Search by Firms and Labor Market Policies

Gonul Sengul*
Central Bank of Turkey †

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Abstract

This paper develops a model of search by employers in which search to fill a vacancy affects firms' probability of hiring, duration of the employment relationship, cost of a vacancy and the expected productivity of the job. I employ a model with uncertainty about the quality of a match: it could be of good or bad quality. Firms conduct interviews where they learn the probability of the match being of good quality and select the worker with the highest probability. Hence, more interviews increase the chance of getting a good quality match thereby reducing separations. I find that firms mostly adjust the number of interviews they conduct when labor market policies are introduced to the model. Counterfactual exercises where firms cannot adjust the number of interviews reveal that selection channel mostly mitigates the effect of policy on unemployment rate.

Keywords: Labor market search, unemployment, employer search, labor market policies.

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*Istanbul School of Central Banking, Central Bank of the Republic of Turkey. Email: Gonul.Sengul@tcmb.gov.tr.

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1 Introduction

The importance of search for information in the labor market is widely recognized, starting from the seminal work of Stigler (1962). Although there is a vast empirical and theoretical literature focusing on the worker's search behavior, less is known about the other side of the labor labor market; search by firms. This paper aims to contribute towards this gap by developing a model of search by employers and investigating the unemployment response to different labor market policies in the presence of such channel.

Search by firms is centered around selection of the best candidate among applicants of a vacancy. van Ours and Ridder (1993) use data from Netherlands and find that vacancies mostly hire among applicants that apply for the job shortly after the vacancy is opened, but hiring takes place long after the application. Similarly, van Ours and Ridder (1993), Barron et al. (1985), Barron and Bishop (1985) and Barron et al. (1997) find that employers put effort into assessing the suitability of applicants and selecting the best candidate. Moreover, as firms search more for the better candidate the cost they incur increases (Barron and Bishop (1985)). Thus, employers' search affects not only the arrival rate of an employee but also the compatibility of the new hire for that job as well as the vacancy cost. A better suited match will be more productive and last longer. However, in a standard search model à la Pissarides (2000), the intensity of search by employer only affects the arrival rate of a candidate.[1]

To formally analyze the selection efforts of firms, I employ a discrete time infinite horizon search and matching model in which workers and firms are homogenous and there is match specific quality: An employment relationship between a firm and a worker (match) can be of either good or bad quality. Good quality matches produce higher output. The true quality of the match is unknown before the employment relationship starts and it is revealed after parties observe the output.

A firm posts a vacancy and picks the number of workers to conduct interviews with, incurring some cost. An interview reveals the probability of the worker being a good match for the firm. Firm picks the worker with the highest probability of good quality match at the end of the interviews.[2] Firms choose the number of interviews to maximize the value of their vacancy. A firm's choice of interviews depends on the productivity gap between a good and a bad quality match output, the cost of interview, the probability of a match in the following periods, the cutoff rule for an acceptable match, as well

[1]Pissarides (1984) also models employer search ("job advertisement") in a similar fashion.
[2]If firms pick only one interview, then there is no "selection".

as the distribution that governs the match quality.

The probability of the worker being a good match for the firm comes from a distribution. Since the firm interviews some number of workers and picks the one with the highest probability, the distribution of the match quality that determines the job's productivity is the empirical distribution of the largest order statistics of the probability of a good match. Hence, firms' search behavior determines the equilibrium distribution of the match quality. There is also a threshold probability in the model above which employment relationships form.

An increase in the number of interviews in an economy affects unemployment through changing inflow and outflow rates. The fraction of new employment relationships that are of bad quality declines with more selection, reducing the separations into unemployment. The effect on inflow rate is less apparent. More interviews increase the cost of a vacancy and change the expected returns from an employment relationship at the same time. Whether the number of vacancies in an economy increases or decreases with more interviews depends on the parameter values. Hence its effect on the number of vacancies, thus on job finding rate is ambiguous. In the presence of firms' selection effort, any labor market policy can potentially alter the incentives to interview, generating an extra channel through which policies affect the unemployment rate. I calibrate the model to match US labor market moments and use this model to analyze the unemployment response to firing tax, hiring subsidy, minimum wage and unemployment insurance policies and the contribution of selection effort channel to such response.

Firing tax is known to increase unemployment as it discourages firms to open vacancies, thereby reducing the job finding rate. In an economy with selection effort, implementing a firing tax increases firms' incentives to conduct interviews. This is because good quality matches become more valuable as it saves firms from paying the firing tax. As more interviews reduce separations, we observe less increase in unemployment rate as a response to firing tax than we would have observed in a counterfactual economy without selection (without adjustment in the number of interviews). The mitigating effect of selection on unemployment increases with the firing tax.

With hiring subsidy in place, hiring the wrong worker becomes relatively less costly, reducing firms' incentives to invest in selection. A decline in the number of interviews increases bad quality matches in the economy, increasing (endogenous) separations. Moreover, there is more hirings (vacancies) in equilibrium as not only hiring subsidy, but also decline in the total vacancy cost due to less interviews increases job creation. In the calibrated model, for low values of subsidy, effect of increasing job finding rate dominates (as the policy is not large enough to change firms' selection effort), and the unemployment rate falls. As the hiring subsidy increases, the effect of increasing separations dominates and the unemployment rate goes up.

The paper also looks at the implications of minimum wage and unemployment insurance policies. Minimum wage policy qualitatively has the same effect on equilibrium as firing tax policy. Number of interviews increases with minimum wage while unemployment flow rates decrease and unemployment increases. However, the selection effort channel does not always respond to labor market policies. Firms choose not to change their number of interviews for plausible values of unemployment insurance policy, given the calibrated parameters. This is because there is no direct effect of unemployment insurance on selection decision. What is more is that the general equilibrium effects through changes in other equilibrium values (cutoff probability and the vacancy to unemployment ratio) have opposing effects on selection. The net effect is not large enough to alter firms' interview choices. Nonetheless, unemployment increases with unemployment insurance.

This paper is related to the recent literature that models firm selection. Villena-Roldán (2008) develops a model of firms' recruitment behavior to explain the negative duration dependence of unemployment and re-employment wages. Firms interview applicants, who are heterogenous in their innate productivity, and observe their productivity. They hire the most productive workers, generating an endogenous positive relationship between unemployment exit rate and productivity, and hence wages. Wolthoff (2014) develops a directed search model with worker-specific productivity where firms decide on the number of interviews they conduct. He characterizes the equilibrium and looks at its implications over the business cycle.[3] Tasci (2006) models firms' recruitment choice as deciding between two different screening technologies with one being more costly and more effective (i.e., delivering matches with higher expected quality) than the other. He shows that firms change their choice of technology as a response to productivity shocks and this behaviour can explain some of the volatility of the key labor market indicators over the business cycle.[4]

This paper is also related to papers that study labor market policies. The closest to it is Pries and Rogerson (2005), where they develop a model to

[3] Also, Merkl and Van Rens (2012) develop a model with ex-ante heterogenous workers in their training costs. In the model firms hire workers with training costs below some threshold value. They argue that with such selective hiring, welfare costs of unemployment are larger.

[4] In a model with a similar worker selection, Chugh and Merkl (2011) characterize efficient allocations and business cycle fluctuations.

explain worker and job turnover differences between US and Europe through differences in hiring practices. In their model, hiring strategy is the cutoff probability of a good match. This paper is an extension of their model as it adds another dimension to hiring strategy: firms can choose the number of interviews they conduct and hence can have direct effect on employment duration and productivity as well as the cost of a vacancy. The results obtained from a counterfactual economy of this model where firms cannot adjust the number of interviews they conduct are consistent with those in Pries and Rogerson (2005). Findings suggest that selection effort channel mitigates the effect of many of the labor market policies on unemployment rate. Pissarides (1985) finds that employment subsidies reduce unemployment while unemployment benefits and wage taxes raise it. Kitao et al. (2011) find that hiring subsidy increases job finding rate as well as endogenous separations (which occur due to shocks to productivity and hiring subsidy increases the reservation productivity). As a result, unemployment also increases.

The rest of the paper is organized as follows. The following section lays out the model. The equilibrium of the model is defined and analyzed in section 3. Section 4 discusses the different labor market policies while section 5 presents the quantitative results of the model. Lastly, section 6 concludes.

2 Model

There is a unit measure of homogenous workers and a continuum of ex-ante identical firms. All agents are risk neutral, and they discount future at rate β. A worker can be either unemployed or employed while a firm is either vacant (looking for a worker) or producing. A firm can employ at most one worker. Vacancies incur a cost and the unemployed workers receive unemployment value b. The production unit in the economy is a firm-worker pair and wages are outcomes of Nash Bargaining.

The production unit produces $y = y^i$ amount of output, where i is the quality of the match between the worker and the firm. The output y^i takes on the value $y^g(y^b)$ if the match is of good (bad) quality, where $y^g > y^b$. I assume that $y^b = b$ and $y^g > b$. Under this assumption bad quality matches are undesirable in equilibrium, firm and worker pairs terminate such matches.[5] The Nash bargaining assumption guarantees the unanimity of the separation or match formation decision.[6] In addition to endogenous separation, production

[5] The weaker assumption that $y^b \leq b$ would suffice for bad quality matches be undesirable.

[6] That is because parties bargain over the net surplus of the match, and if the surplus is positive (negative) they decide to form the match (separate).

units that are active (that produce in the current period) are subject to an exogenous destruction at rate δ.

The quality of a match is ex-ante uncertain; a worker-firm pair does not know it before they start producing. However, they know the probability that the prospect match is of good quality when they decide whether to form the employment relationship. This information is revealed during the following selection process.

Selection Process: Let the number of unemployed workers be **U** and the number of vacant jobs be **V**. An unemployed worker applies to all vacancies.[7] Hence each firm receives **U** many applications and **decides** on how many workers to interview (n), where $n \geq 1$. An interview is a meeting between a vacant firm and an unemployed worker during which the firm learns the probability (γ) that this employment relationship is of good quality. The good quality match probability, γ, is a random variable drawn from a distribution Ψ. The firm collects information on the probability of a good quality match with the worker interviewed, γ_i, from each one of the n interviews. Based on this information, the firm selects the worker who is the most likely to be a good quality match, i.e., $\max\{\gamma_1, \gamma_2, \gamma_3, ..., \gamma_n\}$. Then, the firm reveals the value of γ to the worker with the highest γ and they decide whether to form the employment relationship.[8] Note that the highest γ drawn may still not be high enough probability for the firm and the worker to decide to form the employment relationship. Nonetheless, let's call this a match (which may or may not become active). As will be discussed later, there is a cutoff probability in equilibrium, above which all new matches become active.

To derive the match probabilities, let m^i be the number of interviews and m^o be the number of offers a worker receives. A worker gets an interview with n/U probability, and has V many trials to be successful at. Hence, m^i has a Binomial distribution; $m^i \sim B(V, n/U)$. A worker with m^i many interviews gets an offer with $1/n$ probability from each of these interviews. Thus, number of offers, conditional on number of m^i has the Binomial distribution, i.e., $m^o \sim B(m^i, 1/n)$). The unconditional probability that a worker receives s many offers is:

$$Pr(m^o = s; V, U, n) = \sum_{k=s}^{V} g(m^i = k; V, \frac{n}{U}) g(m^o = s; k, \frac{1}{n}),$$

where $g(\cdot)$ is the probability mass function. After some algebra, one can show

[7] This assumption guarantees that the firms will get more applications than the number of interviews they would choose.

[8] The assumption that worker does not learn the γ at the interview simplifies the modeling as worker would be indifferent and pick randomly if she receives multiple offers.

that the probability of receiving no offers is:

$$Pr(m^o = 0; V, U, n) = (1 - \frac{1}{U})^V = (1 - \frac{\theta}{V})^V = e^{-\theta}, \tag{1}$$

where $\theta = \mathbf{V}/\mathbf{U}$ is the market tightness. We get the last equality as $\mathbf{U}$ and $\mathbf{V}$ go to infinity (as the number of unemployed and vacancies are large) while holding the market tightness, θ, constant. This probability is derived in the appendix. Let χ be the probability that an unemployed worker ends up with a match. Then,

$$\chi = 1 - Pr(m^o = 0; V, U, n) = 1 - e^{-\theta},$$

as a worker who gets at least one offer will end up with a match. Since a worker can receive multiple offers, it is possible that the worker chosen by the firm may not be available. As workers do not know the probability that they are good match for each firm, they are indifferent across multiple offers. Let ϕ be the probability that the worker firm makes an offer to chooses the firm. We can write this probability as[9]

$$\phi = \frac{\chi}{\theta} = \frac{1 - e^{-\theta}}{\theta}. \tag{2}$$

One interesting note here is that $1 - \chi$ does not depend on the number of interviews in the economy per se.[10] Number of interviews affect the meeting probability through its equilibrium effect on the market tightness.

3 Equilibrium

Let V be the value of a firm with a vacancy, and $J(\gamma)$ be the value of a firm in a match. The value of a vacancy is the discounted value of expected profits, net of cost of the vacancy.

$$V = \max_{n^j} \Big[- C(n^j) + \beta \int_0^1 \big\{ \phi J(\gamma) + (1 - \phi) V \big\} d\Psi^{n^j}(\gamma) \Big], \tag{3}$$

where Ψ^{n^j} is the distribution of the maximum statistics of n_j draws from Ψ and $C(n^j)$ is the cost of conducting n_j many interviews. $C(n^j)$ is an increasing

[9]See appendix for details.

[10]This is due to the assumption that firms contact workers even if the good quality match probability is lower than the threshold value.

function of n^j and $C(1) > 0$. If the worker that is the best among interviewed is available, which happens with ϕ probability, the firm gets the value of a match with this worker, $J(\gamma)$. If not, the firm searches again in the subsequent period. Equation (4) formalizes the problem of a firm that is in a match with a worker.

$$J(\gamma) = \max\Big\{V,\ E(y|\gamma) - w(\gamma) + \beta\delta V + \beta(1-\delta)\big(\gamma J(1) + (1-\gamma)J(0)\big)\Big\}, \quad (4)$$

where $E(y|\gamma) = \gamma y^g + (1-\gamma)y^b$ is the expected value of output and $w(\gamma)$ is the wage. The firm decides whether to terminate the match or produce with the worker. If the match is terminated, the firm gets its outside option value V. If the production takes place, the firm gets the current period profits (output net of the wage paid to the worker) and the discounted value of being in a match in the subsequent periods. If the production unit gets the exogenous destruction shock, then the employment relationship will not survive to the next period. If the match survives (which happens with $(1-\delta)$ probability), then with γ (1-γ) probability it is revealed to be of good (bad) quality and gets the value of $J(1)(J(0))$.[11]

Let U be the present value of unemployment to a worker. Moreover, let $W(\gamma)$ be the present value of being in a match for a worker where γ is the probability that the match is of good quality. If a worker is unemployed, she gets the unemployment benefit, b, at the current period. With $1-\chi$ probability the worker does not get any offers from firms, thus continues to be unemployed in the subsequent period. The worker gets at least one offer with χ probability and gets an expected value from being in a match with a firm. The value of unemployment can be formally expressed as follows:[12]

$$U = b + \beta(1-\chi)U + \beta\chi \int_0^1 W(\gamma) d\Psi^n(\gamma). \quad (5)$$

[11] Note that after the first period, when the match quality is revealed to be good ($\gamma = 1$) or bad ($\gamma = 0$), equation 4 becomes:

$$J(0) = \max\big\{V,\ y^b - w(0) + \beta\delta V + \beta(1-\delta)J(0)\big\},$$
$$J(1) = \max\big\{V,\ y^g - w(1) + \beta\delta V + \beta(1-\delta)J(1)\big\}.$$

Recall that in equilibrium bad quality matches are destroyed endogenously, hence $J(0) = V$.

[12] The value of unemployment can be written as

$$U = b + \beta(1-\chi)U + \beta\chi \int_0^1 \hat{\chi}(\gamma|n) W(\gamma) d\Psi,$$

where $\hat{\chi}(\gamma|n)$ is the probability that the worker gets an offer with γ probability of being in a good match with a prospect employer. The probability that a worker is selected by a firm after an interview with the probability of a good quality match being γ is $\hat{\chi}(\gamma|n) = \Psi^{(n-1)}(\gamma)$.

If a worker is in a match with a firm and with γ probability the match is of good quality, the worker decides whether to stay in the match or separate to unemployment. If she stays in the match, the worker gets the wage in the current period. If the match survives to the next period and it is revealed to be of good quality, the worker will get the value of being in a good quality match, $W(1)$. If the match is revealed to be of bad quality, which will happen with probability $1-\gamma$, the worker will get the value of being in a bad quality match, $W(0)$.[13]

$$W(\gamma) = \max\Big\{U,\ w(\gamma) + \beta\delta U + \beta(1-\delta)\Big[\gamma W(1) + (1-\gamma)W(0)\Big]\Big\}. \tag{6}$$

The wage is the outcome of a Nash bargaining where worker's bargaining power is μ. The wage is determined such that the worker's net gain from being in the match is μ fraction of the total net surplus this match generates. Hence, the worker's and the firm's decision about match formation is unanimous. Let $X(\gamma)$ be the decision rule for the optimal match formation, such that $X(\gamma)$ takes on the value of 1 if it is optimal to activate the match which has the γ probability of being good quality, and 0 otherwise. In equilibrium there is a cutoff probability γ^* such that for all $\gamma > \gamma^*$ match formation is optimal. Moreover, let $E(X)$ be the expected probability of match formation.

$$E(X) = \int_0^1 X(\gamma) d\Psi^n. \tag{7}$$

Also let $E(\gamma|X)$ be the expected probability of a good quality match conditional on the match being formed, which is defined as:

$$E(\gamma|X) = \frac{\int_0^1 \gamma X(\gamma) d\Psi^n}{E(X)}. \tag{8}$$

To write down the employment transitions, let the number of unemployed of the current period be u, the number of employed with good quality and unknown quality matches of the current period be e^g, and e^n, respectively. The number of unknown quality matches in the subsequent period ($e^{n'}$) is the

[13] Similar to the firms' problem, when the match quality is revealed to be good ($\gamma = 1$) or bad ($\gamma = 0$), equation 6 becomes:

$$W(0) = \max\big\{U,\ w(0) + \beta\delta U + \beta(1-\delta)W(0)\big\},$$
$$W(1) = \max\big\{U,\ w(1) + \beta\delta U + \beta(1-\delta)W(1)\big\}.$$

Recall that in equilibrium bad quality matches are destroyed endogenously, hence $W(0) = U$.

newly formed matches as any unknown quality match of the current period either dissolves or becomes good quality match by the subsequent period.

$$e^{n'} \;=\; u\chi E(X).$$

Workers with good quality matches in the subsequent period ($e^{g'}$) are current workers in a good quality match who produce and survive the exogenous destruction rate δ, $E(\gamma|X)$ fraction of current period workers in unknown quality matches (who learn their true quality at the end of the current period after producing, and $E(\gamma|X)$ fraction of them turns out to be in a good quality match). Hence, the number of good quality employments in the subsequent period is

$$e^{g'} \;=\; (1-\delta)e^g + e^n(1-\delta)E(\gamma|X).$$

Unemployed workers go through the process described above and χ fraction of them match and decide whether to form an employment relationship. $E(X)$ fraction of these actually turn into an employment relationship. Hence, $\chi E(X))$ fraction of currently unemployed become employed in the subsequent period, while the reminder continue to be unemployed. The number of unemployed in the subsequent period is the sum of currently employed who get hit by an exogenous job destruction shock, currently employed unknown quality employments which reveal to be of bad quality, and the current unemployed who could not find a job.

$$u' = u(1-\chi E(X)) + \delta(e^g + e^n) + e^n(1-\delta)\big(1 - E(\gamma|X)\big).$$

Equilibrium: The steady state equilibrium is a list $\{e^g, e^n, v, u, w(\gamma), X(\gamma), J(\gamma), V, W(\gamma), U, n\}$ such that

- $\{J(\gamma), V, W(\gamma), U\}$ satisfy equations (3), (4), (5), and (6).
- There is free entry; v/u satisfies $V = 0$.
- $w(\gamma)$ is the solution to the Nash bargaining, so that

$$W(\gamma) - U = \mu\big[W(\gamma) - U + J(\gamma) - V\big].$$

- Match formation decision $X(\gamma)$ is such that

$$X(\gamma) = \begin{cases} 1 & \text{if} \quad \gamma \geq \gamma^* \\ 0 & \text{if} \quad \gamma < \gamma^*, \end{cases} \tag{9}$$

  where γ^* makes firms and workers indifferent to match formation.

- The flows between employment and unemployment states are constant.

$$\begin{aligned} e^g &= (1-\delta)e^g + e^n(1-\delta)E(\gamma|X), \\ e^n &= uf, \\ u &= 1 - e^n - e^g. \end{aligned}$$

- n solves firm's maximization problem:

$$n = \arg\max_{n_j} \Big[-C(n^j) + \beta \int_0^1 \{\phi J(\gamma) + (1-\phi)V\} d\Psi^n(\gamma) \Big],$$

  where ϕ is defined in equation (2).

One can characterize the equilibrium in terms of three values; selection effort n, market tightness $\theta = v/u$ and cutoff probability γ^*. For a given value of n and γ^*, the market tightness is determined by the free entry condition. One can define the total net surplus of a match, $S(\gamma)$, as the summation of present values for the firm and the worker, net of their outside options, i.e., $S(\gamma) = W(\gamma) - U + J(\gamma) - V$. The net surplus is:

$$S(\gamma) = \max\Big\{0,\ E(y|\gamma) - (1-\beta)U + \beta(1-\delta)\big(\gamma S(1) + (1-\gamma)S(0)\big)\Big\}, \quad (10)$$

making use of the free entry condition that $V = 0$ in equilibrium. Free entry condition implies:

$$0 = (1-\beta)V = -C(n) + \beta\phi(1-\mu)\int_0^1 S(\gamma) d\Psi^n(\gamma)$$

Using equation above, we can rewrite the value of unemployment as

$$(1-\beta)U = b + \beta\chi\mu \int_0^1 S(\gamma) d\Psi^n(\gamma) = b + \theta C(n)\frac{\mu}{1-\mu}. \quad (11)$$

Notice that vacancies earn zero in equilibrium, values of good and bad quality match surpluses ($S(0)$ and $S(1)$) are independent of the value of γ, as γ governs the probability of their realizations, not the realized values directly. Also, workers' outside option does not depend on a particular realization of γ. Hence, the surplus in equation (10) is linearly increasing in γ, and thus we can write the surplus as $S(\gamma) = S^{'}(\gamma^*)(\gamma - \gamma^*)$, where[14]

$$S^{'}(\gamma^*) = \frac{(y^g - y^b)}{1 - \beta(1-\delta)(1-\gamma^*)}.$$

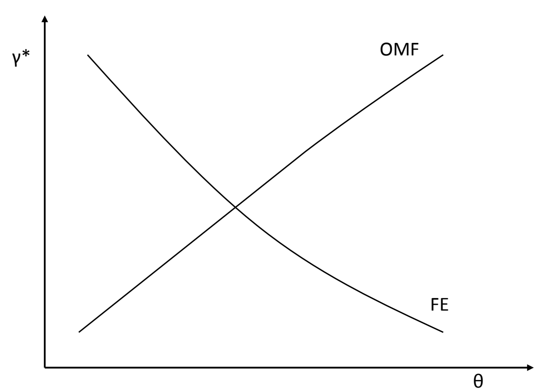
[14] We take the derivative of equation (10) with respect to γ and use $S(1) = S^{'}(\gamma^*)(1-\gamma^*)$.

We can rewrite the free entry condition as:

$$\frac{C(n)}{\beta\phi(1-\mu)} = \frac{(y^g - y^b)}{1-\beta(1-\delta)(1-\gamma^*)}\int_{\gamma^*}^{1}(\gamma-\gamma^*)d\Psi^n(\gamma). \tag{12}$$

The market tightness solves the equation (free entry condition) above, where $S^{'}(\gamma^*)\int_{\gamma^*}^{1}(\gamma-\gamma^*)d\Psi^n$ is the expected value of surplus, conditional on match formation. Note that the right hand side of equation (12) is decreasing in γ^*. Thus, for a given n, as γ^* increases, the number of vacancies should decrease, reducing θ and increasing ϕ, to make free entry condition hold again. Hence, the free entry condition implies a negative relationship between γ^* and θ, for a given n (see Figure 1).

Figure 1: Equilibrium Values of Market Tightness and the Cutoff



Note: FE is the free entry curve, OMF is the optimal match formation curve.

For a given number of interviews n and market tightness θ, the value of γ^* is determined by the optimal match formation condition.[15] Recall that γ^* leaves workers and firms indifferent between forming the production unit or staying unattached. We use the equation $S(\gamma^*) = 0$ and the value of unemployment in equilibrium to get the optimal match formation condition:

$$(1-\beta)U = y^b + \gamma^* S^{'}(\gamma^*). \tag{13}$$

As θ increases, with higher number of vacancies, it gets easier for workers to receive an offer while firms get lower chances of their best candidate being available. A higher θ increases workers' outside option which makes the

[15]The appendix discusses the existence of a cutoff γ. Intuitively, there will be such cutoff value since the value of a bad quality match is negative ($y^b \leq b$) and a good quality has positive value added ($y^g > b$).

surplus from the match at the cutoff probability decrease. Hence, there is a positive relationship between (γ^*, θ) in optimal match formation equation, as illustrated in Figure 1.

Choice of interviews: Note that firms solve optimization problem for a given ϕ (or θ) and γ^*. In a symmetric equilibrium, n is an equilibrium if $\forall n^j \neq n$

$$\frac{(y^g - y^b)}{\big(1-\beta(1-\delta)(1-\gamma^*)\big)}\Big(\int_{\gamma^*}^{1}(\gamma-\gamma^*)d\Psi^n - \int_{\gamma^*}^{1}(\gamma-\gamma^*)d\Psi^{n^j}\Big) > \frac{C(n)-C(n^j)}{\beta(1-\mu)\phi}, \tag{14}$$

where $\phi = \frac{(1-e^{-\theta})}{\theta}$.

Observe that, the choice of number of interviews depends on the productivity gap between good and bad quality matches, exogenous destruction rate, match distribution, and the cost structure of interviews. As the productivity difference between good and bad quality matches increase (decrease), firms are more (less) likely to choose a high number of interviews, as the return from more interviews increases (decreases) for all n values. Moreover, if the cost increases more with additional interview, then firms are less likely to select high number of interviews.

Equilibrium Unemployment: Unemployment is determined by two components: flows into unemployment and flows out of unemployment. In this model, flows out of unemployment, job finding probability, is defined as

$$f = \chi \int_0^1 X d\Psi^n = (1-e^{-\theta}) \int_{\gamma^*}^1 d\Psi^n. \tag{15}$$

Observe that in this model there are two sources that jointly determine the transition from unemployment to employment. First is that the worker needs to be the best worker interviewed, i.e., she needs to get some offers. Second, the worker needs to be good enough to be hired (the probability of good quality match should be high enough). Market tightness, the cutoff value, and the number of interviews determine the equilibrium value of these probabilities. As the number of vacancies increase, so does the probability that a worker receives at least one offer. Hence, the job finding probability is increasing in market tightness. An increase in the equilibrium number of interviews has the same effect, which is to increase the probability of having an acceptable match as the empirical distribution, (Ψ^n), improves. However, an increase in the cutoff value decreases this transition rate as a lower fraction of new matches would be acceptable.

The transition rate from employment into unemployment, job separation rate, is:

$$s = \frac{\delta}{\delta + (1-\delta)E(\gamma|X)},$$

where $E(\gamma|X)$ is defined in equation (8). The total number of separations depends on the exogenous destruction rate and the conditional expected probability of the match being of good quality. Note that, the higher is the fraction of matches that are bad, the higher is the separation rate. As the number of interviews increase, we expect separation rate to decrease since conditional expected probability of good quality matches increase. This is because high n implies a new distribution that first order stochastically dominated the previous one. Moreover, a higher cutoff value implies lower separation as it also increases the conditional expected probability of good quality matches.

Following simple algebra on the equilibrium flow equations and substituting δ from separation equation in and rearranging terms gives the familiar unemployment equation:

$$u = \frac{s}{s+f}.$$

4 Selection Effort and Labor Market Policies

This section aims to explore the effects of labor market policies on unemployment when we take search by firms into account. Policies discussed are firing tax, hiring subsidy, minimum wage and unemployment insurance. There is balanced government budget; policies are subsidized through a lump-sum tax, τ, on all workers in the economy.

Firing Tax: Assume that the government cannot separate "voluntary" separations from exogenous destructions. Hence, government taxes all separations at an amount of p^f. Introducing a firing tax will make the value of new matches that decide whether to produce for the first time different from the active matches. The outside option of a firm that is about to make a hiring decision is different from the outside option of an already producing job as the latter is subject to a firing tax. Let $\tilde{J}(\gamma)$ be the value of a new match. We can formally describe the value of a new and existing match as:

$$\tilde{J}(\gamma) = \max\Big\{V,\ E(y|\gamma) - \tilde{w}(\gamma) + \beta\delta(V - p^f) + \beta(1-\delta)\big(\gamma J(1) + (1-\gamma)J(0)\big)\Big\},$$

$$J(\gamma) = \max\Big\{V - p^f,\ E(y|\gamma) - w(\gamma) + \beta\delta(V - p^f) + \beta(1-\delta)\big(\gamma J(1) + (1-\gamma)J(0)\big)\Big\}.$$

The value of a vacancy is:

$$V = \max_{n^j} \Big[-C(n^j) + \beta \int_0^1 \big\{ \phi \tilde{J}(\gamma) + (1-\phi)V \big\} d\Psi^{n^j}(\gamma) \Big].$$

There is no change in the Bellman equations of the worker, except for that the value of a new versus existing employment relationship can be different. The surplus of a continuing match is

$$\begin{aligned} S(\gamma) &= W(\gamma) - U + J(\gamma) - (V - p^f) \\ &= \max \Big\{ 0,\ E(y|\gamma) - \tau - (1-\beta)(U - p^f) + \beta(1-\delta)\gamma S(1) \Big\}, \end{aligned}$$

while the match surplus for a newly formed match is

$$\begin{aligned} \tilde{S}(\gamma) &= \tilde{W}(\gamma) - U + \tilde{J}(\gamma) - V \\ &= \max \Big\{ 0,\ E(y|\gamma) - \tau - (1-\beta)(U - p^f) - p^f + \beta(1-\delta)\gamma S(1) \Big\}. \end{aligned}$$

Note that surplus from new matches is still linear in the good quality match output. Hence, we can express the surplus as $S^{'}(\gamma^*)(\gamma - \gamma^*)$, where

$$S^{'}(\gamma^*) = \frac{y^g - y^b + \beta(1-\delta)p^f}{1 - \beta(1-\delta)(1-\gamma^*)}.$$

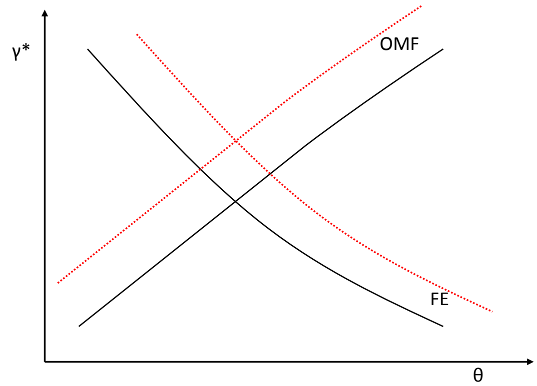
The free entry and optimal match formation equations are:

$$\begin{aligned} \frac{C(n)}{\beta\phi(1-\mu)} &= S^{'}(\gamma^*) \int (\gamma - \gamma^*) \Psi^n(\gamma), \\ b + \theta C(n) \frac{\mu}{1-\mu} &= y^b - \beta p^f + \gamma^* S^{'}(\gamma^*). \end{aligned}$$

For a given value of n, firing tax will shift the free entry curve to right on (θ, γ^*) plane as it increases the expected value of employment relationships (through increasing $S^{'}(\gamma^*)$). Optimal match formation equation shifts left on (θ, γ^*) plane with a firing tax. This is because a firing tax reduces workers' outside option, making the surplus from the match at the margin decline. Hence, we expect a higher cutoff probability whereas change in market tightness depends on the parameter values (Figure 2).

Note that, as only good quality matches can survive, firing tax increases relative value of good quality matches, giving firms incentives to increase their selection. Of course whether firms will do so in equilibrium depends on whether

Figure 2: Firing Policy Response of Market Tightness and the Cutoff



Note: FE is the free entry curve, OMF is the optimal match formation curve. Dotted lines indicate shifts in the corresponding curves due to a firing tax.

increase is large enough to cover the cost of more interviews as well as the general equilibrium effects of cutoff probability and market tightness on expected surplus.

Hiring Subsidy Let us suppose that the government subsidizes new hires. Let p^h be the amount of hiring subsidy. Similar to the firing tax case, introduction of hiring subsidy creates a gap between the value of a new match and that of an existing one. The value of a new job, $\tilde{J}(\gamma)$ is:

$$\tilde{J}(\gamma) = \max\Big\{V,\ p^h + E(y|\gamma) - \tilde{w}(\gamma) + \beta\delta V + \beta(1-\delta)\big(\gamma J(1) + (1-\gamma)J(0)\big)\Big\},$$

while the value of a vacancy is:

$$V = \max_{n^j}\Big[-C(n^j) + \beta\int_0^1 \big\{\phi\tilde{J}(\gamma) + (1-\phi)V\big\} d\Psi^{n^j}(\gamma)\Big].$$

The value of existing matches, $J(\gamma)$, is the same as in equation 4. There is no change in the Bellman equations of workers either.

For a continuing match, the surplus is:

$$\begin{aligned} S(\gamma) &= W(\gamma) - U + J(\gamma) - (V) \\ &= \max\Big\{0,\ E(y|\gamma) - \tau - (1-\beta)U + \beta(1-\delta)\gamma S(1)\Big\}. \end{aligned}$$

The match surplus for a newly formed match is

$$\begin{aligned} \tilde{S}(\gamma) &= \tilde{W}(\gamma) - U + \tilde{J}(\gamma) - V \\ &= \max\Big\{0,\ p^h + E(y|\gamma) - \tau - (1-\beta)U + \beta(1-\delta)\gamma S(1)\Big\}. \end{aligned} \tag{16}$$

Note that surplus from new matches is still linear in the good quality match output. Hence, we can express the surplus as $S^{'}(\gamma^*)(\gamma - \gamma^*)$, where

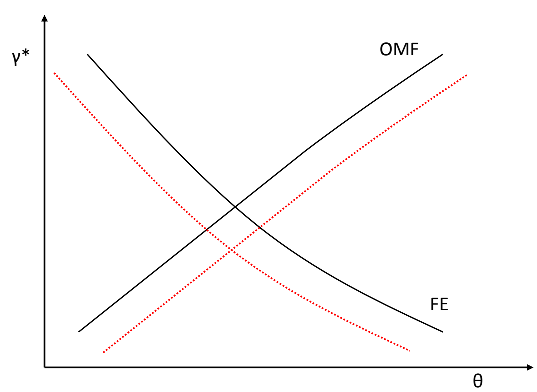
$$S^{'}(\gamma^*) = \frac{y^g - y^b - \beta(1-\delta)p^h}{1 - \beta(1-\delta)(1-\gamma^*)}$$

The free entry and optimal match formation equations are:

$$\frac{C(n)}{\beta\phi(1-\mu)} = S^{'}(\gamma^*) \int (\gamma - \gamma^*)\Psi^n(\gamma),$$
$$b + \theta C(n)\frac{\mu}{1-\mu} = y^b + p^h + \gamma^* S^{'}(\gamma^*).$$

Looking at the surplus for newly formed matches, hiring subsidy increases the value of a new match. For a given value of n, hiring subsidy will shift optimal match formation equation to right on (θ, γ^*) plane as new employment relationships now generate more surplus, all else the same. Since the expected future profits are not as high as the initial one, free entry curve shifts to left on (θ, γ^*) plane. Hence, we would expect lower cutoff probability with hiring subsidy, whereas the change in market tightness is ambiguous, as Figure 3 demonstrates.

Figure 3: Hiring Policy Response of Market Tightness and the Cutoff



Note: FE is the free entry curve, OMF is the optimal match formation curve. Dotted lines indicate shifts in the corresponding curves due to a hiring subsidy.

Note that this analysis is for a given n. Firms are likely to change their selection behaviors as well. As existing matches cannot get the benefit, the policy reduces relative returns to existing matches, and hence to a good quality match. As a result, firms would be less likely to invest in selection effort. Policy also does affect firms' incentives to selection as it changes the workers' outside option and the value of threshold probability.

Minimum Wage: Suppose that the minimum wage, $\bar{\omega}$, is set at a level that is higher than the wage earned at the threshold probability, i.e., $\omega(\gamma^*) < \bar{\omega}$. In this case, for any match with probability γ such that $\omega(\gamma) \geq \bar{\omega}$ wages are outcomes of Nash bargaining as before and both firms and workers agree on match formation decision. Matches with probability γ such that $\omega(\gamma) < \bar{\omega}$, have a disagreement as workers would like to be in the match while firms would not since they will have to pay workers the minimum wage, which is higher than the wage from Nash Bargaining.

The optimal match formation is such that $J(\gamma^*) = V$ and $\omega(\gamma^*) = \bar{\omega}$. This implies the following wage equation

$$\gamma^*(y^g - y^b) + y^b + \beta(1-\delta)\gamma^* J(1) = \bar{\omega},$$

making use of the equilibrium condition $V = 0$. Supposing that the minimum wage does not bind at $\gamma = 1$, we have $J(1) = (1-\mu)S(1)$, and

$$S(1) = \frac{y^g - (1-\beta)U}{1-\beta(1-\delta)},$$

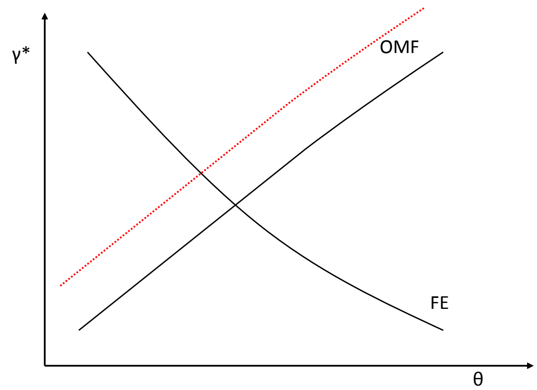
since wages are set according to Nash bargaining when the minimum wage is not binding. Wage equation implies that, holding $J(1)$ constant, an increase in the minimum wage increases the cutoff probability. However, the unemployment value, and hence $J(1)$ will also change. Hence, we cannot analytically conclude how U will change with the minimum wage.

Unemployment Insurance: Suppose the government distributes unemployment insurance. This is the same as increasing the value of b in Bellman equations of the benchmark economy. Note that increase in unemployment benefit increases workers' outside option, hence optimal match formation equation shifts left on (θ, γ^*) plane (Figure 4). As a result, we would expect lower market tightness and higher cutoff probability. It will not directly affect firms' selection effort choice as change in unemployment value affects match surplus regardless of it being good or bad. However, an increase in cutoff probability will reduce expected surplus, while a decline in market tightness will increase it. Hence effect of unemployment insurance on selection effort is ambiguous.

5 Quantitative Analysis

I assign values to the parameters of the model to match some facts of the U.S. labor market. The time period of the model is a month. I set $\beta = 0.9967$, to

Figure 4: Insurance Policy Response of Market Tightness and the Cutoff



Note: FE is the free entry curve, OMF is the optimal match formation curve. Dotted line indicates shift in the OMF curve due to an unemployment insurance policy.

get an annual interest rate of 4 percent. The bargaining power of the workers is generally set to a number between 0.3 and 0.5 in the literature.[16] I set the workers' bargaining power parameter (μ) to its most commonly used value, that is 0.5.

Observe that multiplying $C(n)$, y^g, y^b, and b by the same number does not change the solution to the equation system. Thus, I normalize b to 1. I also set $y^b = b$, which is sufficient for the bad quality matches to be terminated in the equilibrium. Davis et al. (1996) report that around one quarter of annual job loss is due to plant shot-downs in manufacturing.[17] I calibrate the value of exogenous job destruction so that 23 percent of all job destructions is exogenous. To pin down the good quality match output, I target the ratio of the highest wage workers can earn to the lowest wage to be 1.3 in the steady state. Topel and Ward (1992) find that the cumulative change in wages over the first 10 years of work history that is associated with job change is around 33 percent.[18]

I follow Pries and Rogerson (2005) and assume that Ψ is a mean-zero normal distribution, re-scaled for the unit interval. I assume that vacancy cost is linear in number of interviews: $C(n) = c + \kappa(n-1)$. We are left with three parameters to be determined, standard deviation of Ψ and the cost function parameters. First, I find the total vacancy cost as this is sufficient to solve for

[16]See Petrongolo and Pissarides (2001) for a literature survey.
[17]See also Davis and Haltiwanger (1998).
[18]Pries and Rogerson (2005) use wage ratio of 1.25.

Table 1: Parameter Values

β	0.996	Discount factor
b	1	Unemployment income
y^b	b	Bad-quality output
μ	0.5	Workers' bargaining power
δ	0.0069	Exogenous job destruction rate
c	0.865	Vacancy creation cost
y^g	1.84	Good-quality output
σ_Ψ	0.169	Standard deviation of distribution
κ	0.212	Search cost parameter

the market tightness and the cutoff probability, for a given n. To find out the values of the total vacancy cost and the standard deviation of the distribution, I set the number of interviews conducted in equilibrium to three.[19] To do so, I target job finding probability of 0.4 and separation probability of 0.03. Shimer (2012) finds the average job finding and separation probabilities to be 0.4 and 0.03, respectively, from 1948 to 2007. Then, I find the (c, κ) pair for which $n = 3$ is equilibrium, given the rest of the parameters, and the implied total cost of vacancy is the same as the calibrated value. There is a narrow range of such pairs that delivers the calibrated equilibrium outcomes. As qualitative nature of the findings do not change, I report results for the average of these values. Parameter values are displayed in Table 1.

I use the calibrated benchmark model above to asses the effects of each of the policies discussed above on flow rates and unemployment rate.

Firing Tax: I compute equilibrium outcomes for firing tax that is up to 2.5 times the lowest wage earned in the benchmark equilibrium. The results are displayed in Table A.1. Firing taxes increase the number of interviews firms conduct as well as the equilibrium value of the threshold probability (Figure 5). Both separations and job finding probabilities decrease (Figure 6). Job separation rate declines as with more selection there are less bad quality matches in equilibrium, resulting in lower endogenous separations. Job finding probability declines mainly due to a decline in the market tightness. Observe that a lower separation rate would reduce unemployment while a lower job finding rate would increase it. In this calibration exercise, unemployment rate increases with firing taxes since change in job finding rate is stronger (Figure

[19] The reported average number of interviews conducted in Barron and Bishop (1985) is around 4. Moreover, targeting a different number of interviews does not change the main results of this paper.

7). In the counterfactual exercise, where firms cannot adjust the number of interviews they conduct, the increase in unemployment rate is higher, as in this case there is not much change in separation rate while there is still decline in job finding rate.

Hiring Subsidy: Hiring subsidy has the opposite effect on labor market outcomes and selection effort. Figure 8 shows how the equilibrium number of interviews and the cutoff probability changes as the rate of hiring subsidy increases (also see Table A.2.). Introducing the hiring subsidy (that is upto 30 percent of the lowest wage in the benchmark case) to the economy (or increasing the subsidy) reduces the number of interview conducted by firms. Similarly, the cutoff probability that is required for an acceptable match goes down with the hiring subsidy. As a result separations in the economy rise. Job finding probability also increases as there are more vacancies and more matches are acceptable (Figure 9). How unemployment reacts to this depends on how much job finding and separation rates increase, respectively, as their rise has opposing effects on the unemployment rate. For this calibration exercise when firms response to hiring subsidy by reducing their number of interviews we see unemployment increasing (Figure 10).

To tease out the role of selection, I conduct the following counterfactual exercise: I compute equilibrium outcomes for the same hiring subsidy rates under the assumption that firms cannot change the number of interviews they conduct. The response of cutoff probability to hiring subsidy is less than it is in the presence of selection effort (Figure 8). Job separation probability is increasing with subsidy, but at a much smaller pace. Selection effort affects the separations significantly. Job finding probability also increases in the counterfactual exercise, but less so than the presence of selection (Figure 9). As a result, unemployment rate is expected to monotonically decline with hiring subsidy when the firms' selection effort channel is ignored.

Minimum Wage I look at the equilibrium response to minimum wage that is up to five percent of the lowest wage in the benchmark equilibrium. As Table A.3 displays, minimum wage policy increases the number of interviews as well as the cutoff probability (also see Figure 11). As a result we observe decline in separation rate and the job finding rate (Figure 12). These declines are such that the unemployment rate rises. Notice that this response is qualitatively similar to firing taxes. When we compute the response of the counterfactual economy without the selection channel to minimum wage policy, we observe that the increase in cutoff probability is larger, whereas changes in separation and job finding rates are relatively less.

Unemployment Insurance: I compute equilibrium outcomes for unemployment benefit that is up to 30 percent of the lowest wage observed at

Figure 5: Response to Firing Tax: Selection and Cutoff Probability

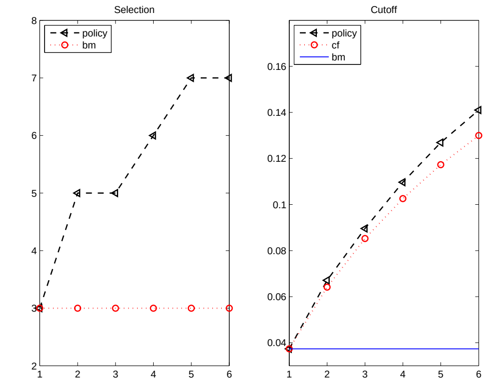


Figure 6: Response to Firing Tax: Flow Rates

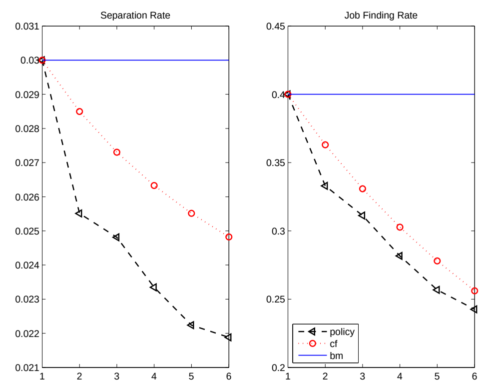


Figure 7: Response to Firing Tax: Unemployment Rate

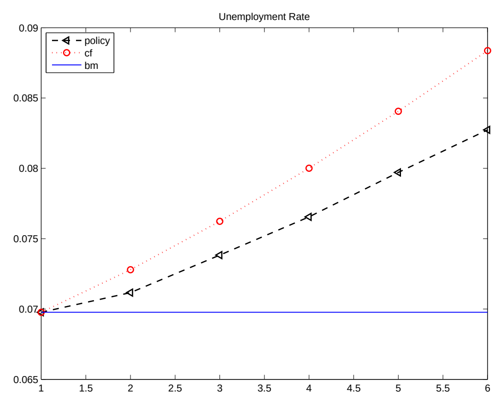


Figure 8: Response to Hiring Subsidy: Selection and Cutoff Probability

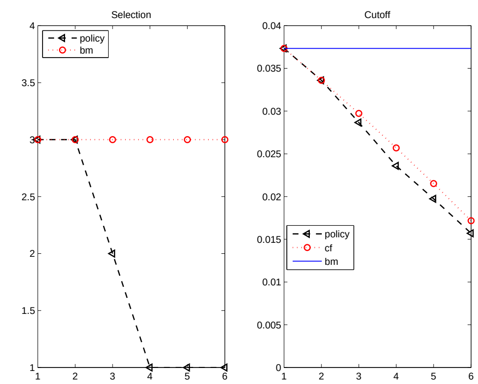


Figure 9: Response to Hiring Subsidy: Flow Rates

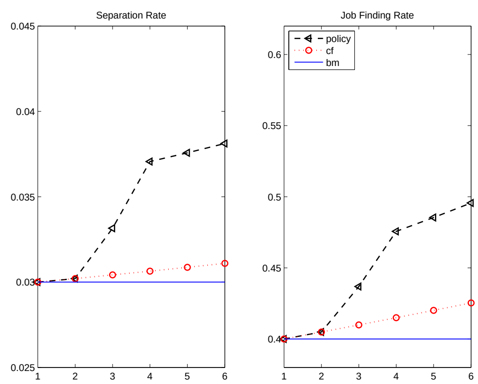


Figure 10: Response to Hiring Subsidy: Unemployment Rate

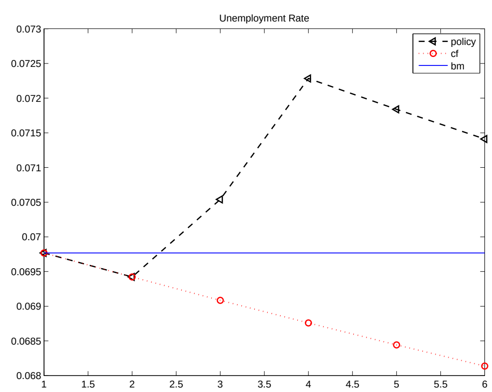


Figure 11: Response to Minimum Wage: Selection and Cutoff Probability

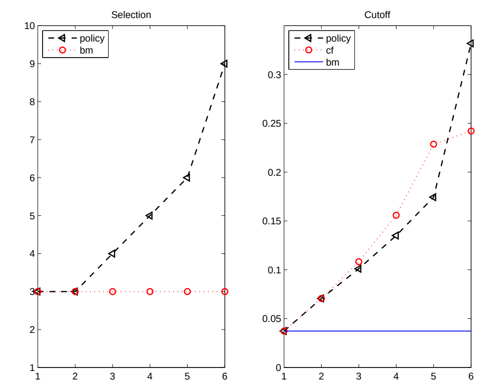


Figure 12: Response to Minimum Wage: Flow Rates

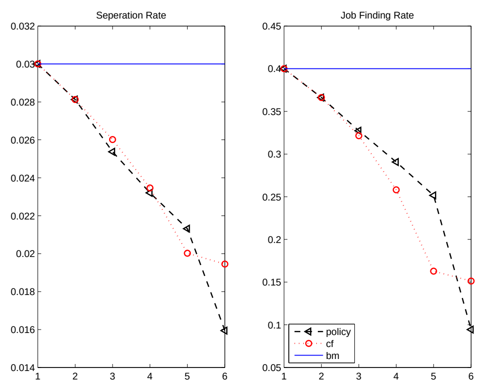
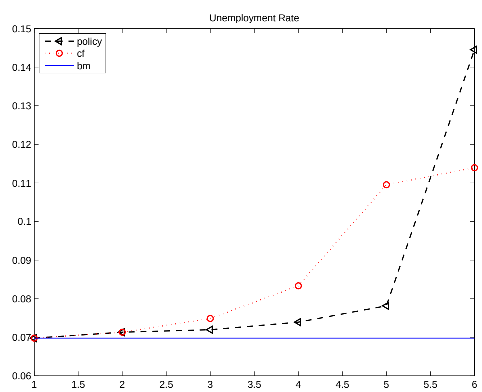


Figure 13: Response to Minimum Wage: Unemployment Rate



the benchmark equilibrium. Cutoff probability increases with unemployment benefit while the market tightness decreases, as discussed before. For this calibration, the equilibrium number of interviews does not change. Unemployment increases, mostly due to decreasing job finding rate. Results are reported in Table A.4.

6 Concluding Remarks

The literature on theoretical analysis of firms' search behavior is relatively scarce. To contribute towards this gap, I employ a discrete time infinite horizon model with homogeneous workers and firms and match specific output. An employment relationship between a firm and a worker (match) can be of either good or bad quality. Good quality matches produce higher output. Moreover, bad quality matches are undesirable. The true quality of the match is unknown before the employment relationship starts and it is revealed after the parties observe the output.

Unemployed workers apply to all vacancy posts and firms pick the number of workers to conduct interviews with, incurring some cost. An interview reveals the probability of the worker being a good match for the firm. Firms choose the number of interviews to maximize the value of their vacancy and select the one with the highest probability of good quality match among workers interviewed. A firm's choice of interviews depends on the productivity gap between a good and a bad quality match output, the cost of interview, the probability of a match in the subsequent periods, the cutoff rule for an acceptable match, as well as the distribution that governs the match quality.

As a firm hires the worker with the highest probability of being a good match among all the workers interviewed, firms' search behavior endogenously determines the distribution of good quality match probabilities. Hence, search by firms affects not only the probability of finding a worker, but also the productivity of the job, as well as the flow from employment to unemployment. Moreover, number of interviews also determines the total cost of a vacancy, further affecting job creation.

I analyze unemployment rate response to different labor market policies in the presence of selection channel. When labor market policies in place are strong enough to alter firms' interview decisions, we observe that selection channel mitigates the effect of such policies on unemployment rate. For some policies, the mitigating effect could be strong enough to reverse the response. Findings of this paper indicate that firms' strategic behavior while hiring can matter significantly. Further research should focus more on understanding the complex hiring processes.

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A Appendix

A.1 Derivation of Match Probabilities

Recall that n is the number of interviews chosen by firms in the economy. The probability that a worker receives an interview from a particular firm is $\frac{n}{\mathbf{U}}$ as there are n many positions out of $\mathbf{U}$ many applications for that firm. Moreover, the worker has $\mathbf{V}$ many trials to be successful at getting an interview. The number of interviews a worker can receive, m^i, has a Binomial distribution with parameters $\mathbf{V}$ and $\frac{n}{\mathbf{U}}$. Let $g(\cdot)$ be the Binomial probability mass function. Then,

$$g(m^i; V, \frac{n}{U}) = \left(\begin{array}{c} V \\ m^i \end{array} \right) (\frac{n}{U})^{m^i} (1 - \frac{n}{U})^{V - m^i}.$$

Each of the workers interviewed has the same ex-ante probability of being selected by the prospect employer, which is $1/n$, as they are ex-ante identical for the firm. The number of offers worker will receive from m^i many interviews, m^o, has a binomial distribution:

$$g(m^o; m^i, \frac{1}{n}) = \left(\begin{array}{c} m^i \\ m^o \end{array} \right) (\frac{1}{n})^{m^o} (1 - \frac{1}{n})^{m^i - m^o}.$$

Hence, the number of firms that will make a job offer to a particular worker among all applications (the unconditional probability of the number of offers that a worker receives), is:

$$Pr(m^o = s; V, U, n) = \sum_{k=s}^{V} g(m^i = k; V, \frac{n}{U}) g(m^o = s; k, \frac{1}{n}). \tag{A.1}$$

Firms care about the number of job offers a worker gets, as this number will affect the probability of the worker accepting their job offer. If a worker gets more than one job offer, she picks a firm randomly.[20] The probability that a firm's best option is available is as follows: Let's call this worker j and suppose worker j has $s \geq 1$ many offers.[21] The probability that the chosen worker receives a total of s many offers is the same as the probability that this worker receives $s-1$ offers from $V-1$ other firms:

$$\begin{aligned}
Pr(m_j^o = s-1; V-1, n, U) &= \sum_{k=s-1}^{V-1} g(m_j^i = k; V-1, \frac{n}{U}) g(m_j^0 = s-1; k, \frac{1}{n}) \\
&= \sum_{k=s-1}^{V-1} \frac{(k+1)U}{Vn} \frac{sn}{k+1} g(m_j^i = k+1; V, \frac{n}{U}) g(m_j^0 = s; k+1, \frac{1}{n}) \\
&= \sum_{k=s-1}^{V-1} \frac{sU}{V} g(m_j^i = k+1; V, \frac{n}{U}) g(m_j^0 = s; k+1, \frac{1}{n}) \\
&= \sum_{k=s}^{V} \frac{sU}{V} g(m_j^i = k; V, \frac{n}{U}) g(m_j^0 = s; k, \frac{1}{n})
\end{aligned}$$

Let ϕ be the probability that the worker j chooses the firm among s many

[20]This assumption simplifies the model a good deal as otherwise firms and the worker would get into wage re-bargaining and the second best alternatives of firms would become important.

[21]$s \geq 1$ as the worker j definitely has an offer from this firm.

offers. This probability is:

$$\phi = \sum_{s=1}^{V} \frac{Pr(m_j^0 = s; V, U, n)}{s} = \sum_{s=1}^{V} \frac{1}{s} \sum_{k=s}^{V} \frac{Us}{V} g(m_j^i = k; V, \frac{n}{U}) g(m_j^0 = s; k, \frac{1}{n})$$

$$\phi = \frac{1}{\theta} \sum_{s=1}^{V} \sum_{k=s}^{V} g(m_j^i = k; V, \frac{n}{U}) g(m_j^0 = s; k, \frac{1}{n}) = \frac{1}{\theta} \sum_{s=1}^{V} Pr(m^o = s; V, U, n)$$

$$\phi = \frac{1}{\theta}\Big(1 - Pr(m^o = 0; V, U, n)\Big)$$

We can write the probability that a worker receives no interviews more explicitly as

$$\begin{aligned} Pr(m^o = 0; V, U, n) &= \sum_{t=0}^{V} \binom{V}{t} (\frac{n}{U})^t (1 - \frac{n}{U})^{V-t} \binom{t}{0} \frac{1}{n}^0 (1 - \frac{1}{n})^t \\ &= \sum_{t=0}^{V} \binom{V}{t} (\frac{n}{U})^t (1 - \frac{n}{U})^{V-t} (1 - \frac{1}{n})^t \\ &= \sum_{t=0}^{V} \binom{V}{t} \Big(\frac{n}{U}\big(1 - \frac{1}{n}\big)\Big)^t (1 - \frac{n}{U})^{V-t} \\ &= \Big(\frac{n}{U}\big(1 - \frac{1}{n}\big) + 1 - \frac{n}{U}\Big)^V = \big(1 - \frac{1}{U}\big)^V \end{aligned}$$

We get the last line by applying the binomial theorem.

Let **U** and **V** go to infinity (as the number of unemployed and vacancies are large) while holding the ratio of vacancies to unemployed $\theta = \mathbf{V}/\mathbf{U}$ constant. Then,

$$Pr(m^o = 0; V, U, n) = (1 - \frac{1}{U})^V = (1 - \frac{\theta}{V})^V = e^{-\theta}, \tag{A.2}$$

and hence

$$\phi = \frac{1 - Pr(m^o = 0; V, U, n)}{\theta} = \frac{1 - e^{-\theta}}{\theta}. \tag{A.3}$$

A.2 Match Formation Decision Rule and the Existence of a Cutoff Probability

Recall that surplus, $S(\gamma) = W(\gamma) - U + J(\gamma) - V$, is:

$$S(\gamma) = \max\Big\{0,\ E(y|\gamma) - (1-\beta)U + \beta(1-\delta)\big(\gamma S(1) + (1-\gamma)S(0)\big)\Big\}.$$

Moreover, free entry condition is:

$$0 = -C(n) + \beta\phi(1-\mu)\int_0^1 S(\gamma)d\Psi^n(\gamma),$$
$$\frac{C(n)}{\beta\phi(1-\mu)} = \int_0^1 S(\gamma)d\Psi^n(\gamma),$$

which implies that the value of unemployment is:

$$(1-\beta)U = b + \beta\chi\mu\int_0^1 S(\gamma)d\Psi^n(\gamma) = b + \theta C(n)\frac{\mu}{1-\mu}.$$

Moreover, note that $S(1)$ and $S(0)$ are:

$$S(1) = \max\{0, \ \frac{y^g - (1-\beta)U}{1-\beta(1-\delta)}\} = \max\{0, \ \frac{y^g - b - \theta C(n)\frac{\mu}{1-\mu}}{1-\beta(1-\delta)}\},$$
$$S(0) = \max\{0, \ \frac{y^b - (1-\beta)U}{1-\beta(1-\delta)}\} = \max\{0, \ \frac{y^b - b - \theta C(n)\frac{\mu}{1-\mu}}{1-\beta(1-\delta)}\},$$

Suppose $y^g > b$ and $y^b \leq b$. Then surplus from a match with $\gamma = 1$ is positive while surplus from a match with $\gamma = 0$ is negative, i.e.,

$$0 < \frac{y^g - b - \theta C(n)\frac{\mu}{1-\mu}}{1-\beta(1-\delta)},$$
$$0 > \frac{y^b - b - \theta C(n)\frac{\mu}{1-\mu}}{1-\beta(1-\delta)}.$$

Recall that $S(\gamma)$ is linearly increasing in γ. Hence, there is a cutoff $\gamma^* \in (0,1)$, such that the surplus is exactly zero:

$$0 = \gamma^*(y^g - y^b) + y^b - b - \theta C(n)\frac{\mu}{1-\mu} + \beta(1-\delta)\gamma^* S(1).$$

A.3 Results

Table A.1: Response to Firing Tax Policy

$\tilde{p}^*$	0	0.5	1	1.5	2	2.5
Benchmark Economy						
n	3	5	5	6	7	7
χ	43.0	35.7	34.8	31.5	28.6	27.9
γ^*	0.037	0.067	0.090	0.110	0.127	0.141
$E(X)$	92.9	93.2	89.6	89.4	89.7	87.1
$E(\gamma\|X)$	22.5	26.5	27.3	29.1	30.5	31.1
u	6.98	7.12	7.38	7.65	7.97	8.27
f	40.0	33.3	31.1	28.2	25.7	24.3
s	3.00	2.55	2.48	2.33	2.22	2.19
y	1.69	1.69	1.69	1.69	1.68	1.68
Counterfactual Economy						
χ	43.0	41.8	40.6	39.4	38.3	37.2
γ^*	0.037	0.064	0.085	0.103	0.117	0.130
$E(X)$	92.9	86.8	81.5	76.8	72.6	68.9
$E(\gamma\|X)$	22.5	23.7	24.8	25.7	26.5	27.3
u	6.98	7.28	7.62	8.00	8.41	8.84
f	40.0	36.3	33.1	30.3	27.8	25.6
s	3.00	2.85	2.73	2.63	2.55	2.48
y	1.69	1.69	1.68	1.68	1.67	1.66

Firing tax is $\tilde{p}^*$ times the lowest wage in benchmark. n: number of interviews; χ: probability of getting at least one offer; γ^*: cutoff probability; $E(X)$: probability of an acceptable match; $E(\gamma|X)$: conditional probability of a good quality match; u: unemployment rate; f: job finding rate; s: separation rate; y: total production in the economy. All values, except for γ^* and y, are in percent.

Table A.2: Response to Hiring Subsidy Policy

$\tilde{p}^*$	0	0.06	0.12	0.18	0.24	0.30
Benchmark Economy						
n	3	3	2	1	1	1
χ	43.0	43.2	47.4	52.3	52.5	52.8
γ^*	0.037	0.034	0.029	0.024	0.020	0.016
$E(X)$	92.9	93.7	92.3	90.9	92.4	94.0
$E(\gamma\|X)$	22.5	22.3	20.3	18.1	17.8	17.5
u	6.98	6.94	7.05	7.23	7.18	7.14
f	40.0	40.5	43.7	47.6	48.5	49.6
s	3.00	3.02	3.32	3.71	3.76	3.81
y	1.69	1.69	1.69	1.68	1.68	1.68
Counterfactual Economy						
χ	43.0	43.2	43.4	43.5	43.7	43.9
γ^*	0.037	0.034	0.030	0.026	0.022	0.017
$E(X)$	92.9	93.7	94.5	95.3	96.2	97.0
$E(\gamma\|X)$	22.5	22.3	22.1	22.0	21.8	21.6
u	6.98	6.94	6.91	6.88	6.84	6.81
f	40.0	40.5	41.0	41.5	42.0	42.5
s	3.00	3.02	3.04	3.06	3.09	3.11
y	1.69	1.69	1.69	1.69	1.70	1.70

Hiring subsidy is $\tilde{p}^*$ times the lowest wage in benchmark. n: number of interviews; χ: probability of getting at least one offer; γ^*: cutoff probability; $E(X)$: probability of an acceptable match; $E(\gamma|X)$: conditional probability of a good quality match; u: unemployment rate; f: job finding rate; s: separation rate; y: total production in the economy. All values, except for γ^* and y, are in percent.

Table A.3: Response to Minimum Wage Policy

$\tilde{p}^*$	1	1.01	1.02	1.03	1.04	1.05
Benchmark Economy						
n	3	3	4	5	6	9
χ	43.0	43.0	39.5	36.4	33.6	23.8
γ^*	0.037	0.071	0.101	0.135	0.174	0.332
$E(X)$	92.9	85.2	82.9	79.9	74.9	39.7
$E(\gamma\|X)$	22.5	24.0	26.7	29.2	31.9	42.9
u	6.98	7.13	7.19	7.39	7.81	14.45
f	40.0	36.6	32.7	29.1	25.2	9.4
s	3.00	2.81	2.54	2.32	2.13	1.59
y	1.69	1.69	1.69	1.69	1.68	1.57
Counterfactual Economy						
χ	43.0	43.0	42.8	42.1	40.4	41.2
γ^*	0.037	0.071	0.108	0.156	0.229	0.242
$E(X)$	92.9	85.2	75.2	61.3	40.3	36.7
$E(\gamma\|X)$	22.5	24.0	26.0	28.9	34.0	35.0
u	6.98	7.13	7.49	8.33	10.95	11.40
f	40.0	36.6	32.2	25.8	16.3	15.1
s	3.00	2.81	2.60	2.35	2.00	1.95
y	1.69	1.69	1.69	1.67	1.63	1.62

Minimum wage is $\tilde{p}^*$ times the lowest wage in benchmark. n: number of interviews; χ: probability of getting at least one offer; γ^*: cutoff probability; $E(X)$: probability of an acceptable match; $E(\gamma|X)$: conditional probability of a good quality match; u: unemployment rate; f: job finding rate; s: separation rate; y: total production in the economy. All values, except for γ^* and y, are in percent.

Table A.4: Response to Unemployment Insurance Policy

$\tilde{p}^*$	0	0.06	0.12	0.18	0.24	0.30
n	3	3	3	3	3	3
χ	43.0	39.2	35.1	30.8	26.1	21.2
γ^*	0.037	0.038	0.040	0.041	0.042	0.043
$E(X)$	92.9	92.7	92.5	92.2	91.9	91.6
$E(\gamma \vert X)$	22.5	22.5	22.6	22.6	22.7	22.7
u	6.98	7.61	8.42	9.50	11.02	13.27
f	40.0	36.4	32.5	28.4	24.0	19.4
s	3.00	2.99	2.99	2.98	2.97	2.97
y	1.69	1.68	1.67	1.65	1.62	1.58

Unemployment insurance is $\tilde{p}^*$ times the lowest wage in benchmark. n: number of interviews; χ: probability of getting at least one offer; γ^*: cutoff probability; $E(X)$: probability of an acceptable match; $E(\gamma|X)$: conditional probability of a good quality match; u: unemployment rate; f: job finding rate; s: separation rate; y: total production in the economy. All values, except for γ^* and y, are in percent.