Labor and Finance : Mortensen and Pissarides meet Holmstrom and Tirole

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June 10, 2013

Abstract

In real life labor markets firms hold at all times a variety of liquid assets not invested in their core business. Such external use of funds acts as an insurance against future adverse financial shocks, and typically varies across firms and sectors. As a result, different firms use different degrees of financial leverage. This paper investigates the consequence of firms' use of funds on their hiring and firing policy. Using a standard matching model of unemployment, the paper finds an equilibrium interplay between labor market imperfections and financial market imperfections. We show that financial market imperfections- such as the probability of refinancing or firms' share of their pleadgeable income- affect equilibrium unemployment. In addition, we show that as labor market frictions vanishes, firms do not hold liquid asset in equilibrium, suggesting a fundamental complementarity between labor market frictions and holding of liquid assets by firms. In this sense, the paper brings together the work on liquidity by Holmstrom anf Tirole (2011) with the traditional Mortensen Pissarides (2004) model of equilibrium unemployment. The model implies also that at times of adverse financial shocks, firms that are more leveraged are more likely to liquidate their assets and destroy jobs. Empirically, we test whether there is a causal link between firms leverage and job destruction at times of adverse financial shocks. We draw on firm-level data on employment adjustment matched with balance sheet records throughout the Great Recession and find that highly leveraged firms destroy more jobs during a financial crisis.

1 Introduction

In real life labor markets firms hold at all times a variety of liquid assets not invested in their core business Such external use of funds acts as an insurance against future adverse shocks and typically varies across firms and sectors. As firms choose the size of this war chest, they automatically decide how much to depend on external financing and how much to be leveraged. Holmstrom and Tirole (2011) have recently rationalized the demand for liquid funds and the size of leverage by firms and business. While the use of external funds is now fairly understood in the corporate finance literature, it is largely ignored by the traditional labor market analysis. At the same time, Mortensen and Pissarides' (1994) model of equilibrium unemployment ignores the financial constraints of firms.

This paper investigates the consequence of firms' use of liquid funds on their hiring and firing policy. Using a standard matching model of unemployment, the paper shows that there is an equilibrium interplay between the value of unemployment and financial conditions. Firms choose ex-ante the size of their business as well as the composition of their funds. Financial markets are imperfect and firms use a share of their pleadgeable income as a collateral for raising funds. Yet, over their life time firms are subject to adverse financial schocks that call for reinvestments. Such reinvestment option crucially depends on the firms' holding of financial assets as well as on the probability of obtaining further funding. If funding is not available when refinancing is needed, firms may be forced to liquidate assets and destroy jobs. Financial market imperfections- such as the probability of obtaining refinancing, or firms share of their pleadgeable income- affect equilibrium unemployment. In addition, we show that as labor market frictions vanishes, firms do not hold liquid asset in equilibrium, suggesting a fundamental complementarity between labor market frictions and holding of liquid assets by firms. In this sense, the paper brings together the work on liquidity by Holmstrom anf Tirole (2011) with the traditional Mortensen Pissarides (2004) model of equilibrium unemployment.

The model implies also that at times of adverse financial shocks, firms that are more leveraged are more likely to liquidate their assets and destroy jobs. Empirically, we test whether there is a causal link between firms leverage and job destruction at times of adverse financial shocks. We exploit matched employment-balance sheet data at the firm-level to look into the relationship between employment adjustment and leverage throughout the 2008-9 financial crisis. Since leverage is clearly an endogenous variable, we instrument the firms financial position by their access to third party collateral provided within a consortium of firms. We find a sizeable and negative effect of leverage on employment adjustment, which according to our identification assumption can be interpreted as a causal effect of leverage on hiring and firing policies of firms.

We are certainly not the only ones to study the interplay between finance and labor. In the aftermath of the Great Recession, Pagano and Pica (2010) studied the effects of financial market imperfections on labor adjustment in the context of a perfect labor market. Monacelli, Quadrini and Trigari (2012) investigate the interaction between the firms wage policy and its financial structure. Wasmer and Weil (2005) study the interplay between matching frictions in both the labor and the financial markets. Yet, we are probably the first to bridge the gap between the two main models of firms and finance. Holmstrom and Tirole (2011) represent the basic model of firms' demand for liquid assets. Mortensen and Pissarides (1994) offer the key framework for the analyses of unemployment. Empirically, Gatti et al. (2010) and Belke enf Fehn (2001) show that there are various interactions between unemployment and financial frictions.

The structure of the paper is as follows. Section 2 sets the scene by providing basic concepts and definitions. Section 3 introduces the model, and characterizes its equilibrium. Section 4 extends the model to allow for heterogeneous firms and derive testable empirical implications. Section 5 takes the basic prediction of the model to the data, and tests whether firms more leveraged are more likely to destroy jobs during the 2008-2009 recessions. Section 6 concludes.

2 Basic Concepts and Definitions

Firms need funds for internal use (labor costs at large plus investment in machine) or for external use (liquidity as a precautionary savings for future investment). Firms may obtain funds through the pleadgeable income, as well as their private wealth.

Let's introduce some basic definition

- Firms' Use of Funds
$$\text{Firms' Use of Funds} = \widetilde{I} + A + C(.)A$$
where $\widetilde{I}$ are the liquid funds held by the firms, A are the funds invested in the physical machines, so that A measures the size of investment, and $C(.)A$ are the funds needed to finance all labor costs

- Firms Pleadgeable income. A firm can obtain all of these funds from its pledgeable income. A fraction ρ of the PDV of the surplus from the operations ican be pledged. If the joint firm-worker surplus of an investment A with liquid fund $\widetilde{I}$ is $S(A, \widetilde{I})$, then total funding of the firm is
$$\text{Total Funding} = P = \ Y_o + \rho S(A, \widetilde{I})$$
where Y_o is the entrepreneur private wealth that can be fully pledged.

- Firms Internal Funds. We can now further define firms' internal funds as the fraction of funds that are invested in the firm
$$\text{Firms's internal funds=}\frac{A + C(.)A}{P}$$

- Firms external funds are the funds left liquid for future investment needs (also called the firm war chest)
$$\text{Firm's external funds} = \frac{I}{P}$$

- We define firm's leverage as the share of funds invested internally so that
$$\text{Firm's leverage} = l = 1 - \frac{I}{P} = \frac{P - I}{P}$$

This definition of firm's leverage makes clear that we intend leverage as the share of funds borrowed that are invested in the core operation and are not held in cash. In other words, we intend leverage as funding net of liquid asset.

With these basic concepts, the model that we propose from the next section can help us addressing various questions. Why firms have different leverage? Is there a link between labor market imperfections and firms use of funds. How firms hire and fire? Which are the links between labor and finance Do financial imperfections induce job destruction at time of adverse business conditions?

3 The model

The idea is that firms may need refinancing, for instance because they need to do new investments. In the simple model that we propose, the reinvestment implies that the machines are completely destroyed when an investment shock arrives, and when so happen, the old contract with the bank is void.

3.1 Production technology

1. Entrepreneurs set up a firm at effort cost K
2. The entrepreneur decides the size or capacity A of the firm, and invest A in capital. Maximum capacity is decided ex-ante and it is irreversible.
3. Output is given by $f(A)$. We assume a simple linear technology so that output is $f(A) = yA$.
4. With a given probability rate λ, the project needs refinancing of the same amount A. We refer to such catastrophic event as a λ shock. Conditional on a λ shock, there is a probability τ that the project will not receive refinancing.
5. In addition, the entrepreneur has a flow privante revenue y_o with pdv $Y_0 = \frac{y_0}{r+\lambda}$ that she can borrow from.
6. The firm can hold liquid reserves (deposits) that yield an interest rate r and ensure that-conditional on the adverse shock λ, a size I is available for investment in physical capacity. This is akin to assuming that the the liquid assets held by the firm before the shock λ hits the firm are equal to $\widetilde{\lambda} I$ where $\widetilde{\lambda} = \frac{\lambda}{r+\lambda}$ [1]. We will often refer to the investment I as to the war chest.
7. If the firm does receive refinancing- conditional on a λ shock- it invests A. If it does not receive refinancing, it has to use own resources I to refinance the investment. Output is then yI.
8. We require that $K > Y_0$.
9. A second λ shock kills the firm
10. The contract with the financiers is associated with the initial investments. The refinancing shock λ not only kills the initial investments, but it terminates the debt contract with the bank.

3.2 Asset values, Surplus and Profits

It is convenient to define the NPV of the joint revenue from a match, $W_1(A; I)$, as the joint revenue obtained by a firm of investment size A with liquid deposit I available for reinvestment. The underscript 1 refers to the joint revenue before the shock λ hit the match. The revenue W_1 is joint and does not include wages as they are a pure transfer between the entrepreneur and the workers. It follows that we can write

$$\begin{aligned} rW_1(I, A) &= yA + \lambda[\tau W_d(I) + (1-\tau)(W_2(A) - (A - I)) - W_1(I, A)] \qquad (1) \\ rW_2(A) &= yA - \lambda W_2(A) \\ rW_d(I) &= yI - \lambda W_d \end{aligned}$$

where W_1, W_2 and W_d are NPVs of the joint revenues before the refinancing shock, after the shock with access to finance, and after the shock with no access to the bank, respectively. Consider the first equation. The first term shows the income flow of the machines. The second term reflects the

[1] This can be easily seen as

$$\begin{aligned} r\widetilde{\lambda} I &= \lambda(I - \widetilde{\lambda} I) \\ \widetilde{\lambda} &= \frac{\lambda}{r+\lambda} \end{aligned}$$

capital loss associated with a reinvestment shock that happens with probability rate λ, after which the machines are destroyed and have to be replaced, and the firm looses W_1. After the shock, the firm gets refinancing with probability $1-\tau$, and regains W_2, the net present value of joint income of a fully financed old firms less the cost of reinvesting $A-I$. As the firm invests the liquid assets I, the cost in this case is simply $A-I$. With probability τ, the firm does not get refinancing, in which case the NPV of the joint income is simply W_d and the cost is fully paid by the liquid deposit I. The other equations can be explained in a similar fashion, after recalling that the second adverse shock λ permanently destroys the firm. Solving gives

$$\begin{aligned} W_d &= \frac{yI}{r+\lambda} \\ W_2 &= \frac{yA}{r+\lambda} \end{aligned}$$

As the joint income $W_1(A,I)$ and $W_2(A)$, require a measure of A workers, we can define the surplus from the match of an entrepreneur and A workers as

$$\begin{aligned} S_1(A,I) &= W_1(A,I) - AU \\ S_2(A) &= W_2(A) - AU \\ S_d(I) &= W_d(I) - IU, \end{aligned} \tag{2}$$

where U is the value of being unemployed. The third equation is the surplus from a situation of distress in which only $I \leq A$ workers are employed. To obtain the surplus $S_1(A,I)$ the firm has to invest in three dimensions. First, it has to set up the real investment A in "machine". Second, it has to commit financial resources equal to $\widetilde{\lambda} I$ in order to have a warchest I conditional on the λ shock. Finally, it has to invest $C(U)$ in labor related costs per worker, where the determination of $C(U)$ is detailed in the next section. As a consequences, firm profits $V(A,I)$ read

$$V(A,I) = S_1(A,I) - I\widetilde{\lambda} - (1+C)A$$

Using the definition of the surplus, and rearranging, the value of profits read

$$V(A,I) = \left[\frac{y-rU}{r+\lambda} - 1\right]\left(1+\widetilde{\lambda}(1-\tau)\right)A + \left[\frac{y-rU}{r+\lambda} - 1\right](\tau\widetilde{\lambda})I - C()A \tag{3}$$

Equation 3 is one of the key equations of the model and deserves some comments. Firm profits are a linear combinations between the investment in capacity A and the investment in liquidity I. The term in square bracket is the real net internal return expressed as a present discounted value of the flow surplus $y-rU$. Note that the investment in real capacity A has a weight equal to $1+\widetilde{\lambda}(1-\tau)$ as only with probability $1-\tau$ the firm finds refinincing and production can continue. Conversely, the investment in liquidity $\widetilde{\lambda} I$ turns productivity with probability τ, when the firm does not find refinincing and invest the warchest. Finally, the firm has to commit an amount $C()$ per worker in search related costs, as illustrated in the next section.

Having defined the asset values and surplus, we now move to search

3.3 Search and Worker's Rent

A firm operating at capacity A hires A workers. Let R denote the rent offered per employee, cv the cost of posting v vacancies, and U the value of being unemployed. Finding a workers involve a flow cost and an instantaneous probability of matching equal to $q(\theta)$ where q is the matching function and θ is the traditional market tightness or the fraction of vacancies to unemployment. Since the expected duration of a vacancy is $1/q$, the expected cost of posting a vacancy is c/q. Since search costs and wages tap into the pool of money availiable to investment, the firm has an incentive to minimize the sum of the two. As the cost of posting vacancies is c/q, total costs of hiring and paying a worker, referred to as labor costs, are

$$C = \min\left[\frac{c}{q(\theta)} + R\right] \qquad \text{S.T.} \qquad rU = z + \theta q(\theta) R \tag{4}$$

where R is the NPV of the rent associated with the job. The constraint is the traditional value of search unemployment for a given worker, and z is the specific income of the unemployed. The constraint implicitly defined an indifference curve $\theta = \theta(R, U)$ where U is the given value of unemployment. Further

$$\frac{d\theta}{dR} = -\frac{\theta q(\theta)}{q(1-\beta)R}$$

where β is the absolute value of the elasticity of $q(\theta)$, with Cobb Douglas independent of θ. Total search cost define implicitly an isocost and the equilibrium is going to be a tangency condition between the isocost C and the indifference curve U.

Formally, the first order condition for a minimum- once we use the indifference curve is thus

$$\frac{cq'(\theta)}{q^2}\frac{\theta q(\theta)}{q(1-\beta)R} = 1$$

or

$$R = \frac{c}{q}\frac{\beta}{1-\beta}$$

Total labor cost is thus

$$C = \frac{c}{q}\frac{1}{1-\beta} \tag{5}$$

Over and beyond the rent, the firm pays the worker a flow value rU per period employed, as we further discuss at the end of this section. Finally, θ is given by

$$\theta q(\theta) = \frac{rU - z}{R} = (rU - z)\frac{1-\beta}{\beta}\frac{q}{c}$$

hence

$$\theta(U) = \frac{rU - z}{c}\frac{1-\beta}{\beta} \tag{6}$$

It follows that we can write both the total labor costs C and market tightness θ as an increasing function of U, $C = C(U); \theta = \theta(U)$ with $C'(U) > 0$ and $\theta'(U) > 0$.

Up to now we have not said anything about the time profile of wages. As all agents have utility functions that are linear in NPV income (with the same discount factor), the time profile of wages does not matter. One possibility is that R can be paid out immediately, and that the worker so receives rU thereafter. Another possibility that we mentioned above is that a worker receives a constant wage. If the firm has no cash, this wage is given by

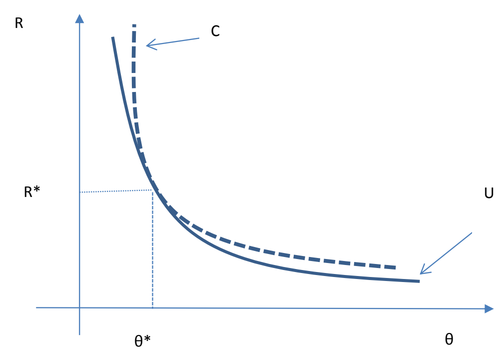
$$w = rU + (r + \tilde{\lambda}\tau)R$$

If the firm has a full war chest, the wages write

$$w = rU + (r + \tilde{\lambda})R$$

It follows that wages are lower if the firm has a full war chest. The reason is that the firm pays the same NPV rents R to the worker, independently of the size of the war chest. This means that the firm pays a higher wage when it does not have a war chest, since the workers expect to last shorter. Hence the cost to the firm in terms of wages by extending the employment period by one unit is rU. As will be clear below, we do not allow the firm to defer wages until after the refinancing shock occurs, after which the financial constraints may be less severe.

Figure 1: The cost minimization and the optimal search and workers' rent



3.4 The financial contract and the borrowing constraint

As stated initially, a firm invest in capacity and buys machines, and use the joint surplus from the investment in machine as collateral. When the machine is gone, the contract is terminated. The NPV of the pledgeable income writes

$$P = Y_0 + \frac{\rho(y - rU)A}{r + \lambda} \tag{7}$$

The first term is the total amount the firm can borrow from the private wealth of the entrepreneur Y_0; the second term is the amount the firm can borrow on the additional income it receives from the investments. If the firm borrows P, it pays back all its pledgeable income until the machine is destroyed, in which case the contract is terminated. Note that the difference $(1 - \rho)yA$ is private benefits to the entrepreneur, and hence cannot be saved.

The firm can use P either to invest or to build a war chest. Without frictions in the credit market ($\rho = 1$), it is costless to build a war chest, as the interests on the war chest is equal to r. However, with frictions, there is an opportunity cost associated with building the war chest, as the firms alternatively could invest more. Note that the firm cannot use the war chest as collateral. It cannot repay more than ρyA, and hence if it borrows more it will have to use the war chest to repay the loan - and hence the war chest will be empty when the shock hits.[2]

3.5 The Value of the Firm, conditional on entry

The firms' maximization problem can now be written as

$$\begin{aligned} V(U) \quad &= \quad \left[\frac{y - rU}{r + \lambda} - 1\right]\left(1 + \widetilde{\lambda}(1 - \tau)\right)A + \left[\frac{y - rU}{r + \lambda} - 1\right](\tau\widetilde{\lambda})I - C()A && (8) \\ \text{s.t.} \quad & I\widetilde{\lambda} + (1 + C)A - P \geq 0 && (9) \\ & 0 \leq I \leq A;\ A \geq 0;\ I \geq 0 \end{aligned}$$

where- given the nature of the war chest and the structure of the shock- the war chest itself can not be larger than the investment A while they both need to be non negative.

The maximization problem is a linear problem in A and I with two linear constraints and two non negative constraints. The first constraint shows the available resources are used by the firm for three destinations: i) to finance the build up of capacity A, to finance search and labor costs C, and to build up the war chest I. As we will see, the equilibrium can have also a graph interpretation. To begin, we just show that a binding borrowing constraint (31) implies that

$$\begin{aligned} A \quad &= \quad \frac{Y_0 - \widetilde{\lambda}I}{1 + C(U) - \rho\frac{(y - rU)}{r + \lambda}} && (10) \\ &= \quad k(U)(Y_0 - \widetilde{\lambda}I) \end{aligned}$$

where we defined $k(U) > 1$ as the investment multiplier, or

$$k(U) = \frac{1}{1 + C(U) - \rho\frac{(y - \rho U)}{r + \lambda.}}$$

[2]This is a tricky issue. Suppose y is income and suppose $\rho < 1$ in order to give incentives to the entrepreneur. If the bank can take the war chest, this will create incentives. On the other hand, the entrepreneur has control over the chest, and hence may divert the use of the chest and/or hide it. This indicates that the firm only to a limited extent may use the war chest as collateral, and hence borrow $\rho_i I$ on the war chest. Assuming that $\rho_i < \rho$ the results would qualitatively be the same. Here we assume that $\rho_i = 0$.

Note further that $\frac{\partial k}{\partial U} < 0$. It follows that

$$\frac{dI}{dA} = -\frac{1}{k\widetilde{\lambda}} \tag{11}$$

so that the the borrowing constraint is just a negative line in a (I, A) space, as indicated by Fig. 3. At the same time, the objective function is a family of linear iso-profits in a (I, A) space, and , the typical iso-profits is downward sloping as indicated in Fig 3 and 2.

Making use of the financial constraint 10, the firm problem is

$$\begin{aligned} V(U) &= \max_{I,A} \left[\frac{y - rU}{r + \lambda} - 1\right] \left(1 + \widetilde{\lambda}(1-\tau)\right) A + \left[\frac{y - rU}{r + \lambda} - 1\right] (\tau\widetilde{\lambda}) I - C() A \\ s.t.\ \ I &= -\frac{A}{k(U)\widetilde{\lambda}} + \frac{Y_0}{\widetilde{\lambda}}; \quad I \leq A \end{aligned} \tag{12}$$

The objective function makes clear that the firm's value is a weighted average between investing in capacity A and accumulating a war chest I. Given the linear nature structure of the model and the firm's isoprofit, the firm equilibrium will be at a corner solution. Figures 3 and 2 describe the two possible equilibria. In Figure 2 the maximize capacity is A and the firm does not hold any cash reserve. We label such condition the *no cash* equilibrium. Conversely, in Figure 3 the firm use cash and operate along the constraints $I = A$. We label such condition the *Warchest-or cash- equilibrium*, as we argue next

Definition 1 *The firm optimization problem has two possible outcomes. In the No cash Equilibrium the firm maximizes capacity and does not use any cash. In the Warchest equilibrium the firm holds cash in equilibrium so that $I = A$*

The derivation of the two equilibria depends on the relative slopes of the iso-profits and the borrowing constraint. The warchest equilibrium requires that the slope of the isoprifts be-in absolute value- smaller than the slope of the borrowing constraint, so that we can obtain a simple condition for the war chest equilibrium.

Proposition 2 *The firm will choose to hold cash and establish a warchest equilibrium as long as*

$$\left[\frac{y - rU}{r + \lambda} - 1\right] (1 + \widetilde{\lambda}(1-\tau)) \leq C(U) + \tau\widetilde{\lambda} \left[\frac{y - rU}{r + \lambda} - 1\right] \frac{1}{k(U)\widetilde{\lambda}} \tag{13}$$

proof. The condition is obtained by susbtituting the borrowing constraint in the objective function and, thereafter obtaining the condition under which $\frac{dV(A, A(I))}{dA} < 0$.

From proposition 17 three important results follows.

Proposition 3 *An increase in the probability of distress τ makes the warchest equilibrium more likely*

The latter is a very important proposition, since it provides formally the idea that the warchest acts as a sort of insurance against distress. An increase in τ implies that the firm is more likely to lose access to financial markets conditional on an adverse shock λ. As a consequence, cash is more likely. *Proof* The proof follows from the fact that τ reduces the lhs and increases the rhgs of equation 33

Proposition 4 *An increase in the pledgeability parameter ρ makes the warchest equilibrium less likely*

An increase in pleadgeability increase the financial resources available to the firm and reduce the incentives to hold cash deposits. [....] *Proof* The proof follows simply from the fact that ρ affects the slope of the financial constraint by making it steeper [...]

Figure 2: The No cash equilibrium

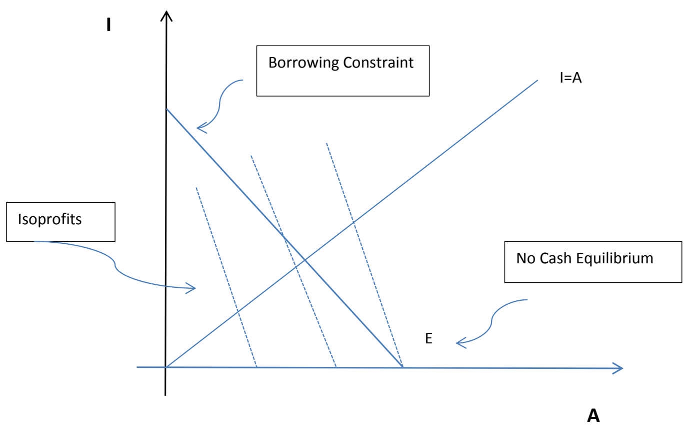
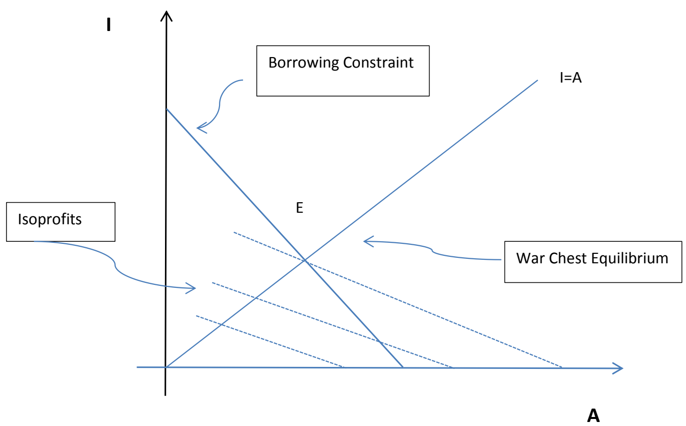


Figure 3: The firm holds cash. The Warchest equilibrium



Proposition 5 *An increase in c makes cash more likely*

Proof An increase in c induces an increase in the rent cost C and a reduction in the multiplier $k(U)$. Both effects tends to increase the right hand side and make cash more likely.

When the parameter restriction on proposition 17 is satisfied the firm will set the borrowing constraint so that $A = \hat{I}$ where

$$\hat{I}(U) = \frac{k(U)Y_0}{1 + \widetilde{\lambda}k(U)} \tag{14}$$

Conversely, when the parameter restriction in proposition 17 is not satisfied, the firm will opt for a no cash equilibrium and will choose capacity $A = \hat{A}$ along the borrowing constraint so that $I = 0$ where $\hat{A}$ solves

$$\hat{A}(U) = k(U)Y_0 \tag{15}$$

Finally, note that since the multiplier is decreasing in the value of unemployment U, it is immediate to see that both optimal capacity level $\hat{I}(U)$ and $\hat{A}(U)$ are decreasing in U, so that $\frac{\partial \hat{I}}{\partial U} < 0$ and $\frac{\partial \hat{A}}{\partial U} < 0$

3.6 General Equilibrium, Existence and Uniqueness

We can now define the general equilibrium

Definition 6 *The general equilirbium of the model is a* $n - tuple : C, \theta, A, I, U, u, n_1, n_2$ *that satisfies*

1. *Minimum Search and labor costs* $C(U)$ *and optimal market tightness* θ *(equations (6) and (5))*
2. *Optimal Capacity A and Cash holdings I (equations (15) and (14) for the no cash and warchest firm equilibrium respectively)*
3. *Free Entry (equation (16))*
4. *Balance flow conditions and equilibrium unemployment (equation 20)*

Once the firm chooses the optimal capacity for given value of unemployment U, the final derivation of U is determined by the free entry condition

$$V(U) = Max\left[V^A(U); V^I(U)\right] = K \tag{16}$$

where $V^A(U)$ and $V^I(U)$ read respectively,

$$V^A(U) = \left[\left(\frac{y - rU}{r + \lambda} - 1\right)(1 + \widetilde{\lambda}(1 - \tau)) - C(U)\right] A^*(U) \tag{17}$$

$$V^I(U) = \left[\left(\frac{y - rU}{r + \lambda} - 1\right)(1 + \widetilde{\lambda}) - C(U)\right] I^*(U) \tag{18}$$

and the optimal capacity and cash holdings read

$$I^*(U) = \begin{cases} \hat{I} & \text{if } \left[\frac{y-rU}{r+\lambda} - 1\right](1 + \widetilde{\lambda}(1 - \tau)) \leq C(U) + \tau\widetilde{\lambda}\left[\frac{y-rU}{r+\lambda} - 1\right]\frac{1}{k(U)\widetilde{\lambda}} \\ 0 & \text{otherwise} \end{cases}$$

and

$$A^*(U) = \begin{cases} \hat{A} & \text{if } \left[\frac{y-rU}{r+\lambda} - 1\right](1 + \widetilde{\lambda}(1 - \tau)) \geq C(U) + \tau\widetilde{\lambda}\left[\frac{y-rU}{r+\lambda} - 1\right]\frac{1}{k(U)\widetilde{\lambda}} \\ \hat{I} & \text{otherwise} \end{cases}$$

We are now in a position to establish existence and uniqueness of the general equilibrium

Theorem 7 *The general equilibrium exists and it is unique as long as*

$$V^A(rU = z) > K \tag{19}$$

Proofs First note that both functions $V^A(U)$ and $V^I(U)$ are decreasing in U ($V'^I(U) < 0$ and $V'^A(U) < 0$ The condition in the theorem ensures that a single crossing between the V function and K exists. To proof uniqueness consider two equilibrium candidates from equation 16, as u^A and u^I solving respectively $V^A(u^A) = K$ and $V^I(u^I) = K$. Suppose that $u^A \neq u^I$ and $u^A > u^I$. Since they are both equilibrium candidates it follows

$$K = V^I(u^I) \geq V^A(u^I) > V^A(u^A) = K$$

which is clearly a contradiction since both functions are strictly decreasing and , by monotonicity, are equal to K only if $u^A = u^I$. *QED.*

From the existence theorem a corollary follows

Corollary 8 *If there are two equilibrium candidates u^A and u^I, the no cash is the equilibrium candidate if $u^A \geq u^I$*

Proofs Consider the two equilibrium candidates $V^A(u^A) = k$ and $V^I(u^I) = K$. Suppose $u^I > gequ^A$ then

$$K = V^A(u^A) > V^I(u^A)$$

but if $u^I > u^A$ then $V^I(U^a) > V^I(u^I)$ where the latter condition follows from the monotonicity of V^I. But the latter is a contradiction since it implies that u^I is simultaneously $V^I(u^I) = K$ and $V^I(u^I) < K$. So it must be that $u^A > u^I$. *QED.*

To complete the specification of the economy we have to account for the aggregate labor flows. In the economy there is a measure 1 of workers that can be employed in new firms or firms that already experienced the first λ shock. We label respectively n_1 and n_2 the share of workers employed in the two type of firms. In the warchest equilibrium, conditional on a λ shock firms do not fire any worker and continue with their cash holdings. Let ω be an indicator function that a value 1 if the economy is in a no-cash equilibrium. The general balance flow conditions read

$$\begin{aligned}
\theta q(\theta) u &= \omega\lambda n_2 + (1-\omega)(\lambda\tau n_1 + \lambda)n_2 \\
\omega\lambda n_1 + (1-\omega)(\lambda(1-\tau))n_1 &= \lambda n_2 \\
u + n_1 + n_2 &= 1
\end{aligned}$$

The first equation is simply the outflows from unemployment and inflows into unemployment, where the latter involve also the share of workers in type 1 firm that do not find refinancing in the no cash equilibrium. The second condition is the flow into n_2 from type 1 firm and outflows out of n_2. Again, in the no cash equilibrium only the surviving employed enter the type 2 state. The last condition is the aggregate labor market condition. Solving for the stock yields

$$\begin{aligned}
u &= \omega\frac{\lambda}{\lambda + 2\theta q(\theta)} + (1-\omega)\frac{\lambda}{\lambda + (1 + (1-\tau))\theta q(\theta)} \\
n_1 &= \omega\frac{\theta q(\theta)}{\lambda + 2\theta q(\theta)} + (1-\omega)\frac{\theta q(\theta)}{\lambda + (1 + (1-\tau))\theta q(\theta)} \\
n_2 &= \omega\frac{\theta q(\theta)}{\lambda + 2\theta q(\theta)} + (1-\omega)\frac{\theta q(\theta)(1-\tau}{\lambda + (1 + (1-\tau))\theta q(\theta)}
\end{aligned} \tag{20}$$

3.7 Characterization and comparative statics

We already established that the presence of market frictions, crucially determined by the search cost c and the associated rent $C(U)$, are an important determinant of the cash condition. We also established the an increase in c makes cash more likely. Workers represent an investment that is associated with the capacity A. Such investment creates a rent to the firm and such rent is likely to be protected by the investment in liquidity. In the economics of the model there is thus a complementarity between the imperfection of the labor market and the tendency of a firm to hold cash. Such complementarity turns out to be crucial, as the following theorem demonstrates.

Theorem 9 *As market frictions disappers and the labor market tends to a frictionless labor market ($c \to 0$, $rU \to w$), cash is never used in equilibrium*

Proof. In the Appendix we solve the limit version of the as frictions disappear and workers fully participate in the labor market. In the limit version of the model as $c \to 0$, unemployment disappear and the labor market is charaterized by an endogenous wage along an inelastic labor supply. In other words, the endogenous wages is the permanent income of the workers so that $w \to rU$, and free entry of firms ensure determines the equilibrium value of the endogenous wage. As long as such wage is larger than a workers' reservation utility z, the limit model delivers full employment. The appendix shows that in such model, the cash condition becomes

$$(1 + \widetilde{\lambda}(1 - \tau)) \leq \frac{\widetilde{\lambda}}{k(w)\widetilde{\lambda}} \tag{21}$$

where $k(w) = \frac{1}{1-\rho\frac{y-w}{r+\lambda}} > 1$. As the lhs is cearly greater than one, the rhs is strictly less than one as long as teh multiplier $k(w) > 1$. Thus cash is never used in such frictionless labor market.. See Appendix for details.

As we argued in the existence theorem of the previous section, the general equilibrium of the model when cash is used in equilibrium is determined by the firm allocation decision and the free entry that uniquely solves for U. Formally

$$\left[\frac{y - rU}{r + \lambda} - 1\right](1 + \widetilde{\lambda}(1 - \tau)) \leq C(U) + \tau\widetilde{\lambda}\left[\frac{y - rU}{r + \lambda} - 1\right]\frac{1}{k(U)\widetilde{\lambda}}$$

$$\frac{K}{Y_0(\frac{1}{k(U)} + \tilde{\lambda})} = \frac{y - rU}{r + \lambda}(1 + \tilde{\lambda}) - (1 + C(U)) \tag{22}$$

where the second equation is obtained by substituting equation 14 in equation 16

Once U is determined by equation 22, the problem of the firm is immediately solved and a value of A and I obtained from equations (15) and (14. From the labor costs part of the model, the value of U implies also unique equilibrium values of C and θ from equations (6) and (5). Finaly, given a value of θ the equilibrium stocks are immediately by equations 20.

In light of this simple structure, it is possible to use the graph representation of equation 22 to discuss comparative static results in the model. The left hand side of equation 22 is increasing in U while the right hadn side is a decreasing function. The condition of the previous section ensure existence of the equilibrium. In terms of intuition, the left hand side of the equation can be labeled as the *Cost Capacity* ratio, or the fraction of the entry cost to the financial multiplier that crucial determines firm capacity. An increase in U is a proxy to an increase in labor cost, which- in turn- determines a reduction in the financial multiplier and the optimal capacity/employment of each firm, so that the *Cost Capacity* ratio. The right hand side is *Profit per worker*. An increase in U increases the outside option of workers and firm labor cost so that it reduces the wedge per worker. Figure 4 reports the representation of the general equilibrium as well as the comparative static results that follow.

Proposition 10 *A marginal increase in the difficulty of obtaining refinancing (an increase in τ), has no effect on the warchest allocation.*

Formally, the previous proposition depends from the fact that the difficulty of obtaining refinancing does not enter equation 22, while it is one of the determinants of proposition 17.The economics is as follows. An increase in the probability of obtaining refinincing makes the equilibrium with cash more likely. Yet, once the economy settle in the cash equilibrium, a marginal increase has no longer effects.

Proposition 11 *An increase in the pleadgeability parameter (ρ) increases the value of unemployment, market tightness and reduces equilibrium unemployment.*

The other parameter that describes financial market imperfections is the pleadgeability parameter ρ An increase in ρ relaxes the financial constraint and increases the value of unemployment. The pleadgability parameter does not affect profit per worker's directly but it clearly relaxes the financial multiplier. The increase in ρ increases the optimal firm capacity and reduces the cost capacity ratio. In terms of Figure 22, the equilibrium in panel c) shifts from A to be B. The increase in capacity leads also to an increase in market tightness and a fall in equilibrium unemployment.

Proposition 12 *An increase firm productivity (y) increases the value of unemployment, market tightness and reduces equilibrium unemployment.*

An increase in y clearly increases profit per worker at given unemployment value. Simultaneously, it increase the financial multiplier and the optimal firm size. This would be akin to business cycle fluctuations. In terms of comparative static, this induces a fall in equilibrium unemployment and an increase in market tightness.

Proposition 13 *An increase in the entry cost K, reduces the value of unemployment, market tightness and increases equilibrium unemployment.*

The entry cost K induces no partial equilibrium effect on the *profit per worker*, while it clearly increases the *cost capacity ratio*. The equilibrium effect is thus a reduction in the value of unemployment U. Further, fewer firms enter the market, with lower lower labor costs to ensure a larger value of profits in general equilibrium.

Before turning to the section on heterogeneous firms, we characterize the equilibrium with no cash. Formally

$$\begin{aligned}
&\left[\frac{y-rU}{r+\lambda}-1\right](1+\widetilde{\lambda}(1-\tau)) \geq C(U)+\tau\widetilde{\lambda}\left[\frac{y-rU}{r+\lambda}-1\right]\frac{1}{k(U)\widetilde{\lambda}} \\
&\frac{K}{k(U)Y_0} = \frac{y-rU}{r+\lambda}\left[(1-\rho+\tilde{\lambda}(1-\tau)\right]-\tilde{\lambda}(1-\tau)-(1+C(U))
\end{aligned} \tag{23}$$

Proposition 14 *A marginal increase in the difficulty of obtaining refinancing (an increase in τ), reduces the value of unemployment and increases equilibrium unemployment when the firm uses no cash.*

In the no cash equilibrium, the increases in the difficulty of obtaining refinincing reduces profit per worker but it has no effects on the financial multiplier. The profits per workers is reduced and the value of unemployment in Figure 5 is reduced.

Figure 4: The General Equilibrium Effects of an increase in y, ρ and K when the firm uses cash

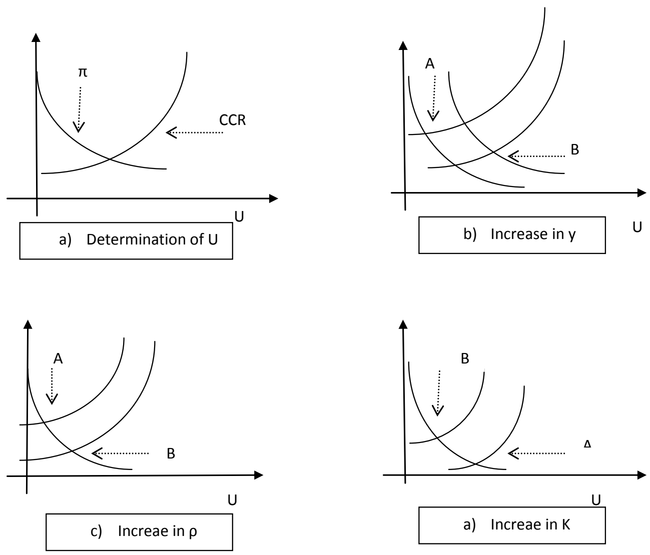
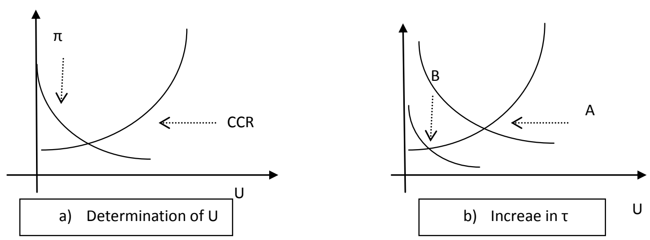


Figure 5: The General Equilibrium Effects of an increase in τ, when the firm uses no cash



4 Heterogeneous Refinancing, financial shocks and empirical implications

In this section we analyze an extended version of the model to allow for firm heterogeneity. Such an extension will allow us to derive empirical implications from our analysis.

The general equilibrium analysis proved two important results linked to the probability of obtaining refinancing τ.

1. An increase in τ makes the warchest equilibrium more likely
2. An increase in τ reduces the value of unemployment U in the equilibrium with no cash.

From these two results it is easy to establish the following claim

Claim 15 *Suppose the conditions of proposition 7 for the existence of the general equilibrium are satisfied. Then there exists a unique τ^* ($0 \leq \tau^* \leq 1$) so that firms have cash if and only if $\tau > \tau^*$*

In the no-cash equilibrium candidate, U is strictly decreasing in τ. In a cash equilibrium candidate, U is independent of τ. Hence the crossing point is unique.

In light of the previous claim, we extend the model to allow firms to have different values of τ. Specifically, we assume that the value of τ takes two possible values τ^h, and τ^l, with $\tau^h > \tau^l$. The firm specific value of τ is determined upon entry and we assume that there is a probability α that τ takes the value τ^h. Further we assume that

$$\tau^h > \tau^* > \tau^l,$$

so that- in light of the previous claim- firms behave very differently if their specific value of τ is τ^h or τ^l. In details, firms in the high τ will select an investment size $I(\tau^h)$ coherent with a warchest equilibrium while firms in the low τ wil select an investment size $A(\tau^l)$ coherent with a no cash equilibrium.

The labor market is partitioned in a submarket in which jobs for the no cash firms are offered and a submarket in which the other types of jobs are offered. Following the reasoning of the previous section, the rent and search costs will be such that

$$\theta^i(U^i) = \frac{rU^i - z}{c}\frac{1-\beta}{\beta}; \quad i = h, l \tag{24}$$

Since workers are free to move across sub-markets, it immediately follows that a no arbitrage condition imply that $U^h = U^l = U$, from which it follows that the market tightness in the two markets is also the same so that $\theta^h = \theta^l = \theta$ Since a fraction α of firms is characterized by a value of τ^h, the free entry condition

$$K = \alpha \left[\frac{y - rU}{r + \tilde{\lambda}} - 1 - C(U)\right] I(\tau^h, U) + (1-\alpha) \left[\frac{y - rU}{r + \tilde{\lambda}}(1 + \tilde{\lambda}(1-\tau) - \tilde{\lambda}(1-\tau) - 1 - C(U)\right] A(\tau^l, U) \tag{25}$$

While the previous equation uniquely determines the equilibrium value of U, to close the model and solves uniquely for the stock values, it is necessary to determine also the fraction δ of workers that search in the sub-market with $\tau = \tau^h$. The measure 1 of workers partition in the two markets in the following ways

$$u(\tau^h, \delta) + n_2(\tau^h, \delta) = \delta$$
$$u(\tau^l, \delta) + n_1(\tau^l, \delta) = 1 - \delta,$$

where $u(\tau^h, \delta)$ and $u(\tau^l, \delta)$ are the stocks of unemployed people that search in the submarket with τ^h and τ^l respectively, while $n_2()$ and $n_1()$ are the workers employed in warchest or cash firms respectively. From the previous expression it is evident that in each sub-market workers find only one type of firms, so that $n_1(\tau^h, \delta) = 0$ and $n_2(\tau^l, \delta) = 0$. Using the value of the stock derived in the general equilibrium it is evident that

$$\begin{aligned} u &= (1-\delta)\frac{\lambda}{\lambda + 2\theta q(\theta)} + \delta\frac{\lambda}{\lambda + (1 + (1-\tau))\theta q(\theta)} \\ n_1(\tau^l) &= (1-\delta)\frac{\theta q(\theta)}{\lambda + 2\theta q(\theta)} \\ n_2(\tau^h) &= \delta\frac{\theta q(\theta)(1-\tau}{\lambda + (1 + (1-\tau))\theta q(\theta)} \end{aligned} \tag{26}$$

To uniquely pindown a value of δ, consider that the vacancies posted by each firm are proportional to their desired size, so that $v^h = \kappa I(\tau,^h)$ and $v^l = \kappa A(\tau,^l)$. By definition of market tightness in each sub-market we have that

$$\theta(\tau^l) = \frac{\kappa A(\tau^l)}{n_1(\tau^l)}; \quad \theta(\tau^h) = \frac{\kappa I(\tau^h)}{n_2(\tau^h)};$$

Since we already established that $\theta(\tau^l) = \theta(\tau^h)$, it immediately follows that

$$\frac{n_1(\tau^l)}{n_2(\tau^h)} = \frac{A(\tau^l)}{I(\tau^h)} \tag{27}$$

As we argued in the introduction, leveraged firms are those firms that do not invest funds in external resources and hold no cash reserves. The model thus delivers the following empirical implications

1. leveraged firms are larger;
2. firms that are less leveraged are less exposed to refinancing risks
3. leveraged firms fire workers when refinancing fails

The first implication is obvious, and simply follows from the fact $A(\tau^h) > I(\tau^l)$. The second implication is also straightforward, and follows from the fact that firms that use cash do not directly respond to a specific marginal change in τ as long as they are already in the cash equilibrium. To consider the third empirical implication consider a marginal increase in τ so that $\tau^{h2} > \tau^{h2}$ and $\tau^{l2} > \tau^{l2}$ but assume that $\tau^{h2} > \tau* > \tau^{2l}$, so that the qualitative behavior of the two type of firms does not change. We can call this situation an **increase in refinancing risk**. It is obvious that only firms that are leveraged will fire workers and will be affected by the financial shock.

The following section evaluates the empirical relevance of the last implication.

5 Leverage and Employment Adjustment

The model above predicts that firms that are less leveraged are less vulnerable to financial shocks. Cash-constrained firms have to cut down capacity as credit frictions increase, reducing employment more than firms that built up a war chest of liquid assets, to be used in case of adverse financial shocks. in other words, the holding of liquid assets makes the firm less efficient in normal times, but provides an insurance against financial shocks.

In this section we test the above empirical implication of the model drawing on a dataset of firm-level employment adjustment and leverage during the Great Recession. Our data cover the period 2007-9 and are obtained by matching data from the EFIGE survey of European firms with information from balance sheets obtained in the Amadeus archive. Efige samples some 16,000 European firms

Table 1: Measures of Leverage, Descriptive Statistics

Country	Number of Firms	Revenues growth 2008-2009		Size of Firms (Employees 2007)	
		Average	Standard Deviation	Average	Standard Deviation
AUT	443	63.5%	0.740	100	33
FRA	2,973	-8.3%	0.010	50	8
GER	2,935	-5.2%	0.008	96	11
HUN	488	-12.4%	0.015	68	9
ITA	3,021	-18.6%	0.005	40	2
SPA	2,832	-16.8%	0.015	45	3
UK	2,067	0.1%	0.032	20	773

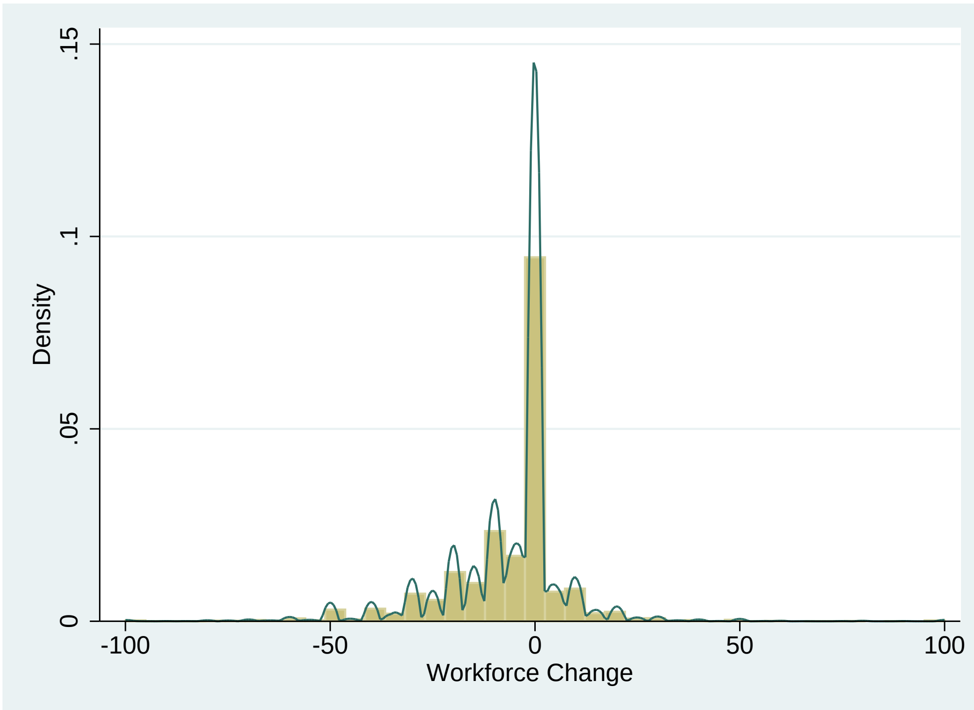
Variable	Average	Min	Max	Standard Deviation
Gearing Ratio (2007)	1.20	0.00	997.53	175.46
Solvency Ratio (2007)	33.62	-99.00	100.00	25.74
Long Term Debt to Assets (2007)	0.12	0.00	17.39	0.36
Δe	-6.18	-100	100	15.16
$\Delta \bar{y}$	-0.09	-0.30	5.64	0.39
Size of Firms (2007)	116.65	0.00	365,630	3,595.00
Third Party Collateral	0.04	0	1	0.21

(3,000 in large countries, such as Germany, France, Italy, Spain and the UK, and 500 firms in smaller countries, such as Austria and Hungary). The questionnaire is very detailed on a number of structural characteristics of firms such as organization, job composition, innovation activities, finance as well as product and labor market strategies. The Amadeus archive provides financial and business data on Europe's biggest 500,000 companies by assets. Hence, the matched sample covers only large firms (the average firm size in terms of employees is 81) which creates problems of cross-country comparability.

Table 1 provides some descriptive statistics on the measures of leverage which are used in the empirical analysis in 2007, the year before the beginning of the Great Recession. In particular, the *Gearing ratio* is the debt to equity ratio measuring the extent to which the firm is using creditor's vs. owner's funds. The *Solvency Ratio* measures the ratio of after tax net profit (excluding non-cash depreciation expenses) over debt and is a measure of one company's ability to meet long-term obligations. Finally, the *Long-term debt to assets ratio* evaluates the importance of the debt having a duration longer than one year and therefore less exposed to a liquidity crisis: it measures loans and financial obligations lasting more than one year over total assets of the firm. As shown by table 1, there is significant cross-country and within country (across sectors) variation in these measures. At the same time, there are large differences in the average size of firms across countries, which confirms that data are not cross-country comparable.

We are interested in evaluating employment adjustment during the Great Recession. Consequently, our main variable of interest is defined by drawing on the following question asked to employers at the beginning of 2010: *During the last year (2009) did you experience a reduction or an increase/decrease of your workforce in comparison with 2008?* . For those stating to have changed employment levels,

Figure 6: Firm-level net employment change, Distribution of firms



a second question elicited the percentage change in the workforce. We imputed a zero value to firms declaring that they did not experience any change in employment in the first question. Figure 6 plots the distribution of firms in the -100(%) to +100 (%) range using also a Kernel density estimator (blue line) to characterise the distribution. As we are dealing with a global recession year, most firms appear to be downsizing: the median is 0, the mean is -6. In addition to the mode at 0, there are also some spikes at -10, -20 and -30. This may indicate that respondents answered doing some rounding. Some of our estimates below take into account of such heaping.

In order to obtain preliminary insights as to the importance of finance in employment adjustment, figure 7 plots the Kernel estimates for firms that successfully applied for credit (continuous line), as well as firms that did not apply for credit (dotted line) or that applied, but were not successful (dash line). This suggests that the firms that were un-succesfull in refinancing operations were, on average, heavily downsizing (on average by almost 20 %) while the distribution of employment adjustment among successful debtors and firms that did not apply for credit is remarkably similar. The concentration of employment losses (about 30 per cent of the total) among firms experiencing difficulties in refinancing operations is not informative as to causality: it may well be that firms did not obtain credit because they were downsizing and considered not be viable creditors by banks.

Table 3 reports estimates of the following equation

$$\Delta e_{ijc} = \alpha + \alpha_j + \alpha_c + \alpha_j * \alpha_c \beta \Delta y_{jc} + \gamma Lev_{ijc} + \delta S_{ijc} + \epsilon_{ijc} \tag{28}$$

where Δe is the reported employment growth rate *during* the period 2008-9, i denotes the firm, j the sector and c the country, S is set of size dummies (employment or turnover) and Lev is either the Gearing Ratio, the Solvency Ratio or the Long-term Debt to Asset ratio all measured *before* the Great Recession (according to 2007 balance sheet data). We also include country and sector dummies

Figure 7: Firm-level net employment change, Distribution of firms by access to credit

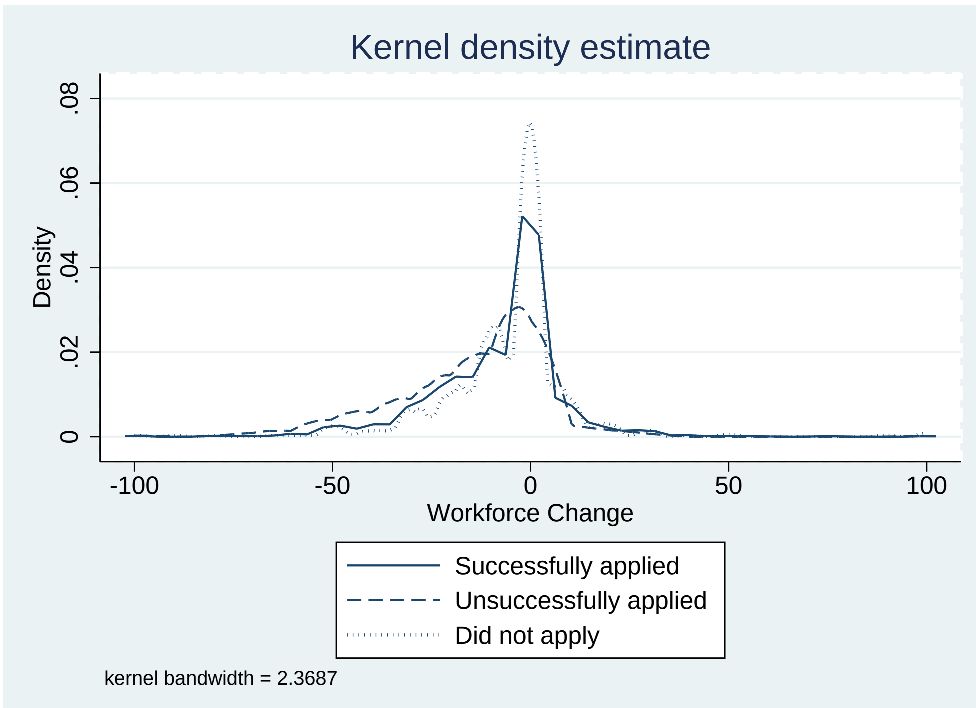


Table 2: All Firms

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	$\Delta e(\%)$	$\Delta e(\%)$	$\Delta e(\%)$	$\Delta e(\%)$	$\Delta e(\%)$	$\Delta e(\%)$
Method	OLS	IV	OLS	IV	OLS	IV
			Second stage			
$\Delta \bar{y}$	1.107	-57.31	1.049	98.56	1.040	727.4
	(0.910)	(133.3)	(0.901)	(169.1)	(0.910)	(1533)
Gearing	-0.004***	-0.029**				
	(0.001)	(0.012)				
Solvency			0.04***	0.603***		
			(0.006)	(0.213)		
LT DA					-0.133	-346.4
					(0.607)	(630.0)
Constant	-8.123***	-13.09	-10.73***	-13.19	-10.02***	108.8
	(2.594)	(17.11)	(2.630)	(20.69)	(2.555)	(243.5)
Country	YES	YES	YES	YES	YES	YES
Sector	YES	YES	YES	YES	YES	YES
Country*Sector	YES	YES	YES	YES	YES	YES
Size	YES	YES	YES	YES	YES	YES
			First stage			
		Gearing		Solvency		LT DA
Third party collateral		108.24***		-6.846***		0.012
		(16.476)		(1.686)		(0.022)
Observations	8596	2358	9649	2900	8064	2324

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

as well as interactions between the two sets of dummies.

The odd columns of table 5 report the OLS estimates of the above equation. The gearing ratio is negatively associated with plant-level employment change while for the solvency ratio it is the opposite. Long-term debt instead does not seem to significantly affect plant level job creation and destruction. Leverage is clearly endogenous. The remaining three columns of table 5 display 2-stages least squares estimates in which leverage is instrumented by a dichotomic variable capturing firms that can use third party collateral being part of a consortium of firms. The underlying identification assumption is that the presence of this collateral affects the (equilibrium) level of leverage prevailing before the financial crisis while it does not directly affect employment variation during the Great Recession. The first-stage results point to a significant (and positive) effect of third party collateral on leverage. In the second stage we still find a negative and statistically significant effect of leverage on firm-level employment adjustment. The effects of leverage on employment adjustment is non-negligible: bringing, say, a typical Austrian firm to the average gearing ratio of a German firm involves additional employment losses of the order of 3 per cent during a financial recession; increasing by 10 basis points the solvency ratio (like moving an average Italian firm to France) involves a 6 per cent increase of employment.

As shown by the bottom row of Table 2, the 2SLS estimates have substantially less observations that the OLS estimates. This is because there are many missing values in the question about third party collateral. In the Statistical Annex regressions are displayed that replace missing values with 0. There are not substantial differences.

Table 3: Only Firms Downsizing

VARIABLES	(1) $\Delta e(\%)$	(2) $\Delta e(\%)$	(3) $\Delta e(\%)$	(4) $\Delta e(\%)$	(5) $\Delta e(\%)$	(6) $\Delta e(\%)$
Method	OLS	IV	OLS	IV	OLS	IV
			Second stage			
$\Delta\bar{y}$	0.547	-95.87	1.322	14.79	1.378	-181.8
	(1.243)	(132.8)	(1.209)	(179.7)	(1.243)	(739.2)
Gearing	-0.003**	-0.034*				
	(0.001)	(0.017)				
Solvency			0.057***	0.748**		
			(0.009)	(0.314)		
LT DA					-2.449*	-343.7
					(1.474)	(669.0)
Constant	-20.23***	-24.75	-23.08***	-31.40	-21.95***	-38.91
	(3.314)	(16.62)	(3.324)	(21.79)	(3.268)	(91.39)
Country	YES	YES	YES	YES	YES	YES
Sector	YES	YES	YES	YES	YES	YES
Country*Sector	YES	YES	YES	YES	YES	YES
Size	YES	YES	YES	YES	YES	YES
			First stage			
		Gearing		Solvency		LT DA
Third party collateral		88.366***		-5.928***		0.012
		(21.310)		(1.989)		(0.024)
Observations	4151	1195	4677	1458	3783	1091

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3 and 4 display estimates of equation (28) when only firms downsizing or only firms upsizing are considered. We report also in this case both OLS and 2SLS results. This suggests that the correlation between leverage and firm-level employment adjustment is driven by firms that are downsizing. We do not find significant effects of leverage on employment adjustment when using instrumental variables.

The effects of leverage survive when we put on the left-hand-side a categorical variable (0 for downsizing, 1 for firms keeping the same employment level, 2 for those upsizing) in order to cope with the heaping problems mentioned above. There is still a statistically significant effect, which is in line with the model's predictions. We also run regressions (reported in the annex) including firm-level output growth (rather than the average growth rate at the sectoral level) as right-hand-side variable. Such a specification clearly creates a problem of endogeneity, but potentially captures idyosincratic shocks unrelated to the financial recession. Also in this case, there is still an effect of leverage on employment growth. Coefficients are remarkably stable across these different specifications.

Overall, the firm-level results suggest that leverage matters for employment adjustment during a financial recession and affects mainly job destruction. Ceteris paribus, more leveraged firms destroy more jobs than firms with a higher solvency ratio.

Table 4: Only Firms Upsizing

VARIABLES	(1) $\Delta e(\%)$	(2) $\Delta e(\%)$	(3) $\Delta e(\%)$	(4) $\Delta e(\%)$	(5) $\Delta e(\%)$	(6) $\Delta e(\%)$
Method	OLS	IV	OLS	IV	OLS	IV
			Second stage			
$\Delta\bar{y}$	-0.0915	-33.53	3.051	2388	0.734	61.58
	(3.048)	(679.9)	(2.029)	(184896)	(3.557)	(376.5)
Gearing	-0.0041*	0.0354				
	(0.0023)	(0.171)				
Solvency			-0.007	12.71		
			(0.017)	(1001)		
LT DA					0.025	-28.87
					(0.727)	(251.7)
Constant	16.84***	0.976	17.36***	-401.6	16.75***	16.73
	(5.979)	(106.2)	(6.126)	(32826)	(6.154)	(45.25)
Country	YES	YES	YES	YES	YES	YES
Sector	YES	YES	YES	YES	YES	YES
Country*Sector	YES	YES	YES	YES	YES	YES
Size	YES	YES	YES	YES	YES	YES
			First stage			
		Gearing		Solvency		LT DA
Third party collateral		31.11***		0.082		-0.021
		(68.121)		(7.166)		(0.103)
Observations	1060	307	1181	379	1033	325

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5: All firms (Δe categorical)

VARIABLES	(1) $\Delta e(\%)$	(2) $\Delta e(\%)$	(3) $\Delta e(\%)$
$\Delta \bar{y}$	-0.0157	-0.0165	-0.0201
	(0.0420)	(0.0411)	(0.0426)
Gearing	-0.000160***		
	(3.95e-05)		
Solvency		0.00104***	
		(0.000293)	
LT DA			0.0249
			(0.0286)
Constant	0.589***	0.522***	0.541***
	(0.120)	(0.120)	(0.119)
Country	YES	YES	YES
Sector	YES	YES	YES
Country*Sector	YES	YES	YES
Size	YES	YES	YES
Observations	8,693	9,757	8,161
R-squared	0.078	0.076	0.072

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6 Final Remarks

We develop a micro-founded model of labor-finance interactions generating endogenously a demand for liquid assets. The models yields a number of testale implications. The most relevant in the context of the Great Recession is that highly leveraged firms should experience larger employment losses during a financial crisis. Micro data on employment adjustment and balance sheets indicate that highly leveraged firms and sectors are characterized by higher job destruction rates during financial recessions. If our identification assumptions are deemed plausible, the relationship between leverage and employment adjustment can be interpreted as a causal effect of leverage on employment adjustment.

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7 Theoretical Annex

8 Statistical Annex

Table 6: All firms, replacing with 0s missing values for third party collateral

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	$\Delta e(\%)$	$\Delta e(\%)$	$\Delta e(\%)$	$\Delta e(\%)$	$\Delta e(\%)$	$\Delta e(\%)$
Method	OLS	IV	OLS	IV	OLS	IV
			Second Stage			
$\Delta\bar{y}$	1.107	1.216	1.049	1.628	1.039	-9.038
	(0.910)	(0.951)	(0.901)	(1.050)	(0.910)	(7.400)
Gearing	-0.004***	-0.029***				
	(0.0008)	(0.007)				
Solvency			0.039***	0.409***		
			(0.006)	(0.087)		
LT DA					-0.133	-172.4
					(0.607)	(115.5)
Constant	-8.138***	-6.174**	-10.74***	-25.26***	-10.04***	-10.20
	(2.594)	(2.764)	(2.630)	(4.580)	(2.555)	(8.473)
Country	YES	YES	YES	YES	YES	YES
Sector	YES	YES	YES	YES	YES	YES
Country*Sector	YES	YES	YES	YES	YES	YES
Size	YES	YES	YES	YES	YES	YES
			First Stage			
	Gearing		Solvency		LT DA	
Third Party Collateral	159.592***		-13.33***		0.030	
	(13.622)		(1.536)		(0.019)	
Observations	8,593	8,593	9,646	9,646	8,061	8,061

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

9 The Model with a frictionless labor market

The labor market is frictionless and the wage is w. Labor supply is perfectly inelastic and workers work as long as the equilibrium wage w is larger than z, the shadow value of leisure. There is a measure 1 of workers. Workers can be hired at no costs.

In the limit version of the model as $c \to 0$, unemployment disappear and the labor market is charaterized by an endogenous wage along an inelastic labor supply. In other words, the endogenous wages is the permanent income of the workers so that $w \to rU$, and free entry of firms ensure determines the equilibrium value of the endogenous wage. As long as such wage is larger than a workers' reservation utility z, the limit model delivers full employment. Total profits thus read

Table 7: All firms, firm specific Δy

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	$\Delta e(\%)$	$\Delta e(\%)$	$\Delta e(\%)$	$\Delta e(\%)$	$\Delta e(\%)$	$\Delta e(\%)$
Method	OLS	IV	OLS	IV	OLS	IV
			Second Stage			
Δy	4.527***	12.89***	4.779***	14.73***	4.074***	12.58**
	(0.315)	(1.159)	(0.310)	(1.216)	(0.314)	(5.411)
Gearing	-0.004***	-0.034***				
	(0.001)	(0.013)				
Solvency			0.042***	0.594***		
			(0.007)	(0.205)		
LT DA					0.350	-292.6
					(0.640)	(462.9)
Constant	-11.17***	-4.574	-13.86***	-32.21**	-13.02***	4.667
	(3.179)	(12.44)	(3.193)	(16.01)	(3.119)	(60.85)
Country	YES	YES	YES	YES	YES	YES
Sector	YES	YES	YES	YES	YES	YES
Country*Sector	YES	YES	YES	YES	YES	YES
Size	YES	YES	YES	YES	YES	YES
			First Stage			
	Gearing		Solvency		LT DA	
Third Party Collateral	98.691***		-7.560***		-0.016	
	(16.626)		(1.58)		(0.094)	
Observations	7,569	1,882	8,373	2,238	6,880	1,701
R-squared	0.103	0.061	0.101	-0.213	0.085	-21.229

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8: Only firms downsizing, firm specific Δy

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	$\Delta e(\%)$	$\Delta e(\%)$	$\Delta e(\%)$	$\Delta e(\%)$	$\Delta e(\%)$	$\Delta e(\%)$
Method	OLS	IV	OLS	IV	OLS	IV
			Second Stage			
Δy	10.07***	6.329***	8.818***	12.28***	7.706***	6.413
	(0.904)	(1.952)	(0.768)	(2.316)	(0.821)	(8.496)
Gearing	-0.003**	-0.049**				
	(0.001)	(0.025)				
Solvency			0.054***	0.754**		
			(0.010)	(0.322)		
LT DA					-0.594	-396.3
					(1.847)	(843.8)
Constant	-20.61***	-10.63	-23.39***	-39.84**	-22.43***	3.198
	(3.830)	(17.07)	(3.805)	(19.71)	(3.797)	(86.19)
Country	YES	YES	YES	YES	YES	YES
Sector	YES	YES	YES	YES	YES	YES
Country*Sector	YES	YES	YES	YES	YES	YES
Size	YES	YES	YES	YES	YES	YES
			First Stage			
	Gearing		Solvency		LT DA	
Third Party Collateral	76.504***		-6.861***		0.019	
	(22.76)		(2.011)		(0.021)	
Observations	3,646	977	4,058	1,159	3,219	823

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 9: Only firms upsizing, firm specific Δy

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	$\Delta e(\%)$	$\Delta e(\%)$	$\Delta e(\%)$	$\Delta e(\%)$	$\Delta e(\%)$	$\Delta e(\%)$
Method	OLS	IV	OLS	IV	OLS	IV
			Second Stage			
Δy	0.559*	6.865***	0.628*	8.730***	0.643*	7.123
	(0.334)	(2.338)	(0.349)	(3.109)	(0.360)	(7.520)
Gearing	-0.003	-0.048				
	(0.00218)	(0.0865)				
Solvency			0.001	-0.594		
			(0.018)	(1.286)		
LT DA					-0.145	193.4
					(0.697)	(996.5)
Constant	17.05**	11.03	16.47*	55.85	16.32*	18.06
	(8.082)	(17.93)	(8.508)	(95.18)	(8.500)	(67.32)
Country	YES	YES	YES	YES	YES	YES
Sector	YES	YES	YES	YES	YES	YES
Country*Sector	YES	YES	YES	YES	YES	YES
Size	YES	YES	YES	YES	YES	YES
			First Stage			
	Gearing		Solvency		LT DA	
Third Party Collateral	53.056		4.092		-0.016	
	(70.059)		(6.396)		(0.094)	
Observations	918	239	1,004	282	863	230

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

$$V(w) = S_1(A, I) - I\widetilde{\lambda} - A$$

that after substitution of the surplus read

$$V(w) = \left[\left(\frac{y-w}{r+\lambda} - 1 \right) (1 + \tilde{\lambda}(1-\tau)) \right] A + \lambda\tau \left[\frac{y-w}{r+\lambda} - 1 \right] I \tag{29}$$

. The NPV of the pledgeable income writes

$$P = Y_0 + \frac{\rho(y-w)A}{r+\lambda}$$

The firms' maximization problem can now be written as

$$\begin{aligned} V(w) \quad &= \quad \max_{A,I} \left[\left(\frac{y-w}{r+\lambda} - 1 \right) (1 + \tilde{\lambda}(1-\tau)) \right] A + \lambda\tau \left[\frac{y-w}{r+\lambda} - 1 \right] I & (30) \\ \text{s.t.} \quad & I\widetilde{\lambda} + 1A - P \geq 0 & (31) \\ & 0 \leq I \leq A; \;\; A \geq 0; \;\; I \geq 0 \end{aligned}$$

where- given the nature of the war chest and the structure of the shock- the war chest itself can not be larger than the investment A while they both need to be non negative.

Making use of the definition of $S_1(A, I)$ from equation **??** and the financial constraint 10, the firm problem is

$$\begin{aligned} V(w) \quad &= \quad \max_{I,A} \left[\left(\frac{y-w}{r+\lambda} - 1 \right) (1 + \tilde{\lambda}(1-\tau)) \right] A + \lambda\tau \left[\frac{y-w}{r+\lambda} - 1 \right] I & (32) \\ s.t. \;\; I \quad &= \quad -\frac{A}{k(U)\widetilde{\lambda}} + \frac{Y_0}{\widetilde{\lambda}}; \;\; I \leq A \end{aligned}$$

The objective function makes clear that the firm's value is a weighted average between investing in capacity A and accumulating a war chest I. Given the linear nature structure of the model and the firm's isoprofit, the firm equilibrium will be at a corner solution. Figures 3 and 2 describe the two possible equilibria. In Figure 2 the maximize capacity is A and the firm does not hold any cash reserve. We label such condition the *no cash* equilibrium. Conversely, in Figure 3 the firm use cash and operate along the constraints $I = A$. We label such condition the Warchest equilibrium, as we argue next

Definition 16 *The firm optimization problem has two possible outcomes. In the No cash Equilibrium the firm maximizes capacity and does not use any cash. In the Warchest equilibrium the firm holds cash in equilibrium so that $I = A$*

The derivation of the two equilibria depends on the relative slopes of the iso-profits and the borrowing constraint. The warchest equilibrium requires that the slope of the isoprifts be-in absolute value- smaller than the slope of the borrowing constraint, so that we can obtain a simple condition for the war chest equilibrium.

Proposition 17 *The firm will choose to hold cash and establish a warchest equilibrium as long as*

$$\left[\frac{y-w}{r+\lambda} - 1 \right] (1 + \tilde{\lambda}(1-\tau)) \leq \tilde{\lambda}\tau \left[\frac{y-w}{r+\lambda} - 1 \right] \frac{1}{k(w)\tilde{\lambda}} \tag{33}$$

proof. The slope of the isoprofit is immediately obtained from equation **??** while the slope of the borrowing constraint is given by equation 11. The condition simply imposes that the former is smaller than the latter, simplifying this implies that

$$(1+\tilde{\lambda}(1-\tau)) \leq \tilde{\lambda}\tau \frac{1}{k(w)\tilde{\lambda}} \tag{34}$$

Theorem 18 *As market frictions disappers and the labor market tends to a frictionless labor market ($c \to 0$, $rU \to w$), cash is never used in equilibrium*

Proof. In the Appendix we solve the limit version of the as frictions disappear and workers fully participate in the labor market. The appendix shows that in such model, the cash condition becomes

$$(1+\widetilde{\lambda}(1-\tau)) \leq \frac{\widetilde{\lambda}}{k(w)\widetilde{\lambda}} \tag{35}$$

where $k(w) = \frac{1}{1-\rho\frac{y-w}{r+\lambda}} > 1$. As the lhs is cearly greater than one, the rhs is strictly less than one as long as teh multiplier $k(w) > 1$. Thus cash is never used in such frictionless labor market.. .