Financial Frictions and Un(der)employment Insurance PRELIMINARY*

Marco Brianti
Boston College

Tzuo Hann Law
Boston College

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Abstract

We study the effects of unemployment insurance (UI) and underemployment insurance (EI) in a general equilibrium model of search and matching featuring financial frictions and risk-averse workers. Equilibrium is inefficient because the market insures risk-averse workers through low-unemployment and low-wage jobs. Additionally our model features underemployment risk which manifests in two ways. First, employed workers inefficiently separate because firms cannot retain workers due to financial frictions. Second, employed workers face wage uncertainty. Underemployment risk further lowers capital utilization. UI alleviates unemployment risk but exacerbates underemployment risk. EI is required to restore efficiency even when workers are risk neutral. UI and EI together restore efficiency when workers are risk averse.

*Correspondence: Department of Economics, Boston College, 140 Commonwealth Avenue, Chestnut Hill, MA 02467. Email: brianti@bc.edu (Marco Brianti) and tzuo.law@bc.edu (Tzuo-Hann Law).

1 Introduction

We study the impact of unemployment insurance (UI) and underemployment insurance (EI) on labor market outcomes when financial frictions are present. More specifically, firms are unable to borrow or reissue equity after hiring and cannot condition debt repayment on idiosyncratic productivity shocks. As a result, firms cannot fully insure risk-averse workers from wage fluctuations. We conduct our analysis in a general equilibrium model of search and matching with aforementioned financial frictions. In our model, equilibrium is inefficient for two reasons. First, as in Acemoglu and Shimer (1999), risk averse workers wish to avoid unemployment and in response, the market insures workers through equilibrium low wage jobs with lower unemployment rates. The increased vacancy risk reduces capital utilization leading to sub-optimally low equilibrium capital-labor ratios. Secondly, employed workers face two risks after matching. Workers face separation risk because constrained firms are unable to retain workers while simultaneously making interest payments. Workers also face wage risk because firms are not able to smooth wages across states of the world. This lowers capital utilization further. Interestingly, separation risk due to financial frictions induces inefficiencies even when workers are risk neutral.

We consider the roles of unemployment insurance (UI) and underemployment insurance (EI) in restoring efficient allocations. UI is well known and we model it as a transfer to workers who remain unemployed after the matching phase of our model. EI supplements wages of employed workers. Examples of real world implementations include *Kurzarbeit* (short-work) in Germany described in Contessi and Li (2013). In our model, all transfers are funded by lump sum taxes on workers' initial wealth.

We highlight the interaction of the two insurance channels and explain how they work to restore efficiency. As in Acemoglu and Shimer (1999), UI in our model encourages risk-averse workers to apply to higher wage jobs with higher unemployment risk.[1] EI remedies the inefficient competitive market via two distinct channels. First, EI insures workers from wage and

[1] We assume as do Acemoglu and Shimer (1999) that search effort is exogenous. As they point out in their paper, our results remain so long endogenous reductions in search effort are not too large.

separation risk. Second, EI reduces the cost of capital for all firms since lower separation risks facilitates lower competitive interest rates.

We consider two implementations of EI. The first implementation eliminates inefficient separations but does not remedy wage risk. This form of EI is sufficient to restore efficiency when workers are risk neutral. In this implementation, UI and EI interact in an interesting manner. Higher UI increases the minimum wage that a firm must pay to retain a worker because of increased incentives to quit. This effectively increases the states of the world where the firm cannot simultaneously meet debt and wage obligations – increasing inefficient separations and necessitating more EI. When workers are risk averse, we use an implementation of EI which eliminates separation risk *and* ensures that all employed workers enjoy the same level of consumption. This implementation of EI along with the appropriate level of UI restores efficiency. We also show that with UI alone, it is impossible to achieve efficiency. Our results imply that unemployed workers must provide insurance to employed workers to obtain efficiency.

Our mechanism requires inefficient separations or incomplete insurance among employed workers in *some* states of the world. For clear exposition, we use a stylized model where inefficiencies are present in all states of the world post matching. In particular, we assume that firms cannot raise any capital after matching and cannot condition debt payments on productivity. In effect, we rule out *all* capital markets post matching. In the paper, we explain how our results survive relaxation of some assumptions.

To the best of our knowledge, we are the first to consider how UI and EI affect labor market outcomes when firms are unable to fully insure workers post matching. We are not the first to consider the impact of unemployment benefits in the presence of risk-aversion through the lens of DMP. As previously mentioned, our paper is most closely related to Acemoglu and Shimer (1999). We analyze an extra insurance channel in the presence of financial frictions and ex-post idiosyncratic productivity relative to their setup. Our model nests theirs and the first best outcomes are the same in both models by design to facilitate clear isolation of the channels that we explore. We are also related to Golosov et al. (2013) who propose regressive taxes to achieve constrained efficiency. In their model, firms use no capital, are ex-ante heterogeneous and there are no financial frictions post matching. A menu of wages due to ex ante firm heterogeneity is posted in their model while in our model, a single wage contract is posted and all wage variation is ex-post after productivity shocks realize. Our papers are of course related to earlier seminal works of Diamond (1982), Mortensen (1977), Pissarides (2000), Hosios (1990) and Moen (1997). Our choice of embedding financial frictions and default into a search model to study how labor market insurance affects labor market outcomes is empirically motivated. Gilson (1990) find that firms experience heightened turnover when under financial distress. Agrawal and Matsa (2013) find that high unemployment benefits lead to high corporate leverage particularly for labor-intensive and financially-constrained firms.

We proceed to describe the model and present our main results. We discuss limitations in the implementation of EI, explain how our paper relates to Acemoglu and Shimer (1999) and describe the effects of extensions previously mentioned before concluding.

2 Model

There is a continuum 1 of homogeneous workers, each with utility function $u(c)$ over consumption. We assume $u(\cdot)$ to be twice differentiable with $u'(\cdot) > 0$ and $u''(\cdot) \leq 0$. Each worker is endowed with an initial level of asset A which they can either store or invest with a mutual fund. The absence of aggregate risk implies the mutual fund's gross rate of return equals the returns of storage which is 1. Worker's consumption is then equal to the initial level of endowment A, minus a lump-sum tax τ, plus the income deriving either from wages or UI plus home production. Thus, her utility is $u(A - \tau + y)$ where y can be wages, w, or UI plus home production, $b + \zeta^U$.

There is a large mass of potential firms and each of them can access a production function $f : (0, \infty) \to (0, \infty)$ which needs one worker and a strictly positive amount of capital k to produce $\phi f(k)$ units of the consumption good. This function is continuously differentiable with $f'(0) > 1$ and $f''(\cdot) < 0$. Without loss of generality, we assume that $\phi \sim U[0, 1]$ is known only after matching.[2]

Workers and firms look for a successful match in a directed search environment. At the beginning of the period, firms decide whether to rent capital $k > 0$. If it does so, it enters the labor market and posts a state contingent wage schedule $w(\phi)$. In response, each worker observes all wage schedules and decide where to apply. If the worker successfully matches, ϕ is revealed and the firm pays the worker $w(\phi)$. If $w(\phi)$ is greater than $b + \zeta^U$, the match endures, production happens, worker enjoys $w(\phi)$, interest Rk is repaid, and the firm gets what remains as profits. If $w(\phi)$ is smaller than $b + \zeta^U$, the worker quits, and all the capital is lost without debt repayment.

Importantly, we assume that firms cannot issue neither new debt nor equity after the realization of ϕ and hence must pay the lender fixed Rk failing which, the firm is unable to operate. This extreme assumption where the mutual fund is essentially a senior claimant of revenues compared to the worker can be motivated for example by any inability to perfectly condition payments on ϕ except perhaps on whether the firm is operating or not. As long there exist states of the world where the firm is unable insure workers perfectly after matching, the mechanism we highlight in this paper applies.

The rental rate of capital R satisfies a no arbitrage condition $\lambda R = 1$ where λ generically represents the probability of repayment. Firms maximize expected profit and free entry results in zero expected profits. Since firms face budget constraints and cannot borrow, profits are zero in all states of the world. This also means that $w(\phi) = \phi f(k) - Rk$.[3] This wage schedule is sufficiently described by the wage corresponding to maximum output of $\phi = 1$, $\bar{w}$. Further, the wage schedule is bounded below by the consumption level guaranteed by $b + \zeta^U$ as explained in Figure 1.

In equilibrium, all the firms offer the same wage schedule and depending on the number of incoming firms v we define market tightness $\theta = \frac{v}{u}$. Since workers can freely look for a vacancy they will always access the market implying $u = 1$ and $\theta = v$. The number of successful matches is defined by

[2] Replacing ϕ with $F^{-1}(\phi)$ with appropriate technical assumptions gives the desired generality with no substantive change to the proofs.

[3] We explain the more general case where firms are partially funded by equity which in turn, yields a wage schedule where the firm makes positive profits in some states.

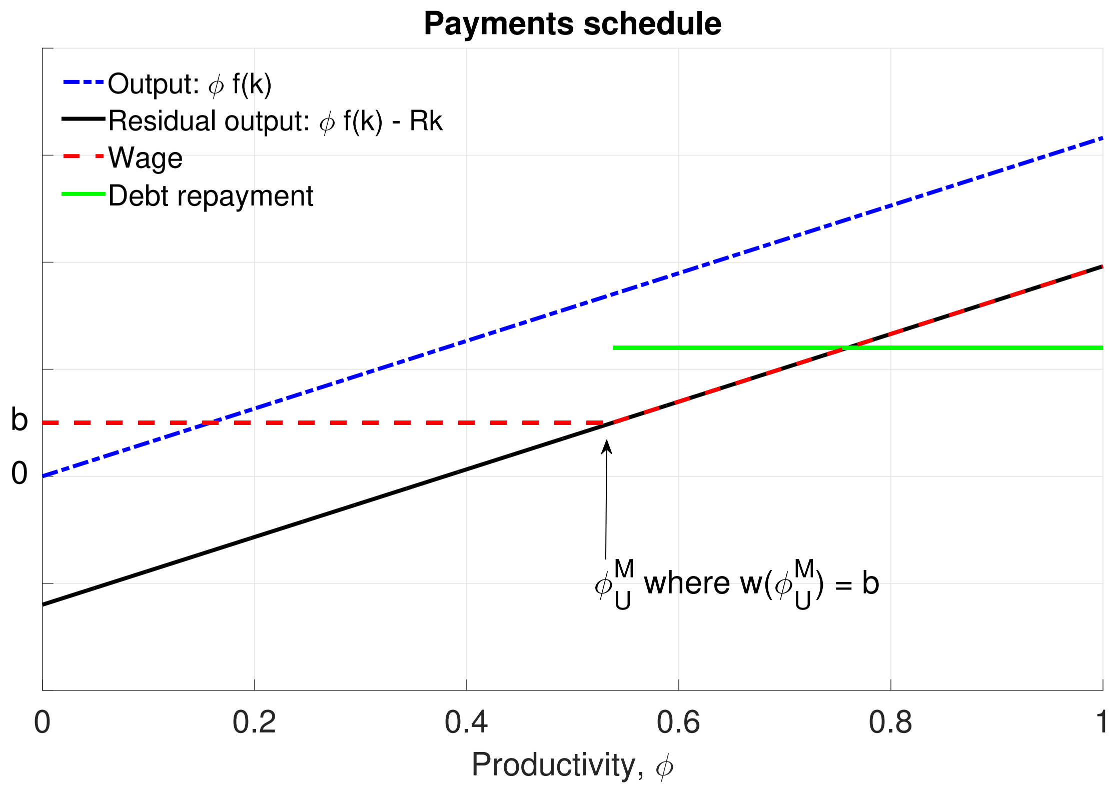

Figure 1: In this example, $\zeta^U = 0$ while $b = 0.5$. The productivity level $\phi \in [0, 1]$ is on the x-axis. Since profits $f(\phi) - w(\phi) - Rk$ cannot be negative, profits must be zero in all states of the world for the expected profit to be zero. Hence, wages equal $w(\phi) = \phi f(k) - Rk$ in all states of the world where the wages exceed b. ϕ_U^M is the threshold where output less debt payments equal b or more generically, $b + \zeta^U$ in the market equilibrium. The firm operates and pays Rk with probability $1 - \phi_U^M$ and the worker consumes following the wage schedule above with b taking over if wages fall below home production.

a constant return to scale matching function $m(u, v)$ which can be rewritten as $m(1, \theta)$. The probability of finding a job equal to $p(\theta) = \frac{m(1,\theta)}{u}$ and the probability of filling a vacancy $q(\theta) = \frac{m(1,\theta)}{v}$.

2.1 Competitive Equilibrium

An allocation is a tuple $\{K, W, \Theta, U\}$, where $K \subset \mathbb{R}_+$ is a set of capital investment levels, $W : \mathbb{R}_+ \to \mathbb{R}_+$ is the set of $\overline{w}$ which describes the wage schedule as explained before. Offered by firms making a specific capital choice, $\Theta : \mathbb{R}_+ \to \mathbb{R}_+$ is the market tightness associated with each $\overline{w}$, and $U \subset \mathbb{R}_+$ is worker's ex-ante utility. In equilibrium, all the firms will make the same capital choice and offer the same wage schedule since both firms and workers are ex ante homogeneous. We use $y^U = b + \zeta^U$ to represent unemployment income to save on notation.

Definition 2.1. *An equilibrium is an allocation $\{K^*, W^*, \Theta^*, U^*\}$ with the following properties*

1. *Profit maximization*

   For all $\overline{w}$ and k

$$q[\Theta^*(\overline{w})]\left[\int_{w(\phi)\geq y^U}[\phi f(k) - w(\phi) - Rk]d\phi\right] \geq 0$$

   with equality if $k \in K^*$ and $\overline{w} \in W^*(k)$. $\overline{w}$ describes $w(\phi)$.

2. *Utility maximization*

   For all $\overline{w}$

$$U^* \geq p[\Theta^*(\overline{w})]\int_{\phi_U^M(k)}^{1}[u(A-\tau+w(\phi))]d\phi + \{1-p[\Theta^*(\overline{w})][1-\phi_U^M(k)]\}u(A-\tau+\zeta^U)$$

   where $\Theta^*(\overline{w}) \geq 0$ with complementary slackness and with equality if $\overline{w} \in W^*(k)$.

3. *Limited commitment*

   For all k

$$w[\phi_U^M(k)] = y^U \quad \Rightarrow \quad \phi_U^M(k)f(k) - Rk = y^U$$

4. *No arbitrage condition*

   For all k and $\overline{w}$

$$q[\Theta^*(\overline{w})][1-\phi_U^M(k)]Rk = k \quad \Rightarrow \quad R = \frac{1}{q[\Theta^*(\overline{w})][1-\phi_b(k)]}$$

Condition 1. ensures that given the market tightness associated with each committed wage, firms choose wages and capital to maximize profits. However, free entry implies the maximized value of profits being zero. Condition 2. is derived by the assumption that workers make their application decisions in order to maximize utility. Condition 3. implies that workers have the right to quit if the realized ϕ implies a wage below the level of unemployment benefits. Condition 4. implies that the financial intermediary is indifferent between investing in a zero-aggregate risk mutual fund or lending resources to an entrant.

2.2 Planner's Solution

We now consider a planner who takes as given the production technology and matching technology. The planner dictates how much capital each firm should use, the number of firms $\theta = v$ who should enter, and at which productivity state a worker should quit and work at home in order to maximize output to be redistributed later. The planner's problem can be stated as

$$\max_{\theta,k,\phi_{SP}} p(\theta)(1-\phi_{SP})\left(A+\underbrace{(1+\phi_{SP})\frac{1}{2}f(k)}_{\mathbf{E}f(k)|\phi>\phi_{SP}}\right)+[1-p(\theta)(1-\phi_{SP})](A+b)-\theta k$$

FOC for θ equates the marginal gain in output from an additional matching to the marginal cost of vacancy creation which in this case is the capital needed to enter the labor market.

$$p'(\theta)(1-\phi_{SP})\left(A+(1+\phi_{SP})\frac{1}{2}f(k)\right)-p'(\theta)(1-\phi_{SP})(A+b)-k=0$$
$$\Rightarrow$$
$$p'(\theta)(1-\phi_{SP})\left((1+\phi_{SP})\frac{1}{2}f(k)-b\right)-k=0$$

FOC for k equates the marginal productivity of capital to the number of firms who enter and survive post match separations.

$$p(\theta)(1-\phi_{SP})\frac{1}{2}(1+\phi_{SP})f'(k)-\theta=0$$
$$\Rightarrow$$
$$(1-\phi_{SP})\frac{1}{2}(1+\phi_{SP})f'(k)-\frac{1}{q(\theta)}=0$$
$$\Rightarrow$$
$$\frac{1}{2}(1+\phi_{SP})f'(k)-\frac{1}{q(\theta)(1-\phi_{SP})}=0 \tag{1}$$

FOC for ϕ_{SP} states that workers should quit if they are producing less than b.

$$\phi_{SP} = \frac{b}{f(k)}$$

Combining the previous three equations yields Figure 2.

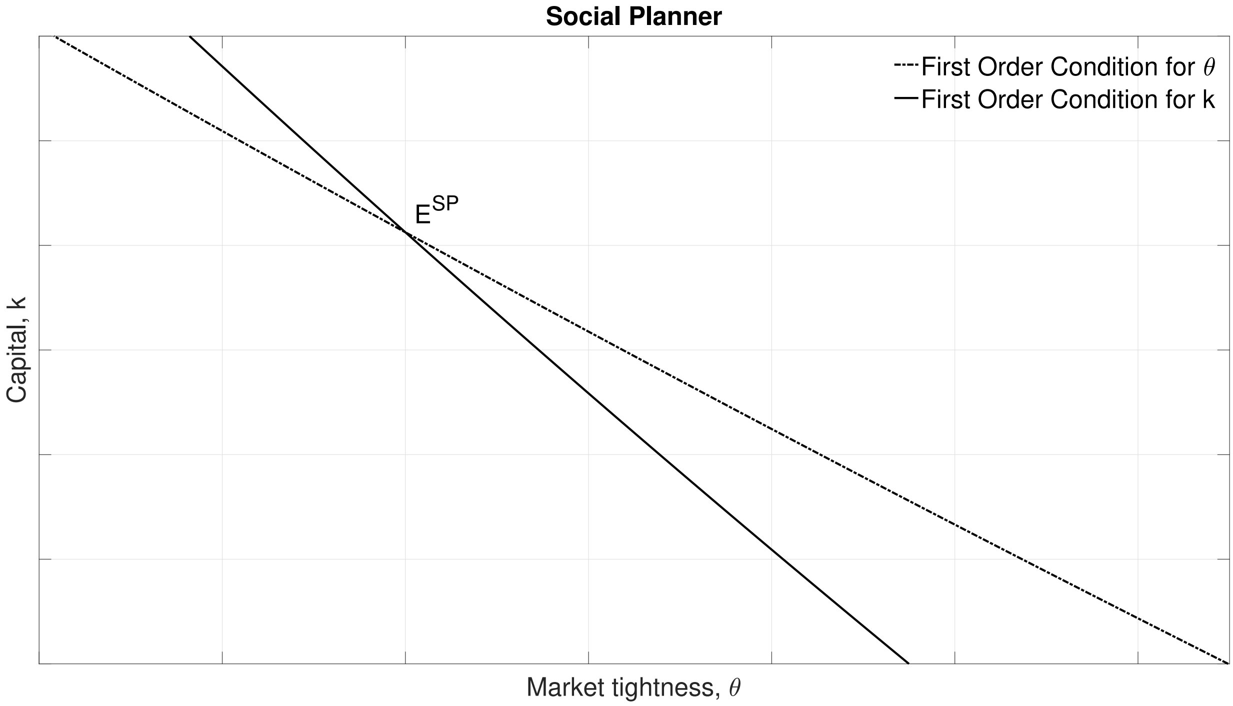

Figure 2: Plugging optimal quitting into the first order conditions for k and θ and solving them simultaneously yields the planning solution. Acemoglu and Shimer (1999) convey the same idea with wage and tightness after establishing a map between capital and wages. We do not do this here because financial frictions and ϕ yields a wage schedule with a kink at y^U. We use k which maps 1:1 to the wage schedule $w(\phi)$ as explained in Section 2.

3 Competitive Equilibrium with Risk Neutral Workers

In the competitive equilibrium, interest rates are given by the mutual fund facing zero aggregate risk. Firms compete to maximize ex-ante worker utility U subject to the constraints described earlier. The limited commitment constraint generates an inefficiency which we now highlight.

Market equilibrium is described by

$$\max_{\theta,k} p(\theta)(1-\phi_U^M)\Big(A+w(\phi)\Big)+[1-p(\theta)(1-\phi_U^M)](A+b)$$

subject to

$$q(\theta)\int_{\phi_U^M}^{1}\phi f(k)-Rk-w(\phi)d\phi=0$$

$$R=\frac{1}{q(\theta)(1-\phi_U^M)}$$

$$\phi_U^M f(k)=b+Rk$$

The last constraint captures limited commitment. Workers work as long as

$$w(\phi)\geq b$$

Combining equations yields

$$\phi_M f(k)-\frac{k}{q(\theta)(1-\phi_M)}=b.$$

Solving for ϕ_U^M gives

$$\phi_U^M=\frac{f(k)+b-\sqrt{(f(k)-b)^2-\frac{4f(k)k}{q(\theta)}}}{2f(k)}$$

which states that for any k and θ, in particular, k^* and θ^*, $\phi_U^M=\phi_{SP}$ if and only if

$$\frac{4f(k^*)k^*}{q(\theta^*)}=0$$

which cannot be possible since $k^*>0$ and $q(\theta^*)\in(0,1)$ in a non-degenerate planning solution. Hence,

$$\phi_U^M>\phi_{SP}$$

which implies inefficient quits for all levels of capital and entry. This happens because of the fixed interest payments due to the firm's inability to condition interest payments on productivity. The worker quits in states of the world where he produces more at work than at home. In other words, different from similar models which do not consider financial frictions after matching, market equilibrium with risk neutral workers is inefficient. We show this graphically in Figure 3.

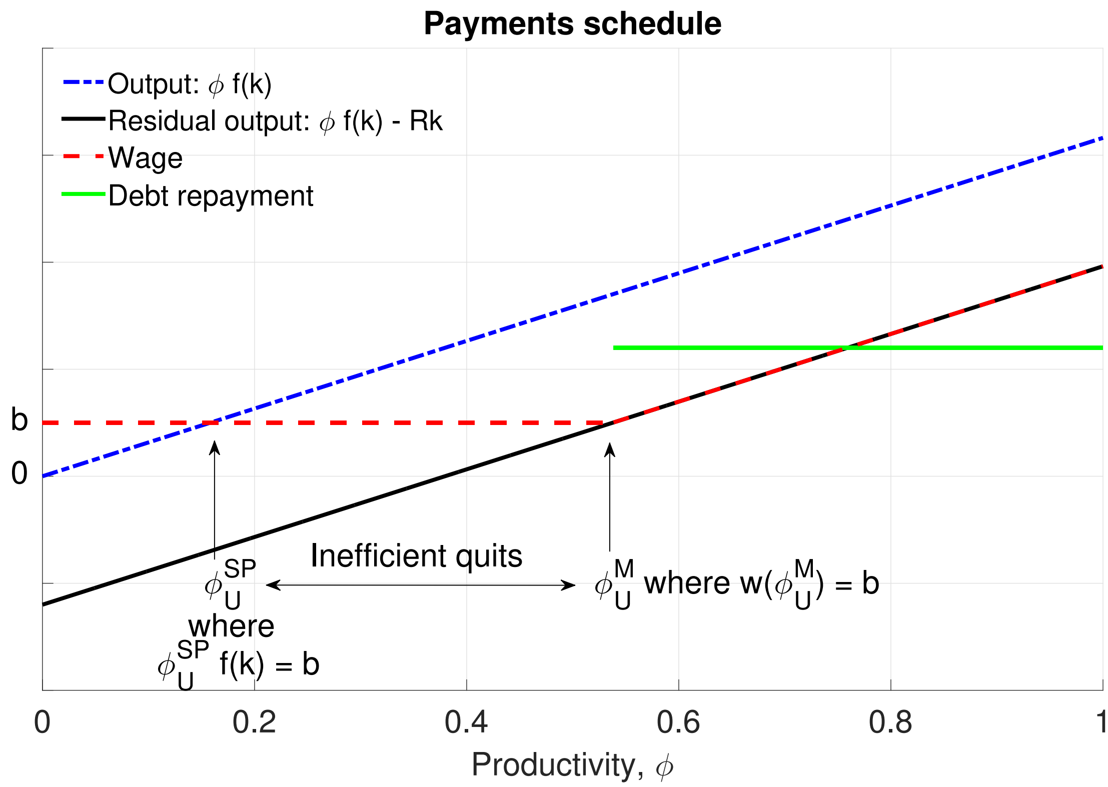

Figure 3: Plugging optimal quitting into the first order conditions for k and θ and solving them simultaneously yields the planning solution. Acemoglu and Shimer (1999) compare wages to tightness. We do not do this here because financial frictions and ϕ yields a wage schedule. We use k which maps 1:1 to the wage schedle $w(\phi)$ as explained in Section 2.

3.1 Underemployment Insurance with Risk Neutral Workers

The key mechanism causing inefficiency in the market equilibrium is the firm's inability to pay the mutual fund whenever the worker is producing more while employed. As such, a policy to reverse this inefficiency would be one where the government guarantees repayment so long productivity levels exceed the planner's production threshold ϕ_{SP}. In other words, a transfer to firms in the amount Rk^{SP} where $R = \frac{1}{q(\theta^{SP})(1-\phi_{SP})}$ would align market consumption with the planners allocations. This ensures that all firms who produce more than b end up producing.

Interest rate associated with the transfer is $\frac{1}{q(\theta^{SP})(1-\phi_{SP})}$ is different from interest rate under the market equilibrium described earlier. This difference is the effect of EI on the interest rate charged by the mutual fund. By committing to EI, we move ϕ_M to ϕ_{SP} and θ^M to θ^{SP}. As a result, the equilibrium interest rate is now $\frac{1}{q(\theta^{SP})(1-\phi_{SP})}$ which is exactly the amount needed to ensure that efficient capital use takes place. In a picture, this is

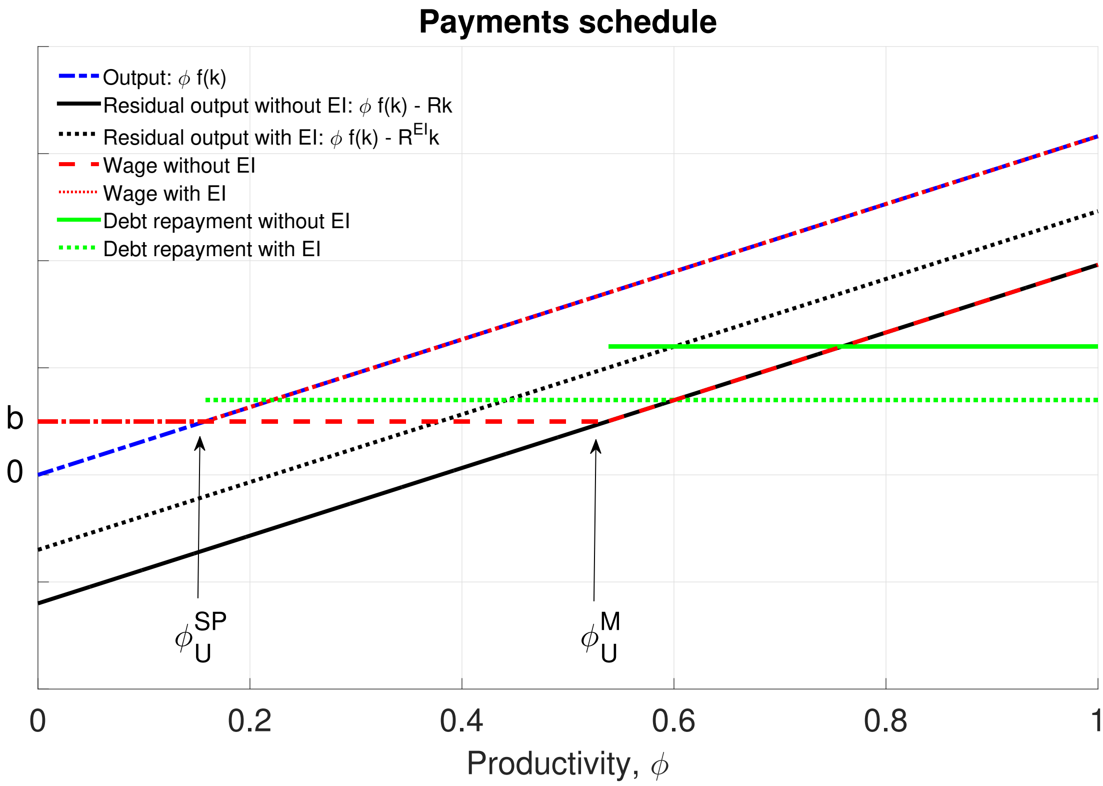

Figure 4: We show here that a lump sum transfer to all employed workers funded by lump sum taxes on all workers eliminates inefficient quits. This restores efficiency when workers are risk neutral. Note that firms repay debt in more periods of the world and that the interest on debt is lower than without EI intervention. Also note that the consumption of workers in the market equilibrium with EI is identical to the consumption of workers in the planning solution.

The taxes needed to fund such a transfer is exactly

$$
\begin{aligned}
\tau^{EI} &= p(\theta)\zeta^E(1-\phi_{SP}) \\
\zeta^E &= \frac{1}{q(\theta)(1-\phi_{SP})}k^S P
\end{aligned}
\tag{2}
$$

To see that this restores the planning solution, note that equilibrium taking these transfers as given can be described by

$$\max_{\theta,k} p(\theta)(1-\phi_{SP})\left[A+(1+\phi_{SP})\frac{1}{2}f(k)-Rk+\zeta^E-\tau^{EI}\right]+[1-p(\theta)(1-\phi_{SP})](A+b-\tau^{EI})$$

Since $\zeta^E = Rk$ and $\tau^{EI} = (1-\phi_{SP})p(\theta)\zeta^E$, we obtain

$$\max_{\theta,k} p(\theta)(1-\phi_{SP})\left[A+(1+\phi_{SP})\frac{1}{2}f(k)\right]+[1-p(\theta)(1-\phi_{SP})](A+b)-(1-\phi_{SP})p(\theta)Rk.$$

Since $R = \frac{1}{q(\theta)(1-\phi_{SP})}$ we get

$$\max_{\theta,k} p(\theta)(1-\phi_{SP})\left[A+(1+\phi_{SP})\frac{1}{2}f(k)\right]+[1-p(\theta)(1-\phi_{SP})](A+b)-\theta k$$

which is the planning problem.

4 Competitive Equilibrium with Risk Averse Workers

We now add risk aversion to our analysis. With risk aversion and financial frictions, two sources of uninsured risk arise. First, the lack of insurance markets for unemployed workers results in the market providing unemployment insurance through a low unemployment, low capital utilization (and hence, low wage) equilibrium. This channel was introduced in Acemoglu and Shimer (1999). Our introduction of financial frictions and ex-post productivity shocks introduces a second form of risk in the form of wage uncertainty among employed workers and increased separation probability due to the inability to meet wage and debt obligations. Since the separation probability as well as the wage uncertainty increases in capital utilization, this further reduces capital utilization.

Following Acemoglu and Shimer (1999), UI allows employed workers to insure unemployed workers. In our model, this does not restore constrained efficiency because higher UI increases the number of separations into unemployment since more workers quit to enjoy added benefits of unemployment. In addition, there remains uninsured risk in wages. We formally prove this by showing that the optimality condition for capital with financial frictions in the market equilibrium does not intersect the optimality condition for capital in the planning problem.

To achieve constrained efficiency, the planner eliminates wage uncertainty by equating wages across all employed workers and in the process, eliminates inefficient quits. To fund such a transfer, an additional lump sum tax is levied implying that unemployed workers insure employed workers from wage and separation uncertainty.

We first formally show that an equilibrium using only UI and EI to prevent inefficient quits does not implement the efficient allocation. We also impose $b = 0$ for simplicity while noting that our proof generalizes to $b > 0$. The worker's ex ante utility with the policies implemented is

$$\max_{\theta,k} p(\theta)\int_0^1 u\left(A + \phi f(k) - \frac{k}{q(\theta)} - \tau\right)d\phi + [1-p(\theta)]u(A - \tau + \zeta^U)$$

FOC for θ

$$\begin{aligned}
&+ p'(\theta)\int_0^1 u\left(A + \phi f(k) - \frac{k}{q(\theta)} - \tau\right)d\phi \\
&+ p(\theta)k\frac{q'(\theta)}{q(\theta)^2}\int_0^1 u'\left(A + \phi f(k) - \frac{k}{q(\theta)} - \tau\right)d\phi \\
&- p'(\theta)u(A - \tau + \zeta^U) = 0 \\
&\Rightarrow
\end{aligned}$$

$$\begin{aligned}
&+ p'(\theta)\left[\int_0^1 u\left(A + \phi f(k) - \frac{k}{q(\theta)} - \tau\right)d\phi - u(A - \tau + \zeta^U)\right] \\
&+ \theta\frac{q'(\theta)}{q(\theta)}k\int_0^1 u'\left(A + \phi f(k) - \frac{k}{q(\theta)} - \tau\right)d\phi = 0
\end{aligned} \tag{3}$$

FOC for k

$$p(\theta)\int_0^1 u'\left(A + \phi f(k) - \frac{k}{q(\theta)} - \tau\right)\left[\phi f'(k) - \frac{1}{q(\theta)}\right]d\phi = 0$$

$$\Rightarrow$$

$$\int_0^1 u'\left(A + \phi f(k) - \frac{k}{q(\theta)} - \tau\right)\left[\phi f'(k) - \frac{1}{q(\theta)}\right]d\phi = 0$$

$$\Rightarrow$$

$$\int_0^1 f(k)u'\left(A+\phi f(k)-\frac{k}{q(\theta)}-\tau\right)\left[\phi f'(k)-\frac{1}{q(\theta)}\right]d\phi = 0 \tag{4}$$

To prove that no combination of UI and EI implemented to prevent inefficient quits alone is enough to implement the constrained efficient allocation, we show that (1) intersects (4) intersects if and only if workers are risk neutral.

Evaluating (4) using integral by parts yields

$$\begin{aligned} & u\left(A+f(k)-\frac{k}{q(\theta)}-\tau\right)\left[f'(k)-\frac{1}{q(\theta)}\right] \\ & + u\left(A-\frac{k}{q(\theta)}-\tau\right)\frac{1}{q(\theta)} \qquad\qquad {}^{4} \\ & - f'(k)\int_0^1 \left(A+\phi f(k)-\frac{k}{q(\theta)}-\tau\right)d\phi = 0. \end{aligned} \tag{5}$$

To find an intersection between (5) and the planning first order solution for capital, we substitute in $\frac{1}{2}f'(k) = \frac{1}{q(\theta)}$ to obtain

$$\begin{aligned} & + u\left(A+f(k)-\frac{k}{2}f'(k)-\tau\right)\left[f'(k)-\frac{1}{2}f'(k)\right] \\ & + u\left(A-\frac{k}{2}f'(k)-\tau\right)\frac{1}{2}f'(k) \\ & - f'(k)\int_0^1 u\left(A+\phi f(k)-\frac{k}{2}f'(k)-\tau\right)d\phi = 0 \end{aligned}$$

$$\Rightarrow$$

$$\begin{aligned} & + \frac{1}{2}\left[u\left(A+f(k)-\frac{k}{2}f'(k)-\tau\right)+u\left(A-\frac{k}{2}f'(k)-\tau\right)\right] \\ & = \int_0^1 u\left(A+\phi f(k)-\frac{k}{2}f'(k)-\tau\right)d\phi \end{aligned}$$

which is true if and only if $u(\cdot)$ is linear. Hence, the lines do not intersect and no policies failing to address the uninsured wage risk among employed workers will implement the planning solution. We plot a graphical representation of this in Figure 5.

[4]Note that: $\frac{\partial\left[u\left(A+\phi f(k)-\frac{k}{q(\theta)}-\tau\right)\right]}{\partial\phi} = f(k)u'\left(A+\phi f(k)-\frac{k}{q(\theta)}-\tau\right)$

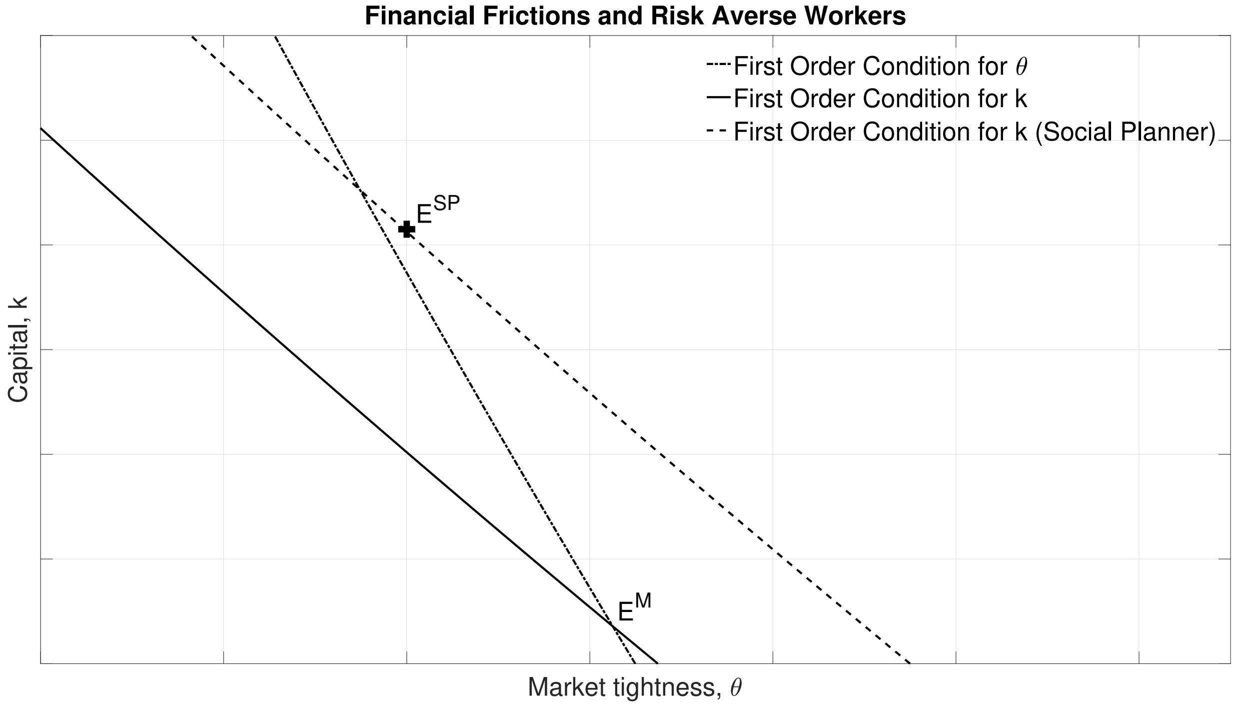

Figure 5: The FOCs for capital in the planning solution and the market solution without EI intervention do not cross.

4.1 Insuring Wage Risk of Employed Workers

We now consider the case where EI ensures that all workers meet a minimum wage which exceeds the consumption level enjoyed by unemployed workers. We guess and verify that a policy which transfers a schedule of EI, $\zeta^E(\phi)$ so that all workers with productivity exceeding ϕ_{SP} enjoy the same wage as the highest earner in the economy implements the constrained efficient outcome. Furthermore, we show that this transfer is funded by an additional tax on unemployed workers. In essence, employed workers insure unemployed workers by contributing to unemployment insurance and unemployed workers insure employed workers by contributing to underemployment insurance.

Note that the consumption level enjoyed by the most productive worker is

$$c(\bar{w}) = A + \overline{w} - \tau$$

where $\tau = \tau^{EI} + \tau^{UI}$ and τ^{EI} is the necessary amount of resources to finance underemployment insurance and τ^{UI} is the necessary amount of resources to finance underemployment insurance. In particular,

$$\tau^{EI} = p(\theta)\frac{1}{2}f(k)$$

and

$$\tau^{UI} = [1 - p(\theta)]\zeta^{UI}$$

where ζ^{UI} is the unemployment insurance transfered to unemployed workers. This implies that

$$\begin{aligned} c(\overline{w}) &= A + f(k) - Rk - p(\theta)\frac{1}{2}f(k) - [1 - p(\theta)]\zeta^{UI} \\ &= A + \left[1 - \frac{1}{2}p(\theta)\right]f(k) - Rk - [1 - p(\theta)]\zeta^{UI} \end{aligned}$$

To see that we achieve the constrained efficient allocation, note that the equilibrium featuring the policies implemented above is described by

$$\max_{\theta,k} p(\theta)u\left(A + f(k) - \frac{k}{q(\theta)} - \tau\right) + [1 - p(\theta)]u(A - \tau + \zeta^{U})$$

The FOC with respect to θ is

$$\begin{aligned} &+ p'(\theta)u\left(A + f(k) - \frac{k}{q(\theta)} - \tau\right) + p(\theta)u'\left(A + f(k) - \frac{k}{q(\theta)} - \tau\right)\frac{k}{q(\theta)^2}q'(\theta) \\ &- p'(\theta)u(A - \tau + \zeta^{U}) = 0 \end{aligned}$$

$$\Rightarrow$$

$$\begin{aligned} &+ p'(\theta)\left[u\left(A + f(k) - \frac{k}{q(\theta)} - \tau\right) - u(A - \tau + \zeta^{U})\right] \\ &+ p(\theta)u'\left(A + f(k) - \frac{k}{q(\theta)} - \tau\right)\frac{k}{q(\theta)^2}q'(\theta) = 0 \end{aligned}$$

$$\Rightarrow$$

$$\begin{aligned} &+ p'(\theta)\left[u\left(A + f(k) - \frac{k}{q(\theta)} - \tau\right) - u(A - \tau + \zeta^{U})\right] \\ &+ u'\left(A + f(k) - \frac{k}{q(\theta)} - \tau\right)\theta\frac{q'(\theta)}{q(\theta)}k = 0 \end{aligned}$$

FOC for k

$$p(\theta)u'\left(A + f(k) - \frac{k}{q(\theta)} - \tau\right)\left(\frac{1}{2}f'(k) - \frac{1}{q(\theta)}\right) = 0$$
$$\Rightarrow$$
$$\frac{1}{2}f'(k) - \frac{1}{q(\theta)} = 0$$

Since this last FOC for k is equal to the FOC of k of the social planner then with UI we can restore efficiency following the insights of Acemoglu and Shimer (1999). Indeed, our equations are now identical to the equations in Acemoglu and Shimer (1999) with their production function rewritten as $\frac{1}{2}f(k)$ reflecting the expected output in the economy. We have effectively completed capital markets. Using their results completes our proof.

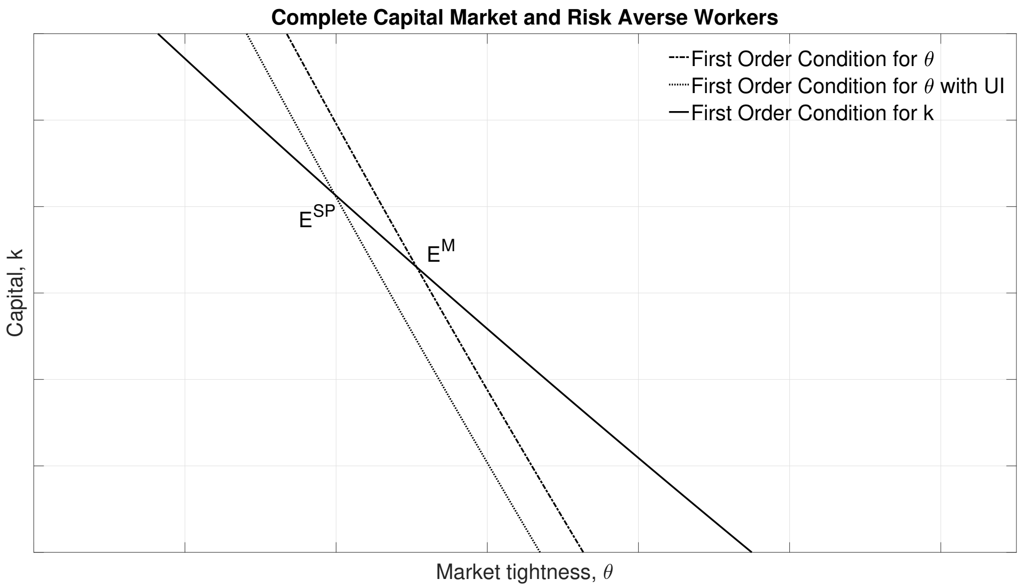

Figure 6: With the FOC for capital delivering the same line as the FOC for capital in the planning solution, the FOC for vacancies can be shifted by unemployment insurance to restore the efficient outcome.

5 Discussion

TBC

6 Conclusion

We study the effects of unemployment insurance (UI) and underemployment insurance (EI) in a general equilibrium model of search and matching featuring financial frictions and risk-averse workers. We explain how incomplete capital markets give rise to unemployment risk, separation risk, and wage risk. We also explain how the competitive equilibrium is inefficient. We show that UI and EI are able to restore efficient outcomes and explain how they work.

Our focus on EI and how financial frictions prevent firms from completely insuring workers is particularly important given the central role of firm financing in modern labor markets. For instance, Gorton and Ordoñez (2016) and Rios-Rull and Huo (2016) among others highlight that financial crises can play an important role in a recession. Our results suggest that optimal labor market insurance implementations differ depending on whether financial frictions are present. The extent of financial frictions can vary over time and we need to consider them in how we construct insurance policies to achieve desired outcomes. Future work includes policy evaluations using quantitatively relevant dynamic models which feature the mechanisms we highlight in empirically relevant magnitudes. We also think that moral hazard issues are central to EI implementation and deserve further study.

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