Aggregate Implications of Financial and Labor Market Frictions*

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(Preliminary and incomplete version)

Abstract

This paper develops a model with both financial and labor market frictions, and jointly analyzes the precautionary behavior of firms and households. Financial frictions generate costly bankruptcy risk for firms and limited insurance against unemployment risk for workers. We solve and simulate a calibrated version of the model and show that the precautionary decisions of households and firms interact with each other to significantly amplify the effect of financial factors on aggregate output and unemployment, even in the absence of price and wage rigidity. This result can be interpreted as a negative demand externality. Firms fire workers to maximize profits, but do not internalize the negative effect of the increase in unemployment on households. Households consume less to increase precautionary saving, but do not internalize the negative impact of their decision on firms' profits and default risk. The importance of this externality is quantitatively large. We calibrate an economy with moderate default risk in firms and a very small risk aversion and precautionary behavior of households, obtaining an equilibrium unemployment level of 6.5%. Increasing risk aversion to more realistic levels increases equilibrium unemployment up to 11.1%. The same increase in risk aversion applied to an economy with more severe firm financing frictions increases unemployment from 7.7% to 21.6%. Finally, we conduct policy experiments and analyze to what extent firing costs and unemployment benefits reduce the impact of this negative externality.

Keywords: Precautionary Savings, Unemployment Risk, Borrowing Constraints, Firm Bankruptcy Risk

JEL Classification Numbers: E21, E24, G33

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1 Introduction

Households and firms take precautionary measures to face an uncertain future. Households reduce consumption and increase savings when unemployment risk increases. Firms lay off workers or scale down expansion plans if demand growth becomes more volatile. This precautionary behavior should be an important element in evaluating the importance of financing frictions especially during financial crises and recessions, which are periods of heightened uncertainty. This paper develops a model with both financial and labor market frictions, and jointly analyses the precautionary behavior of firms and households. We solve the model and simulate an economy where financial frictions generate bankruptcy risk for firms and limited insurance against unemployment risk for households, and we show that the precautionary decisions of households and firms interact with each other to amplify the effect of financial factors on aggregate output and unemployment.

In the model we consider an economy populated by heterogeneous firms and heterogeneous households. Firms use labor to produce a good which can be consumed but not stored. A fixed amount K of an asset which we call "capital" is also available in the economy. Capital is owned by households and firms, is accepted as medium of exchange, and is the numeraire of this economy. In addition, the stock of capital K provides a return every period in terms of consumption goods, and is the only saving technology available to firms and households.

In the production side of the economy, several industrial conglomerates create firms by matching vacancies with unemployed workers. Firms are provided an initial endowment of capital by the conglomerates. Enforceability problems imply that this initial capital is small, and prevent firms from obtaining additional external resources once they are in operation. Firms have finite lives, because with some exogenous probability their technology becomes obsolete and they liquidate all their assets and shut down. In addition, firms face fluctuations in production costs which cause fluctuations in profits. Therefore if they suffer too large losses and run down their wealth, they go bankrupt and must liquidate even though they are still productive. Firm dynamics generated by these assumptions are realistic: firms are created small, face a high risk of defaulting when young and small, but if they survive they accumulate wealth and become financially unconstrained. In the demand side of the economy, the household sector is modeled as in the Bewley-Huggett-Aiyagari framework, where consumers are risk-averse and face idiosyncratic unemployment risk, which is endogenous in our model. We assume households are unable to borrow so they can only insure partially against this risk through saving by accumulating capital.

We compute the steady state equilibrium of this economy in the absence of aggregate shocks. We simulate different economies for different parameter values, and we show that when firm financing constraints are severe an increase in households' risk aversion and precautionary motive increases the unemployment level in the steady state significantly. The intuition for this result is that both firms and households use capital to save. Firms retain earnings while they are active and as long as the risk of bankruptcy is sufficiently high, and in equilibrium the aggregate stock of capital held by firms increases in their profits. Therefore when households want to save more for precautionary reasons, they reduce consumption and increase their demand of capital, thus reducing the price of the consumption good and the equilibrium interest rate r. In other words, households obtain more capital in equilibrium by reducing the profits and the capital holdings of firms. Suppose now that in this economy there is an unexpected and permanent increase in financial frictions, so that both the number of defaults and the unemployment rate increase. Now households expect that they are more likely to get fired and that, once fired, they will remain unemployed for a longer time. They save more, but in doing so they reduce firms' profits, and make them more financially fragile and more likely to go bankrupt, thus further increasing unemployment and households' precautionary saving.

In the model described so far, bankruptcy is inefficient because it destroys future expected revenues. In reality it also carries fixed bankruptcy costs, which further reduce the residual value of the firm. When we introduce these additional bankruptcy costs in the model, firms with low wealth choose to liquidate their business in advance in order to avoid paying them. So when households increase precautionary savings, which makes firms expect to obtain lower profits and be more vulnerable to future negative cost shocks, the firms choose to liquidate the business for precautionary reasons sooner than before. This precautionary or "voluntary" firing of workers interacts with the precautionary saving of households and greatly amplifies the negative effects of financing frictions on unemployment and output.

This result can be interpreted as a negative demand externality. Firms fire workers to maximize profits, but do not internalize the negative effect of the increase in unemployment on households. Households consume less to increase precautionary saving, but do not internalize the negative impact of their decision on the firms default risk. Our simulations show that the effects of this externality are quantitatively very large. We calibrate an economy with default risk but with a very small risk aversion and precautionary behavior of households, obtaining an equilibrium unemployment level of 6.5%. Increasing risk aversion to more realistic levels, from a coefficient of 0.5 to 4, increases equilibrium unemployment up to 11.1%. The same increase in risk aversion applied to an economy with more severe financing frictions results in a much larger increase in unemployment, which goes from 7.7% to 21.6%.

This paper is related to the recent literature on the aggregate consequences of financing frictions, and in particular on the relation between credit market frictions and unemployment. The link between financial frictions and firing is documented in several empirical papers. For example Campello, Graham and Harvey (2010) use data from the recent great recession to estimate that "Constrained firms planned to cut 10.9% of their employees in 2009, compared to 2.7% at unconstrained firms". More broadly, there is evidence of a precautionary behavior of firms during the recent crisis. Kahle and Stulz

(2011) document that firms on average have increased cash holdings, decreased net equity issuance, and decreased investment, a pattern consistent with firms reacting to increased uncertainty and the anticipation of future credit constraints rather than to currently binding ones. Regarding the theory, our model is related to Krusell, Mukoyama & Sahin, (2009), who consider labor market frictions and heterogeneous households facing incomplete markets, and to Petrosky-Nadeau (2009), who considers a model where financing frictions affect job creation by increasing the cost of posting vacancies.[1]

Monacelli, Quadrini and Trigari (2011) instead consider the relation between financial shocks and wage bargaining. In their model a financial shock reduces the borrowing capacity of firms and increases the surplus being contracted between employer and employees. Therefore wages increase, thus reducing the incentives to create vacancies and equilibrium employment levels. In common with Monacelli, Quadrini and Trigari (2011), in our paper financial frictions affect employment in equilibrium even though the investment decisions of firms are not constrained by a binding borrowing limit. However, we emphasize the importance of precautionary firing of firms, and its interaction with precautionary saving of households.

This paper is also related to the recent research on the financial crisis and the liquidity trap. In particular, Guerrieri and Lorenzoni (2011) develop a model with heterogeneous entrepreneurial households who face uninsurable idiosyncratic shocks and borrowing constraints. They show that an unexpected and permanent tightening of the borrowing limit causes a large drop in the interest rate in the short term, as many households increase precautionary saving. This drop in the interest rate increases consumption and reduces labor supply, and the authors show that for their calibration the drop in labor supply is so large that a recession is generated along the adjustment path of the interest rate. Guerrieri and Lorenzoni (2011) further show that the contraction in output is larger if monetary policy cannot reduce nominal interest rates below the zero lower bound. In

[1] Other papers in this literature are Wesmair and Weil (2004) and Chung (2009).

common with Guerrieri and Lorenzoni (2011), we consider the interaction between financial imperfections and precautionary saving. However, we focus on firms' in addition to households' financing constraints. More importantly, we also introduce labor market frictions, which imply that the unemployment level is endogenous. This feature is essential for our results, because changes in unemployment risk increase, via the households' drop in consumption, precautionary firing of firms and amplify the permanent drop in output in the steady state.

The outline of this paper is as follows: Section 2 describes the model, Section 3 illustrates the calibration and the steady state, section 4 shows the main quantitative results, and section 5 concludes.

2 The Model

We introduce an infinite horizon, discrete-time closed economy populated by two types of agents; workers and capitalists. Workers provide their labor to firms, which are run by industrial conglomerates which are in turn owned by the capitalists. There are two goods in this economy, a perishable consumption good c produced by the firm, and a durable capital good in fixed aggregate supply K which acts as the numeraire. The capital good is the only storage technology in this economy, and one unit produces a return of b units of the consumption good each period.[2] Firms face idiosyncratic cost shocks, and their productivity z is constant across firms and over time.

2.1 Firms

An industrial conglomerate creates a firm when a vacancy is matched with an unemployed worker. Each firm is assigned to a capitalist who manages it with the objective of maximizing the net present value of dividends paid to the conglomerate. In this section we illustrate the activity of firms, while we will describe the vacancy creation decision

[2] The capital good could be thought of as a tree that does not depreciate and that produces each period b units of consumption goods.

of the conglomerate and the consumption decisions of capitalists in sections 2.2 and 2.3 respectively.

Firms produce consumption goods using labor as the only factor of production, and production is subject to idiosyncratic profits shocks. More specifically, each firm produces each period a constant amount z plus a risky amount which has zero mean and is equal to $-\varepsilon$ with probability θ and $(\theta/(1-\theta))\varepsilon$ with probability $(1-\theta)$. $\varepsilon > 0$ can be interpreted as a cost or reinvestment shock. The firm sells each consumption good at price P (in terms of units of capital). The per-period operating profits of a firm are thus given by:

$$\pi(s) \equiv P\left(z + s(-\varepsilon) + (1-s)\frac{\theta}{1-\theta}\varepsilon\right) - w, \tag{1}$$

where the variable $s \in \{0, 1\}$ captures the occurrence of a negative productivity shock and w is the wage paid to the worker. This wage is determined according to an expected revenue sharing rule:

$$w = \varphi P z, \tag{2}$$

where φ satisfies $0 < \varphi < 1$. Implicit in this rule are the assumptions that the idiosyncratic shock is not contractible, so the wage w cannot be made contingent on s, and that the wage is renegotiated every period.

Firms can transfer resources to the next period by accumulating units of capital, which yield a return r in equilibrium. Current holdings of capital of a firm are denoted by a_F. As a result, asset holding dynamics of an active firm are given by:

$$a'_F(s) = a_F(1+r) + \pi(s) - d(a_F), \tag{3}$$

where $d(a_F)$ are dividend payments.

When an industrial conglomerate creates a firm, it provides it with its initial endowment of capital. Financing frictions are introduced with the following three assumptions: (i) the initial endowment cannot be larger than $a_{F,start} > 0$. (ii) Once a firm is created it becomes an independent unit, and it cannot borrow from its own conglomerate, or from other conglomerates, or from workers. In exchange for the initial investment $a_{F,start}$, the conglomerate receives dividend payments. (iii) Firms must maintain a minimum positive amount of asset holdings $\underline{a}_F$ in their balance sheets, where $\underline{a}_F < a_{F,start}$. If assets fall below $\underline{a}_F$, a firm must liquidate and is only able to distribute a fraction χ of its wealth a_F to the conglomerate, where $0 \leq \chi \leq 1$. The bankruptcy cost $(1-\chi)\, a_F$ is not a deadweight loss, but instead is considered fees paid to other industrial conglomerates in return for services provided in connection with the bankruptcy procedure. We interpret assumptions (i)-(iii) as a shortcut for a moral hazard problem between the conglomerate and the manager of the firm. The following two constraints capture assumptions (ii) and (iii), respectively:

$$d(a_F) \geq 0. \tag{4}$$

$$a_F \geq \underline{a}_F, \tag{5}$$

Constraint (4) specifies that dividends have to be positive, which implies that firms need to rely entirely on retained earnings following their creation, and constraint (5) requires that firms' holdings of assets need to be at least equal to $\underline{a}_F$.

At the beginning of each period a firm may continue operating or it may exit. If the firm exits, it liquidates its activity, it may have to pay firing costs to the worker, and pays a final dividend d_{exit} to the conglomerate. A firm may cease to operate for three reasons. First, a firm is forced to liquidate if it does not have sufficient internal resources to absorb a cost shock. In other words, when conditional on suffering the shock its wealth falls below $\underline{a}_F$:

$$a_F(1+r) + Pz - w - \varepsilon < \underline{a}_F, \tag{6}$$

In this case the firm is only able to distribute $d_{exit} = \chi a_F < a_F$ to the conglomerate. Second, even if the firm is not forced to liquidate, it may still exit for exogenous reasons, if its technology becomes useless, and this happens with probability η. In this case, the firm has to pay a firing cost to the worker equal to Fcw, where $Fc > 0$ is severance payments measured in terms of wages, and is able to distribute all of its assets, net of firing costs, as dividends, so $d_{exit} = a_F - Fcw$. Finally, the firm may decide to stop production for precautionary reasons, in order to avoid the costly bankruptcy procedure associated to a forced exit due to insufficient wealth and preserve its asset holdings. Precautionary exit happens when $J(a_F) < a_F - Fcw$, where $J(a_F)$ is the discounted present value of the dividends distributed to industrial conglomerates. That is, when the firm's value is lower than the value of terminating the firm and distributing all assets a_F net of firing costs Fcw as dividends.[3] In this case the firm is liquidated and $d_{exit} = a_F - Fcw$ is paid as dividends to the conglomerate.

In summary, the liquidation dividend $d_{exit}(a_F, E)$, where $E \in \{forced, exogenous, voluntary\}$ captures the nature of the firm exit, is given by:

$$d_{exit}(a_F, E) = 1_{forced}\chi a_F + (1_{exogenous} + 1_{voluntary})(a_F - Fcw) \tag{7}$$

where 1(.) is an indicator function which is equal to one if the argument is true and zero otherwise. The exit decision is captured by the probability at the beginning of a period that a firm exits during that period, which we represent with $\sigma(a_F) = \{\eta, 1\}$, where

$$\sigma(a_F) = \eta + (1-\eta)1_{forced} + (1-\eta)(1-1_{forced})1_{voluntary} \tag{8}$$

The probability is never lower than η given that there is always the exogenous possibility of closure, and may otherwise be equal to 1 when the firm will close with certainty for either forced or voluntary reasons. The value $J(a_F)$ of a firm with asset holdings a_F, calculated at the beginning of a period and conditional on continuation, is given by:

[3]Notice that precautionary closures happen in equilibrium because of the bankruptcy loss $(1-\chi)a_F$. In other words, $J(a_F) - a_F$ may go to zero even if $a_F(1+r) + Pz - w - \varepsilon > 0$, because $J(a_F)$ incorporates the net present value of losing $(1-\chi)a_F$ in the future.

$$J(a_F) = \max_{d(a_F)} d(a_F) + \sum_{s=0,1} \beta p_s \left\{ \sigma(a'_F(s)) d'_{exit}(a'_F(s), E) + [1 - \sigma(a'_F(s))] J(a'_F(s)) \right\}. \quad (9)$$

Firm valuation is done using the common discount rate β.[4] Equation 9 implies that the firm chooses continuation dividends $d(a_F)$ before observing the current cost shock. Because of the possibility of inefficient liquidation, profit maximization requires that the manager of the firm retains all earnings while the firm is active and has low asset holdings, a situation in which there is a non-negligible probability of facing a forced or voluntary exit. Beyond a certain asset threshold, however, the likelihood of facing a non-exogenous exit is so small that if the equilibrium return on savings r is smaller than discount rate β, then the firm will want to distribute as dividends all asset holdings beyond that threshold.

2.2 Vacancies and Matching

There are many capitalists available as potential managers, a number in excess of the number of unemployed consumers N^u. Vacancies and unemployed workers are randomly matched each period and an aggregate constant returns-to-scale matching function specifies that $M(N^u, N^v)$ matches will be created when there are N^u unemployed workers and N^v vacancies. A conglomerate that wishes to form a match with a worker posts a vacancy which costs ξ, which is the value of effort made by capitalists in the conglomerate.[5] The probability that this vacancy is filled in the current period is $\lambda_f = M(N^u, N^v)/N^v$ and the probability that an unemployed worker finds a job is $\lambda_w = M(N^u, N^v)/N^u$. When a worker gets matched, he starts working immediately in the current period. The optimal

[4] Firms use β as the rate to discount future dividends because in equilibrium Capitalists perfectly diversify the idiosyncratic risk of the firms they own.

[5] In other words, the vacancy cost is not an expenditure the conglomerate makes but an amount of disutility for capitalists who are involved in vacancy creation, which the conglomerate internalizes and we assume is equivalent to ξ units of capital.

number of vacancies solves:

$$[J(a_{F,start}) - a_{F,start}] \frac{\partial M(N^u, N^v)}{\partial N^v} - \xi = 0, \tag{10}$$

where $J(a_{F,start}) - a_{F,start}$ is the net present value of profits expected by a newly created firm. The resulting unemployment dynamics are:

$$u' = (1 - \lambda_w)u + (1 - u) \int \sigma(a_F) dF(a_F). \tag{11}$$

The first term in the right hand side of equation (11) captures existing unemployed workers who are not matched to a firm this period, while the second term captures the destruction of jobs at the beginning of this period. A worker that loses his job this period does not enter the pool of unemployed until next period.

2.3 Industrial Conglomerates and Capitalists

There is a continuum of mass 1 of identical industrial conglomerates, who perform several functions. They finance firm creation, which requires providing resources to cover the initial firm wealth $a_{F,start}$. They collect dividends from firms. They provide services in connection with firms' bankruptcy processes for which they receive a fraction $(1 - \chi)$ of the assets of the bankrupt firm. Finally, they pay taxes T to the government, and pay the residual (DIV) out as dividends to capitalists each period:

$$\begin{aligned} DIV = \int_{not\ exit} d(a_F) dF(a_F) + \eta \quad & \int a_F dF(a_F) + \int_{forced} \chi a_F dF(a_F) \\ + \int_{voluntary} a_F dF(a_F) \quad & + \int_{forced} (1 - \chi) a_F dF(a_F) - a_{F,start} M(N^u, N^v) - T \end{aligned} \tag{12}$$

We claim that DIV is always positive, and check that this is the case in our numerical simulations. Conglomerates do not transfer any wealth from period to period, but instead pay out all of their net resources at the end of each period to capitalists, who are assumed to be unable to borrow and therefore consume each period the constant dividend they receive. The assumption that they never postpone consumption is not restrictive because we consider equilibria where $1 + r < 1/\beta$.

2.4 Workers

Workers receive income from labor, are risk averse, face uninsurable unemployment risk, and can save by accumulating units of capital. A worker who is employed chooses asset holdings a' and consumption c in order to solve the following maximization problem:

$$W(a, a_F) = \max_{c,a'} \left\{ u(c) + \beta \sum_{s=0,1} p_s[\sigma(a'_F(s))U(a' + Fcw) + (1 - \sigma(a'_F(s)))W(a, a'_F(s))] \right\} \tag{13}$$

where β is the discount rate, a are the asset holdings of the worker at the start of the period and $W(a, a_F)$ is the value associated to being a worker with asset holdings a who is employed in a firm with asset holdings a_F. Workers may lose their job with probability $\sigma(a'_F(s))$ the following period and become unemployed, which is associated with a value $U(a' + Fcw)$.[6] Workers only terminate a match with a firm when the firm exits, because it is never optimal for them to leave a firm voluntarily. The budget constraint of the worker is:

$$Pc + a' = a(1 + r) + w(a_F). \tag{14}$$

Workers face financing constraints, and are unable to borrow, which implies that:

$$a' \geq 0. \tag{15}$$

The solution to the problem faced by an employed worker are policy rules $a'(a, a_F)$ and $c(a, a_F)$.

[6] Notice that when a worker is fired next period, her asset holdings will equal her savings a' plus the firing costs w_{exit} she receives.

A consumer who is unemployed during period t solves the following problem:

$$U(a) = \max_{c,a'} \left\{ u(c) + \beta[(1-\lambda'_w)U(a') + \lambda'_w W(a', a'_{F,start})] \right\} \tag{16}$$

subject to:

$$Pc + a' = a(1+r) + h, \tag{17}$$

and the same borrowing constraint as an employed worker. Unemployed workers receive an unemployment benefit each period from the government, h, and the probability that a worker finds a job and exits unemployment the following period is λ_w. Should he find a job, the firm with which he is matched will have just entered the market with an asset level $a'_{F,start}$, and so the value associated to being a worker of a newly created firm next period is $W(a', a'_{F,start})$. The solution to the problem faced by an unemployed worker are decision rules $a'(a)$ and $c(a)$.

2.5 The Government

The government runs a balanced budget every period. It collects enough taxes T from the industrial conglomerates to pay the unemployment benefit h to unemployed workers:

$$T = N^u h \tag{18}$$

2.6 Competitive Equilibrium

The goods market equilibrium condition is:

$$(1-u')\int\int c_w(a,a_F)f_e(a,a_F)da\,da_F + u'\int c_u(a)f_u(a)da + DIV/P = zN^{1-u} \tag{19}$$

where $f_e(a, a_F)$ is the function that describes the joint distribution of asset holdings of the workers and asset holdings of the firms for which they work, and $f_u(a)$ is the distribution function of unemployed workers' asset holdings. The first two terms in the left-hand-side capture workers' aggregate consumption (employed and unemployed, respectively), and the third term corresponds to capitalists' aggregate consumption. Total output is given by output per firm z multiplied by the number of active firms N^{1-u}.

The market for capital is cleared by virtue of Walras' Law, and the resulting interest rate r is given by:

$$1 + r = 1 + Pb, \tag{20}$$

given that one unit of capital produces b units of the consumption good each period.

2.7 Recursive Stationary Equilibrium

Definition 1 *The recursive stationary equilibrium consists of a set of value functions* $\{W(a_F, a),\ J(a_F),\ U(a)\}$, *a set of decision rules for asset holdings* $\{a'_w(a, a_F),\ a'_u(a)\}$, *a firm exit decision* $\sigma(a_F)$, *dividends* d, *prices* $\{P,\ r\}$, *vacancies* v, *government taxes* T, *matching probabilities* λ_f *and* λ_w, *and distributions* $f_e(a, a_F)$ *and* $f_u(a)$,*which satisfy:*

Employed Worker optimization

The value function $W(a_F, a)$ and decision rule $a'_w(a, a_F)$ solve (13) subject to (14) and (15), given prices P and r, matching probability λ_w, and firm exit decision $\sigma(a_F)$.

Unemployed Worker optimization

The value function $U(a)$ and decision rule $a'_u(a)$ solve (16) subject to (17) and (15), given prices P and r, matching probability λ_w, and firm exit decision $\sigma(a_F)$.

Operating firm optimization

The value function $J(a_F, a)$ and decision rules $\sigma(a_F)$ and d solve (**??**) subject to (3), (5) and (4), given prices P and r and matching probability λ_f.

Vacancy posting and matching

The number of vacancies posted, v, solves (10). $\lambda_f(z, S)$ and $\lambda_w(z, S)$ are functions of v and u, where the dynamics of u are given by (11).

Consumption Good Market Equilibrium

Price P satisfies the consumption good market equilibrium condition (19).

Capital Market Equilibrium

Interest rate r satisfies the capital market equilibrium condition (20).

Government Budget

The government chooses taxes T to satisfy (18).

Consistency

The density functions $f_e(a, a_F)$ and $f_u(a)$ are the invariant distributions generated by asset choices $a'_w(a, a_F)$ and $a'_u(a)$, firm exit decision $\sigma(a_F)$, dividends d, vacancies v, matching probabilities λ_f and λ_w, and rate of return r.

3 Calibration

We analyze the model by numerical simulations, so we first specify the relevant functional forms and choose parameter values. We assume the utility function of workers is isoelastic

$$u(c) = \frac{c^{1-\gamma}}{1-\gamma}. \tag{21}$$

The risk aversion parameter γ also determines the degree of precautionary behavior. The aggregate matching function for the labor market is as in den Haan, Ramey, and Watson (2000). It is assumed to be constant returns to scale of the form

$$M(N^u, N^v) = \frac{N^u N^v}{(N^{uL} + N^{vL})^{\frac{1}{L}}}, \tag{22}$$

which ensures that the number of matches never exceeds $\min(N^u, N^v)$. Our baseline parameters are in Table 1, and the time period is a quarter. The discount factor β of workers is set at 0.99, and the labor share of profits φ is set equal to 0.5, in line with most of the literature. Among the other parameters, a first set is calibrated to match a set of empirical moments. The matching is not perfect but broadly in line with the empirical evidence. The two parameters that affect the labor market, the vacancy costs

ξ and the matching efficiency L are set so that the worker's job finding rates and the firm job finding rate in the simulated data are consistent with their empirical counterparts. The parameters that describe the firms' technology (z, ε, θ, η and $a_{F,start}$) are determined so that several empirical regularities are broadly delivered in the model, in particular the volatility of profits, the probability of negative profits, the relationship between the size of young and old firms, and the average duration of firms. The matching is reasonably good except the standard deviation of the profits/sales ratio, which is much larger in the model than in the empirical data. This is partly due to the binary nature of the shock ε, and to the fact that "sales" in the model should be interpreted as added value from labor. So the denominator of the profits/sales ratio is much smaller in the model than in the data.

A second set of parameters is not set to a specific value. These are the parameters affecting the amount of precautionary saving (γ and h) and the intensity of financing frictions ($\underline{a}_F$ and χ). We simulate the artificial economy for different values of these parameters, because the aim of this section is precisely to analyze how different levels of financing frictions affect equilibrium output and employment for different levels of employment risk and of risk aversion. Finally, we consider policy experiments where we vary the level of unemployment benefit h and of firing costs Fc.

3.1 Steady State

We simulate the steady state of an economy with $200,000$ workers and a stock of capital K equal to $2,000,000$.

We now briefly describe the policy functions of workers and firms. For all the figures in this section we assume that the recovery rate χ is equal to zero, and that $\underline{a}_F$ is sufficiently large to generate some defaults of firms in equilibrium. In order to facilitate the comparison between economies with different equilibrium price of the capital good, the values are expressed in units of the consumption good. Starting with the workers,

Table 1: Calibration

Parameter (Symbol)	Value	Empirical Moment	U.S.data	Model
Parameters matched to an empirical moment				
Firm starting wealth ($a_{F,start}$)	2.9	$\frac{\text{Median}(a_F(\text{age}=1))}{\text{Median}(a_F)}$	0.47(1)	1.24
Size of liquidity shock (ε)	0.8	St.Dev(profits/sales)	0.35(1)	2.28
Prob. of liquidity shock (θ)	0.2	Prob(profits<0)	0.25(1)	0.20
Exog. prob of job destr. (η)	0.025	Avg firm dur. (if age>5)	43(1)	45
Vacancy cost (ξ)	1	Firm job finding rate (λ_f)	0.71(2)	0.70
Efficiency of matching (L)	1.27	Work. job finding rate (λ_w)	0.45(2)	0.45
Productivity of firms (z)	0.2	Worker separation rate	0.08-0.11(2)	0.039
Productivity of capital (b)	0.003	Interest rate	2%	1.3%
Parameters taken from the literature				
Discount factor (β)	0.99			
Labor share (φ)	0.5			
Sensitivity analysis				
Risk aversion (γ)	$0.5-4$			
Unemployment Benefit (h)	$2\%-50\%$(3)			
Firing costs (Fc)	$0-200\%$(3)			
Minimum firm wealth ($\underline{a}_F$)	$0-2$			
Bankruptcy recovery rate (χ)	$0-1$			

(1) Own calculations using Compustat and Capital IQ for U.S. listed firms.
(2) Den Haan, Ramey and Watson (2000)
(3) In percentage of the quarterly wage

their savings policies are shown in Figure 1, for the cases of coefficient of relative risk aversion $\gamma = 0.5$ and $\gamma = 4$. Unemployed workers consume their entire unemployment benefit, and in addition they slowly decrease their asset holdings to smooth consumption, and do so to a larger extent the larger their wealth. When asset holdings fall towards zero, dissaving also falls to zero, because of a binding borrowing constraint. Employed workers instead display a buffer stock behavior and have positive saving rates if their assets are low, and this behavior is significantly stronger when $\gamma = 4$. It is worth stating that the unemployment benefit h is only 2% of wages in the benchmark calibration. Employed workers with high asset holdings slowly dissave.

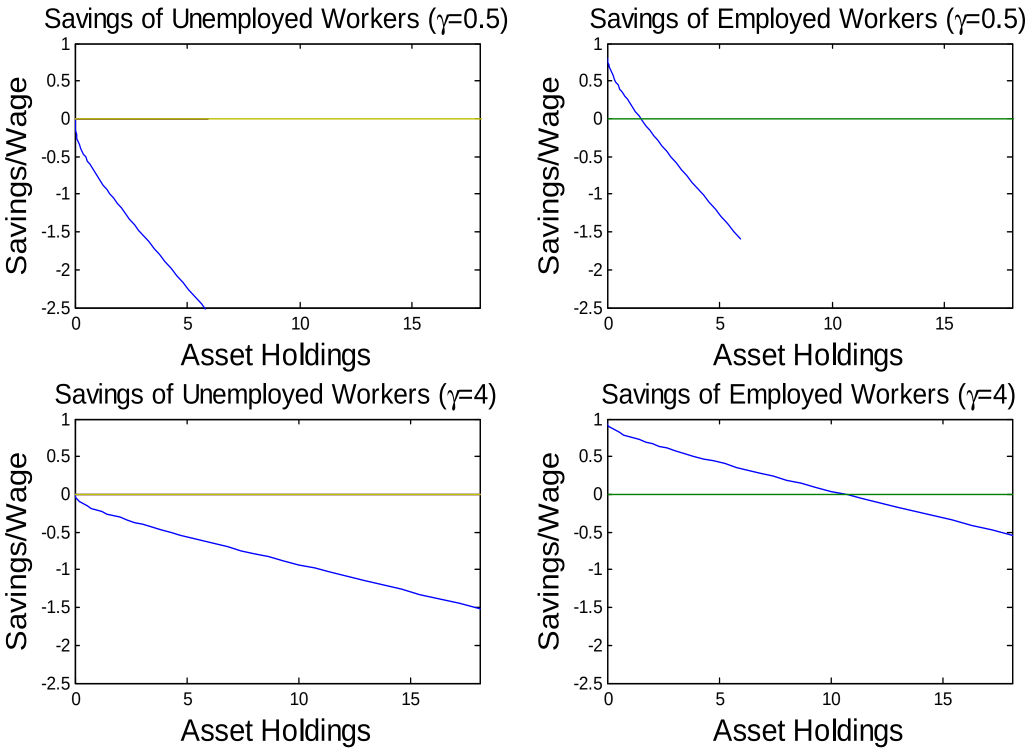

Figure 1: Workers' Saving Policy Functions

The distribution of asset holdings of workers and firms is displayed in Figure 2. The precautionary behavior of workers on the one hand, and their consumption smoothing motive on the other, ensure that their asset holdings converge to a smooth distribution which is relatively symmetric around its mean. When $\gamma = 4$, the strong precautionary behavior of workers induces them to hold more capital, and capital is itself more expensive in terms of the consumption good, than when $\gamma = 0.5$. As a consequence the real asset holdings increase tenfold when raising the risk aversion coefficient from $\gamma = 0.5$ to $\gamma = 4$.

The distribution of firms' asset holdings are determined by three key values. The first important value is initial wealth $a_{F,start}$, which is around 3. Once created, firms that make positive profits increase their wealth until they reach the point at which they start distributing dividends. Since the idiosyncratic shock ε is i.i.d., all firms stop accumulating wealth at the same optimal value in each simulation, and this explains the spike in density around the maximum values of wealth. Between these two values the density is higher on

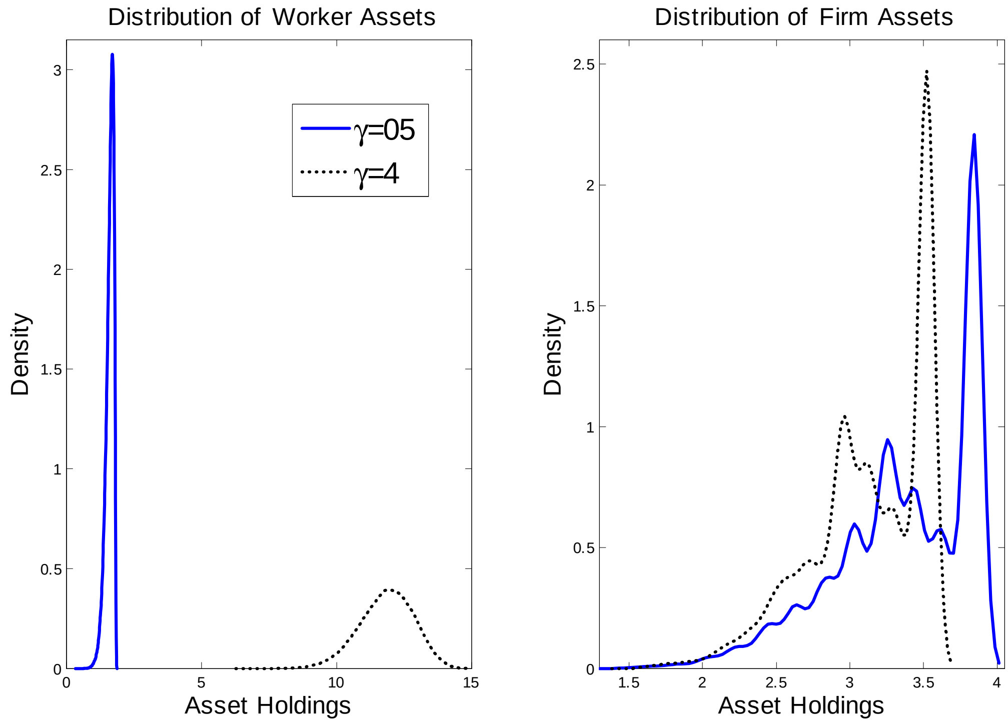

Figure 2: Worker and Firm Asset Holdings Distributions

certain specific points because of the discrete nature of the shock ε. The third important value is the minimum amount of wealth sufficient to stay in the business. Given that firms are created close to the exit region, they will mainly tend to exit for forced or voluntary reasons when young, if they are unlucky and suffer several liquidity shocks. When $\gamma = 4$, workers' strong precautionary behavior induces them to consume less and save more, which drives down the interest rate on wealth and slows wealth accumulation. This in turn means that more firms are concentrated on the left hand side of the distribution, firms are more vulnerable to negative shocks, and all firms have a lower value. In other words, the lower is the interest rate, the longer it takes firms to accumulate wealth to reach the region where they no longer risk inefficient liquidation. Moreover not only are firms on average closer to the threshold of wealth where they exit, but also the threshold itself is higher than when $\gamma = 0.5$ (see figure 3). On the right hand side of the distribution, maximum wealth is lower because firms start distributing dividends earlier. This happens despite the higher risk of forced exit, because the lower interest rate increases the cost of

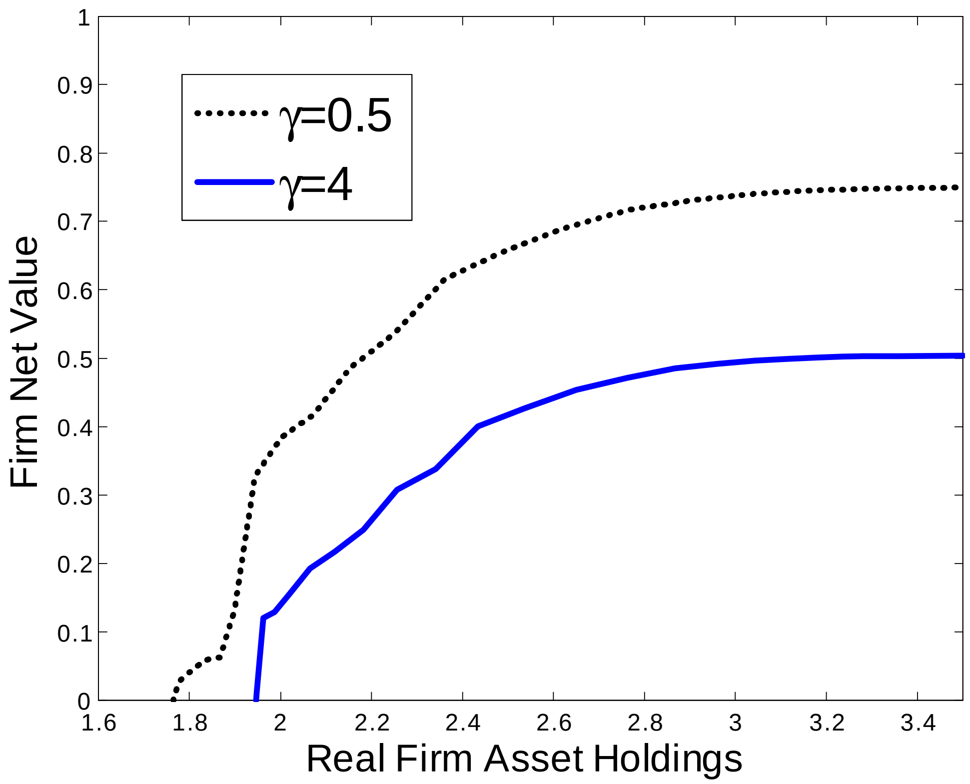

Figure 3: Firm's Exit Decision

postponing dividend payments to capitalists.

Finally, firms' policies with respect to their voluntary exit decision are depicted in Figure 3. In the figure the curves plot the net value of the firm $(J(a_F) - a_F)$. When such value becomes negative the firm exits voluntarily because the net present value of future profits, conditional on positive shocks, is smaller than the net present value of bankruptcy costs conditional on suffering a negative shock and going bankrupt.

Figures 2 and 3 are useful to illustrate the amplification effect between the precautionary saving of firms and workers. Suppose for example that the economy is in the steady state and the degree of risk aversion (γ) and/or the amount of risk (ε) increase unexpectedly and permanently. Workers consume less to increase their savings but the decrease in the interest rate r hurts firm profits, increasing the likelihood of a forced exit. Therefore not only are firms on average less wealthy, but the downward shift of the net value of the firm for $\gamma = 4$ in figure 3 also increases the voluntary exit region. In other words low wealth firms are more likely to exit for precautionary reasons because their growth prospects have worsened, but in doing so they increase both the unemployment risk for workers and the expected duration of unemployment spells. Workers react by further increasing savings and decreasing their consumption, depressing r even more. The final outcome of this process is more precautionary saving of households, more precautionary (voluntary) exits of firms, and a much higher equilibrium unemployment level, as will be discussed in more detail in section 4.

4 Results

In Figure 4 we present the results of simulating the model economy for different values of the workers' coefficient of relative risk aversion γ and of firms' minimum wealth requirement $\underline{a}_F$. We do so for the benchmark calibration discussed in section 3 with bankruptcy recovery rate $\chi = 0$ (so the firm loses 100% of its assets in case of being forced to go bankrupt), low unemployment benefits ($h = 2\%$) and no firing costs ($Fc = 0$).

Variations in γ capture the strength of the workers' precautionary behavior and we experiment with three levels, $\gamma \in \{0.5, 2, 4\}$. In reality changes in the amount of risk are more relevant than changes in risk aversion, and in the model we obtain similar results if we increase risk by increasing ε instead. However the results would be less clean and difficult to interpret, because an increase in ε also affects employment directly by causing more forced exits of firms, while an increase in γ affects employment only indirectly via its effect on the price of capital and the interest rate.

Variations in $\underline{a}_F$ on the other hand capture the intensity of firms' financing frictions. When $\underline{a}_F = 0$, firms' financing constraints almost never bind, because given initial assets $a_{F,start}$ firms require a very large number of cost shocks to occur in a short period of time for them to run down their assets to zero and be forced to liquidate. The probability of this event is very low, and when it happens it does not carry any default cost, so that firms never exit voluntarily. When $\underline{a}_F$ is sufficiently high then the probability of a

Figure 4: **Comparative Statics: Variations in γ and $\underline{a}_F$. (Case: $\chi = 0$)**

χ=0	Price (*P*)	Interest rate (*r*)	Unemployment rate (u)	Average worker assets (a)	Average firm assets (a_F)	Forced exits (% over total firms)	Voluntary exits (% over total firms)
Min Wealth ($\underline{a}_F$)=0							
γ=0.5	0.49	0.610%	4.88%	0.39	2.68	0.04%	0.00%
γ=2	0.91	0.330%	5.71%	3.48	2.09	0.20%	0.00%
γ=4	1.85	0.160%	6.41%	9.33	1.91	0.31%	0.00%
Min Wealth ($\underline{a}_F$)=0.85							
γ=0.5	0.75	0.400%	6.46%	1.61	3.10	0.07%	0.12%
γ=2	1.38	0.220%	8.64%	5.56	2.99	0.07%	0.25%
γ=4	2.24	0.140%	11.07%	10.97	2.85	0.08%	0.40%
Min Wealth ($\underline{a}_F$)=1.14							
γ=0.5	0.78	0.380%	7.70%	1.62	3.36	0.05%	0.26%
γ=2	1.47	0.200%	12.63%	6.05	3.23	0.00%	0.60%
γ=4	2.38	0.130%	21.55%	11.92	3.13	0.00%	0.75%

Note: Wealth is measured in units of the consumption good, and P is the price of capital in terms of the consumption good

bankruptcy is non-negligible and firms occasionally are forced to exit and incur in a loss of value. The loss of value has two components. On the one hand, the firm loses the net present value of future firm profits (net of expected liquidity shocks), which is always positive. On the other hand, the firm loses all of its assets, as $\chi = 0$. Therefore firms who have low assets but are not forced to liquidate may precautionarily exit because the high expected losses from bankruptcy bring $J(a_F)$ below a_F.

In the case of $\underline{a}_F = 0$, in the top part of Figure 4, very few firms go bankrupt and unemployment is low. However, when γ increases from 0.5 to 4, average worker asset holdings increase substantially. This is because workers want to save more to insure against unemployment risk, and as a result, the price of capital increases by almost 400%. Since a unit of capital generates a fixed amount of consumption goods, interest rate r is around 4 times smaller. The lower interest rate slows down wealth accumulation of firms and makes them distribute more dividends to capitalists. As a result average firm asset holdings decrease, and firms are more vulnerable and exit with a higher frequency, causing a larger unemployment rate in equilibrium.

In the middle and lower panels of figure 4 we consider higher values of minimum wealth $\underline{a}_F$. A higher value of $\underline{a}_F$ has two effects. First, firms are more likely to go bankrupt, because their wealth falls below $\underline{a}_F$ after a shorter sequence of negative shocks. On the other hand bankruptcy costs faced by firms that are forced to exit are also higher. The higher probability and higher cost of bankruptcy reduces the value of a firm with low wealth and encourages it to exit voluntarily in order to avoid such costs. When risk aversion is low ($\gamma = 0.5$) the unemployment rate is equal to 7.7% for $\underline{a}_F = 1.14$ (high financing frictions), versus a value of 4.88% in the case of $\underline{a}_F = 0$ (low financing frictions). However, as γ increases the feedback effect between the precautionary behavior of households and firms also increases, reducing the interest rate r, and increasing both voluntary exits and the equilibrium unemployment rate. For $\gamma = 4$ equilibrium unemployment goes from 6.4% for $\underline{a}_F = 0$ to 21.55% for $\underline{a}_F = 1.14$. A very large quarterly frequency of precautionary exits, equal to 0.75%, is responsible for this result. Higher unemployment is also due to lower firm creation, because the higher exit probability reduces the net present value of the firm.

In Figure 5 we present the simulation results for the case in which the bankruptcy recovery rate χ is 1. Firms' forced exit still has costs, which are those associated with the loss of future profits, but since there are no bankruptcy costs firms no longer exit voluntarily and cease to operate only because of forced or exogenous exits. In this case one channel of the feedback effect described before, the increase in voluntary exits of firms when r decreases, is absent. In the absence of this effect, the increases in worker precautionary behavior when $\gamma = 4$, even in the case of severe firm financing frictions ($\underline{a}_F = 2$), generates much smaller increases in unemployment than before. The comparison of figures 4 and 5 highlights the importance of the interaction between workers' and firms' precautionary behavior in generating the results. On the one hand in both the case of χ=1 and χ=0 an increase in risk aversion reduces consumption and firms' profits, increases the probability of bankruptcy, and reduces the value of the firm. On the other

Figure 5: **Comparative Statics: Variations in γ and $\underline{a}_F$. (Case: $\chi = 1$)**

χ=1	Price (P)	Interest rate (r)	Unemployment rate (u)	Average worker assets (a)	Average firm assets (a_F)	Forced exits (% over total firms)	Voluntary exits (% over total firms)
Min Wealth ($\underline{a}_F$)=0							
γ=0.5	0.48	0.620%	4.86%	0.40	2.64	0.05%	0.00%
γ=2	0.89	0.340%	5.75%	3.50	1.94	0.29%	0.00%
γ=4	1.82	0.160%	6.39%	9.22	1.84	0.37%	0.00%
Min Wealth ($\underline{a}_F$)=1.71							
γ=0.5	0.58	0.520%	7.28%	0.11	3.66	0.46%	0.00%
γ=2	0.61	0.490%	7.52%	0.35	3.60	0.49%	0.00%
γ=4	0.66	0.450%	7.99%	0.75	3.51	0.53%	0.00%
Min Wealth ($\underline{a}_F$)=2							
γ=0.5	0.60	0.500%	9.41%	0.12	3.81	0.82%	0.00%
γ=2	0.63	0.470%	10.09%	0.42	3.78	0.86%	0.00%
γ=4	0.69	0.440%	10.89%	0.79	3.76	0.89%	0.00%

Note: Wealth is measured in units of the consumption good, and P is the price of capital in terms of the consumption good.

hand one key element of the amplification effect outlined before is missing in the χ=1 case : the reduction in the value of the firm does not generate any increase in voluntary exits.

5 Policy Implications: Firing costs and unemployment benefits.

The results in the previous section highlight the importance of the feedback between workers' precautionary saving and firms' precautionary firing in amplifying the effect of financing frictions and generating low output and employment in equilibrium. We have shown that such amplification occurs only when both firms and households react to higher unemployment by increasing their precautionary behavior. A corollary of this result is that any policy aimed at reducing the consequences of unemployment for households should dampen their precautionary behavior, reduce this amplification effect and increase employment in equilibrium.

We illustrate this point in more detail with two simple policy experiments. First we study the effect of increasing unemployment benefits financed with lump sum taxes paid by capitalists, and second we introduce firing costs in the form of severance payments in case a firm exits for voluntary or exogenous reasons.

Table 6 illustrates the results. The upper panel displays the results of simulations using the same calibration as in the previous section, with $\gamma = 4$ and $\underline{a}_F = 1.14$. These simulations feature high unemployment arising as a result of financing frictions. The lower panel considers an economy with no bankruptcy costs for firms, and thus no precautionary behavior motive for them, but with relatively high unemployment because of frictions in the labor market (captured by a lower value of matching efficiency l).

An increase in unemployment benefits reduces precautionary savings of workers because these benefits provide insurance against unemployment risk. Lower aggregate savings by workers result in an increase in the equilibrium interest rate and a decrease in the price of capital, which improve firms' financial condition. This effect is strongest when firm financing frictions are severe. In this situation firms' willingness to default voluntarily decreases substantially and the incentives to post vacancies increase, reducing unemployment in equilibrium. An increase in unemployment benefits from 2% to 50% of the equilibrium wage brings the unemployment rate from above 21% to less than 10%. In the opposite case, when firms' precautionary motive is not present because bankruptcy does not carry any costs, the effects of variations in unemployment benefits are muted. Firms' forced exit decreases slightly with an increase in unemployment benefits but given that voluntary exits do not happen in this scenario the amplification effect associated to an increase in firms' precautionary firing is not present. As a result, the variation in the price of capital, the interest rate, unemployment and output is very small.[7]

[7] The unemployment benefit is assumed to be financed by lump-sum taxation on the capitalists. Given that capitalists are hand-to-mouth consumers and thus have a marginal propensity to consume equal to 1, an increase in unemployment benefits will also have the effect of reducing aggregate consumption and increasing aggregate saving as it implies a wealth transfer to workers who have a marginal propensity to consume which is lower than 1.

Figure 6: Policy experiments: firing costs and unemployment benefits.

	Price (P)	Interest rate (r)	Unemployment rate (u)	Average worker assets (a)	Average firm assets (a_F)	Forced exits (% over total firms)	Voluntary exits (% over total firms)
χ=0, Min Wealth ($\underline{a_F}$)=1.14, γ=4: Economy with high unemployment because of financing frictions							
Firing costs=0	2.34	0.130%	21.66%	11.71	3.11	0.00%	0.78%
Firing costs=1	1.97	0.150%	25.30%	9.58	3.14	0.00%	0.74%
Firing costs=2	1.76	0.170%	29.30%	8.42	3.19	0.00%	0.63%
Unemp. Benefit=2%	2.34	0.130%	21.66%	11.71	3.11	0.00%	0.78%
Unemp. Benefit=25%	1.57	0.190%	14.11%	6.77	3.15	0.00%	0.67%
Unemp. Benefit=50%	1.03	0.290%	9.54%	3.23	3.27	0.00%	0.45%
χ=1, Min Wealth ($\underline{a_F}$)=0, γ=0.5, l=0.75: Economy with high unemployment because of labour market frictions							
Firing costs=0	0.52	0.580%	10.08%	0.86	2.50	0.07%	0.00%
Firing costs=1	0.49	0.610%	10.28%	0.66	2.59	0.05%	0.00%
Firing costs=2	0.48	0.630%	10.52%	0.48	2.67	0.04%	0.00%
Unemp. Benefit=2%	0.52	0.580%	10.08%	0.86	2.50	0.07%	0.00%
Unemp. Benefit=25%	0.48	0.630%	9.82%	0.48	2.67	0.04%	0.00%
Unemp. Benefit=50%	0.46	0.660%	9.66%	0.20	2.81	0.03%	0.00%

Note: Wealth is measured in units of the consumption good, and P is the price of capital in terms of the consumption good. Firing costs are severance payments measured in terms of quarterly wages, and unemployment benefits are measured in terms of quarterly wages

Turning to firing costs, we model them as severance payments to workers who are laid off. They have an insurance component similar to the one of unemployment benefits, but different in that they are an up-front fixed payment which is unrelated to the subsequent duration of the worker's unemployment spell. This feature reduces the degree of insurance provided by firing costs, although a combination of large firing costs and a short expected unemployment spell might mean that they are preferred by workers over unemployment benefits. Another potential benefit is that they may reduce voluntary exits by firms and therefore reduce unemployment risk. On the negative side, they reduce firm value and discourage job creation. In both cases, with and without firm bankruptcy costs, the negative effect dominates and firing costs increase equilibrium unemployment rather than reducing it. This negative effect is particularly strong in the simulation with firm precautionary behavior. In this case firm value is already small because of future expected financing constraints, and therefore even a small increase in firing costs may have large negative effects on job creation. Conversely in the simulation with no bankruptcy costs firm value is higher and firing costs have a smaller negative impact.

6 Conclusions

This paper illustrated a model with heterogeneous firms and households, and both financial and labor market frictions. The model aims at capturing some realistic features of the economy: the consumption and saving decisions of workers are affected by unemployment risk; the investment and employment decisions of firms are affected not only by current but also by future expected financial problems, especially during recessions and financial crises. We use the model to study the interaction between the consumption decisions of households and entry and exit decisions of firms. The main message of this quantitative exercise is that, when financing frictions generate a non negligible risk of costly bankruptcy for firms, the interaction between firms and households precautionary behavior greatly amplifies the negative effects of financial factors on the level of output and unemployment. These results are a promising first step towards understanding how financial shocks propagate and affect output and employment, and why periods following financial crises and lower credit availability in the economy are usually characterized by persistently high unemployment levels. As a further step in this research agenda, Caggese and Perez (2012) study to what extent these interactions are important in explaining the observed comovements between financial factors, output and employment fluctuations in the business cycle.

References

[1] Bloom, N. (2009). “The Impact of Uncertainty Shocks”, *Econometrica* 77, 623—686.

[2] Caggese, A, and A. Perez. (2012) "Financial and labor market frictions, precautionary saving, and aggregate fluctuations".

[3] Campello, M., J. Graham and C.R. Harvey (2010). “The Real Effects of Financial Constraints: Evidence from a Financial Crisis", *Journal of Financial Economics*, vol. 97(3), 470-487.

[4] Chugh, S. K. (2009), Costly External Finance and Labor Market Dynamics". Unpublished manuscript, University of Maryland.

[5] Guerrieri, V., and G. Lorenzoni (2011): “Credit Crises, Precautionary Savings and the Liquidity Trap,” Chicago-Booth Working Paper.

[6] Kahle, K., M. and Stulz, R. M. (2011). “Financial Policies, Investment, and the Financial Crisis: Impaired Credit Channel or Diminished Demand for Capital?”, Fisher College of Business Working Paper No. 2011-3.

[7] Krusell,P., Mukoyama,T., and A. Şahin, 2010. "Labor-Market Matching with Precautionary Savings and Aggregate Fluctuations," *Review of Economic Studies*, vol. 77(4), 1477-1507.

[8] Monacelli, T., Quadrini, V. and A. Trigari (2011). "Financial Markets and Unemployment", NBER Working Papers 17389, National Bureau of Economic Research.

[9] Petrosky-Nadeau, N. (2009). "Credit, Vacancies and Unemployment Fluctuations", GSIA Working Papers 2009-E27, Carnegie Mellon University, Tepper School of Business.

[10] Wasmer, E. and P. Weil (2004). The Macroeconomics of Labor and Credit Market Imperfections". *American Economic Review*, 94(4), 944-63.

7 Computational Appendix

To be added.