Financial markets and unemployment

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PRELIMINARY

Abstract

We study the importance of financial markets for (un)employment fluctuations in a model with search and matching frictions where firms can issue debt under limited enforcement of debt contracts. The ability to issue debt affect the hiring decision because more debt allows firms to bargain lower wages. The ability to borrow can change exogenously in response to credit shocks or endogenously in response to productivity shocks. Through this mechanism, credit shocks can generate large employment fluctuations and the impact of productivity shocks is greatly amplified. The theoretical predictions are supported by the estimation of a structural VAR whose identifying restrictions are derived from the theoretical model.

1 Introduction

The recent financial turmoil has been associated with a severe increase in unemployment. In the US the number of unemployed workers jumped from 5.5 percent of the labor force to about 10 percent. What perhaps is more surprising is that the unemployment rate continues to stay close to this higher

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level despite the fact that the recession started three years ago'. In fact the beginning of the recession was officially dated in the fourth quarter of 2007. In this paper we show that difficulties in financial markets can generate large and persistent increases in unemployment.

We study how the availability of credit affects job creation and employment within a model with matching frictions and wage bargaining. The theoretical framework has the typical structure 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. Our contribution is to extend the basic structure of these models in two directions. First, we allow firms to issue debt under a limited enforcement constraint. Second, we introduce an additional source of business cycle fluctuations (or shock), which affects directly the enforcement constraint of borrowers and, indirectly, the availability of credit.

In our framework the ability to issue debt affects employment because more debt allows firms to bargain lower wages. We show that 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. Higher debt reduces the 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.

During macroeconomic expansions induced by productivity improvements, the borrowing limit becomes less tight because firms have less incentives to default, and therefore, they are can issue more debt. By borrowing more, employers are able to contain the increase in wages paid to new workers and, as a result, they create more jobs. In this way the impact of the productivity shock on both employment and unemployment is significantly amplified. This result has some relevance for the recent literature pioneered by Shimer (2005) and Hall (2005) that emphasizes the inability of the baseline search-and-matching model to replicate the observed volatility of unemployment. That literature has suggested that wage stickiness may be the friction necessary to improve the ability of the model to fit key labor market statistics. Gertler and Trigari (2010) shows that wage rigidities could go a long way in capturing the dynamics of the labor market. Our paper emphasizes that the endogenous interaction between labor and financial markets could also contribute to generate larger employment and unemployment fluctuations.

We also study the response of the labor market to a shock that affects directly the availability of credit for employers. We refer to this shock as 'credit shock'. When credit is easily accessible, firms increase their debt and pay lower wages to newly hired workers, which in turn encourages the creation of jobs. On the other hand, a credit contraction forces firms to pay higher wages, inducing lower creation of jobs. These shocks can generate sizable employment fluctuations. Furthermore, the impact on the labor market is very persistent. In this vein, the properties of the model are in line with the findings that recessions associated with credit crunches and/or financial crisis are more severe and persistent.[1]

The debt mechanism considered in our paper is fundamentally different from a traditional credit channel. In the typical credit channel, greater availability of funds affects economic activity either because it provides extra resources to invest or because it reduces the financing cost of the production inputs. Examples of papers that investigate the importance of the credit channel in a matching framework are Chugh (2009) and Petrosky-Nadeau (2009). In the mechanism considered here, instead, the availability of credit affects employment because it reduces the cost of hiring new workers, not because it provides more financing for constrained firms.

The idea that debt allows employers to reduce the compensation of workers and/or managers is not new in the corporate finance and labor literature. Bronars and Deere (1991) document a positive correlation between leverage and bargaining power of workers (proxied by the degree of unionization). More recently, Matsa (2010) shows that strategic incentives from the labor market have a substantial impact on firms' financing decisions. In particular, he conjectures that firms may use financial leverage strategically in order to reduce the impact of bargaining on profits. He also provides extensive empirical evidence that firms with greater exposure to (union) bargaining power tend to have a capital structure skewed towards higher levels of debt.

Although the idea is not new in the corporate finance literature, there are very limited applications to study employment dynamics at the macroeconomic level. An important contribution is Wasmer and Weil (2004). They consider an environment in which bargaining is not between workers and firms but between entrepreneurs and financiers. They show that higher job creation is obtained when financiers appropriate a lower share of the surplus. In this model financiers are needed to finance the cost of posting a vacancy

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[1]IMF (2009), Claessens, Kose, and Terrones (2008), Reinhart and Rogoff (2009).

and the higher surplus extracted by financiers is similar to a higher cost of financing investments.

Our contribution differs from Wasmer and Weil (2004) in three respects. First, we characterize the equilibrium in which the bargaining is between workers and employers, not between employers and financiers. Furthermore, firms make financing decisions at any point in time, not only when the firm is created. Second, we focus on the business cycle properties of the model rather than steady states. Third, we consider an additional source of business cycle fluctuation, the credit shock, in addition to the traditional productivity shock.

In order to study the empirical relevance of the theoretical findings, we estimate a structural VAR where we identify productivity and credit shocks. The identification is based on 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. We also find that TFP shocks generate a credit expansion, which is consistent with the theoretical result that productivity shocks are amplified through the expansion of credit.

The structure of the paper is as follows. Section 2 presents the theoretical model. Section 3 provides an analytical derivation of the impact of productivity and credit shocks. Section 4 characterizes some properties numerically. Section 5 conducts the empirical analysis and Section 6 concludes.

2   The model

There is a continuum of agents of total mass 1 with lifetime utility $\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t c_t$. 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 interest rate is constant and equal to:

$$r = 1/\beta - 1. \tag{1}$$

Firms: Firms are created through the matching of a posted vacancy and a worker. Starting from the next period, a new firm produces output z_t until the match is separated. Separation arises with probability λ. To keep the distinction between workers and firms, we assume that a worker cannot

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be self-employed but needs to search (costlessly) for a job. The number of matches is determined by the typical matching 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 ϕ_t that we will describe below, and a stock of debt b_t. The productivity z_t and the financial state ϕ_t are exogenous stochastic variables, common to all firms (aggregate shocks). The stock of debt b_t is chosen endogenously. Although firms can choose different levels of debt, in equilibrium they all choose the same b_t.

The dividend paid to the owners of the firm 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: An incumbent firm starts with a stock of debt b_t inherited from the previous period. In addition, the firm knows the current productivity z_t and the financial variable ϕ_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 stages: (i) wage bargaining, (ii) financial decision, (iii) default. These sequential stages are illustrated in figure 1.

The timing of decisions for a new firm is very similar except that the initial debt b_t is zero and there is no wage bargaining since production starts in the next period. Still, the newly created firm chooses the debt b_{t+1} and pays the dividend $d_t = b_{t+1}/R_t$. It is further assumed that the newly created match could be separated with probability λ before entering the next period. This is without loss of generality and it is immaterial for the results.

Figure 1: Timing for an incumbent firm
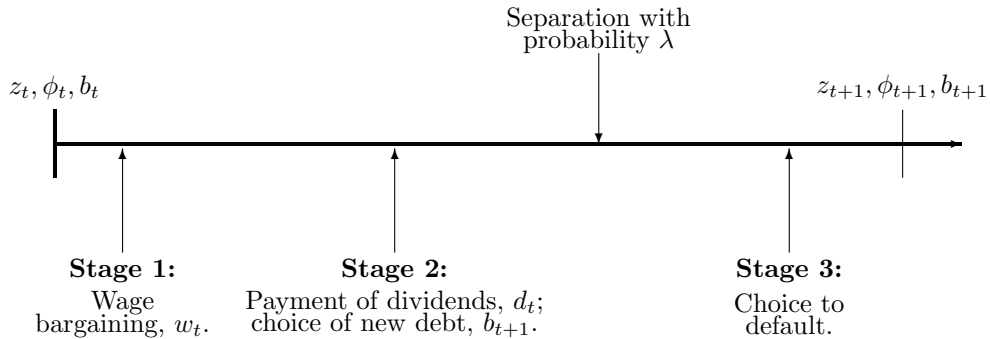
Value of the firm and borrowing limit: We assume that lending is done by competitive intermediaries who pool a large number of loans. We refer to these intermediaries as *lenders*. The amount of borrowing is constrained by limited enforcement. As described above, after the payments of dividends and wages, 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 χ_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 the 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 $\mathbf{s}_t = (z_t, \phi_t, B_t)$, where z_t and ϕ_t are exogenous aggregate states (see more below), while B_t is the aggregate stock of debt. We distinguish aggregate debt from individual debt since an individual firm has always the option to deviate from the financial policies chosen by other firms. Even though in equilibrium they all choose the same debt, we have to allow for out-of-equilibrium deviations in order to characterize the optimal policies. 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 writing $J(z_t, \phi_t, B_t, b_t)$. We will use this notational convention throughout the paper in order to minimize the complexity of the analytical expressions,.

We begin by considering the possibility of default in the event in which the match is separated. In this case the value of the firm is zero. Therefore, the lender anticipates that the recovery value is zero and the debt will not be repaid. Therefore, in order to break even, the lender needs to insure that the firm does not default when the match is not separated. It also requires charging a higher interest rate to cover the losses realized when the match is separated.

If the match is not separated, the value of the firm's equity is $\beta \mathbb{E}_t J_{t+1}(b_{t+1})$, 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 χ_t of the total value of the firm. Therefore, the lender is willing to lend as long as the following constraint is satisfied:

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

This constraint imposes that the recoverable value cannot be smaller than the loan. The variable χ_t is stochastic and affects the borrowing capacity of the firm. Henceforth, we refer to unexpected changes in χ_t as 'credit shocks'.

By collecting the term $b_{t+1}/(1+r)$, we can rewrite the enforcement constraint more compactly as:

$$\phi_t \beta \mathbb{E}_t J_{t+1}(b_{t+1}) \geq \frac{b_{t+1}}{1+r}, \tag{2}$$

where $\phi_t \equiv \chi_t/(1-\chi_t)$. We can then think of credit shocks as unexpected innovations to the variable ϕ_t. This is the exogenous state variable that we included in the set of aggregate states $\mathbf{s}_t$.

We now have all the elements to determine the actual interest rate that will be charged to the firm. Since the loan is made before knowing whether the match is separated, the interest rate charged by the lender will take 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:

$$R(1-\lambda) = 1+r. \tag{3}$$

The left-hand side of (3) is the lender's expected income per unit of debt. The right-hand side is the lender's opportunity cost of finance, also 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 $t+1$. Notice that, due to the assumption of risk neutrality, the interest rate is always constant, and therefore, it bears 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 wage bargaining, however, 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. In other words, *within the current period, the firm takes the outcome of the wage bargaining as given but it does internalize that the new debt b_{t+1} affects the future wages.* We can then write the value of the firm as follows:

$$J_t(b_t) \;\; = \;\; \max_{b_{t+1}} \left\{ z_t - g_t(b_t) - b_t + \frac{b_{t+1}}{R} + \beta(1-\lambda)\mathbb{E}_t J_{t+1}(b_{t+1}) \right\} \quad (4)$$

subject to

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

where the only choice variable is the new debt b_{t+1}.

We can verify that, given 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. We state this property formally in the following Lemma.

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 later, this property greatly simplifies the wage bargaining problem as characterized below.[2]

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[2]This property derives from the assumption that firms have the 'right to manage'

Worker's values: In order to set up the bargaining problem for the determination of wages, 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:

$$H_t(b_t) = g_t(b_t) + \beta \mathbb{E}_t \left[(1 - \lambda) H_{t+1}(b_{t+1}) + \lambda U_{t+1} \right] \tag{5}$$

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 follows:

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

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 $H_{t+1}(B_{t+1})$, that is, the value of being matched with a firm that has the average debt.

Bargaining problem: Let's define the following functions:

$$\hat{J}_t(b_t, w_t) = \max_{b_{t+1}} \left\{ z_t - w_t - b_t + \frac{b_{t+1}}{R} + \beta(1 - \lambda)\mathbb{E}_t J_{t+1}(b_{t+1}) \right\} \tag{6}$$

$$\widehat{H}_t(b_t, w_t) = w_t + \beta \mathbb{E}_t \left[(1 - \lambda) H_{t+1}(b_{t+1}) + \lambda U_{t+1} \right] \tag{7}$$

These are the values, for the firm and the employed worker respectively, for an arbitrary wage w_t paid in the current period and with future wages determined by the function $g_{t+1}(b_{t+1})$. The functions $J_t(b_t)$ and $H_t(b_t)$ were defined in (4) and (5) for a particular wage equation $g_t(b_t)$. Notice that

the debt. Without this assumption the wage bargaining problem would be much more complicated.

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equation (6) explicitly recognizes that the value of the firm depends on the optimal choice of debt b_{t+1}.

For a given bargaining power of workers $\eta \in (0,1)$, the current wage is the solution to the following problem:

$$\max_{w_t} \left\{ \hat{J}_t(b_t, w_t)^{1-\eta} \left[\widehat{H}_t(b_t, w_t) - U_t \right]^{\eta} \right\}. \tag{8}$$

Let $w_t = \psi_t(g; b_t)$ be the solution to (8), where we made explicit the dependence on the wage function g, which determines future wages. The rational expectation solution to the bargaining problem must satisfy the fixed-point 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 (8) we do not have to consider how the choice of w_t affects b_{t+1}. Therefore, in deriving the first order condition we take b_{t+1} as given. After some re-arrangement, the first order conditions of problem (8) can be written as:

$$J_t(b_t) = (1 - \eta)S_t(b_t), \tag{9}$$

$$H_t(b_t) - U_t = \eta S_t(b_t), \tag{10}$$

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

Choice of debt: Let's first rewrite the net surplus as follows:

$$S_t(b_t) = z_t - a - b_t + \frac{b_{t+1}}{R} + \beta \mathbb{E}_t \left[(1 - \lambda - p_t \eta)S_{t+1}(b_{t+1}) \right] \tag{11}$$

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

$$\frac{\partial S_t(b_t)}{\partial b_t} = -1. \tag{12}$$

A property that will be used below.

Using (9), the firm's problem (4) can be re-written as:

$$J_t = \max_{b_{t+1}} \left\{ z_t - g_t(b_t) - b_t + \frac{b_{t+1}}{R} + \beta(1-\lambda)(1-\eta)\mathbb{E}_t S_{t+1}(b_{t+1}) \right\} (13)$$

subject to

$$\phi_t \beta \mathbb{E}_t S_{t+1}(b_{t+1}) \geq \frac{b_{t+1}}{1+r}$$

Let μ_t be the Lagrange multiplier associated with the enforcement constraint. The first order condition is:

$$\beta(1-\lambda)R(1-\eta)(1+\phi_t \mu_t) = 1 - \mu_t, \qquad (14)$$

where we have used $\partial S_t(b_t)/\partial b_t = -1$.

From condition (14) we can establish that the enforcement constraint is always binding to the extent that workers have some bargaining power. We express this point in the following lemma:

Lemma 2 . *The multiplier μ_t is positive (and thus, the enforcement constraint is binding) if and only if $\eta \in (0,1)$.*

Proof 2 *Equation (14) implies $1 - \eta = (1 - \mu_t)/\beta(1-\lambda)R(1+\phi_t \mu_t)$. To see that $\mu_t > 0 \rightarrow \eta \in (0,1)$, suppose $\mu_t = 0$. Using the zero profit condition (3) and condition (1), this would lead to $1 - \eta = 1$, which is satisfied only if $\eta = 0$. Conversely, suppose $\eta \in (0,1)$. Then using (3) and (1), equation (14) can be written as $\mu_t = \eta/[1 + (1-\eta)\phi_t]$, which implies $\mu_t > 0$.*

A key implication of Lemma 2 is that, to the extent that workers have some bargaining power, the firm always chooses to maximize the debt until the borrowing limit binds. To gather some intuition about the economic interpretation of the multiplier μ_t, it will be convenient to re-arrange the first order condition as follows:

$$\mu_t = \underbrace{\left[\frac{1+r}{1 + \beta(1+r)(1-\eta)\phi_t}\right]}_{\substack{\text{total change} \\ \text{in debt}}} \underbrace{\left[\frac{1}{R} - \beta(1-\lambda)(1-\eta)\right]}_{\substack{\text{marginal gain} \\ \text{from borrowing}}},$$

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which is 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, $\frac{b_{t+1}}{1+r} - \phi_t \beta(1-\eta)\mathbb{E}_t S(z_{t+1}, B_{t+1}, b_{t+1}) \leq \bar{a}$, where $\bar{a} = 0$ is a constant. This is obtained by marginally changing $\bar{a}$. In fact, using the implicit function theorem, we have

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

which is the first term in brackets.

The second term in brackets is the net gain from increasing the next period liabilities b_{t+1} by one unit. If the firm increases b_{t+1} by one unit, it receives $1/R$ units of consumption goods today, which can be paid as dividends. Next period this unit has to be repaid. The effective cost, however, is lower than one, for two reasons. First, the repayment is made only with probability $1 - \lambda$, that is, only if the match is not separated. Second, a higher level of debt allows the firm to reduce the next period wage by η, that is, the part of the surplus going to the worker. This implies that the expected discounted cost for the firm is $\beta(1-\lambda)(1-\eta)$. Therefore, the multiplier μ_t is the total gain from the increase in debt allowed by a marginal relaxation of the enforcement constraint which is equal to the total change in debt (first term in brackets) multiplied by the gain from one additional unit of debt (second term in brackets),

It is interesting to observe that the effective cost of the debt decreases with η: the higher the bargaining power of workers, the higher is the firm's incentive to borrow. When the bargaining power is zero, the firm does not gain from borrowing and $\mu_t = 0$ (since $\beta(1+r) = 1$).

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 κ, vacancies will be posted only if the value of a filled vacancy (new firm) 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 paying 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 filled vacancy is defined as:

$$Q_t = \max_{b_{t+1}} \left\{ \frac{b_{t+1}}{R} + \beta(1-\lambda)(1-\eta)\mathbb{E}_t S_{t+1}(b_{t+1}) \right\} \tag{15}$$

subject to

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

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

As far as the choice of b_{t+1} is concerned, a new firm faces the same problem as incumbent firms (see problem (13)). Even if the new firm has no debt and it does not pay wages, the choice of b_{t+1} is not affected by the existing pair of debt and wage (see Lemma 1). Therefore, new firms choose the same debt as incumbents, which allows us to work with a representative firm. Of course, this is possible because all firms have the same z_t and ϕ_t.

We are now ready to define the value of a vacancy. Let κ be the cost of posting a vacancy and q_t the probability that the vacancy is filled. The value of posting a vacancy is:

$$V_t = q_t Q_t - \kappa.$$

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. Therefore, the enforcement constraint is always binding, that is, $b_{t+1}/(1+r) = \phi_t \beta(1-\eta)\mathbb{E}_t S_{t+1}(B_{t+1})$.

Another general equilibrium condition derives from the assumption of free entry. As long as the value of posting a vacancy is positive, more vacancies will be posted until $V_t = q_t Q_t - \kappa = 0$. Using the binding enforcement constraint and the free entry condition, Appendix A derives the following expression for the wage:

$$w_t = (1-\eta)a + \eta(z_t - b_t) + \frac{[(1-\eta)\beta p_t + \phi_t A]\eta\kappa}{q_t(1+\phi_t)A}, \tag{16}$$

where $A \equiv \beta(1-\lambda)(1-\eta) > 0$.

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This expression makes clear that the initial debt b_t acts like a reduction in productivity in the wage equation. Instead of getting a fraction η of the output, the worker gets a fraction η of the output 'net of debt'. Thus, for a given bargaining power η, the larger is the debt 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, responds to a credit shock (change in ϕ_t) and to 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 will be created.

3.1   Change in ϕ_t

To derive some intuition we consider a temporary shock that affects only one newly created firm. In this way we can abstract from general equilibrium effects. Starting from a steady state equilibrium, let's assume that there is one firm with a newly filled vacancy for which the value of ϕ_t increases. The increase is purely temporary and it reverts back to the steady state value starting in the next period.

To determine how the change in ϕ_t affects the value of this single firm, let derive the derivative of Q_t with respect to ϕ_t:

$$\frac{\partial Q_t}{\partial \phi_t} = \left[\frac{1}{R} + A \frac{\partial \mathbb{E}_t S_{t+1}(b_{t+1})}{\partial b_{t+1}} \right] \frac{\partial b_{t+1}}{\partial \phi_t}$$

Applying the implicit function theorem to the enforcement constraint holding with equality, $b_{t+1}/R = \phi_t A E S_{t+1}(b_{t+1})$, we can write:

$$\frac{\partial b_{t+1}}{\partial \phi_t} = \frac{RA \mathbb{E}_t S_{t+1}(b_{t+1})}{1 - \phi_t RA \frac{\partial \mathbb{E}_t S_{t+1}(b_{t+1})}{\partial b_{t+1}}}$$

Recalling that $\partial \mathbb{E}_t S_{t+1}(b_{t+1})/\partial b_{t+1} = -1$ (see equation (12)), we can sub-

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stitute in $\partial Q_t / \partial \phi_t$ to obtain:

$$\frac{\partial Q_t}{\partial \phi_t} = (1 - RA) \left(\frac{A \mathbb{E}_t S_{t+1}(b_{t+1})}{1 + \phi_t RA} \right) \tag{17}$$

The expression in (17) allows us to assess the effect of a credit shock on the value of a newly created firm. Formally, we have the following proposition:

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

Proof 3 *Using (1) we have that $RA = 1 - \eta < 1$. Hence the derivative in (17) is positive if $\eta \in (0,1)$* ∎

Therefore, an increase in ϕ_t increases 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 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. Thus, the value of the firm increases if the firm can borrow more.

In deriving this result we assumed that the change in ϕ_t was only for only one newly created firm. By doing so we did not have to consider the possible general equilibrium effects of this change. However, since ϕ_t is an aggregate variable, the change affects all new firms. Therefore, the value of all posted vacancies increase and more jobs will be created. This will have some general equilibrium effects that cannot be characterized analytically. The general equilibrium effects will be studied quantitatively using numerical tools.

3.2   Change in z_t

In general, productivity shocks generate an employment expansion because the value of a filled vacancy increases. This would arise even if the debt does not change. For example if we fix it to zero. What we want to show here is that the endogeneity of debt amplifies the employment impact of a

productivity shock. To derive some intuition about the amplification mechanism, we consider a productivity shock that affects only one newly created firm. As in the case of a credit shock, this allows us to abstract from general equilibrium effects.

Starting from a steady state equilibrium, let's assume that there is one newly created firm, that is, a firm with a vacancy filled in the current period, 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 firm will be more productive also in the next period when it starts producing. Of course, if the increase in z_t were only temporary, it would not have any effect since the new firm does not produce in the current period.

The derivative of Q_t with respect to z_t is:

$$\frac{\partial Q_t}{\partial z_t} = A\frac{\partial \mathbb{E}_t S_{t+1}(b_{t+1})}{\partial z_t} + \left[\frac{1}{R} + A\frac{\partial \mathbb{E}_t S_{t+1}(b_{t+1})}{\partial b_{t+1}}\right]\frac{\partial b_{t+1}}{\partial z_t}$$

Applying the implicit function theorem to the enforcement constraint $b_{t+1}/R = \phi_t A\mathbb{E}_t S_{t+1}(b_{t+1})$, we obtain

$$\frac{\partial b_{t+1}}{\partial z_t} = \frac{\phi_t RA\frac{\partial \mathbb{E}_t S_{t+1}(b_{t+1})}{\partial z_t}}{1 - \phi_t RA\frac{\partial \mathbb{E}_t S_{t+1}(b_{t+1})}{\partial b_{t+1}}}$$

Since $\partial\mathbb{E}_t S_{t+1}(b_{t+1})/\partial b_{t+1} = -1$ (see equation (12)), substituting in the derivative of the firm's value Q_t we get:

$$\frac{\partial Q_t}{\partial z_t} = A\frac{\partial \mathbb{E}_t S_{t+1}(b_{t+1})}{\partial z_t} + (1 - RA)\left(\frac{\phi_t A\frac{\partial \mathbb{E}_t S_{t+1}(b_{t+1})}{\partial z_t}}{1 + \phi_t RA}\right) \qquad (18)$$

We can compare the above expression to the equivalent expression we would get if the borrowing constraint were exogenous. More specifically, we replace the enforcement constraint (2) 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,

$$\frac{\partial Q_t}{\partial z_t} = A\frac{\partial \mathbb{E}_t S_{t+1}(b_{t+1})}{\partial z_t} \qquad (19)$$

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

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z_t. This term is positive if $\eta > 0$, that is, if the worker has some bargaining power (in fact we have that $1 - RA = \eta > 0$). 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. The additional term we have in the right-hand-side of equation (18) captures the amplification generated by the endogeneity of the borrowing limit.

The amplification result has been derived under the assumption that only one firm is affected by the productivity improvement. When the change in z_t arises in aggregate, the value of any filled vacancy increases. Given the free entry condition $q_t Q_t = \kappa$, this will generate an increase in the number of posted vacancies and more jobs will be created. As in the case of a credit shock, there will be general equilibrium effects that cannot be characterized analytically. We thus turn to the quantitative exercise where the general equilibrium is characterized numerically.

4   Numerical simulations

In this section we present some quantitative experiments where we solve the model numerically. We first discuss the calibration.

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 ξ is a constant. We set the parameter α and the bargaining power η both to 0.5.

After normalizing the steady state value of productivity to 1, we have five parameters that can be pinned down using steady state conditions: the steady state value of the enforcement variable, $\bar{\phi}$, the utility flow for unemployed workers, a, the separation rate, λ, the cost to create a vacancy, κ, and the constant in front of the matching function, ξ. These five parameters are calibrated using the following conditions: (i) the steady state debt-to-output ratio is 1; (ii) the utility flow for unemployed workers, a, is 95% the steady-state value of wages; (iii) the steady state unemployment rate is 5 percent; (iv) the probability of filling a vacancy is 0.7; (v) the probability of finding a job is 0.93.

At this point we are left with the parameters determining the stochastic process for the two shocks. Assuming that they both follow independent first order autoregressive processes, we need to assign the persistence parameters, ρ_ϕ and ρ_z, and standard deviations, σ_ϕ and σ_z. For the productivity shock we set $\rho_z = 0.95$ and $\sigma_z = 0.01$, which are relatively standard values in the literature. For the parametrization of the credit shock there is not a well established literature. We assign $\rho_\phi = 0.95$ and the standard deviation is chosen to have a response of employment of similar magnitude as the response to a productivity shock. This is obtained by setting $\sigma_\phi = 0.01$.

Responses to a productivity shock: The top panel of Figure 1 plots the impulse response of employment to a productivity shock. The bottom panel plots the response to a credit shock. The numbers are percent deviation from the steady state. To show the importance of issuing debt, we compare those responses to the ones we would obtain in the case in which the stock of debt is not allowed to deviate from the steady-state. We refer to this case as *exogenous debt limit*. More specifically, we impose the borrowing constraint $b_{t+1} \leq \bar{b}$, where $\bar{b}$ is the steady state debt in the model with endogenous borrowing limit.

As can be seen from the top panel, the response of employment to a productivity shock is greatly amplified when the borrowing limit is endogenous. After the increase in productivity, the firm's value increases. Because of the nature of the enforcement constraint, the increase in the firm's value relaxes the borrowing limit. Thanks to the higher debt, the wage paid by new firms increases less and this leads to more job creation.

The dynamics of debt and wages are shown in the next two figures. The top panel of Figure 2 shows that the debt increases in response to the productivity improvement and returns to the original steady state gradually. The pattern of wages is shown in Figure 3. At impact wages increase significantly. This is because workers anticipate that the firm is taking more debt and, starting from the next period, their wages will be reduced. However, what matters for job creation is not the current wage but the wage that new firms will pay starting in the next period. As can be seen from Figure 3, the wage paid starting in the next period is homogeneously *lower* than the wage paid when the borrowing limit is exogenous. This is the key mechanism that generates amplification through the higher incentive to create jobs.

We would like to point out that the amplification mechanism derives from

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the change in the value of the match for the firm, which is an asset price. In this vein our mechanism shares some similarities with the amplification channel emphasized by Bernanke and Gertler (1989) and Kiyotaki and Moore (1997). In our model, however, the change in the asset price generates an economic expansion not because it allows for greater financing of investment but because it improves the bargaining position of firms.

Responses to a credit shock: The bottom panel of Figure 1 plots the response of employment to a *temporary* credit shock. The response is qualitatively similar to the response to a productivity shock. Of course, in the case of a credit shock, imposing an exogenous borrowing limit is equivalent to eliminating the credit shock, which explains why employment does not move. The responses of debt and wages are plotted in the lower sections of Figures 2 and 3. Especially important is the dynamics of the wage starting from the period after the shock. After raising at impact, the wage falls below the steady state level. Since the value of a new firm depends on future wages, the incentive to create jobs increases.

The final exercise simulates the economy in response to a permanent decline in ϕ_t. Suppose that starting from a steady state equilibrium, the economy experiences the following sequence of values for $\phi_t : \phi_t = \{\bar{\phi} - \Delta\}$. Here Δ is a positive number that denotes the deviation from the steady state value. Notice that the sequence of ϕ_t is not anticipated. Agents continue to form expectations based on the AR process. As can be seen in Figure 4, employment falls below the steady state and remains at this lower level for the whole simulation period. Although not reported, the persistence in the unemployment rate would be quite high even if the credit shock is temporary. For example if ϕ_t increases only in the current period and returns to the steady state in the next period.

This final exercise shows how problems in financial markets can generate long lasting increases in unemployment. A feature that characterizes the recent dynamics of the US labor market.

5   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:

$$(I - \mathbf{A}_1 L - \mathbf{A}_2 L^2 - ... - \mathbf{A}_n L^n) \begin{pmatrix} z_t \\ b_t \\ e_t \end{pmatrix} = \mathbf{P} \begin{pmatrix} \epsilon_{z,t} \\ \epsilon_{b,t} \\ \epsilon_{e,t} \end{pmatrix}$$

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 rates of TFP, z_t, the growth rates of private credit, b_t, and the growth rates of employment, e_t. A more detailed description of the data is provided below.

The vector $(\epsilon_{z,t}, \epsilon_{b,t}, \epsilon_{e,t})$ are the orthogonalized disturbances. In order to assign a particular economic interpretation to these shocks, we impose that some of the elements of the matrix $\mathbf{P}$ are equal to zero. To be more specific, let's write the matrix in extensive form:

$$\mathbf{P} = \begin{pmatrix} p_{zz} & p_{zb} & p_{ze} \\ p_{bz} & p_{bb} & p_{be} \\ p_{ez} & p_{eb} & p_{ee} \end{pmatrix}$$

By imposing that some of the elements of $\mathbf{P}$ 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 $\epsilon_{b,t}$ cannot 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 $\mathbf{P}$ 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 in the model an improvement in productivity affects employment with one period lag (due to the matching frictions), innovations to productivity cannot affect employment at impact. Therefore, we set $p_{ez} = 0$.

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

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.

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 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 5. 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 5 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 an 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 6. Also in this case we find that productivity shocks have a statistically significant impact on the growth rate of private credit and unemployment.

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 which we assumed in the theoretical model. However, we have not imposed that the residual shock $\epsilon_{e,t}$ also cannot have an 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. This implies that the structural VAR is over-identified. The impulse responses, plotted in Figure 7, confirm the results obtained with the identification strategy adopted above.

6   Conclusion

In this paper we have studied the importance of financial flows for employment (and unemployment) fluctuations. We have extended the basic structure of the models studied in Pissarides (1997) and Mortensen and Pissarides (1994) by allowing firms to issue debt under limited enforcement of financial contracts. We have emphasized that our approach goes beyond a mere cumulation of frictions, respectively in financial and labor markets. In fact, firms have an incentive to borrow in order to affect the wage-bargaining process. In this sense, our analysis translates to a general equilibrium macroeconomic environment the insight, emphasized in a recent corporate finance literature,

that firms may use financial leverage in order to improve their bargaining position with workers. 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 employment fluctuations and the impact of productivity shocks is greatly amplified. The determination of wages based on bargaining is central to these results.

The paper has also investigated the empirical relevance of these results 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 credit shocks on employment is statistically significant and productivity shocks lead to a credit expansion. These findings confirm the importance of the financial mechanism for the performance of the labor market.

Appendix

A   Wage equation

Consider the value of a filled vacancy defined in (15). Using the binding enforcement constraint, $b_{t+1}/(1+r) = \phi_t\beta(1-\eta)\mathbb{E}_tS_{t+1}(B_{t+1})$, to eliminate b_{t+1}, the value of a filled vacancy becomes:

$$Q_t = (1+\phi_t)A\mathbb{E}_tS_{t+1}(B_{t+1}),$$

where $A = \beta(1-\lambda)(1-\eta)$.

Next we use the free entry condition $V_t = q_tQ_t - \kappa = 0$. Substituting the above expression for Q we get an expression for the expected value of the surplus:

$$\mathbb{E}_tS_{t+1}(B_{t+1}) = \frac{\kappa}{q_t(1+\phi_t)A}$$

Substituting into the definition of the surplus—equation (11)—and taking into account that $b_{t+1}/R = \phi_tA\mathbb{E}_tS_{t+1}(B_{t+1})$, we get:

$$S_t(B_t) = z_t - a - b_t + \frac{[\beta(1-\lambda-p_t\eta)+\phi_tA]\kappa}{q_t(1+\phi_t)A} \tag{20}$$

Now consider the net value for a worker:

$$W_t(B_t) - U_t = w_t - a + \eta(1-\lambda-p_t)\beta\mathbb{E}_tS_{t+1}(B_{t+1})$$

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

$$\eta S_t(B_t) = w_t - a + \frac{\eta(1-\lambda-p_t)\beta\kappa}{q_t(1+\phi_t)A} \tag{21}$$

Finally, combining (20) and (21) we get the expression for the wage:

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

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Figure 1: Model simulation - Employment.

EMPLOYMENT RESPONSE TO PRODUCTIVITY

EMPLOYMENT RESPONSE TO CREDIT SHOCK
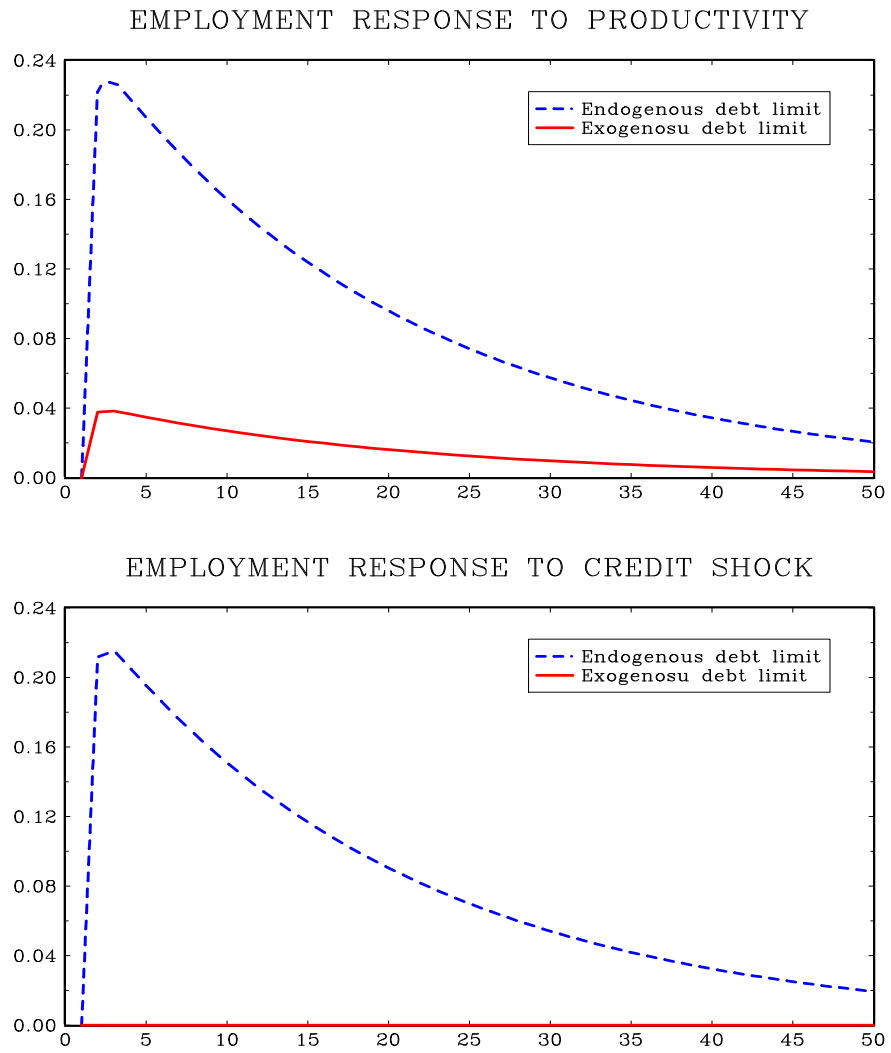
Figure 2: Model simulation - Debt.

DEBT RESPONSE TO PRODUCTIVITY

DEBT RESPONSE TO CREDIT SHOCK
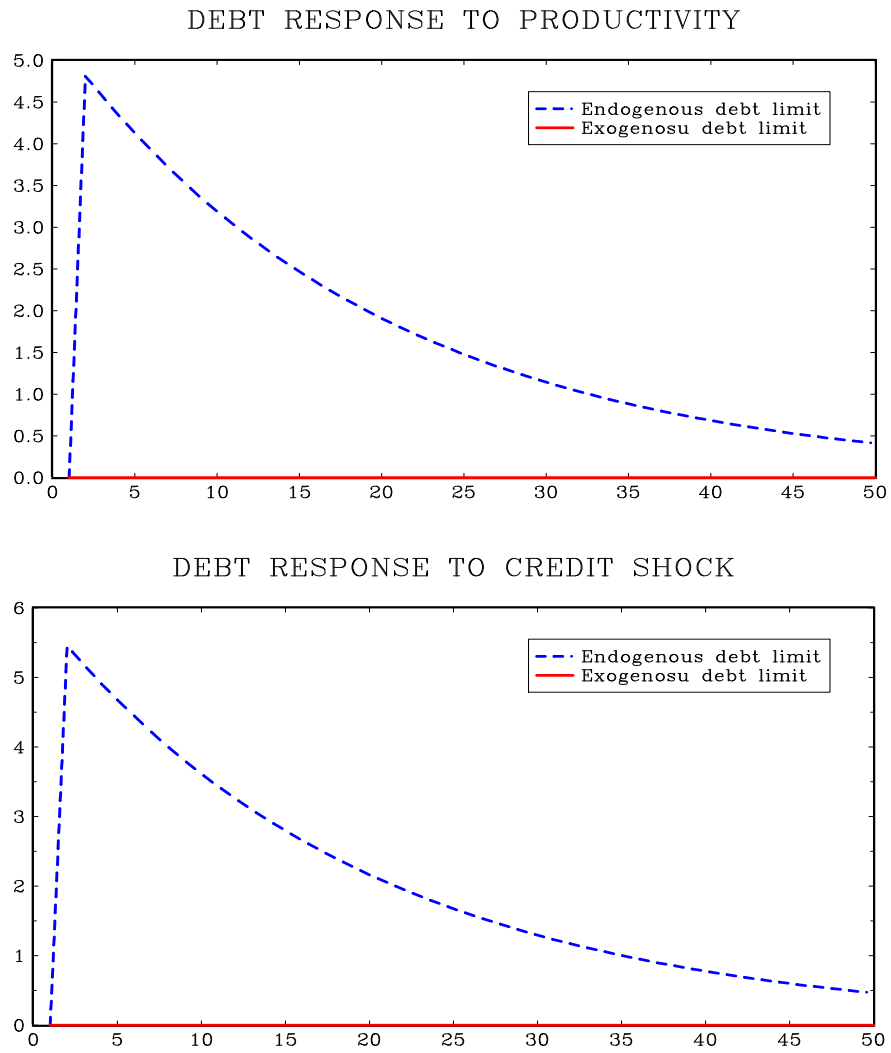
Figure 3: Model simulation - Wage.

WAGE RESPONSE TO PRODUCTIVITY

WAGE RESPONSE TO CREDIT SHOCK
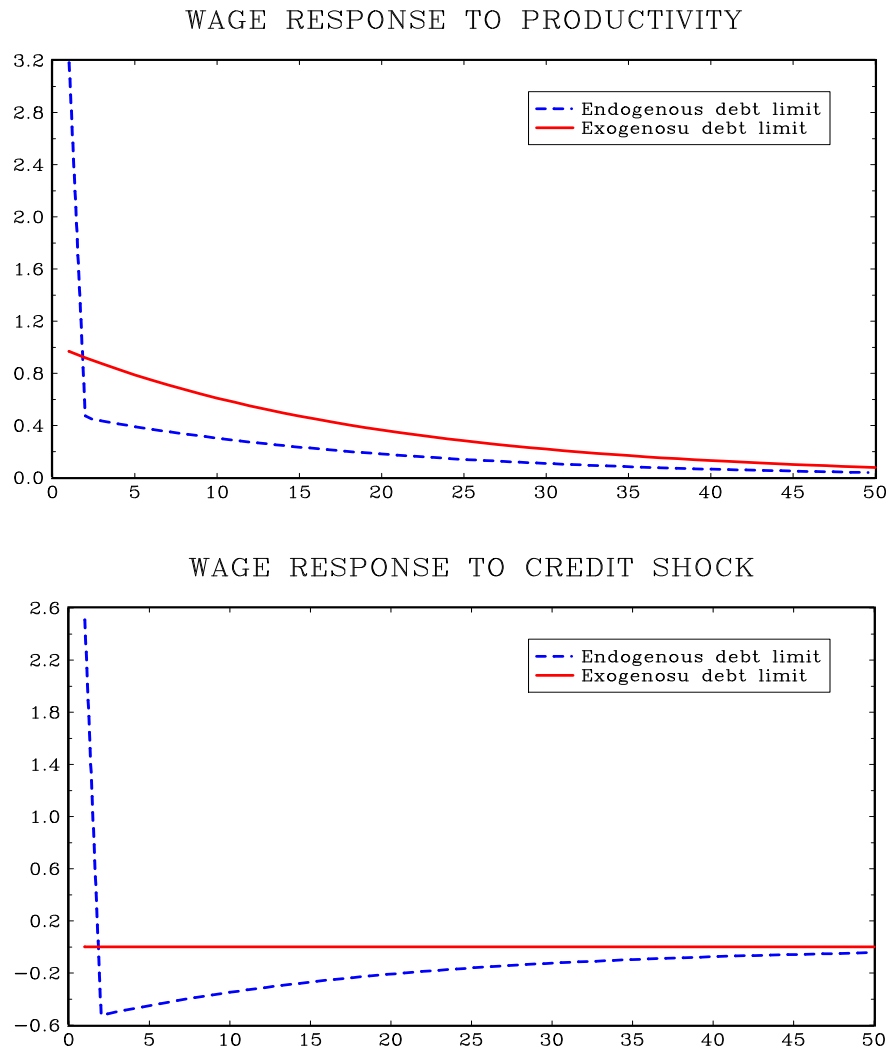
Figure 4: Response to a permanent negative credit shock.

EMPLOYMENT

DEBT

WAGES
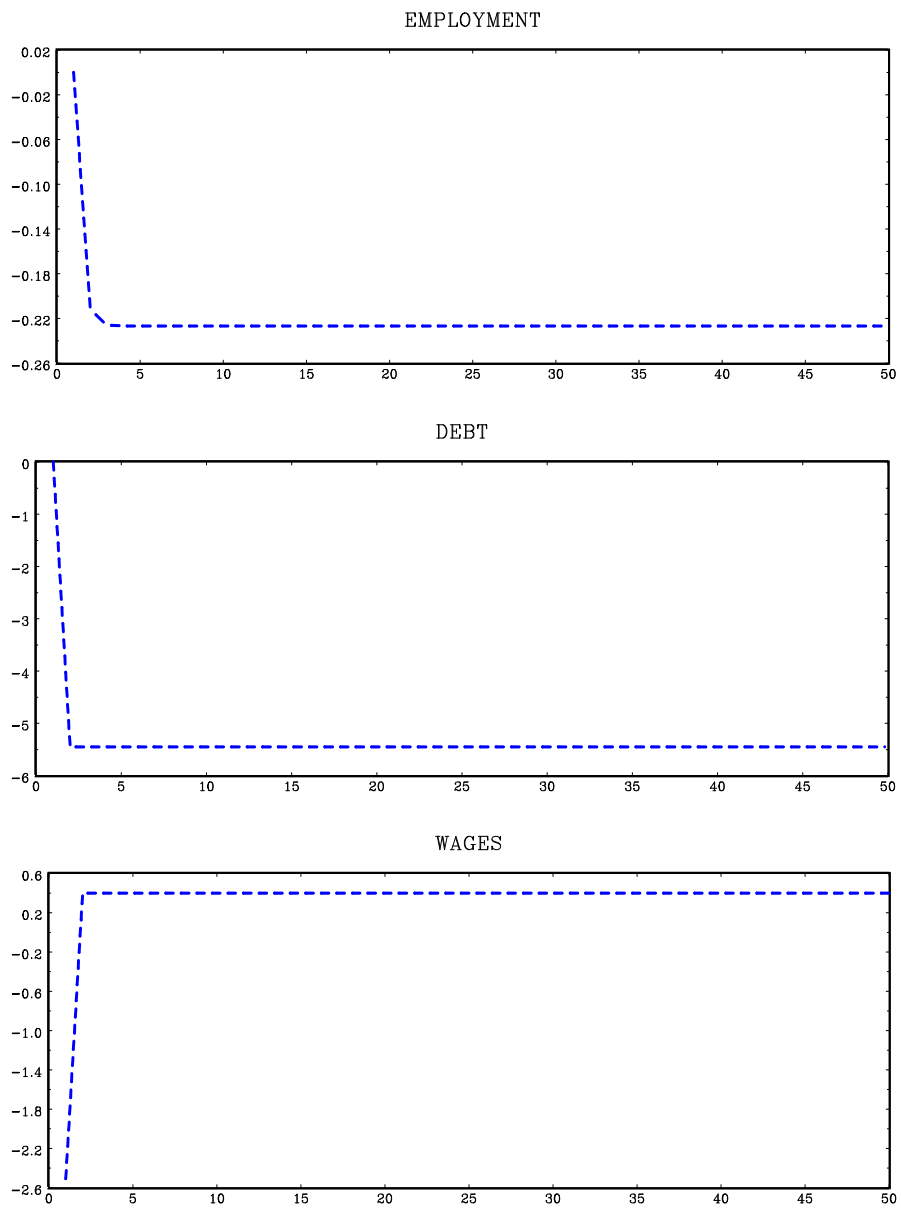
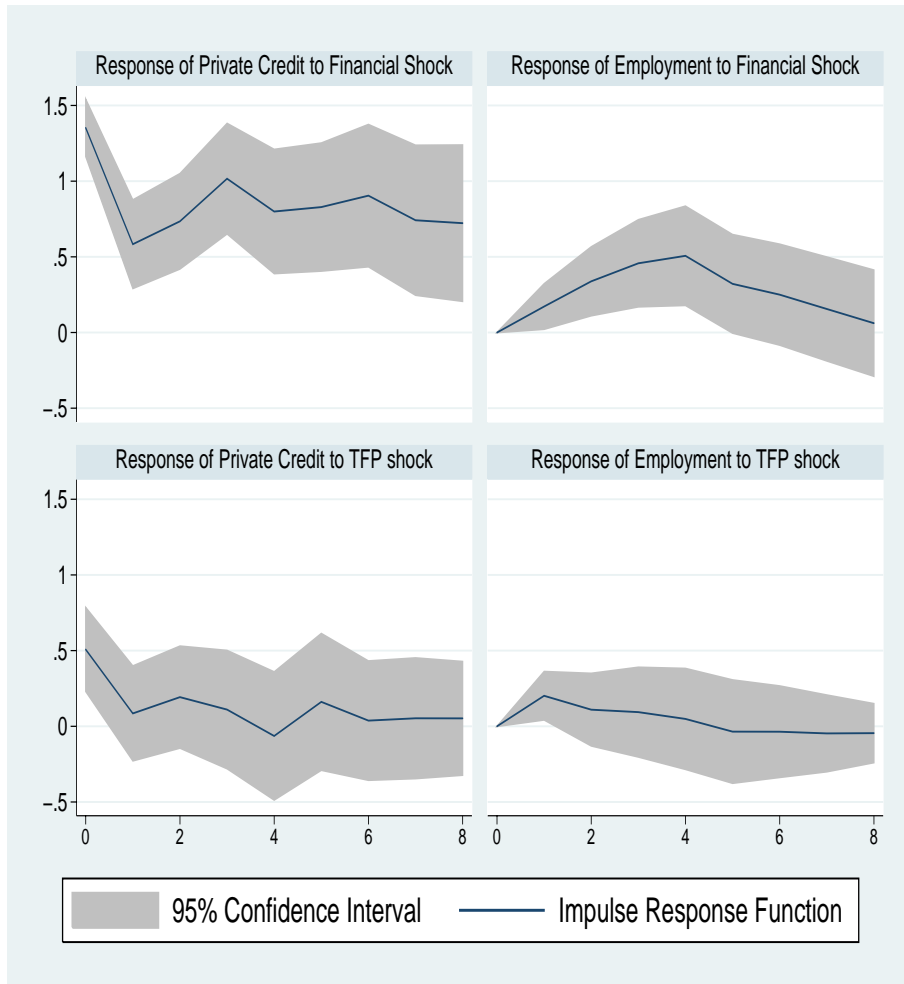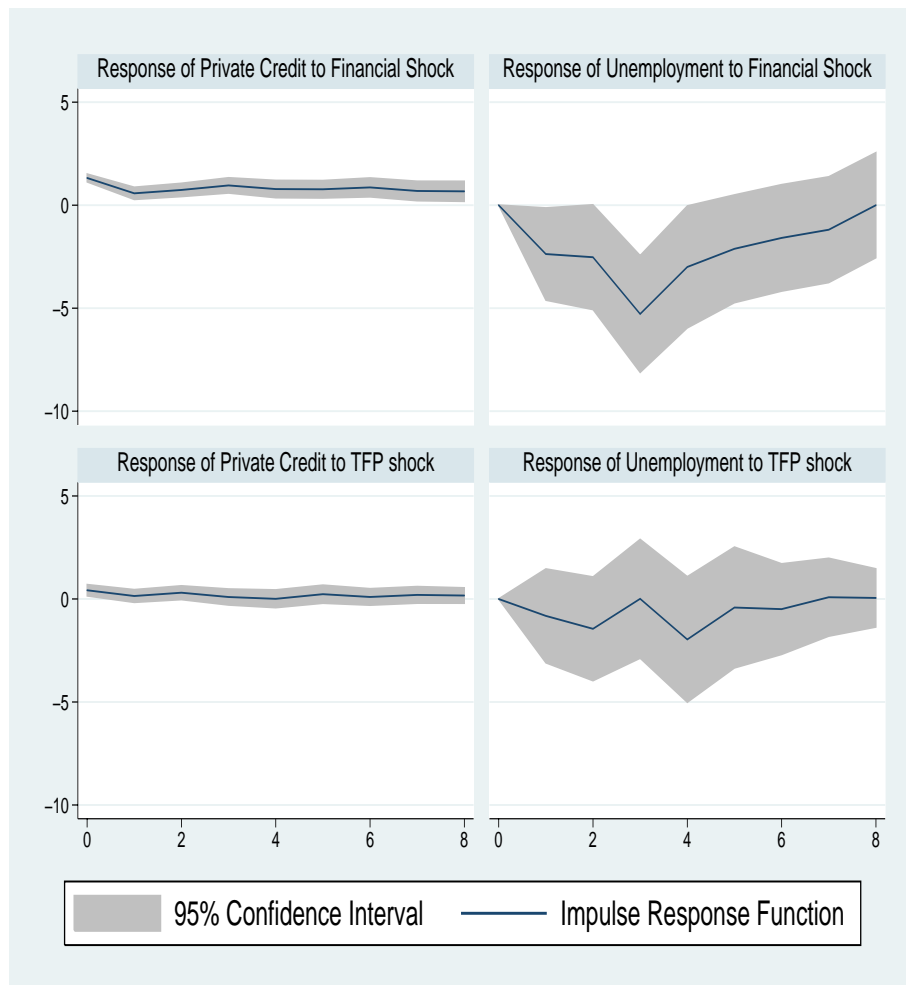Figure 5: Exactly identified structural VAR.

Figure 6: Exactly identified structural VAR.

Figure 7: Over-identified structural VAR.