Bureau of Labor Statistics.

The VAR includes total factor productivity, $z_t$, private credit, $b_t$, employ-
ment, \( e_t \) and wages, \( w_t \). The matrix \( P \) takes the form

\[
P = \begin{pmatrix}
    p_{zz} & p_{zb} & p_{ze} & p_{zw} \\
    p_{bz} & p_{bb} & p_{be} & p_{bw} \\
    p_{ez} & p_{eb} & p_{ee} & p_{ew} \\
    p_{wz} & p_{wb} & p_{we} & p_{ww}
\end{pmatrix}.
\]

The identification is based on the following restrictions:

1. Since TFP evolves exogenously in the model, credit and other shocks cannot affect TFP. Therefore, we set \( p_{zb} = p_{ze} = p_{zw} = 0 \).

2. Since an improvement in productivity affects employment with one period lag (due to the matching frictions), innovations to productivity and credit cannot affect employment at impact. This requires \( p_{ez} = p_{eb} = 0 \).

3. Finally, the residual shocks to employment and wages are identified using a non-structural triangular restriction, that is, \( p_{we} = 0 \).

As can be seen from Figure 8, the impulse responses for private credit and employment are similar to the responses obtained with the three dimensional VAR. As far as wages are concerned, we observe that they first increase and then decrease. This is not inconsistent with the predictions of the model in response to a credit shock if we focus on the wages paid by incumbent firms. However, the responses are not statistically significant at 5% confidence interval.

**Alternative identification:** In the identification scheme adopted above, we have imposed that financial shocks do not impact TFP, at least in the current period. This is consistent with the exogenous nature of productivity assumed in the theoretical model. However, we have not imposed in the VAR that the residual shock \( \epsilon_{e,t} \) cannot have an immediate impact on TFP. Therefore, we now repeat the estimation imposing this additional restriction, that is, \( p_{ze} = 0 \). By doing so we have a total of four restrictions and the structural VAR is over-identified. The impulse responses, plotted in Figure 9, confirm the results obtained with the identification strategy adopted above.
Discussion: The VAR results are consistent with the theoretical model. In particular, it shows the importance of credit shocks. However, the empirical findings do not allow us to separate the transmission mechanism emphasized in this paper from the typical credit channel. However, as far as the most recent crisis is concerned, the fact that liquidity has increased immediately after the crisis suggests that our mechanism may be important for explaining the sluggish recovery observed in the labor market.

7 Conclusion

In this paper we have studied the importance of financial flows for employment (and unemployment) fluctuations. We have extended the basic matching model by allowing firms to issue debt under limited enforcement of financial contracts. Our approach goes beyond a mere cumulation of frictions, respectively in financial and labor markets. Firms have an incentive to borrow in order to affect wage bargaining as emphasized in the corporate finance literature. Our paper embeds this mechanism in a general equilibrium environment and investigates its role for the dynamics of aggregate employment.

In our model the ability to borrow can change exogenously in response to credit shocks or endogenously in response to productivity shocks. Independently of the sources of credit expansion, higher debt allows firms to bargain lower wages. Through this mechanism, credit shocks can generate large and persistent employment fluctuations. The determination of wages based on bargaining is central to these results.

The paper has also investigated the empirical relevance of credit shocks using a structural VAR where the shocks are identified with zero short-term restrictions derived from the theoretical model. The estimation of the VAR shows that the impact of these shocks on employment is statistically significant. Although these findings do not allow us to separate the transmission mechanism based on wage bargaining from the typical credit channel, they support the view that financial markets are important for the performance of the labor market.
Appendix

A Wage equation

Consider the value of a filled vacancy defined in (14). Using the binding enforcement constraint, \( b_{t+1} = \phi_t(1 - \eta)E_tS_{t+1}(B_{t+1}) \), to eliminate \( b_{t+1} \), the value of a filled vacancy becomes:

\[
Q_t = (1 + \phi_t)\beta(1 - \eta)E_tS_{t+1}(B_{t+1}) \cdot 
\]

Next we use the free entry condition \( V_t = q_tQ_t - \kappa = 0 \). Substituting the above expression for \( Q_t \), the expected value of the surplus can be written as

\[
E_tS_{t+1}(B_{t+1}) = \kappa q_t(1 + \phi_t)\beta(1 - \eta) 
\]

Substituting into the definition of the surplus—equation (10)—and taking into account that \( b_{t+1} = \phi_t(1 - \eta)E_tS_{t+1}(B_{t+1}) \), we get

\[
S_t(B_t) = z_t - a - b_t + \frac{[1 - \lambda - pt\eta + \phi_t(1 - \lambda)(1 - \eta)]\kappa}{q_t(1 + \phi_t)(1 - \eta)} 
\]

(25)

Now consider the net value for a worker,

\[
W_t(B_t) - U_t = w_t - a + \eta(1 - \lambda - pt)\beta E_tS_{t+1}(B_{t+1}) 
\]

Eliminating the expected value of the surplus and remembering that \( W_t(B_t) - U_t = \eta S_t(B_t) \) we get:

\[
\eta S_t(B_t) = w_t - a + \frac{\eta(1 - \lambda - pt)\kappa}{q_t(1 + \phi_t)(1 - \eta)} 
\]

(26)

Finally, combining (25) and (26) we get the expression for the wage:

\[
w_t = (1 - \eta)a + \eta(z_t - b_t) + \frac{\eta[p_t + (1 - \lambda)\phi_t]\kappa}{q_t(1 + \phi_t)} 
\]

B Model with infrequent negotiation

Suppose that wages are negotiated (bargained) when a new match is formed and then they are renegotiated in future periods with some probability \( \psi \). In the interim periods wages are kept constant.

The value for a newly hired worker who bargains the first wage at time \( t \) is

\[
W_t(b_t) = w_t + \beta E_t \left\{(1 - \lambda) \left[ \psi W_{t+1}(b_{t+1}) + (1 - \psi)W_{t+1}(b_{t+1}; w_t) \right] + \lambda U_{t+1} \right\} \cdot 
\]

(27)
where $\hat{W}_{t+1}(b_{t+1}; w_t)$ is the value if the wage is not renegotiated. This depends on the wage chosen in the previous period. The value of being unemployed is

$$U_t = a + \beta \mathbb{E}_t \left[ p_t W_{t+1}(B_{t+1}) + (1 - p_t)U_{t+1} \right].$$  

Subtracting (28) to (27) and re-arranging we get

$$W_t(b_t) - U_t = w_t - a + \beta \mathbb{E}_t \left\{ (1 - \lambda) \left[ \psi \left( W_{t+1}(b_{t+1}) - U_{t+1} \right) \right] + (1 - \psi) \left( \hat{W}_{t+1}(b_{t+1}; w_t) - U_{t+1} \right) \right\} - p_t \left( W_{t+1}(B_{t+1}) - U_{t+1} \right)$$

(29)

Since in equilibrium $b_{t+1} = B_{t+1}$, we can rewrite the equation as

$$W_t(b_t) - U_t = w_t - a + \beta \left[ (1 - \lambda) \psi - p_t \right] \mathbb{E}_t \left( W_{t+1}(b_{t+1}) - U_{t+1} \right) + \beta (1 - \lambda)(1 - \psi) \mathbb{E}_t \left( \hat{W}_{t+1}(b_{t+1}; w_t) - U_{t+1} \right)$$

(30)

To simplify notations, define

$$\rho = \beta (1 - \lambda)(1 - \psi)$$
$$\delta_t = \beta \left[ (1 - \lambda) \psi - p_t \right]$$

Then the net value of the worker can be written as

$$\hat{W}_t(b_t) = w_t - a + \delta_t \mathbb{E}_t \hat{W}_{t+1}(b_{t+1}) + \rho \mathbb{E}_t \hat{W}_{t+1}(b_{t+1}; w_t)$$

(31)

The next period value without bargaining is

$$\hat{W}_{t+1}(b_{t+1}; w_t) = w_t - a + \delta_{t+1} \mathbb{E}_{t+1} \hat{W}_{t+2}(b_{t+2}) + \rho \mathbb{E}_{t+1} \hat{W}_{t+2}(b_{t+2}; w_t)$$

(32)

Substituting in (31) at $t + 1, t + 2$, etc., the net value for the worker is equal to

$$\hat{W}_t(b_t) = \frac{w_t - a}{1 - \rho} + \Omega_t(b_t),$$

(33)
where the function $\Omega_t(b_t)$ is defined as

$$\Omega_t(b_t) = E_t \delta_t \hat{W}_{t+1}(b_{t+1}) + \rho E_t \delta_{t+1} \hat{W}_{t+2}(b_{t+2}) + \rho^2 E_t \delta_{t+2} \hat{W}_{t+3}(b_{t+3}) + ...$$

The function has a recursive structure, and therefore, we rewrite it as

$$\Omega_t(b_t) = \delta_t E_t \hat{W}_{t+1}(b_{t+1}) + \rho E_t \Omega_{t+1}(b_{t+1}).$$ \hfill (34)

Using the bargaining outcome $\hat{W}_t(b_t) = \eta S_t(b_t)$ in (33) and (34), we obtain

$$\eta S_t(b_t) = \frac{w_t - a}{1 - \rho} + \Omega_t(b_t),$$ \hfill (35)

$$\Omega_t(b_t) = \eta \delta_t E_t S_{t+1}(b_{t+1}) + \rho E_t \Omega_{t+1}(b_{t+1}).$$ \hfill (36)

Finally, the surplus is the same as in the baseline model, that is,

$$S_t(b_t) = z_t - a - b_t + \frac{b_{t+1}}{R} + (1 - \lambda - \eta p_t) \beta E_t S_{t+1}(b_{t+1}).$$ \hfill (37)

### B.1 Evolution of aggregate wages

Denote by $\bar{w}_{t-1}$ the average wage in period $t - 1$. Then the average wage in period $t$ is equal to

$$\bar{w}_t = \left(1 - \frac{\lambda}{N_t}ight) \left[1 - \psi(1 - \psi) \bar{w}_{t-1} + \psi w_t \right] + \left(\frac{m_t}{N_t}\right) w_t \hfill (38)$$

To determine the average wage at time $t$, we need to know the average wage in the previous period and the share of employment that bargains a new wage at time $t$. This is equal to

$$s_t = \frac{\psi(1 - \lambda) N_{t-1} + m_t}{N_t},$$

where $m_t$ is the number of new matches. Using $s_t$, the average wage equation can be written as

$$\bar{w}_t = (1 - s_t) \bar{w}_{t-1} + s_t w_t.$$
B.2 Summary

The consideration of infrequent negotiation is captured by the following equations

\[ \eta S_t(b_t) = \frac{w_t - a}{1 - \rho} + \Omega_t(b_t) \quad (39) \]
\[ \Omega_t(b_t) = \eta \delta_t \mathbb{E}_{t+1} S_{t+1}(b_{t+1}) + \rho \mathbb{E}_{t} \Omega_{t+1}(b_{t+1}) \quad (40) \]
\[ \bar{w}_t = (1 - s_t) \bar{w}_{t-1} + s_t w_t \quad (41) \]
\[ s_{t+1} = \frac{\psi(1 - \lambda) N_t + m_t}{N_{t+1}} \quad (42) \]

Notice that equation (39) is not an additional equation but it simply replaces the previous equation for the worker’s value. Equations (40)-(42) are new. The set of state variables is expanded with the new states \( s_t \) and \( \bar{w}_{t-1} \).
References


Figure 6: Three variables (exactly identified) VAR: TFP, private credit, employment.

Figure 7: Three variables (exactly identified) VAR: TFP, private credit, unemployment.
Figure 8: Four variables (exactly identified) VAR: TFP, private credit, employment and wages.

Figure 9: Three variables (over-identified) VAR: TFP, private credit and employment.