Avoiding Layoffs: On-the-job Search and Partial Insurance

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Abstract

Several pieces of evidence are interpreted as if workers search on-the-job to prevent a layoff, so that it is not unusual they accept wage cuts when moving to new jobs. We conceptualize these behavior as a self-insurance mechanism obtained by exerting effort. Since on-the-job search insures against idiosyncratic risk unlike assets, it helps understand limited participation in asset markets. We formalize these intuitions by constructing an economy with idiosyncratic dismissal shocks and costly on-the-job search. Workers may use on-the-job search not only as a mechanism to climb the wage ladder, but also to avoid future bad shocks and hence, on-the-job search acts as an insurance mechanism. We show that consumption evolves according to a standard Euler equation in which current effort impacts the income distribution tomorrow. We solve and calibrate the model to assess its quantitative empirical performance.

VERY PRELIMINARY.

1 Introduction

Economists have primarily thought that consumption is smoothed through assets, which are contracts that deliver units of consumption when one or various events occur. How much insurance you can get depends on whether is possible or not to buy or sell contingent contracts. Hence, standard theories of consumption fluctuates between two poles. At the first one, we have the complete capital market à la Arrow-Debreu-McKenzie (Arrow and Debreu, 1954; McKenzie, 1954) where individual consumption is fully isolated from idiosyncratic risk. At the second, we have the Permanent Income Hypothesis tradition, with models assuming that only a risk-free asset exists in partial equilibrium (Hall and Mishkin, 1982; Zeldes, 1989), or the Aiyagari (1994) model which contains the same assumptions in a general equilibrium context.

In this paper, we depart to some extent from this tradition to propose additional sources that individuals have to smooth consumption. Our general claim is that individuals can exert effort in order to change the distribution of outcomes they will face. For example, consider what would you do if you learn that your employer is going into a serious financial trouble. Naturally, the likelihood of a layoff increases. A large literature of displaced workers (Jacobson, LaLonde, and Sullivan, 1993; Farber, 2017) abundantly suggests that you will face a longer unemployment spell and end up earning substantially less than you did before. A good idea for you in this context is start looking for a new job while you still have one. In a realistic setting of incomplete capital markets, avoiding unemployment is key for stabilizing income and consumption. In this paper, we formalize this intuition in a partial-equilibrium quantitative model with on-the-job search and incomplete capital markets and explore its implications.

Is using on-the-job search as an insurance mechanism something real? There are various scattered pieces of evidence that point in that direction. First, Fallick and Fleischman (2004), using CPS data, document that job-to-job flows are quantitatively important, twice as large as employment-to-unemployment flows. Moreover, people engaged in on-the-job search are more likely to change employer and, more likely to experience a job loss in the next month. Presumably, workers who perceive a high possibility of a job loss in the near future, engage in on-the-job search. Fujita (2012) reports survey evidence showing that 40% of on-the-job searchers justify their doing by fear of layoff or unsatisfactory current job in the UK.

Second, a sizable share of the job-to-job movers accept wage cuts. Connolly and Gottschalk (2008) find that 44% percent of all job to job transitions lead to lower real wages. Tjaden and Wellschmied (2014) report a similar magnitude, too. While on-the-job search theory predicts that movers will enjoy higher utility continuation values in their new positions rather than wage, it still seems hard to square this evidence with the standard approach. In contrast, our theory predicts workers moving to new jobs and taking wage cuts to avoid their layoffs.

Yet a third piece of evidence speaks about the potential importance of the underlying mechanism. It is documented the lack of financial sophistication among consumers even in developed countries with high financial literacy and solid financial sectors. Most of the population does not voluntarily hold financial assets other than money or savings accounts. This has been regarded as a financial participation puzzle (Mankiw and Zeldes, 1991; Vissing–Jørgensen, 2002; Guvenen, 2007). On top of fixed entry costs that may explain some part of the phenomenon, we think individuals have other ways to self-insure, such as on-the-job search. Unlike most existent financial assets, search effort insures against an idiosyncratic layoff risk. Hence, our theory can help explain why many individuals do not hold sophisticated financial assets as they cannot offer consumption contingent in individual-level events.

We study an economy where agents may engage in on-the-job-search and face idiosyncratic shock to experience a job loss. On-the-job search is therefore used as an insurance mechanism since by engaging in it, workers may avoid unemployment spells. We want to study the implications of this model to employment fluctuation and savings behavior. We also aim to assess the contribution of the on-the-job search to self-insurance, and how agents substitute the standard consumption-savings self-insurance mechanism with on-the-job-search.

Our basic model clarifies the mechanism. The optimal effort is determined by the marginal cost of exerting effort and the marginal benefits, which correspond to the possible gains of climbing the wage ladder and the gains of avoiding unemployment.

The full model allows us to study how the agents uses the standard self-insurance mechanism and on-the-job search. The optimal effort is again determined by the trade-off of marginal cost and benefits of effort. On the consumption/savings side, the optimal decisions are determined by the standard Euler equation. However, the job search behavior changes the probability of future outcomes (stay, switch jobs, unemployment) and the Euler equation is characterized by these probabilities. Hence, the on-the-job search behavior changes the consumption/savings behavior.

The calibration of the model is preliminary.

Our paper is related to a literature that has linked labor market risks and consumption. As much of literature we built on top of Burdett (1978) seminal paper. Lise (2012) studies an economy where on-the-job search impacts the savings behavior of agents. While his work is close to ours, Lise (2012) does not allow for varying layoff or idiosyncratic productivity risk explicitly and solely focuses on stochastic outside job offers. Consequently, compared to our framework, he understates the role of insurance of on-the-job search and mainly focuses on the risk of falling down the job ladder as individuals gain experience. Guvenen and Smith (2014) use information contained in the joint dynamic of individual's labor earnings and consumption choice decision to quantify the amount of income risk that individuals face and the extent to which they have access to informal insurance against that risk. They show that up to one half of persistence shocks are insured through informal channels, without being explicit about what those channels are. We believe that on the job search might be a useful mechanism to avoid periods of low consumption associated with a job loss and hence on-the-job-search is one of the informal channels of insurance that Guvenen and Smith (2014) discuss. Chaumont and Shi (2017) study the relationship between on the job search with inequality and wealth accumulation. Our model differs from theirs in several dimensions: we consider random search instead of directed search, we have both extensive and intensive margin whereas they only take into account extensive margin.]

2 Empirical Evidence

We use the Survey of Consumer Expectations (SCE) of the Federal Reserve Bank of New York (NY Fed) and its Labor Market (LM)and Job Search (JS) Supplements. Most of our variables are coming from the JS supplement, which was design by Faberman, Mueller, Şahin, and Topa (2017) and described in great detail by them. To provide evidence of that on-the-job search is indeed a relevant insurance mechanism, we also link the JS and LM supplements to the main SCE survey to describe the joint job search and consumption behavior.

2.1 Evidence on layoff probability

The main monthly administered SCE survey contains the question Q13new with the wording : " What do you think is the percent chance that you will lose your ["main" if Q11>1, "current" if Q11=1] job during the next 12 months?" which essentially resembles the annual subjective probability of layoff of the interviewee. Since it is expressed in annual terms, we compute the monthly equivalent assuming it remains constant over

Table 1: Dynamics of Inverse of Layoff probability

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Inv Layoff pr (x_{t-1})	0.651***	0.615***	0.629***	0.704***	0.652***	0.624***	0.627***	0.696***
	(0.015)	(0.051)	(0.041)	(0.098)	(0.015)	(0.049)	(0.041)	(0.097)
Known lh wage		-0.012				-0.035**		
		(0.014)				(0.015)		
Annual lwage (SCE-LAB)			-0.006	-0.061**			-0.010	-0.080***
			(0.007)	(0.027)			(0.008)	(0.030)
Log Assets				0.010				0.012
				(0.010)				(0.013)
Observations	32,427	2,444	4,906	992	32,147	2,400	4,898	987
R-squared	0.402	0.351	0.395	0.423	0.406	0.381	0.396	0.429
Year & Region FE	-	-	-	-	✓	✓	✓	✓
Demogr	-	-	-	-	✓	✓	✓	✓
Mean dv (x)	-2.419	-2.416	-2.442	-2.418	-2.420	-2.422	-2.442	-2.416

Note: Robust standard errors in parentheses . *** $p < 0.01$, **$p < 0.05$, * $p < 0.1$

a year. Therefore, the monthly equivalent is $p_t = 1 - (1 - \text{Q13new}_t/100)^(1/12)$. Since probabilities lie between 0 and 1, it is convenient to map this magnitude into the real line to study its dynamical properties through a standard AR(1) model. Therefore we define $x_t = \Phi^{-1}(p + \epsilon)$ where ϵ takes value 0.001 if $p = 0$ and $\epsilon = -0.001$ if $p = 1$. $\Phi^{-1}(\cdot)$ stands for the inverse cumulative function of a Gaussian distribution. These slight adjustments are necessary to define the underlying risk x over the real line.

The next step is to compute an AR(1) model to understand the persistence of the shock, a key magnitude for a quantitative model we develop below. The results are shown in Table 1.

The persistence coefficient lies between 0.6 - 0.7, and the average of the estimated AR(1) process is around -2.42, which implies an average expected monthly separation rate of $\Phi(-2.42) == 0.77\%$. Column 2 explores how persistence changes when we control for a known log hourly wage coming from the JS survey which equals the current wage if employed, or the last reported if unemployed. Column 3 repeats the exercise using an annual log wage from the LM survey, which has higher periodicity, and therefore the sample size is greater. In general, we observe that higher wages are correlated with lower layoff shocks. We finally also control for log of reported financial assets in Column 4, but it does not show a significant effect. Columns 5-8 repeat previous exercises, now including year and US regional fixed effects, and demographic controls in the SCE survey such as gender, age, age squared, and a set of educational level dummies. We also include in the Appendix additional robustness checks in Table 7. All specifications indicate a very similar AR(1) process governing the idiosyncratic layoff risk individual process.

2.2 Evidence of search effort

Next, we try to assess if workers effectively exert greater effort when facing higher layoff risk. The answer seems to be positive according to Table 2. Using data from the SCE-LM we come up with three measures of search effort, namely, the number of methods using in searching (which goes back to Shimer (2004)), the number of hours devoted to search (Aguiar, Hurst, and Karabarbounis, 2013), and the number of applications sent. All correlations are positive and robust to several specifications, showing a plausible channel used by job seekers to generate a job to job transition as a way of escape of a layoff threat.

2.3 Evidence of offer acceptance

We finally study the offer acceptance decision. We estimate a simple probit model to explain the acceptance of a job offer. The main determinants are the wage gap between offered and actual wages, the layoff probability, and the interaction between the two. Several specifications with different sets of covariates are shown in Table 3. The signs and magnitudes are robust across specifications. The results show that the acceptance of a job offer monotonically increases as the gap between the offered and current wage increases, but this effect is attenuated by a higher perceived layoff risk. On the other hand, the acceptance probability increases in the layoff risk, but symmetrically, the effect is attenuated by a larger offered-current wage gap. These facts suggest that the standard mechanism of job ladder in on-the-job search traditional models **?** are in place, but the layoff risk also plays a substantial role. Moreover, both explanations compete one another as the interaction term is negative.

We use the estimates of the model to estimate a distribution of acceptance probabilities by low (< 0.05) and high layoff risk (≥ 0.05). The plots for specifications (1) -(4) in Figure 1 clearly show that the estimated acceptance probability distribution shifts to right when the unemployment layoff risk is substantially higher than average. This evidence illustrates the impact that layoff risk has on the acceptance decision.

Table 2: Expected search effort as a function of Layoff probability

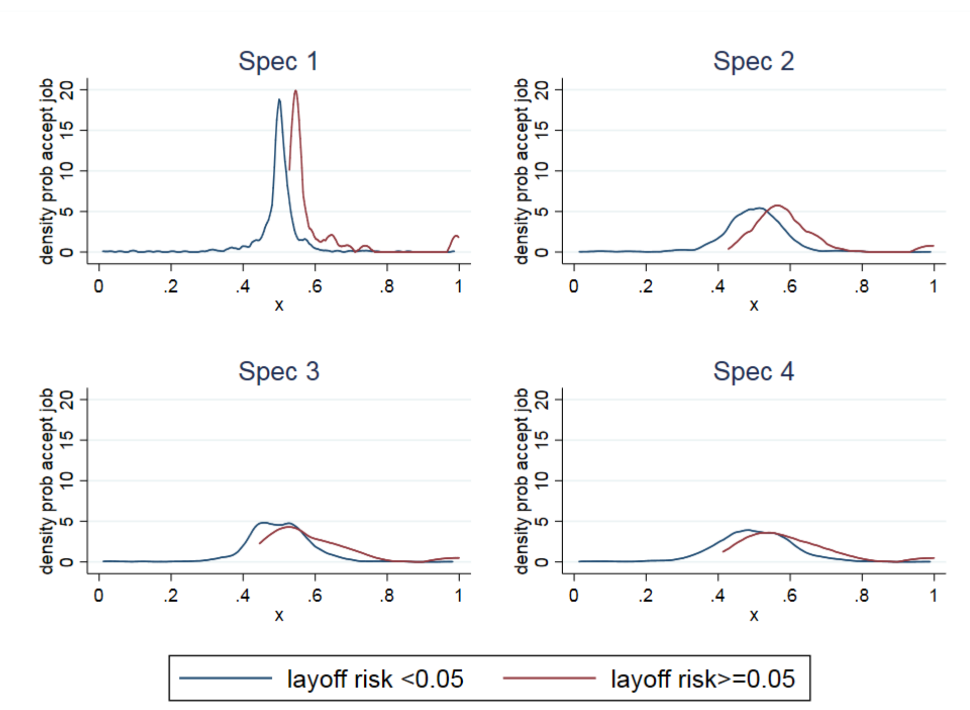
Variables	N^o methods	Hours search	N^o applications
	No controls		
	(1)	(2)	(3)
Layoff prob	3.471***	3.509**	1.916**
	(0.751)	(1.478)	(0.807)
Observations	1,994	1,994	2,535
R-squared	0.024	0.009	0.001
	Year & Region FE		
	(4)	(5)	(6)
Layoff prob	2.459***	2.408	1.972**
	(0.724)	(1.517)	(0.796)
Observations	1,994	1,994	2,535
R-squared	0.178	0.079	0.004
	Demographics		
	(7)	(8)	(9)
Layoff prob	3.487***	3.337**	1.818**
	(0.724)	(1.565)	(0.840)
Observations	1,988	1,988	2,491
R-squared	0.037	0.012	0.003
	Year, Region FE & Demographics		
	(10)	(11)	(12)
Layoff prob	2.656***	2.395	1.846**
	(0.718)	(1.612)	(0.823)
Observations	1,988	1,988	2,491
R-squared	0.185	0.082	0.005

Note: Robust standard errors in parentheses . *** $p < 0.01$, **$p < 0.05$, * $p < 0.1$

Table 3: Estimates for acceptance of job offer

	(1)	(2)	(3)	(4)
log wage gap (offered - current)	0.377***	0.388***	0.372***	0.385***
	(0.111)	(0.110)	(0.115)	(0.114)
layoff prob	2.312*	2.424*	2.587*	2.673*
	(1.277)	(1.323)	(1.447)	(1.478)
log wage gap X layoff prob	-5.635	-6.590*	-6.587	-7.451*
	(3.774)	(3.906)	(4.138)	(4.243)
Observations	570	570	561	561
Year & Region FE	-	✓	-	✓
Demographics	-	-	✓	✓

Figure 1: Distributions of acceptance probabilities



3 The Basic Model

The basic model illustrates the main mechanism of the model.

Time is discrete. Agents maximize the present discounted value of utility flows given by:

$$\max \sum_{t=0}^{\infty} \beta^t (u(c_t) - \lambda s)$$

where $u(c)$ is the utility from consumption and λs is the cost of exerting effort in terms of utility. Agents are paid a wage w offered by the firm and accepted by the worker when they are employed, and receive unemployment benefits b during unemployment spells. Agents are not allowed to save or borrow, they just consume their current income. There is on-the-job search. Dismissal shocks are persistent, modeled as an AR(1) process. In particular, let x be the underlying variable that determines the dismissal. Then, x evolves as follows:

$$x_{t+1} = (1-\rho)\bar{x} + \rho x_t + \varepsilon_{t+1}$$

where $\bar{x}$ is the unconditional mean of x. Given x, the probability of being fired is determined by a function $\delta(x)$[1]. When a worker starts in a new job, his probability of being fired is reset to $\delta(\bar{x})$, independently of whether the worker was unemployed or employed in the previous period. The job finding probability depends on the workers effort s and equals to $p(s)$, where $p(s)$ is an increasing and concave function such that $p(0) = 0$ and $\lim_{s\to\infty} p(s) = 1$. Firms offer wages from a exogenous wage offer function $F(w)$ with support $[\underline{w}, \bar{w}]$. There are no aggregate shocks.

Timing. At the beginning of the period the worker optimally exert effort and consumes his current income. Then an offer arrives with probability $p(s)$. When there is no offer, the unemployed worker remains unemployed and the employed worker is fired with probability $\delta(x)$. When the worker has an offer, he must first choose whether to accept or reject, and if he is employed and rejects then the lay off might take place.

The value function of being unemployed is

$$U = \max_s u(b) - \lambda s + \beta \left\{ p(s) \int_{\underline{w}}^{\bar{w}} \max\{W(w,\bar{x}), U\} dF(w) + (1-p(s))U \right\} \tag{1}$$

[1]Since AR(1) processes are not bounded between [0,1], we model the variable x as the persistent variable that determines the probability of being fired, and $\delta(x)$ is the actual probability. $\delta(x)$ could be any cdf with support in $(-\infty, \infty)$

Rearranging

$$U = \max_{s} u(b) - \lambda s + \beta p(s) \int_{w^*}^{\bar{w}} (W(w,\bar{x}) - U) dF(w) + \beta U$$

where w^* is the reservation wage, ie $W(w^*, \bar{x}) = U$

The value function of being employed is

$$W(w,x) = \max_{s} u(w) - \lambda s + \beta \Bigg\{ p(s) \int_{\underline{w}}^{\bar{w}} \max\{W(w',\bar{x}), \int W(w,x')dG(x'|x)\} dF(w) + \\ (1-p(s)) \Bigg(\delta(x) U + (1-\delta(x)) \int W(w,x')dG(x'|x) \Bigg) \Bigg\}$$

Rearranging

$$W(w,x) = \max_{s} u(w) - \lambda s + \beta \Bigg\{ p(s) \Bigg[\int_{w^*(w,x)}^{\bar{w}} \Bigg(W(w',x) - \int W(w,x')dG(x'|x) \Bigg) dF(w') + \\ \delta(x) \Bigg(\int W(w,x')dG(x'|x) - U \Bigg) \Bigg] + \delta(x) U + (1-\delta(x)) \int W(w,x')dG(x'|x) \Bigg\}$$

where the reservation wage $w^*(w,x)$ is defined by $W(w^*(w,x),x) = \int W(w,x')dG(x'|x)$

For the unemployed worker, the optimal effort is determined by

$$\lambda = \beta p'(s) \int_{\underline{w}}^{\bar{w}} \max\{W(w,\bar{x}) - U, 0\} dF(w)$$

For the employed worker, the optimal effort is determined by

$$\lambda = \beta p'(s) \Bigg\{ \underbrace{\int_{\underline{w}}^{\bar{w}} \max\{W(w',x) - \int W(w,x')dG(x'|x), 0\} dF(w')}_{\text{gain from switching jobs}} + \underbrace{\delta(x) \Bigg(\int W(w,x')dG(x'|x) - U \Bigg)}_{\text{gain from avoiding getting fired}} \Bigg\}$$

From the previous equation we can see that when $\delta(x)$ is higher, and assuming $p(s)$ increasing and concave, then the worker is going to exert more effort. The intuition is straightforward. The more effort he exerts, not only he has higher probability of getting a new job, but he also avoids getting fired.

4 Full-blown Model

We now extend the model to allow to save and borrow at an exogenous rate and thus the worker can smooth consumption. Let a be the worker's asset holdings. We assume that there exists are exogenous borrowing limits $\underline{a}$ and thus $a \geq \underline{a}$.

The value function of being unemployed is

$$U(a) = \max_{a',s} u(a(1+r)-a'+b)-\lambda s+\beta\left\{p(s)\int_{\underline{w}}^{\bar{w}} \max\{W(w,\bar{x},a'),U(a')\}dF(w)+(1-p(s))U(a')\right\} \tag{2}$$

Rearranging

$$U(a) = \max_{a',s} u(a(1+r)-a'+b)-\lambda s+\beta p(s)\int_{w^*(a)}^{\bar{w}} (W(w,\bar{x},a')-U(a'))dF(w)+\beta U(a')$$

FOC (s):

$$\lambda = \beta p'(s)\int_{\underline{w^*(a)}}^{\bar{w}} (W(w,\bar{x},a')-U(a'))dF(w) \tag{3}$$

FOC (a'):

$$u_1((1+r)a-a'+b) = \beta p(s)\int_{w^*(a)}^{\bar{w}} (W_3(w,\bar{x},a')-U_1(a'))dF(w)+\beta U_1(a)+\mu \tag{4}$$

Envelope:

$$U_1(a) = (1+r)u'((1+r)a-a'+b) \tag{5}$$

Substituting, we obtain

$$u_1((1+r)a-a'+b) = \beta p(s)\int_{w^*(a)}^{\bar{w}} W_3(w,\bar{x},a')dF(w)+\beta(1+r)u'((1+r)a'-a''+b)-$$
$$\beta p(s)(1-F(w^*(a)))(1+r)u_1((1+r)a'-a''+b)+\mu$$

After some algebraic manipulations, it can be shown that the previous equation is equivalent to

$$u_1((1+r)a-a'+b) = \beta(1+r)\mathbb{E}[u_1(c)|s^*,a']+\mu \tag{6}$$

Where $\mu > 0$ when the borrowing constraint is binding. Two possible states can be realized next period:

1. With probability $\pi_u(s, w^*(a')) \equiv 1 - p(s)(1 - F(w^*(a')))$ the jobseeker remains unemployed due to a lack of an offer despite search effort, or due to a bad offer conditional on assets level a'; In this case, using the result from the next section, the marginal utility associated is $u_1(a'(1+r) - a'' + b)$.

2. With probability $\pi_e(s, w^*(a')) \equiv p(s)(1 - F(w^*(a')))$ the jobseeker finds a job because of she receives a sufficiently good draw. In this case, the marginal utility is $\mathbb{E}[u_1(a'(1+r) - a'' + w)|w \geq w^*(a')] \equiv \int_{w^*(a)}^{\bar{w}} u_1(a'(1+r) - a'' + w)\frac{dF(w)}{1-F(w^*(a'))}$.

The value function of being employed is

$$\begin{aligned} W(w,x,a) =& \max_{a',s} u((1+r)a - a' + w) - \lambda s + \\ & \beta\Bigg\{p(s)\int_{\underline{w}}^{\bar{w}} \max\{W(w',\bar{x},a'), \int W(w,x',a')dG(x'|x)\}dF(w) + \\ & (1-p(s))\Bigg(\delta(x)U(a') + (1-\delta(x))\int W(w,x',a')dG(x'|x)\Bigg)\Bigg\} \end{aligned} \tag{7}$$

Rearranging

$$\begin{aligned} W(w,x,a) = & \max_{a',s} u((1+r)a - a' + w) - \lambda s + \\ & \beta\Bigg\{p(s)\Bigg[\int_{w^*(w,x,a')}^{\bar{w}}\Bigg(W(w',x,a') - \int W(w,x',a')dG(x'|x)\Bigg)dF(w') + \\ & \delta(x)\Bigg(\int W(w,x',a')dG(x'|x) - U(a')\Bigg)\Bigg] + \delta(x)U(a') + (1-\delta(x))\int W(w,x',a')dG(x'|x)\Bigg\} \end{aligned}$$

where the reservation wage $w^*(w,x,a')$ is defined by $W(w^*(w,x,a'),x,a') = \int W(w,x',a')dG(x'|x)$. Note that the reservation wage now depends on a', which is a choice variable. When the worker chooses asset holdings for next periods, he is also determining his reservation wage.

FOC (s):

$$\begin{aligned} \lambda =& \beta p'(s)\Bigg\{\int_{w^*(w,x,a')}^{\bar{w}} (W(w',\bar{x},a') - \int W(w,x',a')dG(x'|x))dF(w') + \\ & \delta(x)\Bigg(\int W(w,x',a')dG(x'|x) - U(a')\Bigg)\Bigg\} \end{aligned} \tag{8}$$

(8) is just the natural extension of the respective equation of the model without assets.

FOC (a'):

$$u_1((1+r)a-a'+w)=\beta\Big\{p(s)\Big[\int_{w^*(w,x,a')}^{\bar{w}}(W_3(w',\bar{x},a')-\int W_3(w,x',a')dG(x'|x))dF(w')+ \tag{9}$$
$$\delta(x)\Big(\int W_3(w,x',a')dG(x'|x)-U_1(a')\Big)\Big]+$$
$$\delta(x)U_1(a')+(1-\delta(x))\int W_3(w,x',a')dG(x'|x)\Big\}+\mu$$

Envelope:

$$W_3(w,x,a)=(1+r)u_1((1+r)a-a'+w) \tag{10}$$

Again, this equation may be rewritten as

$$u_1((1+r)a-a'+w)=\beta(1+r)\mathbb{E}[u_1((1+r)a-a'+y)|s^*,a']+\mu$$

where y is the income receiving in each state, and $\mu>0$ applies if the borrowing constraint is binding. We see that only three states of the nature are possible:

1. With probability $\pi_{w'}(s,w^*(x,a'))\equiv p(s)(1-F(w^*(x,a')))$ the on-the-job searcher finds a new job paying w' that yields a higher payoff than w. In this case, using the result on envelope thm, the marginal utility associated is

   $$\mathbb{E}[u_1(a'(1+r)-a''+w')|w'\geq w,x,a']\equiv\int_{w^*(w,\bar{x},a')}^{\bar{w}}u_1(a'(1+r)-a''+w')\frac{dF(w')}{1-F(w^*(w,\bar{x},a'))}dG(x'|x).$$

2. With probability $\pi_u(s,w^*(a'))\equiv(1-p(s))\delta(x)$ the on-the-job searcher does not get a new offer and gets fired. In this case, the marginal utility is $u_1(a'(1+r)-a''+b)$.

3. With probability $\pi_w(s,w^*(a'))\equiv(1-p(s))(1-\delta(x))+p(s)F(w^*(x,a'))$ the on-the-job searcher remains with the same wage. She does not get a new offer and keeps her job, or alternatively she got an insufficient new job offer. In this case, the marginal utility is

   $$\mathbb{E}[u_1(a'(1+r)-a''+w)|x,a']\equiv\int_{w^*(w,\bar{x},a')}^{\bar{w}}u_1(a'(1+r)-a''+w)dG(x'|x).$$

Note that for the unemployed and employed worker, the FOC with respect to assets yields the standard Euler equation. There is one caveat, however. By changing her asset position, the agent changes her reservation wage and that impacts on the probability distribution over next period's outcomes. In this sense, both insurance mechanisms are in place.

In the calibrated model, we assume that unemployed and employed agents draw wage offers from different distributions. These facts are documented in Faberman, Mueller, Şahin, and Topa (2017).

5 Calibration

At this stage we are using a preliminary calibration. Some parameters are calibrated using values from the literature whereas others are calibrated using the evidence presented in Section **??** in this paper.

The time period is set to one week. The discount factor is set such that the annual discount factor is 0.95. The risk aversion coefficient is set to 2 as is commonly assumed in the literature. The weekly interest rate is such that the annual interest rate is 3%. The cost of exerting effort is 0.01

The wage offer distributions are set according to the distributions reported by Faberman, Mueller, Şahin, and Topa (2017). They presented the distribution of hourly wages. In out calibration we assume that agents work 40 hours per week. The unemployment benefit b is set to the 10th percentile of the wage distribution for unemployed workers.

The job finding rate as a function of effort is set to an exponential distribution with parameter $\mu = 1$. This distribution has the property of decreasing marginal returns to effort.

The dismissal shock process is calibrated according to the empirical analysis section. The process is discretized using the Rouwenhorst method.

The following table summarizes the parameters we use in our computations.

Table 4: Calibration

Parameter	Meaning	Value
β	Discount factor	$(0.95)^{1/52}$
λ	Cost of exerting effort	0.01
σ	Risk aversion	2
r	Interest rate	$(1.03)^{1/52}-1\%$
b	Unemployment benefits	10 percentile of u distribution
ρ	Persistence of dismissal shock	0.707
σ_ε	Std of dismissal shock	$(0.619)^{1/2}$
F_u	Hourly wage distribution	Log normal
F_w	Hourly wage distribution	Log normal
(μ_u, σ_u)	mean and std of u distribution	$(2.639, 0.35)$
(μ_e, σ_e)	mean and std of e distribution	$(2.796, 0.4)$
p	job finding rate as function of effort	Exponential distribution
μ	parameter exp. dist.	1

6 Solution Method

Due to nonlinearities that the model displays, we use a global solution method. We can identify several steps in order to solve the functional equations given by (2) and (7): (i) Discretize continuous shocks, (ii) compute expectations, (iii) solve value functions, (iv) solve policy functions and (v) compute stationary distributions.

Discretize continuous shocks. In order to compute expected values accurately, a good discretization is needed. Quadrature methods are popular because of their accuracy, although they approximate distributions (ie., for i.i.d shock) and are not useful for processes (AR(1)).

Since unemployed workers receive offers from the same distribution, we use Gauss-Hermite quadrature to approximate the wage offer distribution for unemployed workers. Note than this pins down the grid for wages, so the same grid will be used to approximate the wage distribution for employed workers. We then only need to define the transition matrix for the employed workers. Given a persistence parameter ρ, we approximate the transition matrix using a procedure based on Tauchen (1986).

Value functions. We use collocation to solve for the value functions. The Bellman equations are solved in collocations nodes and outside the nodes the values are interpolated. Value function has three state variables: a asset holdings, w current wage and x dismissal shock. w and x are discretized and a is approximated using cubic splines. The value functions are thus approximated by $\Phi(s)c = V(s)$, where $\Phi(s)$ is the basis function in state s, computed by the tensor product of basis function in each dimension $\Phi(s) = \Phi(x)\otimes\Phi(w)\otimes\Phi(a)$, and c are the unknown coefficients to be determined. To evaluate basis functions and compute tensor products we use Miranda and Fackler (2004) CompEcon toolbox. Coefficients can be solved using either fixed point iteration or Newton's method. For other application of the CompEcon toolkit in labor market models see Petrosky-Nadeau and Zhang (2017).

Compute expectations. We use parametrized expectations to approximate the expected values in the grid points. This means that every expected value is also approximated in the grid, ie $\mathbb{E}[V(s)] = \Phi(s)c^e$, where c^e is unknown. Given a value function $V(s)$, it is easy to define a stochastic matrix associated with a stochastic shock s, P_s[2]. Then, c_e is computed by solving a simple linear system of equations $\Phi(s)c^e = P_s\Phi(s)c$

Policy functions. Policy function is a two-dimensional object, since agents chooses how much to save and how much effort to exert. Given a guess for value function, we solve for policy functions using a 2-dimensional golden search method. Although slow, it is robust and accurate.

Considering all of the above, the functional equation to be solved is:

$$\Phi(s)c_1 = \max_{a',s} u(Ra - a' + b) - \lambda s + \beta\Big\{p(s)\Phi(z,a')c_3 + (1-p(s))\Phi(z,a')c_1\Big\} \tag{11}$$

$$\Phi(s)c_2 = \max_{a',s} u(Ra - a' + w) - \lambda s + \beta\Big\{p(s)\Phi(z,a')c_4 + (1-p(s))\Phi(z,a')c_5\Big\} \tag{12}$$

$$\Phi(a)c_3 = E_{wu}[I_0 P_{xx}\Phi(s)c_2 + \tilde{I}_0\Phi(a)c_1] \tag{13}$$

$$\Phi(s)c_4 = E_{we}[I_1 P_{xx}\Phi(s)c_2 + \tilde{I}_1 E_x\Phi(s)c_2] \tag{14}$$

$$\Phi(s)c_5 = D\Phi(s)c_1 + \tilde{D}E_x\Phi(s)c_2 \tag{15}$$

where $z = (w,x)$ is the idiosyncratic stochastic state variable. We use the following operator: P_{x_0} which makes the stochastic process of x start from its steady state value x_0,

[2] If $s = (w,x,a)$, this stochastic matrix may be referred to either a shock in w, a shock in x, or a joint shock (w,x) (which we do not explore in this paper). For instance, if we want to compute the stochastic matrix in the s space for the w shock, this matrix is determined by $\mathcal{P}_w = I_{N_x}\otimes P_w I_{N_a}$ where $\otimes$ is the Kronecker product and I_N is the identity matrix of size N.

I_0 and $\tilde{I}_0$ which is a binary variable and equals 1 if being employed has higher value than being unemployed in each state s and 0 otherwise (so $\tilde{I}_0 = 1 - I_0$), I_1 and $\tilde{I}_1$ equal 1 if it is better to switch jobs and 0 otherwise, and D and $\tilde{D}$ is an operator with the probabilities of being dismissed. The operators E_{wu}, E_{we}, E_x compute the expected value with respect to the wage distribution of unemployed workers, expected value with respect to wage distribution for employed workers and the expected value with respect the dismissal shock.

Equations (11) and (12) are the value of being unemployed and employed respectively. Equations (13), (14) and (15) represent the Parametrized Expectations. In particular, (13) is the expected value of the maximum between accepting a new job and being unemployed, (14) is the expected value of the maximum of a new job offer and staying in the current job and (15) is the expected value when a job offer is not received and a dismissal shock may hit.

Stacking c_i, the system (11) to (15) is written compactly as

$$(I_5 \otimes \Phi(s))c = u - \lambda s + \Omega c$$

Where $\Lambda = u - \lambda s$ is the utility function in the first $2N$ equations, where $N = N_a \cdot N_w \cdot N_x$, and in the remaining $3N$ equations $\Lambda_i = 0$.

To use Newton's algorithm to solve for c, define $g(c) = \Lambda + \Omega c - (I_5 \otimes \Phi(s))c$, with Jacobian $J = -(I_5 \otimes \Phi(s)) + \Omega$. Update coefficients using the updating rule $c_{k+1} = c_k - J^{-1} g$

Stationary distribution The idea is to write down the transitions in the model in the following way:

$$L_{t+1} = Q' L_t \tag{16}$$

where L_t is a column vector and Q is the transition matrix across states. Then, we can iterate using this matrix until it converges to the stationary distribution[3]. To be more specific, (16) can be written as

$$\begin{pmatrix} L_u \\ L_e \end{pmatrix} = \begin{pmatrix} Q_{uu} & Q_{ue} \\ Q_{eu} & Q_{ee} \end{pmatrix}' \begin{pmatrix} L_u \\ L_e \end{pmatrix} \tag{17}$$

[3]Equivalently, we can compute the eigenvector associated with the eigenvalue 1.

where Q_{ij} is the transition matrix for state i to state j, and u = unemployed, e = employed.

How to compute Q_{ij}'s? we have policy function, which give us transition matrices in the endogenous states, and stochastic processes which give us transition of stochastic states. Some matrices are useful and easy to compute:

Consider the following matrices. Q_{aa}'s are transition matrices for the asset space, $\odot$ is a column-wise Kronercker product, [] is the diag operator, ie, what is inside is written as a diagonal matrix, I_u and I_e are indicators of whether the worker accepts offers. $Q_{x_0,w}$ is the transition matrix of the w process (distribution w_u or w_e depending on the worker) given next period $x = \bar{x}$. Finally, Q_{x',w_0} is the transition matrix of the x process keeping w constant.

In order to compute these matrices, I will loop over states and wage offers and define the entire row associated with the transition matrix of that state.

Unemployed worker

I have a row vector I_u which tells me if the unemployed worker accepts the offer, it compares $W(w,\bar{x},a)$ and $U(a)$. I_u has dimension $N_a N_w$, indexes are $ia = 1,\ldots,N_a$ and $iw = 1 : N_w$.. Index in the I_u vector is $i = ia + (iw-1) * N_a$

If $I_u(i) == 0$, reject offer and stay unemployed, the row associated with this state is

$$Q_{uu}(i,:) = (1-p_u) * Q^u_{aa} + p_u \sum_{w \in \{Reject\}} p(w) Q^u_{aa}(i,:)$$

If $I_u(i) == 1$, accept offer, become employed.

$$Q_{ue}(i,:) = p_u P_w \otimes Q^u_{aa}(i,:)$$

where P_w is a vector that assign prob p_w to the corresponding w and $x = \bar{x}$.

Q_{uu} and Q_{ue} are the basis of Q_u.

Employed worker

We have a vector I_e which tells me if the new offer is accepted. If compares $W(w',\bar{x},w,a)$ and $E[V(w',x',w,a)]$ (notice that the order is important because the Kronecker product is not commutative). Notice also that the first object does not depend on w, and the second one does not depend on w'. I_e has dimension $N_a N_w N_w N_x$.

This is how to construct Q_e.:

Q_{eu} is quite easy. It is simply $Q_{eu} = [(1-p_e)\delta]Q^e_{aa}$.

Q_{ee} associated with no offers is also simple, although we need to make some adjustment. In particular

$Q^{\text{no}}_{ee} = [(1-p_e)(1-\delta)]Q_{x',w0} \odot Q^e_{aa}$ where $\odot$ is the row-wise Kronecker product and $Q_{x',w0}$ is the matrix associated with shifting mass in the x' dimension, keeping w fixed, and repeated downwards so as to match N_a dimensions.

Now, what is left is to compute the transitions in case an offer is received, and conditional on whether it is accepted[4].

To loop over the states, I use the following convention: $i = 1,\ldots,N_a$, to loop over asset space, $j1 = 1,\ldots,N_w$ to loop over current wage, $j2 = 1,\ldots,N_w$ to loop over new offers and $k = 1,\ldots,N_x$ to loop over dismissal shocks. The index in the I_e vector is $s = i+(j2-1)N_a+(j1-1)N_aN_w+(k-1)N_aN_wN_w$ and it is associated with the state (row) si of the transition matrix Q_ee, where $si = i+(j1-1)N_a+(k-1)N_aN_w$.

If $I_e(s) == 0$, reject offer, draw new x, same wage

$$Q_{ee}(si,:) = p_e(si)P_x(k,:) \odot P(j1,j2) \odot Q^e_{aa}(si,:) + Q_{ee}(si,:)$$

where $P_x(k,:)$ matrix that shifts mass in x' dimensions, $P(j1,j2)$ is the vector that shifts mass in w dimensions, full of zeros but in the position of $j1$ (because agents stays with wage $j1$), where it has $p_{we}(j1,j2)$ from the wage transition matrix.

If $I_e(s) == 1$, accept offer, change jobs, new wage.

$$Q_{ee}(si,:) = p_e(si)P_x(k,k_0) \odot P(j1,j2) \odot Q^e_{aa}(si,:) + Q_{ee}(si,:)$$

where $P_x(k,k_0)$ matrix that shifts mass towards x_0 in the x dimensions, $P^*(j1,j2)$ is the vector that shifts mass in w dimensions, full of zeros but in the position of $j2$ (because agents accepted offer of wage $j2$), where it has $p_{we}(j1,j2)$ from the wage transition matrix.

Moments Once we obtain the stationary distribution, which tells us the measure of agents in each possible individual state, computing moment is a matter of summing over the measure of agents we are interested in. For instance, the unemployment rate is the measure of agents in states such that they are unemployed.

[4]Maybe, a better way would be to separate the $E-E$ transitions in “no-offers” (easy to compute, not a transition), “rejected offers” (technically not a transition) and “accepted offers” (transitions the we actually might care about). This has not been done in the codes.

Some of the moments we are focused on are: the unemployment rate, the measure of financially constrained agents, the transitions over employment status (employment-unemployment, unemployment-employment and employment-employment), the distribution of accepted wages (conditional on a distribution of offers).

7 Model Fit

In this section we characterize the solution of model. We first present basic properties of policy functions and values function. We then show some moments generated by the model. We finally present the wealth distribution generated by the model.

7.1 Policy functions and Value Functions

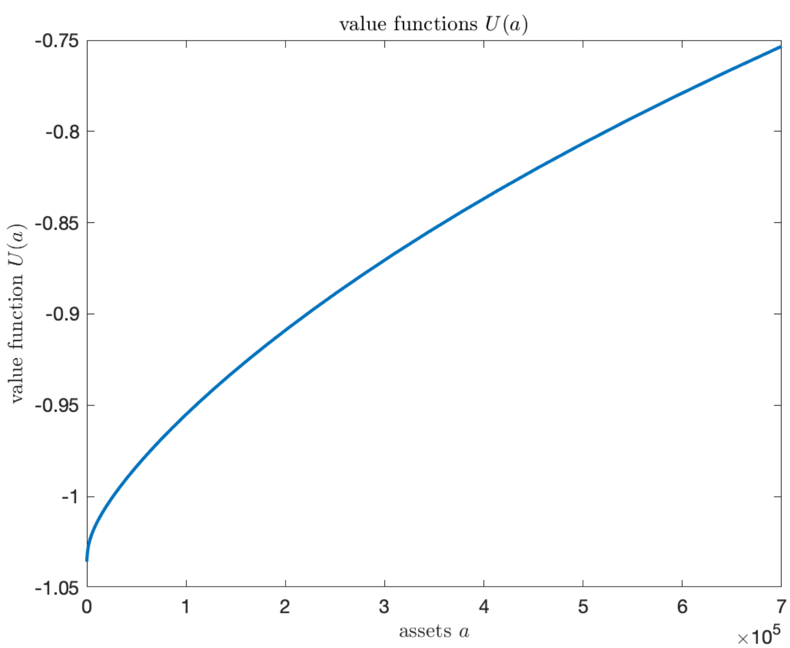


Figure 2: Value function: unemployed

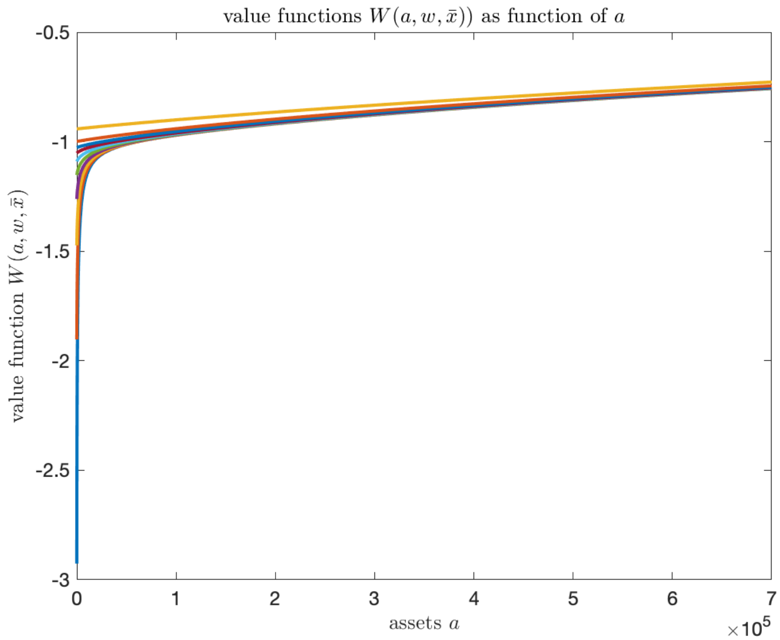


Figure 3: Value function: employed

Figures 2 and 3 show that value functions are increasing and concave as a function of assets. This is a standard feature of model with increasing and concave utility functions.

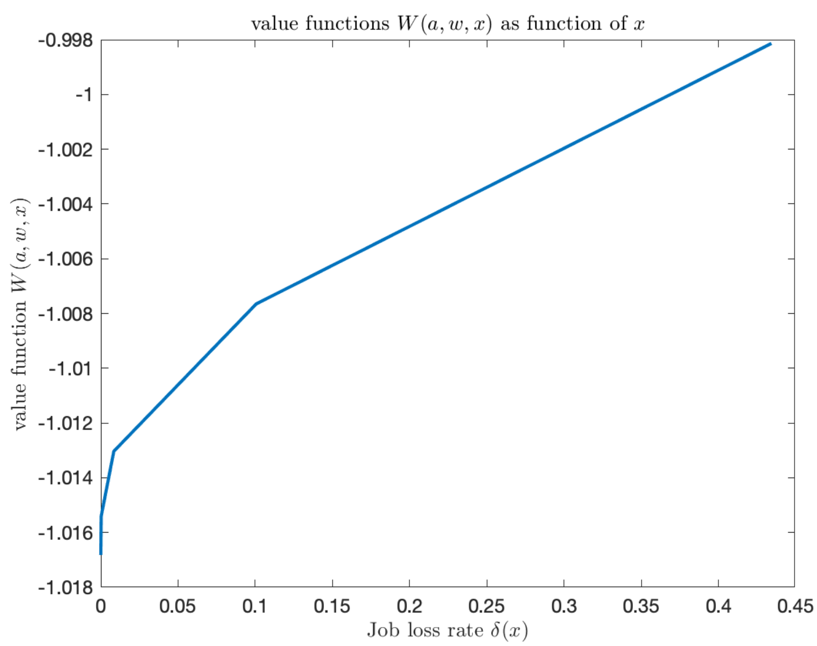


Figure 4: Value function as a function of layoff index

Figure 4 shows the value function of a employed worker (for a given value of wealth and a given wage) as a function of the probability of being dismissed. The value functions displays a negative slope suggesting that agents with higher probability of suffering a layoff are worse off.

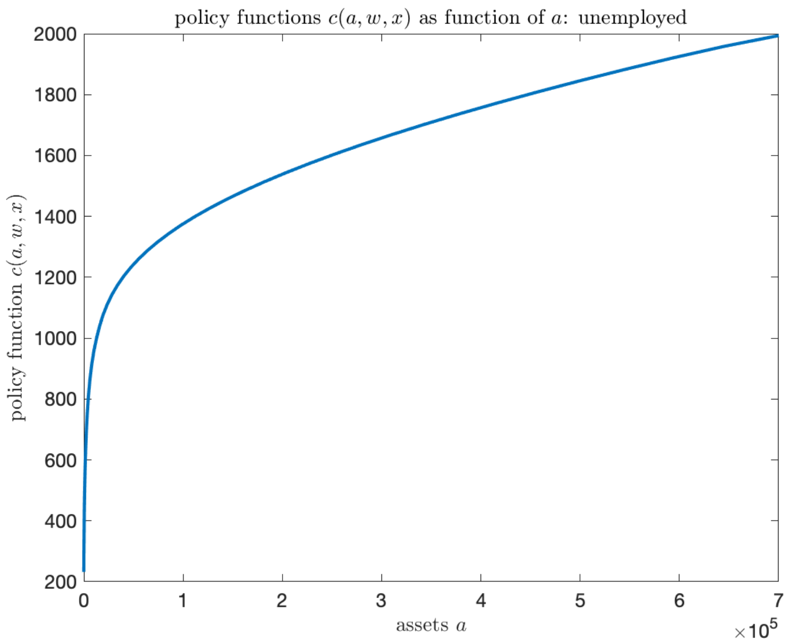


Figure 5: Consumption function: unemployed

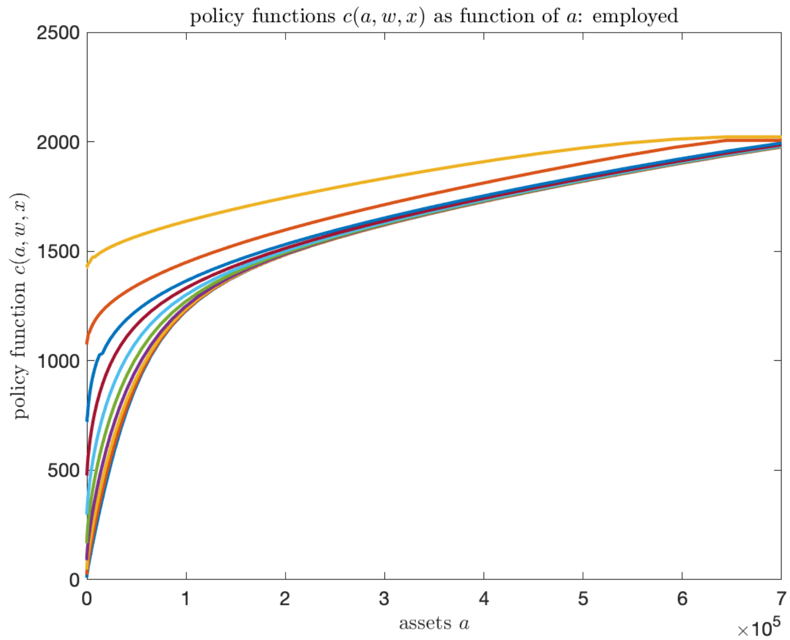


Figure 6: Consumption function: employed

Figures 5 and 6 display the consumption policy function as a function of assets for unemployed and employed workers. Both are increasing and concave.

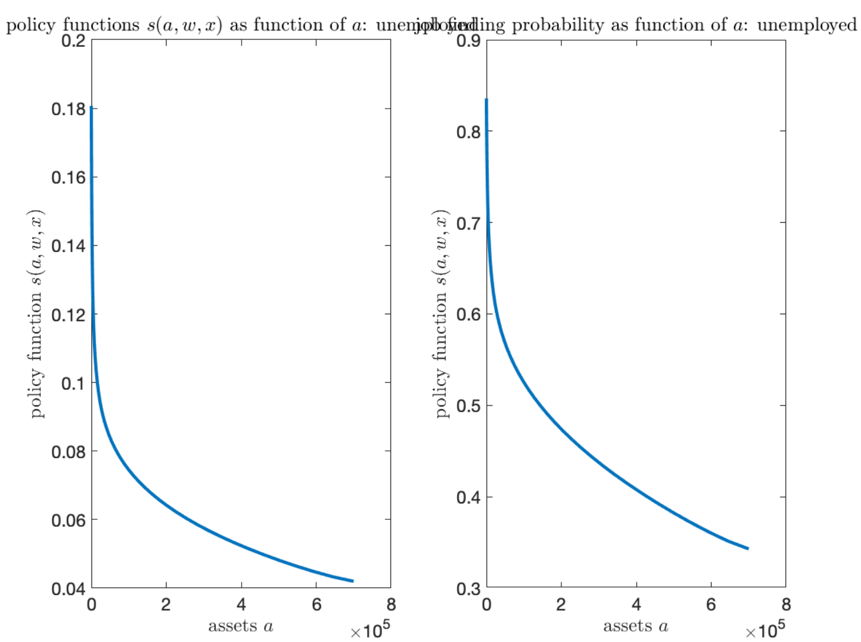


Figure 7: Search effort function: unemployed

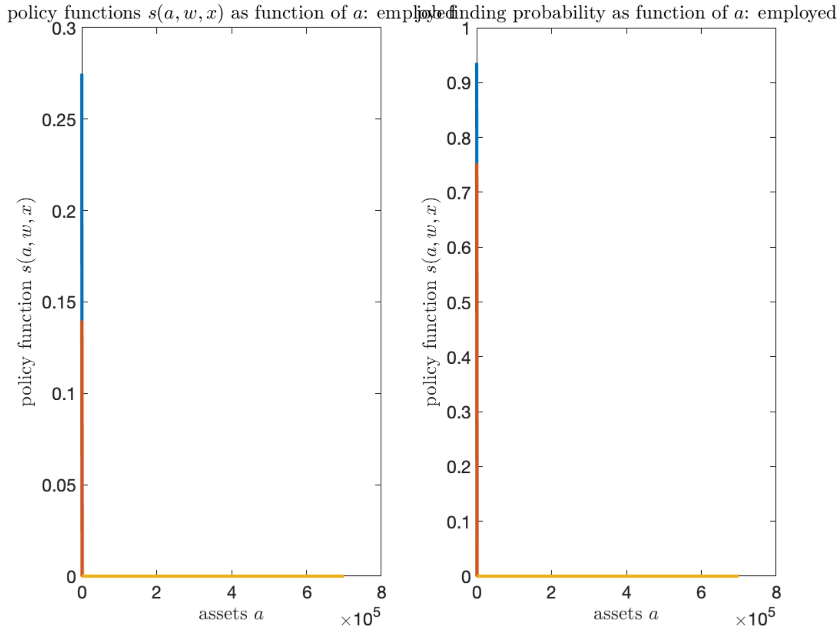


Figure 8: Search effort function: employed

Figures 7 and 8 show the search effort by agents as a function of their assets. The figure also shows the job finding probability associated with the level of effort. The wealth-poor agents are the ones that exert the most effort. For an unemployed worker, not having assets means that they are incapable of smooth consumption which greatly impacts their welfare. For a wealth-poor employed worker exerting effort allows then to receive new offers with potentially higher wages and thus climbing the wage ladder and accumulate wealth which they can later use to smooth consumption. This effect vanishes as agents accumulate wealth.

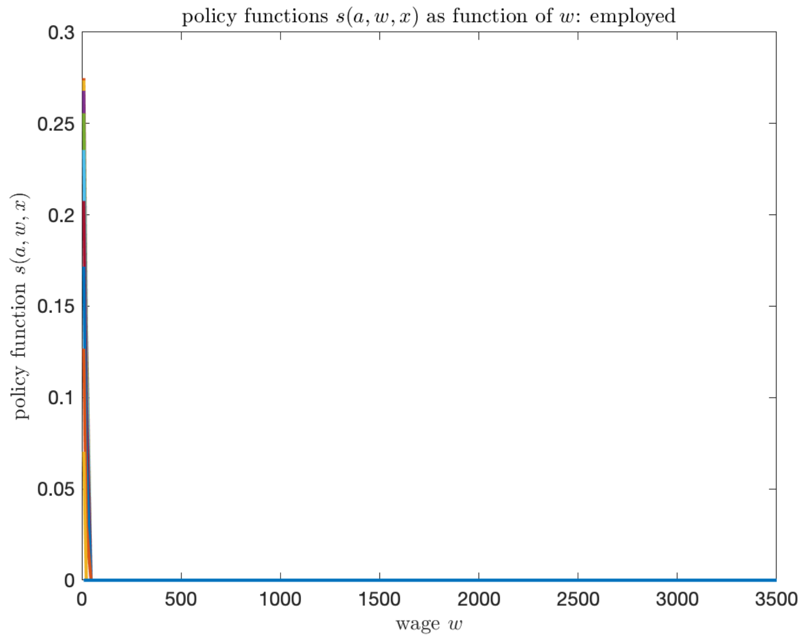


Figure 9: Search effort function: employed

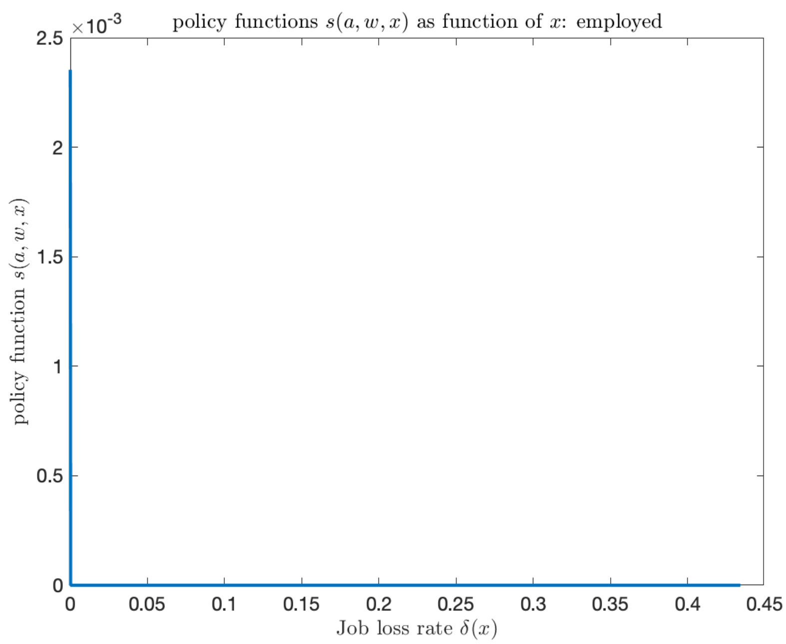


Figure 10: Search effort function: employed

Figure 9 shows the search effect as a function of the current wage. As the current wage increases, agents exert less effort. There are less incentives to search for a better paid job

Moments	Value
Unemployment rate	5.04%
Share of households with zero wealth	0.1%
EU flows	2.23%
UE flows	2.23%
EE flows	5.2%
Mean unemployment duration	2.29 weeks

Table 5: Moments

when the current wage is high in the wage distribution, since the probability of receiving an even higher wage is small.

Figure 10 shows that agents exert more effort when they perceive a higher probability of being dismissed.

7.2 Moments

Table 5 summarizes the moments from the baseline calibration of the model.

7.3 The wealth distribution

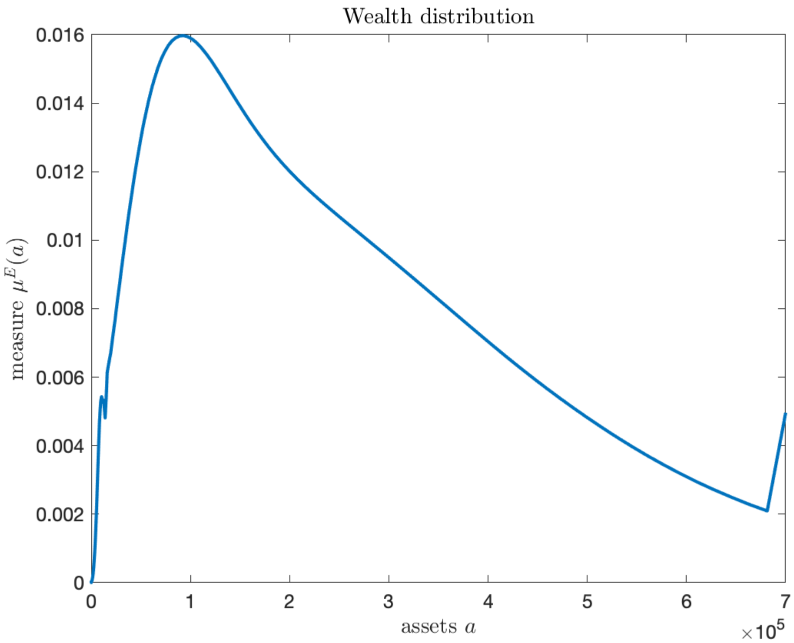


Figure 11: Wealth distribution

Figure 11 displays the wealth distribution in the economy. It is hump-shaped and there is little mass on the bottom of the distribution.

7.4 Distribution of accepted wages

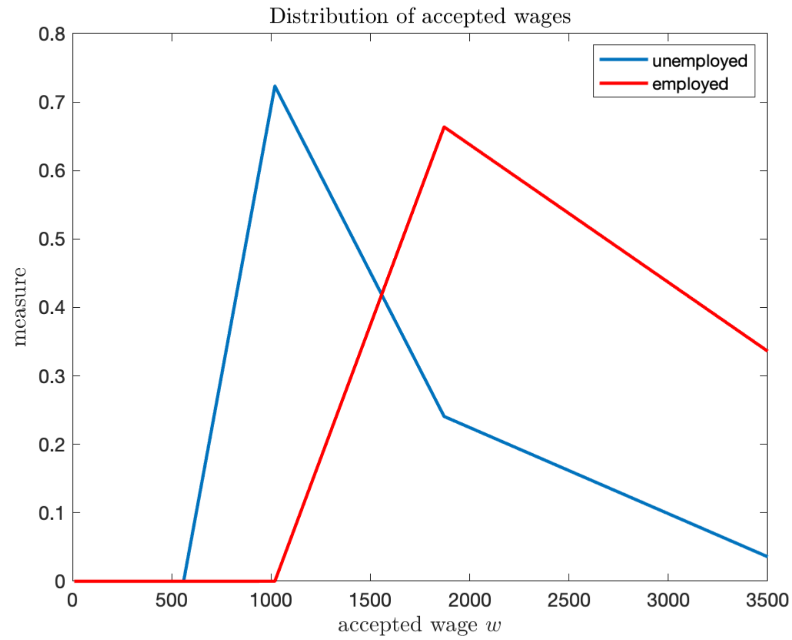


Figure 12: Distribution of accepted wages

Figure 12 shows the observed distribution of accepted wages. This figures resembles the accepted wages distribution reported in Faberman, Mueller, Şahin, and Topa (2017)

8 Comparative Statics

In this section we perform two comparative statics exercise. First, we eliminate the variance of idiosyncratic shocks. This means that we effectively shut down the on=the-job search insurance mechanism, since the probability of being dismissed is the same in any state. Second, we lower the cost of searching on the job. The cost of searching on the job is arguably lower than it was years or decades ago. Information technologies allows people to use new ways of contacting potential employers.

Table 6 summarizes the results of the comparative statics exercises. Keep in mind that we are working with a preliminary calibration. In all the parametrizations we observe a low mass in the lower bound of the asset. This is because agents are capable to escape from the borrowing constraints by simply saving out of the current wage. From the policy functions

Moments	Baseline	No shock	Low cost
Unemployment rate	5.04%	1.7%	4.35%
Share of households with zero wealth	0.1%	0.1%	0.1%
EU flows	2.23%	0.7%	2.08%
UE flows	2.23%	0.7%	2.08%
EE flows	5.2%	1.8%	5.26%
Mean unemployment duration	2.29 (w)	2.27 (w)	2.12 (w)

Table 6: Comparative statics

we can see that the job finding probability is high when agents are wealth-poor. This in turn causes the unemployment spells to be low. Unemployed agents can quickly find jobs (this is a feature of the calibration) and employed workers can avoid unemployment spells by switching to a new job. Agents in the borrowing constraints are unemployed agents which have been unlucky enough to be unemployed for several periods, they consume out their wealth and have not been able to accumulate. Eliminating the shock altogether lowers unemployment rate substantially. This is due to the large job finding probability. Lowering the search cost increases the EE flows while lowering EU and UE flows.

9 Discussion and Conclusion

To be written

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A Robustness of empirical analysis

Table 7: Dynamics of Layoff probability

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Inv Layoff pr (x_{t-1})	0.650***	0.613***	0.629***	0.703***	0.652***	0.625***	0.628***	0.696***
	(0.015)	(0.051)	(0.041)	(0.098)	(0.015)	(0.049)	(0.041)	(0.097)
Known lh wage		-0.014				-0.034**		
		(0.015)				(0.014)		
Annual lwage (SCE-LAB)			-0.006	-0.062**			-0.010	-0.079***
			(0.007)	(0.027)			(0.008)	(0.030)
Log Assets				0.009				0.012
				(0.010)				(0.013)
Observations	32,427	2,444	4,906	992	32,147	2,400	4,898	987
R-squared	0.402	0.353	0.395	0.424	0.406	0.379	0.395	0.428
Year & Region FE	✓	✓	✓	✓	-	-	-	-
Demogr	-	-	-	-	✓	✓	✓	✓
mean dv	-2.419	-2.417	-2.442	-2.418	-2.420	-2.422	-2.442	-2.416

Note: Robust standard errors in parentheses . *** $p < 0.01$, **$p < 0.05$, * $p < 0.1$

Table 8: Expected log of search effort as a function of layoff probability

Variables	log (N^o methods)	log (Hours search)	log (N^o applications)
		No controls	
	(1)	(2)	(3)
Layoff prob	1.039***	0.820***	0.610***
	(0.199)	(0.199)	(0.167)
Observations	1,994	1,994	2,535
R-squared	0.022	0.015	0.009
		Year & Region FE	
	(4)	(5)	(6)
Layoff prob	0.681***	0.502**	0.606***
	(0.186)	(0.195)	(0.166)
Observations	1,994	1,994	2,535
R-squared	0.223	0.186	0.010
		Demogaphics	
	(7)	(8)	(9)
Layoff prob	1.081***	0.824***	0.575***
	(0.199)	(0.202)	(0.170)
Observations	1,988	1,988	2,491
R-squared	0.041	0.024	0.013
		Year, Region FE & Demographics	
	(10)	(11)	(12)
Layoff prob	0.785***	0.559***	0.569***
	(0.188)	(0.204)	(0.169)
Observations	1,988	1,988	2,491
R-squared	0.234	0.191	0.014

Note: Robust standard errors in parentheses . *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$