Equilibrium Default and Slow Recoveries *

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Abstract

The 2007-2009 financial crisis generated a striking short-lived increase in the employment separation rate and a persistent decrease in its finding probability, which resulted in an increase in unemployment and a slow recovery. In this paper we propose a novel mechanism that can account for these patterns. The key innovation relies on the interaction between firms' number of workers and its willingness to default: firms with more debt per worker are less likely to repay and consequently face higher credit spreads. Therefore, at the aggregate level, credit conditions worsen with higher unemployment, which further reduces firms' incentives to hire resulting in a loop between the financial and the labor market.

JEL: E24, E32, E44.

Keywords: Unemployment, limited enforcement, credit market frictions, wage bargaining

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1 Introduction

The 2007-2009 crisis had two striking features. First, output growth and employment experienced a sharp decrease by the end of 2008; and secondly, the recovery has been slow, being still below historical averages by the end of 2012. Figure 1 shows output growth and unemployment, as well as credit spreads and adjusted total factor productivity[1] (TFP) growth for 2007-2012. Every variable is plotted as differences from its historical mean. As can be seen, the decrease in 2008 was accompanied with a spike in credit spreads and a decrease in productivity growth. However, although these measures are back to pre-crisis values by the end of the sample, output and employment remain low. To understand unemployment behavior, Figure 2 shows the finding and separation rates during this period. Similarly to credit spreads, separation increased during 2008 and quickly returned to pre-crisis values. Contemporaneously, the finding probability decreased and remained low thereafter. Arguably, a reasonable explanation of the high and persistent unemployment during the recent recession should involve a short-lived run up in separation rates together with a slow recovery of the finding probability.

In this paper, we develop a tractable general equilibrium model where firms have an intertemporal default decision. The key new component in our model is that, in the presence of search frictions in the labor market, workers become an asset for the firm. The financial and search frictions interact and reinforce each other: periods of low employment generate costly external funding, therefore decreasing hiring and consequently making unemployment a persistent state. The logic is identical to the "financial accelerator", but with the level of workers as another asset. We define this mechanism as the "employment accelerator".

Our model has two key ingredients. First, we model firms as solving a dynamic decision problem: they hire labor, invest and issue debt in order to maximize their present discounted value. However, since debt is not enforceable, there is credit risk: every period, firms will choose to repay if the continuation value of doing so is larger than the one obtained after default. Second, since hiring is costly, incentives to default decrease the more workers the firm has. We assume a natural framework

[1] See Fernald (2010).

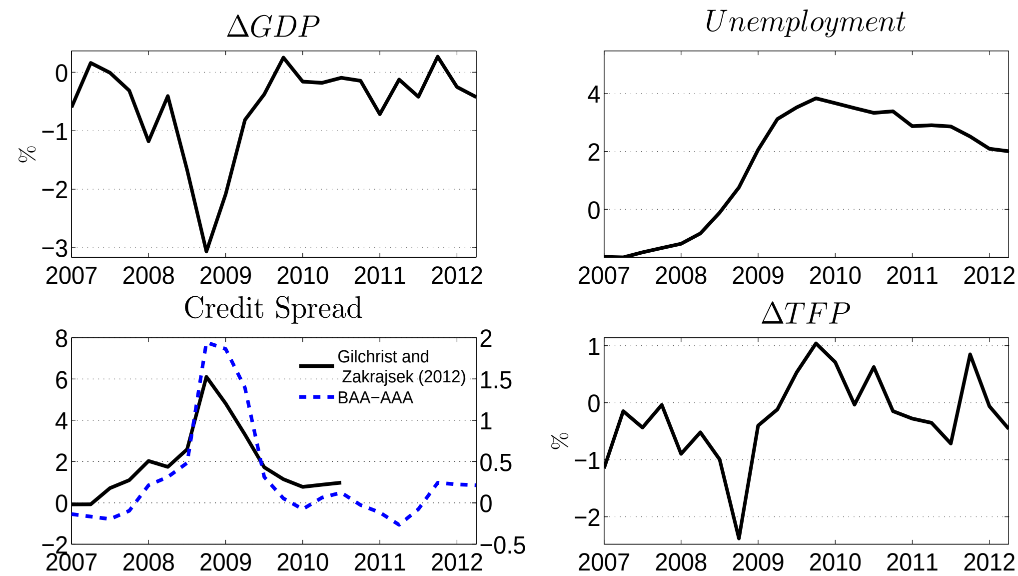

Figure 1: Output and Unemployment during 2007-2009

Note: *Variables are computed as % difference with respect to its average during 1981:1 to 2006:4*

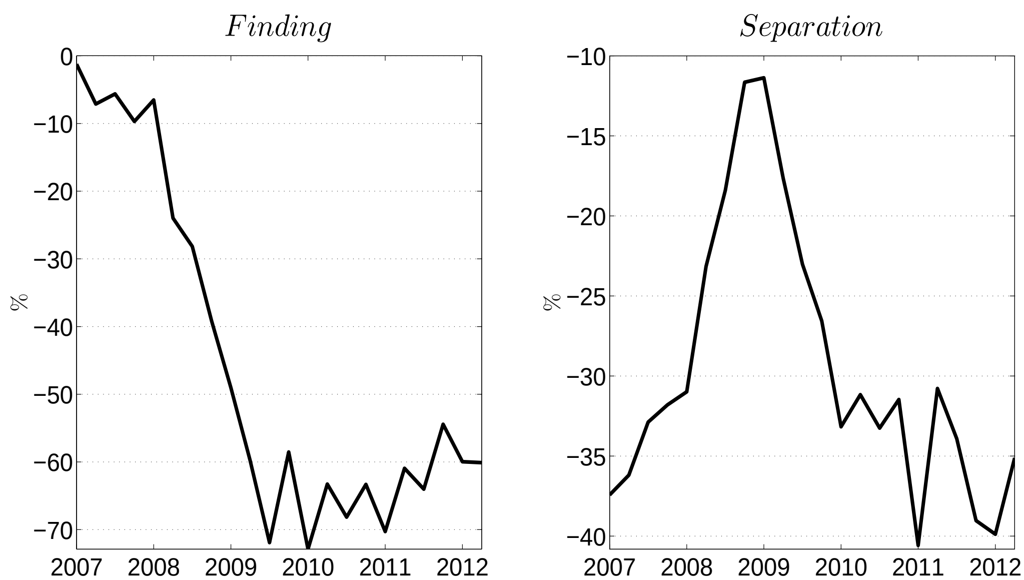

Figure 2: Finding and Separation during 2007-2009

Note: *Variables are computed as % difference with respect to its average during 1981:1 to 2006:4* for the labor market as in Mortensen and Pissarides (1994) to generate a costly adjustment of labor[2].

A distinctive element of our model is that we observe default as a (socially inefficient) equilibrium outcome. After a bad shock hits the economy, many firms default and lose workers. This generates a short-lived endogenous separation, similar to the one observed in Figure 2. Consecutively, the reduced size of firms makes them more risky and consequently face higher credit spreads: the economy enters the "employment accelerator" spiral. This slow recovery dynamic resembles the one showed in Figure 2.

Even if the focus of this paper is on slow recoveries, we believe this two-sided mechanism between financial and labor markets can be a potential interesting explanation for business cycle fluctuations.

1.1 Related Literature

Our paper is related to two lines of research: (i) macroeconomic models with financial frictions; and (ii) models of the labor market with search frictions. We discuss how our paper relates to each topic and comment as well on other works in the intersection of these topics.

Following Bernanke and Gertler (1989), a large body of work has been devoted to understanding the relationship between financial variables and aggregate outcomes. Two canonical references are Kiyotaki and Moore (1997) and Bernanke, Gertler, and Gilchrist (1999)[3]. In many of these papers there is either a static agency problem or a dynamic one but with no equilibrium default. In this paper, we model default as a dynamic, forward-looking decision as in Eaton and Gersovitz (1981), or Arellano (2008) more recently, where default occurs in equilibrium. This contribution makes variables in our model, such as credit spreads and default rates, the outcome of expectations about future paths. For example, credit spreads will reflect expectations about future marginal utilities and default rates as in standard asset pricing theory. The forward-looking behavior of credit spreads contains predictive power which is consistent with the emprical work in Gilchrist and Zakrajsek (2012) among others.

[2]Other works, for instance Bloom, Floetotto, Jaimovich, Saporta, and Terry (2012), generate a cost of hiring by directly assuming labor adjustment costs. We think both frameworks are reasonable.

[3]For more recent contributions see: Gertler and Kiyotaki (2009), Jermann and Quadrini (2012), Brunnermeier and Sannikov (2012), Adrian and Boyarchenko (2012) and Bigio (2012) among others.

As in Gomes and Schmid (2010), in our paper equilibrium default interacts with general equilibrium effects. In both models credit risks generate ex-ante incentives and ex-post consequences. Ex-ante incentives are reflected as movements in asset prices that prevent efficient allocation of resources; a standard "financial accelerator" mechanism. Ex-post consequences are associated with punishments due to default which we model as a loss to the firm in capital and workers. As we will show, these punishments will resemble wedges in labor and capital dynamics, the importance of which has been stressed previously (for example Justiniano, Primiceri, and Tambalotti (2010)). Our paper differs from Gomes and Schmid (2010) in two respects. First, we make simplifying assumptions that allow us to have a finite dimensional state space. This in turn help us to add a labor market friction while still working with a highly tractable model. Second, we allow every firm in our model to make debt and investment decision as a function of the state of the economy. The disadvantage is that we obtain a minimal amount of heterogeneity at the micro level, our focus being aimed principally on the macro implications of the model.

Our paper also intersects with a large literature on frictional unemployment, as in Mortensen and Pissarides (1994) and Shimer (2005)[4]. Closest in spirit to our work are Monacelli, Quadrini, and Trigari (2011) who also study the interaction between financial frictions and labor markets[5]. We share a common mechanism with this paper; that firms have an incentive to issue debt since it improves their bargaining position for wages. There are two main differences between our papers. First, equilibrium default rationalizes the existence of credit spreads which we show to be important. Furthermore, this allows us to use a time series on credit spreads to discipline our quantitative experiments. Second, the combination of multi-workers firm together with a search friction makes the number of employees a state for the firm, affecting thus its default decision and its funding costs. This is a new mechanism which we show to be relevant.

The rest of the paper is organized as follows. Section 2 describes the model. Section 3 provides the main characteristics and implications of our model. Section 4 performs a quantitative evaluation. Section 5 concludes.

[4]See Andolfatto (1996), Merz (1995), Gertler and Trigari (2009) among others

[5]For further work in this intersection see: Garin (2011), Petrosky-Nadeau (2011) and the references therein.

2 Model

Time is discrete and indexed by $t = 0, 1, 2, \ldots$. The economy is populated by a continuum of firms and a representative household. Firms have access to a production technology given as

$$y = axk^{\alpha}n^{1-\alpha} \tag{1}$$

where k and n stand for capital and labor respectively. Its productivity is given by an idiosyncratic component a and an aggregate one x. In order to hire labor, firms must post vacancies in a labor market with search frictions in the spirit of Mortensen and Pissarides (1994). Finally, they can accumulate capital which depreciates at a constant rate δ.

Household preferences are given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t e^{\xi_t} u(C_t) \tag{2}$$

where $u(\cdot)$ satisfies standard assumptions, β is his discount factor and ξ_t is a preference shock. The household is composed of a continuum of workers who individually search for labor opportunities and bargain over wages with firms. Although at any point in time they may be either employed or unemployed, we follow Andolfatto (1996) and Merz (1995) and assume that at the end of the period workers pool all their resources together and have perfect consumption insurance among them.

In order to fund its activities, firms can issue debt or equity[6]. However, since firms may decide to default, debt is risky. The only financial assets traded in this economy are the bonds issued by each one of these firms. We also assume that the household owns all of these firms.

In order to gain tractability, we make the following assumptions

Assumption 1 *The idiosyncratic productivity component a is i.i.d. across firms and time with distribution H. The aggregate productivity component x and the preference shock ξ follow a jointly Markov process $(x, \xi) \sim P((x', \xi'), (x, \xi))$ that satisfies standard properties.*

[6] In our setup, we undertsand equity injections as negative dividend payments.

Assumption 2 *Upon an episode of default, the firm loses a fraction φ_k of its capital and a fraction φ_n of its workers.*

Assuming that the idiosyncratic productivity component is *i.i.d.* allows us to reduce the dimensionality of the state space. This type of assumption has extensively been used in the financial frictions literature[7]. Regarding default punishments, previous work[8] typically assumed that upon default the firm is excluded from the market, which in this economy means that the entire firm is lost. Here, we allow a more flexible type of punishment in which only a fraction is lost. However, in Appendix B we show that for the particular case of $\varphi_k = \varphi_n = 1$ our assumption is identical to that of full exclusion. As we will see later, having a punishment associated with the firm's assets (and consequently the price of these assets) breaks the link between leverage and the spread endogenously: the state of the economy will also matter.

Timing within a period is as follows. At the beginning of period t, every firm starts with a level of debt b, capital $\bar{k}$, workers $\bar{n}$ and a realization of the exogenous shocks x, ξ and a. After this, each firm decides weather to default or not. Notice that, in the case of default, there is an endogenous separation at the beginning the period. Next, firms and workers that are still matched bargain over wages. Consecutively, production takes place and workers receive wages and unemployment benefits. Then, firms make investment, vacancy posting and portfolio decisions (debt and equity); while simultaneously households make portfolio and consumption decisions. Finally, labor market opens: exogenous separations and new matches are realized. Period $t+1$ begins. Figure 3 shows the timing just described.

We will next explain the firm's and household's problem, define a recursive equilibrium and characterize it. For the moment we will let z denote the aggregate state of the economy and later define it explicitly[9].

Notation 1 *Let z denote the aggregate state of the economy*

Since the amount of capital and matched workers changes within the period due to the default

[7]See for instance Gertler and Kiyotaki (2009), Kiyotaki and Moore (2008) and Bigio (2012) where they assume this for investment opportunities.

[8]For instance Arellano, Bai, and Kehoe (2011), Arellano (2008), Gomes and Schmid (2010).

[9]"Finding the state is an art".

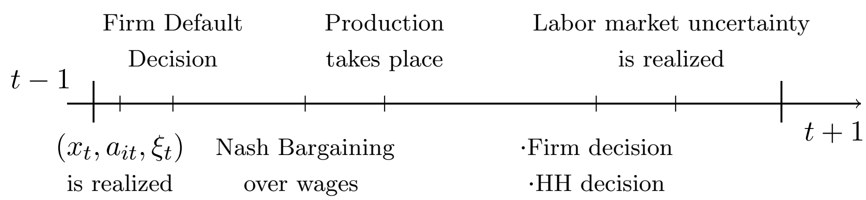

Figure 3: Timing in the model in Period t

decision, it will become useful to develop notation to separate variables before and after default. We will use the following notation

Notation 2 *Let $\{K, N\}$ be the aggregate amount of capital and workers in the economy ex-post default, analogously denote $\{k, n\}$ at the firm level. In addition, let $\{\bar{K}\bar{N}\}$ be the aggregate amount of capital and workers in the economy ex-ante default, analogously denote $\{\bar{k}, \bar{n}\}$ at the firm level.*

We will refer to employment (and unemployment) as the number of workers engaged in production, which is after the default decision. Thus, employment is N and $U = 1 - N$ is unemployment.

2.1 Firms

At the end of the period, the firm must choose dividend payments d, vacancies v, debt issuance b' and next period's capital $\bar{k}'$. At this point his wealth has already been determined by his production and default decision made at earlier stages of the period. Let $E(\omega, n, z)$ be the value of a firm with *ex-post* default wealth ω and n workers when the aggregate state of the economy is z. Then

$$E(\omega, n, z) = \max_{\{d,v,b',\bar{k}'\}} \left\{ d + \beta \mathbb{E}_{z',a'} \left[\Lambda(z,z') \max_{\{d,nd\}} \left\{ E(\omega'_d, n'_d, z'), E(\omega'_{nd}, n'_{nd}, z') \right\} |z \right] \right\} \quad (3)$$

subject to

$$\begin{aligned}
\omega &\geq d + \bar{k}' + c(v,n) - nT(z) - p(\tilde{b}', \tilde{k}', z) b' \\
k'_d &= (1-\varphi_k)\bar{k}', \;\; n'_d = (1-\varphi_n)\bar{n}' \\
k'_{nd} &= \bar{k}', \;\; n'_{nd} = \bar{n}' \\
\omega'_d &= (1-\delta)k'_d + a'x'k'^{\alpha}_d n'^{1-\alpha}_d - w(a', \tilde{b}', \tilde{k}', z')n'_d \\
\omega'_{nd} &= -b' + (1-\delta)k'_{nd} + a'x'k'^{\alpha}_{nd} n'^{1-\alpha}_{nd} - w(a', \tilde{b}', \tilde{k}', z')n'_{nd} \\
\bar{n}' &= (1-s)n + vq(z) \\
z' &= \Gamma(z)
\end{aligned}$$

where $\tilde{b} = \bar{b}/\bar{n}$ and $\tilde{k} = \bar{k}/\bar{n}$ stand for *ex-ante* default debt and capital per worker respectively and $c(v,n)$ is the cost of posting v vacancies with n workers. We assume that $c(\cdot)$ is homogenous of degree 1. The term $T(z)$ is a transfer that the firm receives per worker, which we later address.

The first line in the feasible set is the firm's budget constraint. Its expenditures are dividend payments, capital purchases and vacancy posting. It can also obtain funds by issuing debt at a price $p(\tilde{b}', \tilde{k}', z)$. Thus, this line states that its wealth must be enough to cover expenditures above funds obtained by debt issuance (and transfers). Note that the cost for posting vacancies $c(\cdot)$ may include adjustment costs which will improve the model's quantitative performance. Similar modelling assumptions are found in Gertler and Trigari (2009), Christiano, Eichenbaum, and Trabandt (2012) or Fujita and Ramey (2007). The following two lines in the constraint set express that, upon default, a fraction of debt and capital is lost. Consequently, wealth next period under no default (ω'_{nd}) is obtained using all of the firm's capital and labor but paying its corresponding debt. Analogously, wealth next period after default (w'_d) does not include debt payments but uses less capital and labor. In both cases, wealth also accounts for the undepreciated capital left after production. Finally, the last line shows the evolution of labor: an exogenous fraction of workers s is lost, and a new amount of matches $vq(z)$ are made where $q(z)$ is the probability of filling a vacancy.

A departure in this model from a neoclassical environment is the dependence of both debt prices and wages on the individual portfolio decision. The reason why debt prices depend on its portfolio is simply because default probabilities depend on this, and prices reflect the likelihood of this scenario. This same logic is found in default models like Arellano (2008), Eaton and Gersovitz (1981) or Gomes and Schmid (2010)[10]. Also, since wages will be the result of a bargaining process, the portfolio composition will affect the bargaining outcome since it affects the profits for a firm of being matched with a worker. This is present as well in Monacelli, Quadrini, and Trigari (2011) and, as we will show below, it generates incentives for the firm to borrow.

The firm's problem is then to maximize the present discount value of dividend payments. In doing so, it takes into account the fact that it may decide to default next period. Furthermore, it internalizes the impact that its portfolio decision will have on prices. Also, as is typical in the literature (for instance Jermann and Quadrini (2012)), the firm uses the household's stochastic discount factor $\Lambda(z,z')$ in order to discount flows. We will show later that this problem has a tractable solution.

Notice that the asset structure of this economy is extremely large. In particular, the firm is choosing to finance its activities from a continuum of bonds indexed by $(\tilde{b}',\tilde{k}')$ with corresponding price $p(\tilde{b}',\tilde{k}',z)$. Since its optimal decision will depend on this price, we need to compute an (equilibrium) value for each one of these bonds. This will be obtained from the household problem.

One of the main inputs in the Nash bargaining process is the marginal value of the worker. The next lemma shows that this is independent of firms' idiosyncratic variables.

Lemma 1 ***[Firms Value Function]*** *The value function of a firm is linear in wealth ω and workers n*

$$E(\omega,n,z)=\omega+e(z)n$$

[10] One difference is the persistence of the idiosyncratic shock. Given our *i.i.d.* distribution assumption, the likelihood of default next period does not depend on the current *idiosyncratic* productivity. This is why the price of debt does not depend on the firm's productivity, although it does on the aggregate state of the economy, which includes x.

Policies for vacancy posting, capital and debt are also linear in labor

$$\begin{aligned} v'(\omega,n,z) &= \tilde{v}(z)n \\ \bar{k}'(\omega,n,z) &= \tilde{k}'(z)\left[(1-s)+\tilde{v}(z)q(z)\right]n \\ b'(\omega,n,z) &= \tilde{b}'(z)\left[(1-s)+\tilde{v}(z)q(z)\right]n \end{aligned}$$

where $e(z), \tilde{v}(z), \tilde{k}'(a)$ *and* $\tilde{b}'(z)$ *are functions of the aggregate state of the economy only. Finally, firms default if and only if their idiosyncratic productivity is below a threshold* $\underline{a}(\tilde{b},\tilde{k},z)$*, where* $\tilde{b}$ *and* $\tilde{k}$ *are the amount of debt and capital per worker with which the firm started the period.*

Note that, given an aggregate state z, all of the firm decisions are independent of wealth and identical in per worker units. This will allow for aggregation and help us to keep the dimensionality of the state space small. Also, the value for the firm of having an additional worker $e(z)$ is constant and identical across firms. This will be a key input later in the Nash bargaining problem. Finally, the default decision follows a threshold as a function of the firms financial position per worker. As we will later see, this threshold will also depend on the value of the firm.

2.2 Household

The household can choose consumption and bond holdings. In particular, he has to decide how much to save in each type of bond indexed by $(\tilde{b},\tilde{k})$. His income has three components: First, wage earnings and unemployment benefits made by workers. Second, dividends paid by firms. Third, last period portfolio returns. Let ω be the wealth from the family at the end of the period and let $V(\omega,z)$ denote the value of a family with wealth ω when the aggregate state of the economy is z. Then

$$V(\omega,z) = \max_{\{C,b'_h(\tilde{b}',\tilde{k}')\}} \left\{U(C)+\beta\mathbb{E}_{z'}[V(\omega',z')|z]\right\} \tag{4}$$

subject to

$$
\begin{aligned}
\omega + d(z) &\geq C + \int p(\tilde{b}', \tilde{k}', z) b_h'(\tilde{b}', \tilde{k}') d(\tilde{b}', \tilde{k}') + \mathbb{T}(z) \\
\omega' &= \int \left[1 - H(\underline{a}(z', \tilde{b}', \tilde{k}'))\right] b_h'(\tilde{b}', \tilde{k}') d(\tilde{b}', \tilde{k}') \ldots \\
&+ \bar{b}U' + \left[\int_0^\infty w(a, \tilde{b}'(z), \tilde{k}'(z), z') dH(a)\right] N' \\
N' &= \left[1 - \varphi_n H(\underline{a}(\tilde{b}'(z), \tilde{k}'(z), z'))\right] \bar{N}' \\
U' &= (1 - N') \\
\bar{N}' &= (1 - s)N + f(z)U \\
z' &= \Gamma(z)
\end{aligned}
$$

The first line in the feasible set is the household's budget constraint. His available income is his wealth ω plus the dividends $d(z)$ paid by the firm that period. His expenditure is given by consumption plus bond purchases. The second and third line describe wealth evolution. Next period, he will receive returns on his portfolios decision which are given by the non-defaulted bonds. He will also obtain labor earnings which are the unemployment benefits plus wages from workers matched with firms for production. Notice that, since there is an endogenous separation at the beginning of the period due to default, we have to adjust for the number of workers when updating from $\bar{N}'$ to N'. In this step, the household already internalizes firm's policies $\tilde{b}'(z)$ and $\tilde{k}'(z)$ which describe equilibrium default probabilities. The last three lines describe the evolution of the state. The mass of unemployed workers is the mass that started the period without a job plus those that were separated due to a default episode. Similarly, the mass of employed workers at the beginning of the period are those that survived a separation (exogenous and due to default) plus the fraction of unemployed that found a match.

The next lemma computes the value of a marginal worker for a household. It has a direct counterpart in the standard model of Mortensen and Pissarides (1994); that being the surplus generated by an employed worker.

Lemma 2 *Let*

$$v(z) = \frac{\partial V(\omega(z), z)}{\partial N} u'(C(z))^{-1}$$

Then,

$$\begin{aligned} v(z) &= \beta(1-s-f(z))\mathbb{E}_{z'}\Bigg[\Lambda(z,z') \\ &\quad \left\{\int_0^\infty \left[1-\varphi_n \mathbb{I}\{a' < \underline{a}(z', \tilde{b}'(z), \tilde{k}'(z))\}\right]\left[w(z', a', \tilde{b}', \tilde{k}') - \bar{b} + v(z')\ \right] dH(a)\right\} | z\Bigg] \end{aligned}$$

where $\Lambda(z, z') = e^{\xi'}\,(u'(C(z'))/u'(C(z)))$

The marginal value is constant in the number of workers mainly due to the lack of disutility of labor[11]. This will greatly simplify the Nash bargaining process next.

2.3 Nash Bargaining

Wages are the solution of a Nash bargaining procedure. In particular, wages are given by

$$w(a, \tilde{b}, \tilde{k}, z) = \arg\max_w \left\{\tilde{e}(a, \tilde{b}, \tilde{k}, z, w)^\gamma \tilde{v}(a, \tilde{b}, \tilde{k}, z, w)^{1-\gamma}\right\} \tag{5}$$

where

$$\tilde{v}(a, \tilde{b}, \tilde{k}, z, w) = \begin{cases} (1-\varphi_n)\left[w - \bar{b} + v(z)\right] & \text{if } a \le \underline{a}(z, \tilde{b}, \tilde{k}) \\ \\ w - \bar{b} + v(z) & \text{if } a > \underline{a}(z, \tilde{b}, \tilde{k}) \end{cases}$$

$$\tilde{e}(a, \tilde{b}, \tilde{k}, z, w) = \begin{cases} (1-\delta)(1-\varphi_k)\tilde{k} + (1-\varphi_n)(e(z) - w) & \text{if } a \le \underline{a}(z, \tilde{b}, \tilde{k}) \\ \quad + ax\tilde{k}^\alpha(1-\Psi) & \\ \\ -\tilde{b} + (1-\delta)\tilde{k} + ax\tilde{k}^\alpha + (e(z) - w) & \text{if } a > \underline{a}(z, \tilde{b}, \tilde{k}) \end{cases}$$

[11] Linear disutility in labor will work as well. See, for instance, Merz (1995) or Garin (2011).

where $\Psi = 1 - (1-\varphi_k)^\alpha (1-\varphi_n)^{1-\alpha}$ is the fraction of output lost by the firm due to default.

Recall that $v(z)$ is the value for the household of having an additional worker at the end of the period. Thus, $\tilde{v}(z)$ is the value at the moment of bargaining, which includes the additional instantaneous profit $w - \bar{b}$ and takes into account the value that will be obtained at the end of the period. Again, since some workers will be separated due to default, we need to subtract a fraction φ_n for low levels of productivity. Analogously, the value for a firm of having a marginal worker at the end of the period is $e(z)$, thus $\tilde{e}(z)$ simply adds the current profit of a match which is production minus wages. Note that for low levels of productivity we must adjust capital and labor as well since the firm experiences a default episode.

Once we have taken into account the changes due to default, the problem in (5) is a standard Nash bargaining problem as used in Mortensen and Pissarides (1994) or Shimer (2005).

2.4 Government, Aggregate Feasibility and Dynamics

We assume a government that serves two functions. First, it collects taxes $\mathbb{T}(z)$ from households in order to pay for unemployment benefits. The government's budget constraint reads

$$\mathbb{T}(z) = U\bar{b}$$

Secondly, the government takes the amount of capital that is lost upon default and rebates this back to firms. Thus, after a default, the fraction of capital lost by the firm will not disappear from the economy, but is accumulated by the government instead. Let $\check{K}$ be the amount of capital that the government has and let λ be the amount of this capital that it is rebated to firms every period. Then

$$\check{K}' = \int \varphi_k \mathbb{I}\{a_i' < \underline{a}(\tilde{b}_i', \tilde{k}_i', z')\}\bar{k}_i di + (1-\lambda)(1-\delta)\check{K}$$

Note that government's capital next period is the fraction not rebated $(1-\lambda)(1-\delta)\check{K}$ after depreciation plus the fraction of defaulted capital which is captured by the integral. Finally, the amount rebated to each firm per unit of worker is given by

$$T(z') = \frac{\lambda(1-\delta)\check{K}}{\int (1-\varphi_n \mathbb{I}\{a_i' < \underline{a}(\tilde{b}_i', \tilde{k}_i', z')\}\bar{n}_i di}$$

where the denominator is the *ex-post* default amount of workers.

Finally, let $Y(z)$ and $I(z)$ be the total output and investment in the economy when the aggregate state of the economy is z. Then

$$\begin{aligned} Y(z) &= \int a_i x \bar{k}_i^{\alpha} \bar{n}_i^{1-\alpha} \left[1 - \Psi \mathbb{I}(a_i < \underline{a}(\tilde{b}_i, \tilde{k}_i, z))\right] di \\ I(z) &= \int \bar{k}_i' di - \int (1-\delta) \left[1 - \varphi_k \mathbb{I}(a_i < \underline{a}(\tilde{b}_i, \tilde{k}_i, z)\right] \bar{k}_i di \end{aligned}$$

Aggregate feasibility for the economy the is

$$Y(z) = C(z) + I(z) + \int c(v_i, n_i) di$$

Finally, as with most of the literature in labor market search, we follow Mortensen and Pissarides (1994) in computing finding probabilities. In particular, let θ be the market tightness which is given by the ratio of vacancies to unemployment

$$\theta = \frac{\int v_i di}{U}$$

We will assume $q(z) = q^m(\theta)$ and $f(z) = f^m(\theta)$ with $\partial q^m/\partial\theta < 0$ and $\partial f^m/\partial\theta > 0$.

Finally, the state of the economy is given by: $z = (x, \xi, \bar{K}, \bar{N}, B, \check{K})$.

2.5 Equilibrium Definition

Definition 1 *A recursive equilibrium for this economy is given by value functions* $\{E(\omega, n, z), V(\omega, z)\}$*, policies functions for the firm* $\{d(\omega, n, z), v(\omega, n, z), b'(\omega, n, z), k'(\omega, n, z)\}$*, policies for the household* $\left\{C(\omega, Z), \{b_h(\omega, z, \tilde{b}, \tilde{k})\}_{\{\tilde{b}, \tilde{k}\}}\right\}$*, finding probabilities* $\{q(z), f(z)\}$*, prices* $\{p(\tilde{b}, \tilde{k}, z), w(a, \tilde{b}, \tilde{k}, z)\}$*; such that, given prices, finding probabilitites and an aggregate law of motion* $\Gamma(z)$*: (i) Firm's policies* *solve its problem and achieve value $E(\omega, n, z)$, (ii) Household's policies solve his problem and achieve value $V(\omega, z)$, (iii) Wages are given as the Nash bargaining solution, (iv) Finding probabilities are consistent with individual policies, (v) Bonds market clears: $\int b'(\omega, n, z) = b_h(\omega, z, \tilde{b}', \tilde{k}')\ \forall \tilde{b}', \tilde{k}'$, (vi) Goods market clears: $Y(z) = C(z) + I(z) + \int c(v_i, n_i) di$, (vii) Law of motion for the state: the mapping $z' = \Gamma(z)$ is consistent with individual policies and markets clearing.*

3 Characterization

Given our assumptions, we can obtain closed form solutions for many interesting objects and derive model implications. We do so in this section. We start by describing equilibrium wages.

Proposition 1 *The wages given by the Nash bargaining solution are as follows*

$$w(a, \tilde{b}, \tilde{k}, z) = \begin{cases} \gamma\left\{\bar{b} - v(z)\right\} + (1-\gamma)\left\{(1-\delta)\frac{1-\varphi_k}{1-\varphi_n}\tilde{k} + ax\tilde{k}^{\alpha}\frac{1-\Psi}{1-\varphi_n} + e(z)\right\} & \text{if } a \leq \underline{a}(z, \tilde{b}, \tilde{k}) \\ \\ \gamma\left\{\bar{b} - v(z)\right\} + (1-\gamma)\left\{-\tilde{b} + (1-\delta)\tilde{k} + ax\tilde{k}^{\alpha} + e(z)\right\} & \text{if } a > \underline{a}(z, \tilde{b}, \tilde{k}) \end{cases} \tag{6}$$

Equilibrium wages are basically identical to the standard wage equation commonly found, for instance in Mortensen and Pissarides (1994) or Shimer (2005). In particular, a higher productivity implies a higher value of a match and consequently a higher wage. In the same line, a higher value of unemployment, measured by $\bar{b} - v(z)$, implies higher wages as well. The differences in our set up are two. First, since firms have heterogenous productivities, the value of a match is firm dependent and consequently wages vary across firms[12]. Second, firm's last period portfolio decision affects the value of a match and thus wages paid. For instance, as can be seen in the second branch in (6), a non defaulting firm pays lower wages the higher is its debt. Naturally, similar logic applies to lower levels of capital. Thus, this wage determination process generates incentives for the firm to issue debt and under accumulate capital. Similar results are in Monacelli, Quadrini, and Trigari (2011), with the exception that they do not have capital in the economy.

[12]Note that this would also be true for the firm's level of debt and capital, except that in equilibrium each one holds the same portfolio per worker.

We now turn to the incentives involved in the default decision. Since this is given by the comparison of value functions, we proceed by comparing these in the default and not default state. From our Lemma 1, and using the expression for wealth in (3), we can separate the value of a firm in four terms as follows

$$E(\omega, n, z) = \begin{cases} \underbrace{-b}_{\text{Term 1}} + \underbrace{(1-\delta)k + axk^{\alpha}n^{1-\alpha}}_{\text{Term 2}} & \text{if no defualt} \\ \quad - \underbrace{w(a, \tilde{b}, \tilde{k}, z)n}_{\text{Term 3}} + \underbrace{e(z)n}_{\text{Term 4}} & \\ & \\ \underbrace{0}_{\text{Term 1}} + \underbrace{(1-\delta)(1-\varphi_k)k + axk^{\alpha}n^{1-\alpha}(1-\Psi)}_{\text{Term 2}} & \text{if default} \\ \quad - \underbrace{w\left(a, \tilde{b}, \tilde{k}, z\right)n(1-\varphi_n)}_{\text{Term 3}} + \underbrace{e(z)n(1-\varphi_n)}_{\text{Term 4}} & \end{cases}$$

Term 1 is the immediate benefit of defaulting, namely: it increases wealth by the amount of not repaid debt which generates incentives to default. **Term 2** implies a cost for default: a fraction $\Psi > 0$ of output and a fraction $\varphi_k > 0$ of capital are lost. **Term 3** is ambiguous: on one hand, the firm pays wages to a lower amount of workers; on the other hand, wages paid change since debt and capital change as well. In general, if the value for the household of being unemployed is high enough[13], the firm can actually decrease total wage payments by defaulting. In particular, when the idiosyncratic productivity is at the default threshold, default actually induces lower wage payments. Finally, **Term 4** is the forward looking behavior incorporated by the firm in the default decision: the larger is the expected discounted value of being matched with a worker ($e(z)$), the more is the cost of defaulting since a fraction φ_n of previous matches is lost. The default decision then weighs all of these dynamic and static trade-offs.

We can now characterize the default decision. As stated in Lemma 1, a firm defaults if its idiosyncratic productivity is below a certain threshold. The following proposition characterizes this

[13] By high enough, we mean a state z such that $\bar{b} - v(z)$ satisfies

$$0 < \gamma \left\{\bar{b} - v(z)\right\} \varphi_n n + (1-\gamma) \left\{(1-\delta)\varphi_k k + axk^{\alpha}n^{1-\alpha}\Psi + \varphi_n e(z)n\right\}$$

value.

Proposition 2 *The default threshold is given by*

$$\underline{a}(\tilde{b}, \tilde{k}, z) = \frac{1}{x\tilde{k}^{\alpha}\Psi}\left[\tilde{b} - \varphi_k(1-\delta)\tilde{k} + \varphi_n(\varsigma(z) - e(z))\right] \tag{7}$$

where $\varsigma(z) = \bar{b} - v(z)$

The result for the default threshold in (7) is reasonably intuitive. In particular, the higher the debt per worker a firm starts this period with, $\tilde{b}$, the higher the threshold and the more likely a default episode. Analogously, the more capital per worker the firm starts with, $\tilde{k}$, the lower the default threshold. Interestingly enough, even if $\varphi_k = 0$ and there is no capital loss after default, a higher level of capital still decreases default probabilities since increases output, a fraction of which is lost under default. On top of this, the value function $e(z)$ enters in the default decision: thus, the model captures a forward looking default decision that internalizes the expected benefits of being matched to a worker from now onwards. This, as discussed below, allows us to jointly generate procyclical financial intermediation together with countercyclical default which is an empirical regularity. Finally, note as well that higher values for the worker of being employed, as captured by $\varsigma(z)$, increases default probabilities. This is because a higher value results in higher wages during the Nash bargaining step, making it less profitable for the firm to have workers and thus increasing the incentive to default. Note that if φ_n equals zero, the firm does not loose any workers and this term does not enter in the default threshold.

We now turn to bond prices.

Proposition 3 *The price of any bond* $(\tilde{b}', \tilde{k}')$ *in this economy is given by*

$$p(\tilde{b}', \tilde{k}', z) = \beta\mathbb{E}_{z'}\left[\Lambda(z, z')\left[1 - H(\underline{a}(\tilde{b}', \tilde{k}', z'))\right]|z\right] \tag{8}$$

Notice that the bond price in equation (8) is a standard asset pricing equation: the value of the bond is the expectation of its payoff weighted by the household's stochastic discount factor. This proposition allow us to price any bond in the economy, even those that are not actually traded in equilibrium. Consequently, we can make sense of objects like risk-free rates and credit spreads while still keeping the model highly tractable. This price function (and not only the price of the bond actually traded) is internalized by the firms when making its portfolio decision: they understand that they can affect the cost of funding by changing their debt and capital holdings.

As mentioned before, since both wages and bond prices depend on the firm's decision, the Modigliani-Miller theorem does not hold in this economy. In particular, when making a portfolio decision the firm understands and internalizes the effect that this decision has on both prices, thus breaking the typical irrelevance of the portfolio composition in the firm's value.

In the previous propositions we discussed the optimal policies of the firm and how these depend on the financial and labor friction. The next proposition links these results to the finding rate.

Proposition 4 *Assume $c(v,n) = \kappa_0 v$, $f^m(\theta) = \theta^{\nu}$ and $q^m(\theta) = \theta^{\nu-1}$. Then, the finding probability $f(z)$ satisfies*

$$f(z) = \kappa_0^{-\frac{\nu}{1-\nu}} \left[V^b(z) + V^k(z) + V^T(z) + V^x(z) - V^u(z)\right]^{\frac{\nu}{1-\nu}} \tag{9}$$

where

$$\begin{aligned}
V^b(z) &= (1-\gamma)p(\tilde{b}'(z),\tilde{k}'(z),z)\tilde{b}'(z) + \beta^*\mathbb{E}_{z'}\left[\Lambda^*(z,z')V^b(z')|z\right] \\
V^k(z) &= \tilde{k}'(z)\left[\gamma(1-\delta)\mathbb{E}_{z'}\left[1-\varphi_k H(\underline{a}(\tilde{b}'(z),\tilde{k}'(z),z'))|z\right] - 1\right] + \beta^*\mathbb{E}_{z'}\left[\Lambda^*(z,z')V^k(z')|z\right] \\
V^T(z) &= \beta^*\mathbb{E}_{z'}\left[\Lambda^*(z,z')\left(\frac{T(z')}{(1-s)} + V^T(z')\right)|z\right] \\
V^x(z) &= \beta^*\mathbb{E}_{z'}\left[\Lambda^*(z,z')\left(\frac{x'\tilde{k}'(z)^{\alpha}\left[\mathbb{E}(a) - \Psi\int_0^{\underline{a}(\tilde{b}'(z),\tilde{k}'(z),z')} ah(a)da\right]}{(1-s)\left[1-\varphi_n H(\underline{a}(\tilde{b}'(z),\tilde{k}'(z),z'))\right]} + V^x(z')\right)|z\right] \\
V^u(z) &= \beta^*\mathbb{E}_{z'}\left[\Lambda^*(z,z')\left(\frac{\bar{b}-v(z')}{(1-s)} + V^u(z')\right)|z\right]
\end{aligned}$$

Where $\beta^* = \gamma\beta(1-s)$ and $\Lambda^*(z,z') = \Lambda(z,z')\left[1-\varphi_n H(\underline{a}(\tilde{b}'(z),z'))\right]$

Equation (9) relates the finding probability to five recursively defined objects: $V^b(z)$, $V^T(z)$, $V^k(z)$, $V^x(z)$ and $V^u(z)$. The term $V^x(z)$ is the expected discounted value to a firm of being matched with a worker. Every period it includes the expected productivity x' times the idiosyncratic productivity $\left[\mathbb{E}(a) - \varphi_n \int_0^{\underline{a}(\tilde{b}'(z),\tilde{k}'(z),z')} ah(a)da\right]$ which accounts for the default probability. The term $V^u(z)$ is the surplus value to the household of being unemployed. The term $V^b(z)$ reflects the profit that a firm can make by issuing debt: the higher is the price of its bond, or the higher are the expectations of these prices in the future, the higher $V^b(z)$ is and the higher the finding probability will be. The term $V^k(z)$ reflects the present value of capital expenditures, adjusted for default. Lastly, $V^T(z)$ reflects the value of transfers to the firms. The terms $V^x(z)$ and $V^u(z)$ are standard and typically found to affect the finding probability in frictional labor market models. The term $V^b(z)$, is a key new component and describes how conditions in financial markets affect the labor market. On top of this, the relevant discount factor in this expression is $\Lambda^*(z, z')$, which augments the household stochastic discount factor $\Lambda(z, z')$ with the default probabilities $\left[1 - \varphi_n H(\underline{a}(\tilde{b}'(z), z'))\right]$. Thus, periods in which the probability of default is high with large credit spreads will depress $V^b(z)$ and $\Lambda^*(z, z')$ and consequently decrease the finding probability as well.

The last proposition showed that periods of depressed financial markets will turn into periods of low employment. Our next proposition shows that this relation also holds in the opposite direction: periods of high unemployment will turn into periods of high interest rates.

Proposition 5 *The default threshold in state z can be expressed as*

$$\underline{a}(z) = \frac{1}{x\bar{K}^{\alpha}\bar{N}^{1-\alpha}\Psi}\left[B - (1-\delta)\bar{K} - \varphi_n \bar{N}(e(z) - \varsigma(z))\right] \tag{10}$$

where B is the amount of debt issued by firms last period.

Equation (10) makes explicit the role of labor as an asset in this economy. Given an amount of initial capital $\bar{K}$ and debt B, the higher the number of workers that start employed $\bar{N}$, the lower the default threshold. In this sense, workers play a similar role to capital: the more workers the firm has, the lower the incentives to default, the more trustworthy it is and the lower the credit spreads are. In contrast, times of low emplyoment will also generate high credit spreads, which will reduce the future number of workers as shown in Proposition 4. In other words, financial conditions worsen with low employment, which makes external funding more expensive and low employment persistent. This is our new mechanism and explanation of the slow recovery.

To conclude this section, we show how the introduction of default creates several key wedges in different equations of typical macroeconomic models.

Proposition 6 *Aggregate output, and capital and employment law of motion are as follows*

$$
\begin{aligned}
Y(z) &= \frac{\left[\mathbb{E}(a) - \Psi \int_0^{\underline{a}(\tilde{b},\tilde{k},z)} ah(a)da\right]}{\left[1-\varphi_k H(\underline{a}(\tilde{b},\tilde{k},z))\right]^{\alpha}\left[1-\varphi_n H(\underline{a}(\tilde{b},\tilde{k},z))\right]^{1-\alpha}} xK^{\alpha}N^{1-\alpha} && (11)\\
K' &= \left[1-\varphi_k H(\underline{a}(\tilde{b}',\tilde{k}',z'))\right]\{I(z)+(1-\delta)K\} && (12)\\
N' &= \left[1-\varphi_n H(\underline{a}(\tilde{b},\tilde{k},z))\right]\{(1-s)N+f(z)(1-N)\} && (13)
\end{aligned}
$$

This proposition shows how default appears in different aggregate equations. Denote $PW(z)$ to be the productivity wedge, $KW(z)$ the capital transition wedge and $NW(z)$ the labor transition wedge, each one given by

$$
\begin{aligned}
PW(z) &= \frac{\left[\mathbb{E}(a) - \Psi \int_0^{\underline{a}(\tilde{b},\tilde{k},z)} ah(a)da\right]}{\left[1-\varphi_k H(\underline{a}(\tilde{b},\tilde{k},z))\right]^{\alpha}\left[1-\varphi_n H(\underline{a}(\tilde{b},\tilde{k},z))\right]^{1-\alpha}}\\
KW(z) &= \left[1-\varphi_k H(\underline{a}(\tilde{b},\tilde{k},z))\right]\\
NW(z) &= \left[1-\varphi_n H(\underline{a}(\tilde{b},\tilde{k},z))\right]
\end{aligned}
$$

The following proposition characterizes the cyclical behaviour of each wedge.

Proposition 7 *Assume $\varphi_k = \varphi_n = \varphi$. An approximation around the non-stochastic steady state of each wedge yields*

$$
\begin{aligned}
P\hat{W}_t &= \left[\frac{1}{1-\varphi H_{ss}} - \frac{\underline{a}_{ss}}{\mathbb{E}(a) - \varphi\int_0^{\underline{a}_{ss}} ah(a)da}\right]\varphi H_{ss}\hat{H}_t\\
K\hat{W}_t &= -\frac{\varphi H_{ss}}{1-\varphi H_{ss}}\hat{H}_t\\
N\hat{W}_t &= -\frac{\varphi H_{ss}}{1-\varphi H_{ss}}\hat{H}_t
\end{aligned}
$$

where sub-indices "ss" denote steady state values.

As the proposition shows, periods of higher default are associated with an increase in the severity of the capital and labor wedge. Regarding the productivity wedge, there are two effects. On one hand, a fraction of firms loose a fraction of production, which is given by $\left[\mathbb{E}(a) - \Psi \int_0^{\underline{a}(\tilde{b},\tilde{k},z)} ah(a)da\right]$. On the other hand, productive firms have more capital relative to unproductive ones, an adjustment given by $\left[1 - \varphi_k H(\underline{a}(\tilde{b},\tilde{k},z))\right]^{\alpha} \left[1 - \varphi_n H(\underline{a}(\tilde{b},\tilde{k},z))\right]^{1-\alpha}$.

4 Quantitative Evaluation

4.1 Calibration

The model parameters can be divided into four groups: First, those that are related to technology and preferences. Second, parameters related to the labor market. Third, the stochastic processes for x and ξ. Fourth, parameters related to default. We take a period to be one month and discuss next how we picked each parameter value.

Preferences parameters are standard. We choose the discount parameter $\beta = 0.99^{1/3}$. The utility function is $u(C) = C^{1-\sigma}/1-\sigma$ and use $\sigma = 2$ which is around standard values. Regarding technologies, we picked the depreciation rate $\delta = 0.025/3$ to match the investment to output ratio and the production function parameter $\alpha = 0.33$ to match a labor share close to 70%. Note that in models of labor search there is no one-to-one mapping between the labor share and the production parameter α, but they are closely related. We assumed that $\ln a \sim N(\mu_a, \sigma_a^2)$, choosing $\sigma_a = 0.2$ to match the default rate and μ_a so that $\mathbb{E}(a) = 1$, where the expectation is a normalization.

For parameters regarding the labor market, we also followed standard strategies. We picked the unemployment benefit $\bar{b} = 0.95$ to match a wage replacement ratio close to 45%. The bargaining parameter γ was set to 0.5 which is in the neighborhood of typical values. The exogenous separation rate s was set to 0.035 which is taken from Shimer (2005). For the cost of vacancy posting we use $c(v,n) = \kappa_0 v + \frac{\kappa_1}{2}(\tilde{v} - \tilde{v}_{ss})^2 n$, with $\kappa_0 = 7.5$ and $\kappa_1 = 0$. The value κ_0 is chosen to match an unemployment rate of 7%. For the matching function we used $f^m(\theta) = \theta^{\nu}$ and $q^m(\theta) = \theta^{\nu-1}$ with $\nu = 0.5$ a middle value in the literature.

For the aggregate shocks we assumed $AR(1)$ processes in logs: $\ln x_t = \rho_x \ln x_{t-1} + \sigma_x \varepsilon_{xt}$ and

$\ln \xi_t = \rho_\xi \ln \xi_{t-1} + \sigma_\xi \varepsilon_{\xi t}$. For the productivity process, we estimated the parameters using the series of total factor productivity of Fernald (2010) and obtained $\rho_x = 0.95^{1/3}$ and $\sigma_x = 0.0075$. For the preference shock, we linearized the bond price equation implied by the model (see equation (8)), compute expectations using a VAR and estimated the process to match an average price of risky bonds using the measure of spreads from Gilchrist and Zakrajsek (2012). See Appendix C for details. We obtained $\rho_\xi = 0.95^{1/3}$ and $\sigma_\xi = 0.008$.

For the parameters regarding default we use $\varphi_n = 0.5$, $\varphi_k = 0.9$ and $\lambda = 0.1$.

Table 1: Model Calibration

Parameters	Value	Moment	Parameters	Value	Moment
β	$0.96^{1/3}$	Risk Free Rate	$\bar{b}$	0.45	Replacement Ratio
δ	0.025/3	Standard	γ	0.5	Standard
$\mathbb{E}(a)$	1	Normalization	κ_0	7.5	Unemployment Rate
σ_a	0.2	Default Rate	κ_1	0	
α	0.33	Labor Share	ν	0.5	Finding Elasticity
ρ_x	$0.95^{1/3}$	Adjusted TFP	φ_n	0.5	-
σ_x	0.0075	Adjusted TFP	φ_k	0.9	-
ρ_ξ	$0.95^{1/3}$	Credit Spread	λ	0.1	-
σ_ξ	0.008	Credit Spread	σ	2	Standard

4.2 Model Evaluation

4.2.1 Model Impulse Responses and Business Cycle Statistics

We analyze the model's quantitative performance by evaluating its impulse responses. Figure 4 shows the model response to a negative innovation in productivity (blue solid line) and preferences (red dashed line). We focus first on the financial shock ξ. The third row shows responses of financial variables. As can be seen, a negative innovation in ξ induces an increase in default even if this does not affect todays firms' individual states: capital, debt and *workers* are unchanged. Default increases because of a forward looking behavior: as shown in the second row, the value of a match $e(z) - \varsigma(z)$ decreases, making less valuable current workers and thus generating incentives to default. This feedback from the value of a worker to the default decision is the key new element in our model. Furthermore, the model predicts a much larger reaction in the value of a match compared to more modest reactions of debt and capital. Figure 5 decomposes the default threshold

$\underline{a}_t$ (equation (10)) into two components: the capital feedback $-\varphi_k K_t(1-\delta)$ and the employment feedback $-\varphi_n N_t(e_t - \varsigma_t)$[14]. As can be seen, both are key determinants in default dynamics: the effect of workers is as important as capital.

As the second row in Figure 4 shows, the finding probability decreases with the financial shock and remains low for many periods even if there is no change in technological fundamentals. As explained in Proposition 4, the finding probability is given by the sum of the present value of a match $(V_t^x - V_t^u)$ as in Mortensen and Pissarides (1994), plus the present value of debt, capital and transfers $(V_t^b + V_t^k + V_t^T)$ which is a new component in the model. Figure 6 shows the decomposition of each component, and we find that the new element in this model is considerably larger than the one obtained in standard set-ups.

Finally, the model response to a financial and a productivity shock are similar, although the later seems smaller in magnitude. Also, notice that the model has hump shaped responses even in the absence of adjustment costs (since we are using $c(v,n) = \kappa_0 v$).

The persistent decrease in employment and output follows from a typical "financial accelerator" mechanism, which is here extended to include the employment feedback. After the financial shock, credit spreads increase, which reduces firms' incentives to accumulate workers, making them less trustworthy and consequently facing higher credit spreads. Even if standard logic, the model delivers this mechanism for the number of workers which is more likely to move more than capital at business cycle frequencies.

Table 4.2.1 compares the business cycle statistics of several variables between model and data. The model does well in matching the persistence of many variables except for default rates, which are very persistent in data but almost *i.i.d.* in the model. The model also predicts well the correlation between variables and output. However, the model underpredicts the volatility of several variables relative to output. For instance, unemployment is still less volatile than its empirical counterpart, the so called "Shimer Puzzle". Also, the model underpredicts the volatility of default and credit spreads. Thus, even if the model offers a good quantitative performace, there are still moments that it cannot match.

[14]Note that here values are *not* normalized per units of workers.

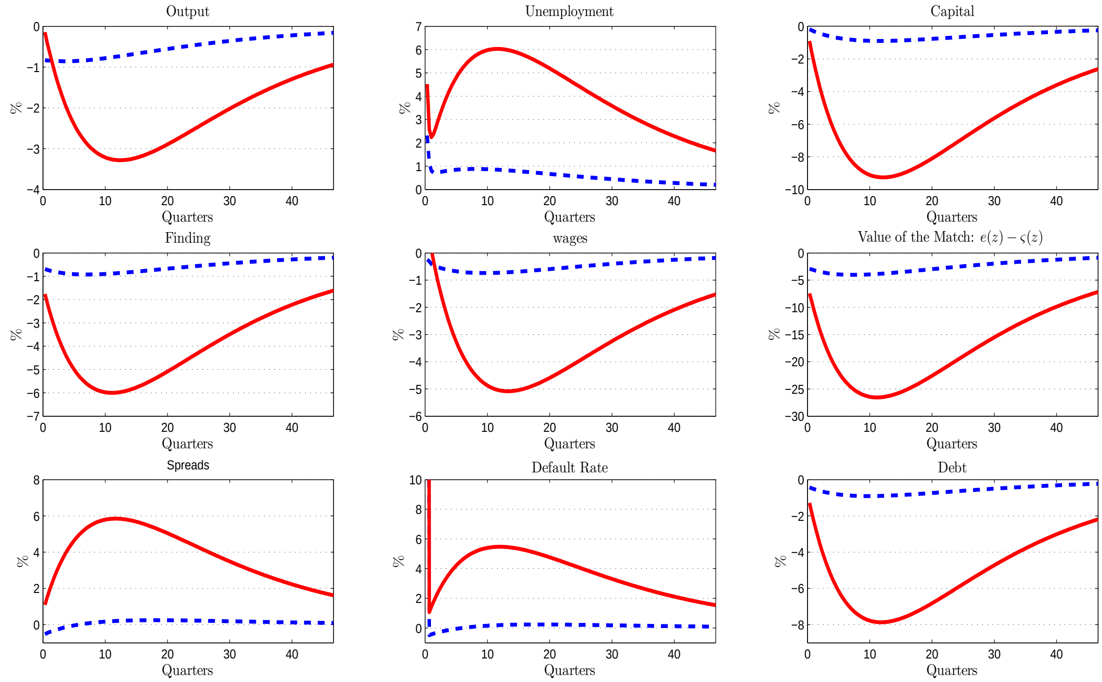

Figure 4: Impulse Response Functions to negative innovations. The red line is a preferences shock and the blue line is a TFP shock.

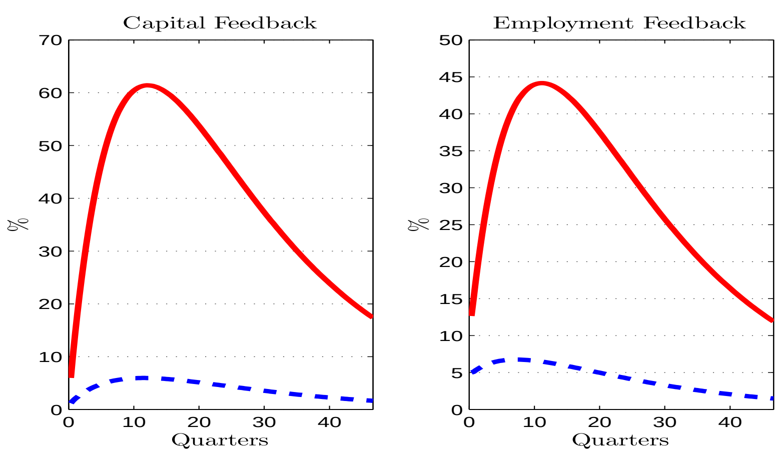

Figure 5: Decomposition of default threshold to negative innovations. The red line is a preferences shock and the blue line is a TFP shock.

4.2.2 A Crisis Experiment

In this section we analyze the results of a shock that resembles the dynamics of the economy during 2007-2012. In particular, we feed the model with a one time large negative innovation in ξ that

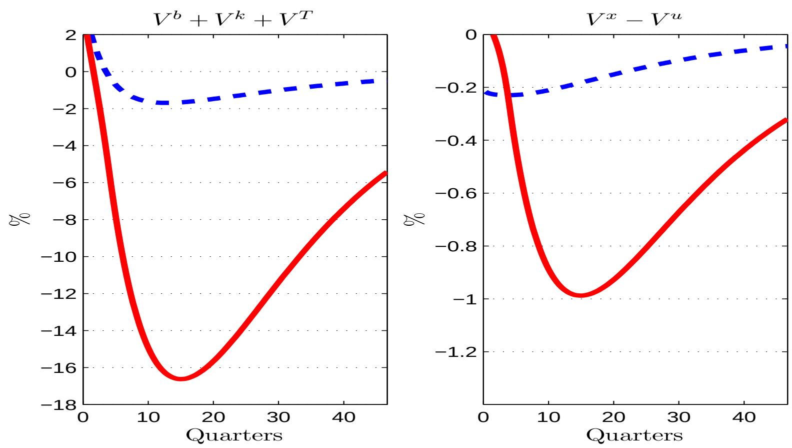

Figure 6: Decomposition of finding to negative innovations. The red line is a preferences shock and the blue line is a TFP shock.

Table 2: Business Cycle Moments

Data	Y	C	I	w	U	v	H	spread
Rela. Std.	1	0.81	4.62	0.60	7.26	8.68	18.78	20.73
Autocorrelation	0.87	0.87	0.80	0.77	0.91	0.91	0.94	0.79
Correlation with y	1	0.85	0.88	0.21	-0.85	0.88	-0.75	-0.26
Model	**Y**	**C**	**I**	**w**	**U**	**v**	**H**	**spread**
Rela. Std.	1	0.92	7.5	1.4	1.7	1.6	4.9	1.5
Autocorrelation	0.99	0.95	0.76	0.98	0.98	0.98	0.04	0.99
Correlation with y	1	0.92	0.33	0.98	-0.98	0.98	-0.30	-0.97

comes back to its steady state value next period. We are particularly interested in how this *i.i.d.* shock generates a slow recovery. Also, in order to appreciate the forward looking component of default and its implications, we give the news about the future shock one year in advanced. Figure 7 shows the response of several variables to a one hundred standard deviations shock[15].

The figure shows two interesting results. First, the economy starts its response as soon as the information arrives. Thus, there is one year where fundamentals are unchanged but output and employment already start to decrease. Upon the arrival of information, there is a spike in default that is reflected as a sharp increase in the endogenous separation rate and an increase in unemployment. The finding probability also starts to decrease with the arrival of information.

[15]Note that this shock implies a one month decrease in ξ, which is probably less persistent than the actual shock that hit the economy during 2007-2009.

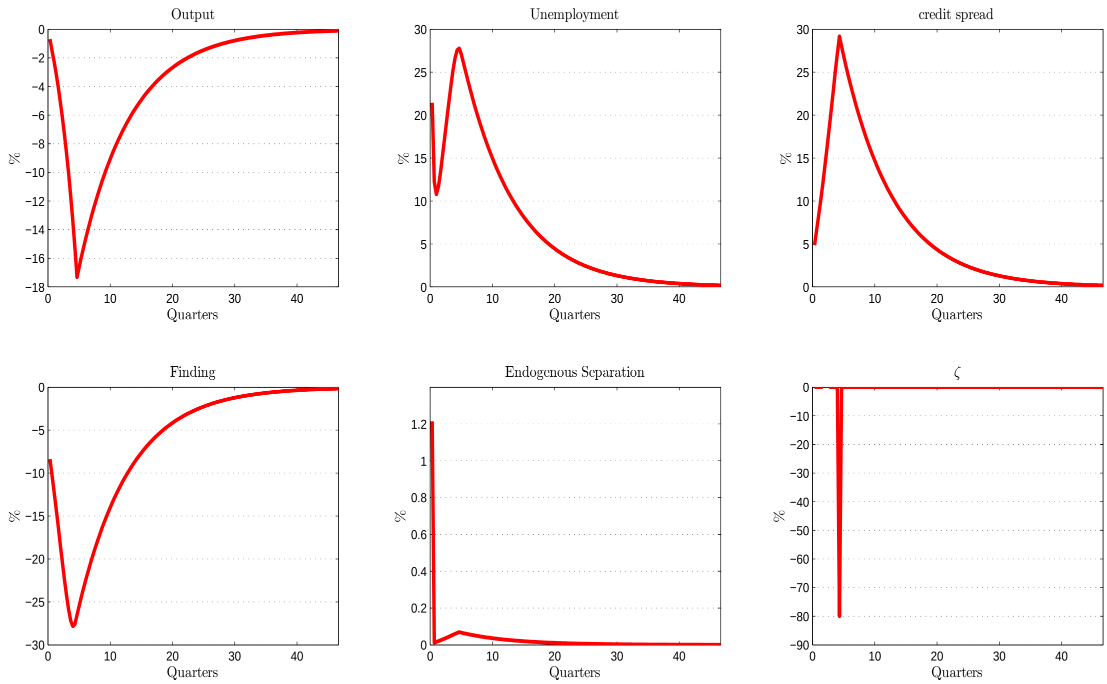

Figure 7: Impulse Response Functions to an *i.i.d.* negative innovation in ξ

Second, the effects on the economy persist long after the innovation in ξ is gone: while preferences are back to normal after a year, unemployment and finding remain low for more than seven years[16]. The model can then explain a sudden increase in the separation rate together with a slow recovery, similar to what we observed for the US economy during 2007-2012.

5 Conclusions

In this paper we presented a model with two key ingredients: equilibrium default and a frictional labor market. We introduced incentives for firms to issue private debt in a model of enforcement that allows the possibility of default in equilibrium. We showed how fluctuations in the probability of default interact with aggregate variables through distortions in firms' investment and hiring decisions. In particular, we exposed a new mechanism of labor market propagation that allows

[16]This persistence is also obtained if the shock and the information arrive simultaneously.

for persistent changes in aggregate employment through its interactions with the price of firms' debt. The introduction of spreads allows our model to speak to a unique subset of quantitative facts regarding the last recession and the business cycle more generally. Finally, we showed that the introduction of a large, temporary financial shock in our model creates dynamics in output, unemployment, default and separation that match the features of the 2007-20012 period of recession and recovery.

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