Credit and hiring

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Abstract

We study an industry dynamics model where access to credit improves the bargaining position of firms with workers and increases the incentive to hire. To evaluate the importance of the bargaining channel for the hiring decisions of firms we estimate the model structurally with simulated methods of moments using data from Compustat and Capital IQ.

Introduction

The idea that firms use leverage strategically to improve their bargaining position with workers is not new in the corporate finance literature. For example, Perotti and Spier (1993) developed a model where debt reduces the bargaining surplus for the negotiation of wages, allowing firms to lower the

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cost of labor. Recent studies by Klasa, Maxwell, and Ortiz-Molina (2009) and Matsa (2010) have tested this mechanism using firm-level data and found that more unionized firms—that is, firms where workers are likely to have more bargaining power—are characterized by higher leverage and lower holding of cash.

These studies provide some evidence that the bargaining channel is relevant for determining the financial structure of firms. However, whether this channel is also important for the hiring decision of firms has not been fully explored in the literature. In fact, if the bargaining strength of workers impacts on the financial structure of firms, it is also possible that the financial structure affects the hiring decision of firms. More specifically, if higher leverage allows employers to negotiate more favorable conditions with employees, the ability to issue more debt increases the incentive to hire more workers. The goal of this paper is to study the importance of the bargaining channel for the hiring decisions of firms by estimating a dynamic model with wage bargaining and endogenous choice of financing. The bargaining channel is also studied in Monacelli, Quadrini and Trigari (2011) in a general equilibrium model with a single-worker representative firm to study the importance of this channel for aggregate dynamics. In the current paper, instead, we take a micro approach and explore the empirical relevance of the bargaining channel using a model with heterogeneous multi-workers firms that we can map to firm-level data.

In the model, the compensation of workers is determined at the firm level through bargaining. Firms choose the financial structure and employment optimally taking into account that these choices affect the cost of labor. Higher debt allows firms to negotiate lower wages which increases the incentive to hire more workers. Higher debt, however, also increases the likelihood of financial distress. Therefore, firms face a trade-off in the choice of the financial structure whose resolution determines the optimal financing and employment decisions. When the financial condition of the firm improves, the likelihood of financial distress declines, making the debt more attractive. This, in turn, improves the bargaining position of the firm with workers, increasing the incentive to hire. It is trough this mechanism that improved financial conditions in the firm generate more demand for labor.

We evaluate the importance of this channel by estimating the model through simulated method of moments. The empirical moments are constructed using firm-level data from Compustat and Capital IQ. The first database provides information on typical balance sheet and operational variables including employment. The second database provides firm level data for unused lines of credit which is important for the identification of some key parameters. More specifically, since the likelihood of financial distress increases with leverage, firms tend to borrow less than their credit capacity to limit the cost of distress. We interpret the difference between the maximum debt capacity and the actual borrowing in the model as unused credit lines. The Capital IQ database then provides valuable information for the identification of the distress cost parameter.

The paper is organized as follows. Sections 1 and 2 present the dynamic model and characterize some of the key properties. Section 3 describes the data and the structural estimation and Section **??** reports the estimation results. Section 4 concludes.

1 A firm dynamics model with bargaining

To facilitate the presentation of the model and the role played by the bargaining channel, we first describe a simplified version without financial distress. After characterizing the properties of the simpler model, we will extend it with the addition of financial distress.

Consider a firm with production technology $y_t = z_t N_t$, where z_t is idiosyncratic productivity and N_t is the number of workers. Employment evolves according to

$$N_{t+1} = (1-\lambda)N_t + E_t, \tag{1}$$

where λ is the separation rate and E_t denotes the newly hired workers.

Hiring is costly. A firm with current employment N_t that wishes to hire E_t workers incurs the cost $\Upsilon\left(E_t/N_t\right)N_t$, where the function $\Upsilon(.)$ is strictly increasing and convex for $E_t > 0$.

The budget constraint of the firm is

$$B_t + D_t + w_t N_t + \Upsilon\left(\frac{E_t}{N_t}\right)N_t = z_t N_t + q_t B_{t+1}, \tag{2}$$

where B_t is the stock of bonds issued by the firm at $t-1$ (liabilities), D_t is the equity payout, q_t is the price of bonds and w_t is the wage paid to each worker.

The issuance of debt is subject to the enforcement constraint

$$q_t B_{t+1} \le \xi_t \beta \mathbb{E}_t S_{t+1}, \tag{3}$$

where S_{t+1} is the net surplus of the firm as defined below. The variable ξ_t is stochastic and captures the financial conditions of the firm, that is, its access to external credit.

1.1 Firm's policies and wages

The policies of the firm, including wages, are bargained collectively with its labor force. The labor force can be interpreted broadly, including managers. In this way the model also captures the agency conflicts between shareholders and managers as in Jensen (1986).

To derive the bargaining outcome, it will be convenient to define few terms starting with the *equity* value of the firm which, recursively, can be written as

$$V_t(B_t, N_t) = D_t + \beta \mathbb{E}_t V_{t+1}(B_{t+1}, N_{t+1}). \tag{4}$$

The equity value of the firm depends on two endogenous states—debt B_t and employment N_t—in addition to the exogenous states z_t and ξ_t. To simplify the notation, the dependence on the exogenous states is not shown explicitly but it is captured by the time subscript t. We will continue to use this notational convention throughout the paper.

The value of an individual worker employed in a firm with liabilities B_t and with N_t employees is

$$W_t(B_t, N_t) = w_t + (1 - \lambda)\beta \mathbb{E}_t W_{t+1}(B_{t+1}, N_{t+1}) + \lambda \beta \mathbb{E}_t U_{t+1}, \tag{5}$$

where U_{t+1} is the value of being unemployed. Given the partial equilibrium approach, the value of being unemployed is exogenous in the model.

The net value of the worker can be rewritten recursively as

$$W_t(B_t, N_t) - U_t \;=\; w_t - U_t + \beta \mathbb{E}_t U_{t+1} + (1 - \lambda)\beta \mathbb{E}_t \Big(W_{t+1}(B_{t+1}, N_{t+1}) - U_{t+1} \Big) \tag{6}$$

The bargaining surplus is the sum of the net values for the firm and the workers,

$$S_t(B_t, N_t) = V_t(B_t, N_t) + \Big(W_t(B_t, N_t) - U_t \Big) N_t \tag{7}$$

We are now ready to define the bargaining problem. Given η the bargaining power of workers, the bargaining outcome is the solution to the maximization problem

$$\max_{w_t, D_t, E_t, B_{t+1}} \quad \Big[\Big(W_t(B_t, N_t) - U_t \Big) N_t \Big]^{\eta} \cdot V_t(B_t, N_t)^{1-\eta},$$

subject to the law of motion for employment (1), the budget constraint (2), and the enforcement constraint (3).

Differentiating with respect to the wage w_t, we obtain the well-known result that workers receive a fraction η of the bargaining surplus while the firm receives the remaining fraction, that is,

$$\Big(W_t(B_t, N_t) - U_t\Big)N_t = \eta S_t(B_t, N_t) \quad (8)$$

$$V_t(B_t, N_t) = (1-\eta)S_t(B_t, N_t). \quad (9)$$

Next we derive the first order conditions with respect to D_t, E_t, B_{t+1}. Using (8) and (9), we find that the dividend, employment and financial policies simply maximize the *net surplus* $S_t(B_t, N_t)$. This property is intuitive: given that the contractual parties (firm and workers) share the net surplus, it is in the interest of both parties to make the surplus as big as possible. Therefore, in characterizing the hiring and financial policies of the firm we focus on the maximization of the net surplus which, in recursive form, can be written as

$$S_t(B_t, N_t) = \max_{e_t, B_{t+1}} \Bigg\{ D_t + (w_t - u_t)N_t + \beta\Bigg[1 - \eta + \eta(1-\lambda)\left(\frac{N_t}{N_{t+1}}\right)\Bigg]\mathbb{E}_t S_{t+1}(B_{t+1}, N_{t+1})\Bigg\}$$

subject to:

$$D_t + w_t N_t = z_t N_t - \Upsilon\left(\frac{E_t}{N_t}\right)N_t + q_t B_{t+1} - B_t$$

$$q_t B_{t+1} \leq \xi_t \beta \mathbb{E}_t S_{t+1}(B_{t+1}, N_{t+1})$$

$$N_{t+1} = (1-\lambda)N_t + E_t.$$

The recursive formulation is obtained by multiplying equation (6) by N_t, summing to (4), and using the sharing rules (8) and (9). The term $u_t = U_t - \beta\mathbb{E}_t U_{t+1}$ is exogenous given the partial equilibrium approach taken in this paper.

We now take advantage of the linearity of the model and normalize by employment N_t. This allows us to rewrite the optimization problem with all variables expressed in per-worker terms, that is,

$$s_t(b_t) \quad = \quad \max_{e_t, b_{t+1}} \left\{ d_t + w_t - u_t + \gamma(e_t)\mathbb{E}_t s_{t+1}(b_{t+1}) \right\}$$

subject to:

$$d_t + w_t = z_t - \Upsilon(e_t) + q_t g_{t+1} b_{t+1} - b_t$$

$$\xi_t g_{t+1} \beta \mathbb{E}_t s_{t+1}(b_{t+1}) \geq q_t g_{t+1} b_{t+1}$$

$$g_{t+1} = 1 - \lambda + e_t,$$

where we have defined $\gamma(e_t) = \beta\Big[(1-\eta)g_{t+1} + \eta(1-\lambda)\Big]$ to simplify the notation. The variable $s_t(b_t) = S_t(b_t)/N_t$ is the per-worker surplus, $d_t = d_t/N_t$ is the per-worker dividend, $b_t = B_t/N_t$ is the per-worker liabilities, $e_t = E_t/N_t$ are the newly hired workers per each existing employee, and $g_{t+1} = N_{t+1}/N_t$ is the gross growth rate of employment.

1.2 First order conditions

To characterize the hiring and financial policy of the firm, we derive the first order conditions with respect to e_t and b_{t+1},

$$q_t b_{t+1} + \beta(1-\eta)\mathbb{E}_t s_{t+1}(b_{t+1}) = \Upsilon'(e_t),$$

$$q_t g_{t+1} + \gamma(e_t)\mathbb{E}_t \frac{\partial s_{t+1}(b_{t+1})}{\partial b_{t+1}} + \mu_t g_{t+1}\left[\xi_t \beta \mathbb{E}_t \frac{\partial s_{t+1}(b_{t+1})}{\partial b_{t+1}} - q_t\right] = 0,$$

where μ_t is the lagrange for the enforcement constraint.

The envelope condition provides the derivative of the surplus, which is equal to $\partial s_t(b_t)/\partial b_t = -1$. Therefore, the normalized surplus is linear in b_t. This allows us to write the surplus as

$$s_t(b_t) = \bar{s}_t - b_t, \tag{10}$$

where $\bar{s}_t$ depends only on the exogenous shocks. The first order conditions can then be rewritten as

$$q_t b_{t+1} + \beta(1-\eta)(\mathbb{E}_t \bar{s}_{t+1} - b_{t+1}) = \Upsilon'(e_t), \tag{11}$$

$$q_t g_{t+1} = \gamma(e_t) + \mu_t g_{t+1}(\beta\xi_t + q_t). \tag{12}$$

1.3 Special case with $q_t = \beta$.

Since we are focusing on a partial equilibrium and we abstract from aggregate shocks, it makes sense to assume that the price of a risk-free (zero coupon) bond is equal to the discount factor, that is, $q_t = \beta$. Then, the first order condition for debt, equation (12), becomes

$$g_{t+1} = (1-\eta)g_{t+1} + \eta(1-\lambda) + \mu_t g_{t+1}(1+\xi_t). \tag{13}$$

The following proposition establishes an important property about the financial policy of the firm.

Proposition 1.1 *If $\eta > 0$, the firm borrows up to the limit whenever $e_t > 0$. If $\eta = 0$ and/or $e_t = 0$, the debt is undetermined.*

Proof 1.1 *If $\eta > 0$, equation (13) implies that the lagrange multiplier μ_t is strictly positive whenever $e_t = g_{t+1} - 1 + \lambda > 0$. Therefore, under the condition $e_t > 0$ the enforcement constraint is binding. When $\eta = 0$ and/or $e_t = 0$, instead, equation (13) implies that μ_t must be zero.*

The intuition for this result is as follows. Whenever the firm chooses to hire, that is, $e_t > 0$, the firm adds new workers who are not yet part of the current labor force but will share the surplus starting next period. Increasing the debt today reduces the next period surplus, allowing for a lower (future) compensation of the new hired workers. This increases the current surplus of the firm which is shared by shareholders and *currently* employed workers only. It is then in the interest of both shareholders and incumbent workers to take on more debt. When the firm does not add new workers, however, higher borrowing does not increase the current surplus because more debt only reduces the future compensation of *existing* workers. In this case there are no gains from borrowing. Thus, as long as the firm adds new workers, bargaining introduces a motive to borrow, breaking the irrelevance result of Modigliani and Miller (1958). For this property, however, the bargaining power of workers must be positive, that is, $\eta > 0$. In the limiting case with $\eta = 0$, however, the Modigliani and Miller's result continues to hold.

We now turn attention to the first order condition for hiring, equation (10). Under the assumption $q_t = \beta$, this condition can be rewritten as

$$\beta\Big[\eta b_{t+1} + (1-\eta)\mathbb{E}_t \bar{s}_{t+1}\Big] = \Upsilon'(e_t). \tag{14}$$

Together with the normalized law of motion for employment, $g_{t+1} = 1 - \lambda + e_t$, this equation establishes a relation between the per-worker debt b_{t+1} and the growth of employment (which also depends on other factors affecting the surplus of the firm through the term $\mathbb{E}_t \bar{s}_{t+1}$). This relation is not linear and depends on the bargaining power of workers η. In particular, as long as $\eta > 0$, there is a positive relation between the debt, b_{t+1}, and hiring, e_t. However, in the limiting case with $\eta = 0$, employment becomes unrelated to debt.

Proposition 1.2 *The hiring decision e_t is strictly increasing in b_{t+1} if $\eta > 0$ but it becomes independent of b_{t+1} if $\eta = 0$.*

Proof 1.2 *It follows directly from (14) given that the convexity of the cost function $\Upsilon(.)$ implies that $\Upsilon'(e_t)$ is strictly increasing in e_t.*

Thus, the financial structure of firms affect the hiring decision as long as workers have some bargaining power. However, when workers do not have any bargaining power—which can be interpreted as representative of a competitive labor market where the determination of wages is external to an individual firm—debt is irrelevant for the hiring decisions of firms. This is because the financial structure becomes irrelevant as already stated in Proposition 1.1. The goal of this paper is to explore the dependence of the hiring decision from the financial structure under the assumption that wage are negotiated and workers have some bargaining power.

2 Financial distress cost

The model presented so far abstracts from the possibility of financial distress. The variable ξ_t captures the financial condition of a firm, that is, its access to credit. A sudden drop in this variable forces the firm to substitute debt with equity and this can be done without any *direct* cost. The only cost is *indirect*, through the impact on wages. However, the assumption that the firm has full flexibility in substituting debt with equity is not plausible, especially in the short-run: if the firm is unexpectedly forced to replace debt with equity, it may not be easy to make the substitution through regular channels and this could place the firm in a situation of financial distress. To capture this idea, we extend the model to allow for the possibility of financial costs associated with financial distress.

Define b_t^* the maximum debt that can be collateralized. This is defined by the condition $b_t^* = \xi_t s_t(b_t^*)$. Since the surplus function $s_t(.)$ is strictly decreasing, the maximum debt b_t^* is increasing in ξ_t.

The firm enters the period with debt b_t chosen in the previous period. Then, after the realization of ξ_t, the collateral constraint may no longer be satisfied, that is, $b_t > b_t^* = \xi_t s_t(b_t^*)$. In this case the firm will be forced to pay back the difference $b_t - b_t^*$ before it can access the equity market or retain earnings. In order to make the payment, the firm needs to raise the funds with alternative sources that are costly. In particular, we assume that the cost incurred to access these alternative sources of funds is $\kappa(b_t - b_t^*)^2$. We call this cost 'financial distress cost' since it is paid to raise emergency funds and could also include, in the extreme, the cost of bankruptcy due to the lack of liquidity. For the analysis that follows we will denote this cost as $\varphi_t(b_t) = \kappa \cdot \max\Big\{b_t - b_t^*, 0\Big\}^2$.

With the possibility of financial distress, the problem of the firm becomes

$$s_t(b_t) = \max_{e_t, b_{t+1}} \Bigg\{ d_t + w_t - u_t + \gamma(e_t)\mathbb{E}_t s_{t+1}(b_{t+1}) \Bigg\}$$

subject to:

$$d_t + w_t = z_t - \Upsilon(e_t) + q_t g_{t+1} b_{t+1} - b_t - \varphi_t(b_t)$$

$$\xi_t g_{t+1} \beta \mathbb{E}_t s_{t+1}(b_{t+1}) \geq q_t g_{t+1} b_{t+1}$$

$$g_{t+1} = 1 - \lambda + e_t,$$

where $\gamma(e_t) = \beta\Big[(1-\eta)g_{t+1} + \eta(1-\lambda)\Big]$.

It will be convenient to define $\tilde{s}_t(b_t) = s_t(b_t) + \varphi_t(b_t)$ the (normalized) surplus value plus the financial cost. Notice that $\tilde{s}_t(b_t) = s_t(b_t)$ if $b_t < b_t^*$. Using this term the problem of the firm can be written as

$$\tilde{s}_t(b_t) = \max_{e_t, b_{t+1}} \left\{ d_t + w_t - u_t + \gamma(e_t)\mathbb{E}_t s_{t+1}(b_{t+1}) \right\} \tag{15}$$

subject to:

$$d_t + w_t = z_t - \Upsilon(e_t) + q_t g_{t+1} b_{t+1} - b_t$$

$$\xi_t g_{t+1} \beta \mathbb{E}_t s_{t+1}(b_{t+1}) \geq q_t g_{t+1} b_{t+1}$$

$$g_{t+1} = 1 - \lambda + e_t,$$

where $s_{t+1}(b_{t+1}) = \tilde{s}_{t+1}(b_{t+1}) - \varphi_{t+1}(b_{t+1})$.

As we will see, the reason to focus on $\tilde{s}_t(b_t)$, instead of $s_t(b_t)$, is because the first function has special properties that will facilitate the characterization of the firm's problem.

2.1 First order conditions

The first order conditions to problem (15) with respect to e_t and b_{t+1} are, respectively,

$$q_t b_{t+1} + \beta(1-\eta)\mathbb{E}_t s_{t+1}(b_{t+1}) = \Upsilon'(e_t), \tag{16}$$

$$q_t g_{t+1} + \gamma(e_t)\mathbb{E}_t \frac{\partial s_{t+1}(b_{t+1})}{\partial b_{t+1}} + \mu_t g_{t+1} \left[\beta \xi_t \mathbb{E}_t \frac{\partial s_{t+1}(b_{t+1})}{\partial b_{t+1}} - q_t \right] = 0 \tag{17}$$

where μ_t is the lagrange multiplier associated with the enforcement constraint. Notice that the first order conditions do not depend on b_t. Therefore, the optimal choice of employment and next period debt is independent of current liabilities. We will see that this property greatly simplifies the solution of the model.

The envelope condition returns $\partial \tilde{s}_t(b_t)/\partial b_t = -1$, which allows us to write the surplus function net of the financial cost as a linear function of debt, that is,

$$\tilde{s}_t(b_t) = \bar{s}_t - b_t. \tag{18}$$

As in the model without financial distress, the variable $\bar{s}_t$ depends only on the exogenous shocks. Therefore, focusing on the problem of the firm after the payment of the distress cost, we continue to have a linear problem which greatly simplifies the analytical characterization.

We can now use the special form of the surplus function to derive expressions for the maximum collateralized debt. Since $\varphi(b_t^*) = 0$, we have that $s(b_t^*) = \tilde{s}(b_t^*)$. Therefore, $b_t^* = \xi_t s_t(b_t^*) = \xi_t(\bar{s}_t - b_t^*)$, which we can solve for

$$b_t^* = \left(\frac{\xi_t}{1+\xi_t}\right)\bar{s}_t. \tag{19}$$

Using the linearity of the surplus $\tilde{s}_t(b_t)$ (equation (18)) the firm's problem (15) can be rewritten as

$$\bar{s}_t = \max_{e_t, b_{t+1}} \left\{ z_t - \Upsilon(e_t) + q_t g_{t+1} b_{t+1} - u_t + \gamma(e_t)\mathbb{E}_t\Big[\bar{s}_{t+1} - b_{t+1} - \varphi_{t+1}(b_{t+1})\Big]\right\} \tag{20}$$

subject to:

$$\xi_t g_{t+1}\beta\mathbb{E}_t\Big[\bar{s}_{t+1} - b_{t+1} - \varphi_{t+1}(b_{t+1})\Big] \geq q_t g_{t+1} b_{t+1}$$

$$g_{t+1} = 1 - \lambda + e_t.$$

Therefore, the optimization problem is recursive in $\bar{s}_t$. As observed above, this term depends only on the exogenous shocks and to solve for the optimal policies we do not need to keep track of the endogenous state b_t. This makes the computational procedure extremely simple as we will described below.

We also take advantage of the linearity of the surplus function in the first order conditions. Let's first notice that, since $s_{t+1}(b_{t+1}) = \bar{s}_{t+1} - b_{t+1} - \varphi_{t+1}(b_{t+1})$, we have that

$$\frac{\partial s_{t+1}(b_{t+1})}{\partial b_{t+1}} = -1 - \varphi'_{t+1}(b_{t+1}), \tag{21}$$

which is continuous in b_{t+1}.

This condition shows that the surplus function before the early repayment of the debt is not linear in the stock of debt. This is because the convexity of the distress cost makes the surplus function concave. This feature of the surplus function introduces a precautionary motive in the choice of debt that discourages excessive borrowing. In this way the firm may choose not to borrow up to the limit and the borrowing constraint $\xi_t g_{t+1}\beta\mathbb{E}_t s_{t+1}(b_{t+1}) \geq q_t g_{t+1} b_{t+1}$ could be occasionally binding.

Substituting (21) in the first order conditions (16) and (17) we obtain

$$q_t b_{t+1} + \beta(1-\eta)\mathbb{E}_t\Big[\bar{s}_{t+1} - b_{t+1} - \varphi_{t+1}(b_{t+1})\Big] = \Upsilon'(e_t), \tag{22}$$

$$q_t g_{t+1} = \gamma(e_t)\Big(1 + \mathbb{E}_t\varphi'_{t+1}(b_{t+1})\Big) + \mu_t g_{t+1}\left[\beta\xi_t\Big(1 + \mathbb{E}_t\varphi'_{t+1}(b_{t+1})\Big) + q_t\right]. \tag{23}$$

Some of the properties stated in Propositions 1.1 and 1.2 also apply to the model with financial distress. In particular, if workers do not have any bargaining power ($\eta = 0$) and $q = \beta$, we can see from equation (23) that the enforcement constraint is never binding ($\mu_t = 0$) and the expected distress cost is zero ($\mathbb{E}_t\varphi_{t+1}(b_{t+1}) = 0$). Since debt does not provide any value to the firm when $\eta = 0$, the firm prefers not to borrow to avoid the financial distress cost. At the same time, since the firm does not borrow and the expected financial cost is zero, the hiring decision, characterized by equation (22), is not affected by the financial status of the firm ξ_t.

2.2 Computation of the optimal policies

The solution of the model consists of the policy functions for hiring, e_t, and for borrowing, b_{t+1}. As shown above, these policies do not depend on the endogenous state b_t but only on the exogenous shocks. The firm's problem (20) is a recursive formulation in the unknown variable $\bar{s}_t$. This variable is independent of the initial state b_t and depends only on the exogenous shocks z_t and ξ_t. If the shocks take a discrete number of values, $\bar{s}_t$ also takes a finite number of values. Therefore, problem (20) is a Bellman's equation where the unknown function $\bar{s}_t$ is a vector with a finite number of elements. The solution can be found by iterating on the Bellman equation until we find a fixed point for $\bar{s}_t$.

Denote by n_z and n_ξ the discrete number of values taken, respectively, by the productivity and financial shocks. Each iteration starts with a guess for $\bar{s}_{t+1}$, which is a vector with $n_z \times n_\xi$ elements (the combination of all possible values of the two shocks). For each combination of the two shocks in the current period, we derive the optimal policies (given the guess for $\bar{s}_{t+1}$) by solving the first order conditions (22) and (23) together with the enforcement constraint $\xi_t g_{t+1} \beta \mathbb{E}_t \Big[\bar{s}_{t+1} - b_{t+1} - \varphi_{t+1}(b_{t+1}) \Big] \geq q_t g_{t+1} b_{t+1}$. Since the enforcement constraint could be satisfied with equality (in which case $\mu_t > 0$) or inequality (in which case $\mu_t = 0$), in solving the first order conditions we have to verify the Kuhn-Tucker conditions for interior or binding solutions. The policy rules for employment and borrowing allow us to determine $\bar{s}_t$ (given the guess for $\bar{s}_{t+1}$) for each combinations of the shocks. The newly found $\bar{s}_t$ are then used as new guesses for $\bar{s}_{t+1}$ in the successive iteration.

We would like to point out that, as long as the exogenous shocks take a finite number of values, the numerical procedure does not use any approximation (besides the assumption that the shocks take a finite number of values) and the solution is exact.

3 Structural estimation

In this section we conduct the structural estimation of the model. We start with the description of the empirical data. We then discuss the estimation procedure and the identification strategy.

3.1 Data

With the exception of unused lines of credit, all variables used in the estimation are from Compustat annual files excerpt. Data on unused lines of credit is not available in Compustat and some studies collect information about credit lines from firms' SEC 10-K files (see, for example, Sufi (2009) and Yun (2009)). For this study, we use data from Capital IQ database which contains a large sample of unused lines of credit from 2002 to 2010. The variable unused lines of credit also refers to *total undrawn credit*. See Filippo and Perez (2012) for a detailed description.

Following the literature, we exclude financial firms and utilities with SIC codes in the intervals 4900-4949 and 6000-6999, and exclude firms with SIC codes greater than 9000. We also exclude firms with a missing value of assets, sales, number of employment, debt, and unused lines of credit. All variables are winsorized at 2.5% and 97.5% percentiles to limit the impact of outliers and the nominal variables are deflated by the Consumer Price Index. The final sample for the estimation is a *balanced* panel of 1,508 firms over 9 years from 2002 to 2010. Appendix A provides the definitions of all variables used in the estimation.

3.2 Simulated method of moments

The model is solved numerically as described in Section 2.2 and most of the parameters are estimated through the simulated method of moments (SMM). The basic idea of SMM is to choose the model parameters such that the moments generated by the model are close to the corresponding moments in the data.

The empirical data is for a panel of heterogenous firms while the simulated data consists of time series generated by simulating one representative firm for a number of periods. To keep consistency between the empirical data and the simulated data, we estimate the parameters of an *average* firm in the data. More specifically, given the panel structure, we first calculate the empirical moments for each firm included in the selected sample. We then compute the average of each moment across firms and use it as the target for the model. We use the bootstrap method to calculate the variance-covariance matrix associated with the target moments.

The estimation procedure can be described as follows.

1. For each firm i, we choose moments $h_i(x_{it})$, where x_{it} is a vector of variables included in the empirical data, where i and t are the subscripts for the firm and the year.

2. For each firm i, we calculate the within-firm sample mean of moments as $f_i(x_i) = \frac{1}{T}\sum_{t=1}^{T} h_i(x_{it})$, where T is the number of years in the empirical sample.

3. We compute the average of the within-firm sample mean across firms as $f(x) = \frac{1}{N}\sum_{i=1}^{N} f_i(x_i)$, where N is the number of firms in the data.

4. We then use the model to generate a panel of simulated data for N firms and for S periods. We set $S = 100 \cdot T$ to make sure that the representative firm ends up in all possible states at least once during the simulation.

5. We calculate the average sample mean of moments in the model as $f(y,\theta) = \frac{1}{N \cdot S} \sum_{i=1}^{N} \sum_{s=1}^{S} h(y_{is},\theta)$, where y_{is} is the simulated data from the model, and θ represents the parameters to be estimated.

6. The estimator $\widehat{\theta}$ is the solution to

$$\min_{\theta} \Big[f(x) - f(y,\theta) \Big]' \cdot \Omega \cdot \Big[f(x) - f(y,\theta) \Big].$$

The weighting matrix Ω is defined as $\widehat{\Sigma}^{-1}$, where $\widehat{\Sigma}$ is the variance-covariance matrix associated with the average of sample mean $f(x)$ in the data. We use the bootstrap method to calculate the variance-covariance matrix $\widehat{\Sigma}$. First, given the population of N firms in the empirical sample, we draw J random samples with size $\frac{N}{2}$. Second, for each draw j, we compute the statistics of the drawn sample, denoted as $f(x)^j$. Third, we approximate the variance-covariance matrix by the variance of $f(x)^j$, i.e.,

$$\widehat{\Sigma} \approx \frac{1}{J} \sum_{j=1}^{J} \left[f(x)^j - \frac{1}{J} \sum_{j=1}^{J} f(x)^j \right]' \cdot \left[f(x)^j - \frac{1}{J} \sum_{j=1}^{J} f(x)^j \right].$$

We set J=10,000 to have enough accuracy in bootstrapping.

3.3 Parameters and moments

In describing the model we have assumed that separation is deterministic. In reality, however, labor retention and hiring are likely to be uncertain. To capture this idea, we also consider a shock to job separation. Employment continues to evolve according to $N_{t+1} = (1-\lambda_t)N_t + E_t$ but λ_t is stochastic and follows a first order Markov process. The structure of the problem takes the same form as in (20). Now, however, there are three shocks that affect the firm: productivity, z_t, credit, ξ_t, and separation, λ_t. The first order conditions are also similar. Each of the three shocks can take 9 possible values and follow independent first order Markov chains.

The only functional form that has not been specified is the hiring cost $\Upsilon(e)$. We assume that this function takes the quadratic form $\Upsilon(e_t) = \phi e_t + \zeta e_t^2$, which implies two parameters, ϕ and ζ.

All model parameters are estimated with the exception of four parameters: the intertemporal discount factor, β, the average productivity $\bar{z}$, the hiring parameter ζ, and the average enforcement variable $\bar{\xi}$. The discount factor β is set to 0.95, which implies an interest rate close to 5 percent. The average productivity $\bar{z}$ is normalized to 1. The hiring parameter ζ is chosen so that the average growth rate of firms is zero (given the other parameters). The value of $\bar{\xi}$ is chosen so that the available credit (used and unused) is 50 percent the total surplus of the firm.

After the calibration of these four parameters, we are left with 11 parameters: the persistence and volatility of the productivity shock, ρ_z and σ_z, the persistence and volatility of credit shock, ρ_ξ and σ_ξ, the persistence and volatility of separation shock, ρ_λ and σ_λ, the financial distress cost, κ, the workers' bargaining power, η, the hiring cost, ϕ, the average separation, $\bar{\lambda}$, the unemployment flow, $\bar{u}$.

To estimate these parameters we consider 15 moments: the mean of the ratio of unused credit over total credit; the standard deviations and autocorrelations of the ratio of unused credit over total credit, employment growth, sales growth and total credit growth; the cross correlations of the ratio of unused credit over total credit, employment growth, sales growth and total credit growth.

3.4 Results

The values of the estimated parameters are reported in the bottom section of Table 1. The estimation assigns a sizable bargaining power to workers with $\eta = 0.692$. This is important for the bargaining channel to be relevant. Another parameter that is important for the bargaining channel is the average separation $\bar{\lambda}$, which is estimated to be 0.309. A high separation rate implies high turnover rates and, therefore, high rates of hiring. High rates of hiring increase the importance of the bargaining channel because, as we have seen in the theoretical section, higher debt allows for lower compensation of newly hired workers. We also observe that credit and productivity shocks are quite persistent while the separation shocks are not persistent.

The values of the moments (observed and simulated) are reported in the top section of Table 1. The model does a reasonable job in replicating the 15 moments used in the estimation. One moment for which there is a sizable difference between the value in the data and the value generated by the model is the autocorrelation in employment growth. In the data the autocorrelation is close to zero. The model, however, generates a positive autocorrelation of 0.345. This is a natural consequence of the particular structure of the model where the *level* of debt affects the *growth* of employment. As a result, a persistent increase in the debt *level* induces, through the bargaining channel, a persistent increase in the *growth* rate of employment. In the data, however, employment growth is not persistent while the debt level displays some persistence. This implies that the bargaining channel alone cannot replicate the absence of serial correlation in employment growth together with the persistence in debt level. The addition of separation shocks (stochastic λ_t) reduces the autocorrelation in employment growth because it affects the growth of employment without affecting the debt level.

In the estimation, the number of moments is larger than the number of parameters. Thus, there is not a one-to-one mapping between parameters and moments. To provide a general idea about the identification of the various parameters, we conduct comparative static exercises in which we increase the value of one parameter, in sequence, and check how the change affects the moments used in the estimation. The results, reported in Table 2, are generated by increase each of the 11 estimated parameters by 10 percent.

The key question we would like to address in this paper is whether the bargaining channel is quantitatively important in explaining employment fluctuations at the firm level. To address this question we simulate the model using the estimated parameters but with only one shock. For example, when we simulate the model with credit shocks only, we set the sequence of draws for z_t and λ_t to their unconditional means, $\bar{z}$ and $\bar{\lambda}$ respectively. Similarly, when we simulate the model with productivity shocks only, we set the sequence of draws for ξ_t and λ_t to their unconditional means $\bar{\xi}$ and $\bar{\lambda}$. It is important to point out that, even if in the simulation we set the realizations of the shocks to the unconditional means, this is not anticipated by firms. They continue to assume that the two shocks follows the process dictated by the estimated parameters. Table 3 reports the simulation results.

With only credit shocks, the model generates a standard deviation of employment growth of 0.05 which is about 37 percent the empirical standard deviation of 0.134. When we simulate the model with only productivity shocks, the standard deviation of employment growth is also about 0.05. Finally, with only separation shocks the model generates a standard deviation of employment growth of 0.08. Since the sum of the three standard deviations does not sum to 0.108, that is, the standard deviation of the model simulated with all three shocks, it means that the transmission mechanism of each shock is not independent of the values of the other shocks. For example, when productivity is low, the impact of a positive credit shock on employment is weaker since firms do not find convenient to hire many workers. In general, however, we can conclude that, based on the estimation, credit shocks contribute significantly to employment fluctuations.

Another feature worth emphasizing is that, with only credit (or productivity) shocks, the model generates a much higher autocorrelation of employment. With only separation shocks, instead, the model generates an autocorrelation of employment that is closer to zero. Thus, the addition of separation shocks brings the model closer to the data.

4 Conclusion

There is a well-established literature in corporate finance exploring the use of debt as a strategic mechanism to improve the bargaining position of firms with workers. Less attention has been devoted to studying whether this mechanism is also important for the employment decision of firms. In this paper we have investigated the theoretical and empirical relevance of this mechanism.

Using a firm dynamics model, we have shown that there is a positive relation between the level of debt and the growth of employment, and the strength of this relation increases with the bargaining power of workers. The estimation results show that the bargaining channel is important for the employment fluctuation of firms. This mechanism could also be important for the long-term dynamics of the firm in the sense that greater uncertainty about the firm's access to credit could have sizable negative effects on its long-term growth.

A Variables: definition and sources

We provide here the definition and sources for the variables used in the estimation:

- $\Delta employ_{it}$: Percentage change in the number of employees from t-1 to t. From Compustat, *emp*.

- $\Delta credit_{it}$: Percentage change in total credit capacity (total debt + unused lines of credit) from t-1 to t. The variable "total debt" is from Compustat, $dlc + dltt$, and the variable "unused lines of credit" is from Capital IQ, total undrawn credit.

- $\Delta sale_{it}$: Percentage change in sales from t-1 to t. From Compustat, *sale*.

- $\frac{unused_{it}}{credit_{it}}$: Ratio of unused lines of credit to total credit capacity (total debt + unused lines of credit) at time t. The variable "total debt" is from Compustat, $dlc + dltt$; and the variable "unused lines of credit" is from Capital IQ, total undrawn credit.

- $\frac{credit_{it}}{asset_{it}}$: Ratio of total credit capacity (total debt + unused lines of credit) to assets at time t. The variable "total debt" is from Compustat, $dlc + dltt$; the variable "assets" is also from Compustat, *at*; and the variable "unused lines of credit" is from Capital IQ, total undrawn credit.

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Table 1: **Moments and Parameters**

TARGET MOMENTS	*Observed*	*Simulated*
$Mean(\frac{unused_t}{credit_t})$	0.411	0.419
$Std(\frac{unused_t}{credit_t})$	0.172	0.150
$Std(\Delta employ_t)$	0.134	0.108
$Std(\Delta sales_t)$	0.181	0.170
$Std(\Delta credit_t)$	0.500	0.483
$Autocor(\frac{unused_{t-1}}{credit_{t-1}})$	0.317	0.376
$Autocor(\Delta employ_{t-1})$	-0.029	0.345
$Autocor(\Delta sales_{t-1})$	0.007	0.035
$Autocor(\Delta credit_{t-1})$	-0.185	-0.130
$Cor(\frac{unused_t}{credit_t}, \Delta employ_t)$	-0.067	0.109
$Cor(\frac{unused_t}{credit_t}, \Delta sales_{it})$	-0.046	-0.013
$Cor(\frac{unused_t}{credit_t}, \Delta credit_{it})$	-0.001	0.271
$Cor(\Delta employ_t, \Delta sales_{it})$	0.497	0.404
$Cor(\Delta employ_t, \Delta credit_{it})$	0.296	0.346
$Cor(\Delta sales_t, \Delta credit_{it})$	0.197	0.148

ESTIMATED PARAMETERS	
Persistence productivity shock, ρ_z	0.717
Volatility productivity shock, σ_z	0.173
Persistence credit shock, ρ_ξ	0.830
Volatility credit shock, σ_ξ	0.175
Persistence separation shock, ρ_λ	0.112
Volatility separation shock, σ_λ	0.099
Financial distress cost, κ	10.323
Workers' bargaining power, η	0.692
Hiring cost, ϕ	0.360
Average separation, $\bar{\lambda}$	0.309
Unemployment flow, $\bar{u}$	0.452

Table 2: **Sensitivity**

	Benchmark	ρ_z	σ_z	ρ_ξ	σ_ξ	ρ_λ	σ_λ	κ	η	ϕ	$\bar{\lambda}$	$\bar{u}$
$Mean(\frac{unused_t}{credit_t})$	0.419	0.439	0.431	0.561	0.475	0.419	0.421	0.432	0.427	0.426	0.402	0.425
$Std(\frac{unused_t}{credit_t})$	0.150	0.149	0.149	0.352	0.184	0.150	0.150	0.151	0.147	0.150	0.145	0.148
$Std(\Delta employ_t)$	0.108	0.119	0.110	0.135	0.111	0.109	0.114	0.108	0.120	0.113	0.120	0.115
$Std(\Delta sales_t)$	0.170	0.172	0.182	0.187	0.171	0.170	0.174	0.170	0.173	0.170	0.170	0.169
$Std(\Delta credit_t)$	0.483	0.502	0.489	2.332	0.659	0.484	0.486	0.484	0.469	0.480	0.479	0.486
$Autocor(\frac{unused_{t-1}}{credit_{t-1}})$	0.376	0.397	0.386	0.310	0.320	0.376	0.378	0.378	0.352	0.372	0.373	0.373
$Autocor(\Delta employ_{t-1})$	0.345	0.419	0.353	0.538	0.364	0.348	0.316	0.341	0.414	0.369	0.406	0.378
$Autocor(\Delta sales_{t-1})$	0.035	0.127	0.016	0.198	0.054	0.038	0.037	0.033	0.110	0.065	0.114	0.079
$Autocor(\Delta credit_{t-1})$	-0.130	-0.116	-0.127	0.001	-0.132	-0.129	-0.128	-0.129	-0.124	-0.127	-0.122	-0.125
$Cor(\frac{unused_t}{credit_t}, \Delta employ_t)$	0.109	0.031	0.097	-0.267	0.019	0.108	0.118	0.103	-0.003	0.069	0.081	0.059
$Cor(\frac{unused_t}{credit_t}, \Delta sales_{it})$	-0.013	-0.073	-0.031	-0.152	-0.031	-0.012	-0.012	-0.013	-0.091	-0.040	-0.042	-0.056
$Cor(\frac{unused_t}{credit_t}, \Delta credit_{it})$	0.271	0.231	0.261	-0.221	0.246	0.270	0.273	0.270	0.219	0.254	0.249	0.243
$Cor(\Delta employ_t, \Delta sales_{it})$	0.404	0.496	0.416	0.520	0.409	0.406	0.379	0.401	0.466	0.437	0.493	0.462
$Cor(\Delta employ_t, \Delta credit_{it})$	0.346	0.372	0.353	0.224	0.243	0.347	0.355	0.342	0.383	0.359	0.388	0.367
$Cor(\Delta sales_t, \Delta credit_{it})$	0.148	0.210	0.181	0.139	0.079	0.148	0.143	0.149	0.134	0.148	0.158	0.166

The first column reports the moments generated by the simulation of the model under the estimated parameters (benchmark parametrization as shown in Table 1). The remaining columns report the simulated moments after increasing the value of the specific parameter by 10%.

Table 3: **The contribution of the three shocks**

	Observed	Benchmark Model	Credit Shock	Productivity Shock	Separation Shock
$Mean(\frac{unused_t}{credit_t})$	0.411	0.419	0.425	0.511	0.511
$Std(\frac{unused_t}{credit_t})$	0.172	0.150	0.150	0.023	0.017
$Std(\Delta employ_t)$	0.134	0.108	0.050	0.051	0.080
$Std(\Delta sales_t)$	0.181	0.170	0.050	0.137	0.080
$Std(\Delta credit_t)$	0.500	0.483	0.445	0.121	0.092
$Autocor(\frac{unused_{t-1}}{credit_{t-1}})$	0.317	0.376	0.383	0.624	0.082
$Autocor(\Delta employ_{t-1})$	-0.029	0.345	0.736	0.626	0.083
$Autocor(\Delta sales_{t-1})$	0.007	0.035	0.736	-0.075	0.083
$Autocor(\Delta credit_{t-1})$	-0.185	-0.130	-0.148	-0.039	-0.052
$Cor(\frac{unused_t}{credit_t}, \Delta employ_t)$	-0.067	0.109	0.289	-0.999	0.997
$Cor(\frac{unused_t}{credit_t}, \Delta sales_{it})$	-0.046	-0.013	0.266	-0.690	0.083
$Cor(\frac{unused_t}{credit_t}, \Delta credit_{it})$	-0.001	0.271	0.314	-0.734	0.987
$Cor(\Delta employ_t, \Delta sales_{it})$	0.497	0.404	0.736	0.694	0.083
$Cor(\Delta employ_t, \Delta credit_{it})$	0.296	0.346	0.220	0.736	0.990
$Cor(\Delta sales_t, \Delta credit_{it})$	0.197	0.148	-0.262	0.994	-0.054

The last three rows report the moments generated by simulating the model under the estimated parameters (benchmark parametrization as shown in Table 1) but with only one of the three shocks. The simulation with only shock is obtained by setting the realizations of the other two shocks to their unconditional means. The decision rules, however, are computed under the assumption that firms expect all three shocks.