An Information Theory of Worker Flows and Wage Dispersion

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Abstract

A direct job change yields an 8% wage gain, but a job change through unemployment yields a persistent 16% wage loss. I develop a model of labor markets where employer information provides these outcomes. Key ingredients are: (1) incumbent employers learn workers' abilities slowly and (2) information diffuses to potential employers. I use the model to understand how the speed of learning and of diffusion affect aggregate employment and wage inequality. Model estimates predict a majority of wage losses after unemployment are from information, not actual lost productivity. *JEL Codes: E24, J6*

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A job separation can be a bane or a boon for a worker. A quit directly to another employer is followed by job stability and higher wages. A lay-off resulting in an unemployment is followed by a wage cut of about 16%. These lower wages persist even 15 years later and are accompanied by repeat unemployment spells[1]. Search models used to understand aggregate employment flows and wage dispersion are at odds with these observations. Davis and von Wachter (2011) survey these models and calculate they can explain <1%-25% of the long-term wage losses following a layoff observed in the data. The goal of this paper is to better understand worker flows, unemployment levels and wage inequality by developing a model of aggregate labor markets that is consistent with individuals' outcomes.

I develop an information theory of labor markets where employer information alone generates worker flows and wage dispersion. Importantly, it provides the diverging wage and employment paths after a job change depending on whether it occurred through unemployment or directly. The theory requires the following ingredients: (1) workers differ in ability; (2) employers do not know the ability of workers; (3) current employers can learn the ability of their workers; (4) outside potential employers can also learn, but at a slower rate.

This theory generates wage and employment patterns of unemployed workers by a similar logic as Gibbons and Katz (1991). If an employer learns a worker is of low ability, she will be fired. In addition, workers of all abilities can also become unemployed if their firm closes. Potential employers cannot observe the ability of an unemployed worker nor the reason a worker became unemployed. Since the pool of unemployed contains some high ability workers, employers continue to hire unemployed workers. However, they do so at a low wage since the unemployed are of lower average ability than the population. Overtime, new employers learn the abilities of their workers and re-fire those of low ability. This produces

[1] Wage and employment paths shown in Figures 3 and 4 on page 35. Statistics from my own calculations from PSID data.

a cycle of wage losses and multiple displacements consistent with the data.

Asymmetry in current and potential employers' information also generates job-to-job switches with wage gains. If an employer learns a worker is of high ability but outside employers do not receive this information, then the current employer does not need to increase the worker's wage to keep her. The worker cannot get a higher wage by quitting to an employer that does not know her ability. The current employer enjoys high profits from employing the worker at a low wage until outside employers learn that she is high ability. After they learn, outside employers offer the worker a higher wage and poach her. The result is similar to the data: permanent wage increases following voluntary quits and low likelihood of future unemployment.

The theoretical contribution is a search and matching model where behavior of plants and workers satisfy a Markov Perfect Equilibrium. There exists an unique pure strategy equilibrium, the equilibrium is pooling over worker types and the evolution of beliefs is easily characterized. These results allow me to put this game theoretic mechanism into a dynamic macroeconomic model. [2]

The second contribution is quantitative. I develop a novel estimation strategy using heterogeneity in individuals' employment dynamics to separate the effects of employer learning and skill growth on wages and job turnover. I estimate skill loss affects about a quarter of the unemployed and it takes about 3.3 years to reacquire skills. This is a sharp contrast to a theory of skill loss alone. The estimate of this model with skills only and no employer learning requires 90% of unemployed workers to suffer skill losses and that skills take 5 years to recover. This suggests models omitting learning vastly overestimate the affect of unemployment on aggregate productivity.

[2]There is an entry cost for job creation and an equilibrium is defined as requiring vacancies to satisfy zero profit condition.

The model is flexible in speed of employer learning and speed of diffusion to outside employers. Public learning, fully private learning, full information and all in-betweens are nested in this framework. I exploit this feature to predict the relationship between information and aggregate employment. I find the speed of employer learning has no significant effect on employment. The speed of information diffusion to outside employers has a significant and non-monotone effect of employment. This is because both very slow and very fast learning increase the value of a match. Slow information diffusion increases the length of the match and fast information diffusion allows firms to select better workers. These comparative statics are useful for understanding the impact of better screening and employee evaluation technologies on aggregate job creation.

1 Related Literature

This work is related to two strands of literature: microeconomic models of employer learning and macroeconomic models of employment flows.[3]

I incorporate a new type of information friction in a macroeconomic search model of employment flows (Jovanovic (1979), Burdett and Mortensen (1989), and others). Specifically, I consider employer learning about workers' general productivities. General productivity affects workers' inside and outside options, while specific productivity (Jovanovic (1979)) affects only the inside option. This difference determines how worker-employer surplus is divided. The value added to the macroeconomic literature is that this theory can separate

[3]The goal of this paper is separate from theory literature on contract design and job assignment with asymmetric employer learning (Waldman (1984),)Harris and Holstrom (1982), and many others). I consider that employers have no control over the speed of learning or spread of information, thus abstracting from the concerns of this literature.

wage losses of displaced workers into a decrease in the match surplus and a shift in the share of the surplus going to firms versus workers. This illuminates how employer information about workers affects job creation, job destruction, and subsequently the macroeconomy.

A large econometric literature tests hypotheses of employer learning under the assumption workers are paid their expected marginal product. For example, Farber and Gibbons (1994) found characteristics observed by employers at hiring (such as schooling) do not affect wage growth and Altonji and Pierret (2001) find aptitude test scores not observed by employers do affect wage growth. Both are consistent with employer learning. Similar identification strategies have been used to test for asymmetry in employer learning (Kahn (2009),Schnberg (2007),Pinkston (2009)). A key assumption or result of these works is that a worker is paid her expected marginal product. This is not necessarily true in theories of private learning. It also implies that the surplus paid to the firm is zero which abstracts from incentives for job creation and precludes predictions for equilibrium employment.

Game theoretic approaches in the literature model learning as fully private or fully public.[4] This is convenient because it avoids lemon markets failures common to models of asymmetric information. However, these assumptions are quantitatively important because they put an implicit restriction on the size of information rents. When learning is fully public, there are no information rents. When learning is fully private, there are full information rents. My model is flexible to these cases and all in between allowing for comparative statics. It also avoids lemons market failure but still affects wages and generates employer changes from information frictions alone with no match- specific factors.[5]

[4]The exception is Pinkston (2009). He considers a second-price auction for workers. The equilibrium in the model I construct with wage posting differs because firms pay less than the workers' expected marginal product and the strategic behavior of the worker affects the equilibrium.

[5]Literature with lemon market failure often adds additional non-pecuniary shock to study switches (such as in Acemoglu and Pischki (1996) and Schnberg (2007)). By modeling asymmetry in the way I do, switching

2 Evidence of Asymmetric Employer Learning

Information cannot be directly measured. Gibbons and Katz (1991) show wage patterns of individually fired workers are consistent with predictions for workers endogenously fired in a model of asymmetric employer learning. Workers unemployed by establishment closure follow patterns of exogenously displaced workers in the same model.

I expand this work by using the event study framework of Jacobson et al. (1992) to estimate the effect of all employer changes on wages, including changes without unemployment. The results, summarized in Figure 3 on Page 35, show three stylized facts. First, the typical displaced worker experiences a wage loss in her next job. Second, the depth and duration of these losses vary by reason for displacement. Individually laid-off workers face short term losses of 16%, while workers whose entire firm shuts down face short term losses of 9%. On average, wages of shut down workers recover to the control group of never displaced in the 6th year following displacement. Wages of fired workers never recover. Even 10 years following displacement the average fired worker earns 15% less than the never displaced.[6] Third, the wage changes of quitters are significant and positive.

The second piece of evidence is the employment patterns of displaced workers. This pattern was first identified by Stevens (1997). I build on her work by documenting differences between shut-down and individually fired workers. Figure 4 on Page 36 shows two-thirds of fired workers are fired more than once, while only one-third of shut-down workers are ever

is an equilibrium outcome with meaningful implications for future switches.

[6] Long-term wage losses following lay-off have been estimated using this regression in a variety of datasets. Studies using different samples from the PSID estimate persistent wage losses within the range of 7-13%. Estimates from the Displaced Workers Survey fall within the range of 8-15%. See Couch and Placzek (2010) for a review of these results. See also Barnette and Michaud (2010) for further documentation on the variance of these results over the business cycle and for workers who switch occupations.

fired.

These facts motivate the key ingredients of an information theory. The first ingredient is that workers differ in *permanent* quality. This is motivated by the difference in long-term outcomes of individually fired workers: persistently lower wages and repeated unemployment spells. The second ingredient is imperfect information about workers' qualities. This is motivated by the similarity in all unemployed worker's initial wage losses, regardless of their long-term outcomes. The idea is new employers cannot sort workers by reason of unemployment or ability and instead learn a worker's ability over an employment relationship. This is also consistent with the fact that individually fired workers are fired repeatedly. If new employers are initially unsure of a worker's type, they continue to hire low quality workers, discover their mistake, and fire them again. The final ingredient is that outside employers slowly learn about workers' quality as well. This is motivated by the idea that a current employer does not need to raise a worker's wage until outside employers learn she is high quality too.

3 A Model of Asymmetric Employer Learning

The environment is similar to Postel-Vinay and Robin (2002). Time is infinite and discrete. Production takes place between single worker-plant matches. Each period an incumbent and many poaching plants offer wage-employment contracts to workers. I add information frictions. An incumbent has private information about their worker's ability and does not know whether poaching plants have been informed of this information. I also assume incumbent plants cannot counter the offers of poaching plants.[7] The worker chooses which offer to take and that plant becomes the incumbent. The incumbent at the end of the period learns

[7]Mechanically, this assumption gives information-driven turnover.

the worker's ability perfectly with an exogenous probability and chooses whether to fire the worker.[8]

Players The economy is populated by a unit measure of workers and a continuum of plants with identical technologies. Workers are characterized by time-invariant ability $i \in \{L, H\}$, low or high, drawn independently across workers: $i = h$ with probability π and $i = l$ with probability $1-\pi$. High ability workers produce more than low ability workers: $y_H > 0 > y_L$. A measure $1 - d$ of plants die each period and are replaced by vacant plants. A measure $1 - \delta$ of workers die every period and are replaced by new entrants.

Actions Workers begin each period matched with an incumbent plant with a standing contract w and two poaching plants.[9] Plants choose a downward rigid wage contract, incumbent: $w' \geq w$ and poachers: $w^* \geq \underline{w}$, to offer the worker. It specifies a wage to be paid every period until either (1) the worker quits; (2) the plant lays off the worker; or (3) the plant raises the wage to a new contract. They may not reduce the wage. Incumbents additionally choose whether to fire $F = 1$ the worker. The action space of a worker is whether to accept the poacher $Q = 1$ or stay with the incumbent $Q = 0$. They may not quit to unemployment.

Payoffs If the worker does not quit ($Q = 0$), the incumbent plant remains incumbent: the worker receives payoff w' and the plant receives payoff $y_i - w'$. If the worker quits ($Q = 1$) a

[8]Wage posting and asymmetry in information is supported by the 2,000 worker survey of Hall and Krueger (2010). They find wage bargaining with a new employer took place less than a third of the time and less than half of worker's new employers knew their last wage. Asymmetry in information between employers. No counter offers are supported by Barron et al. (2006) who find firms would counter offers for 40% of workers.

[9]Denote poaching plants with a star.

poaching plant becomes incumbent: the worker receives payoff w^* and a randomly assigned poaching plant receives payoff $y_i - w^*$. If the worker is not fired ($F = 0$), she enters the next period with the plant and contract she chose. If the worker is fired $F = 1$ or the incumbent dies, the worker collects zero and is assigned to a new plant that observes she is unemployed. If the worker dies, the incumbent dies as well and both receive a payoff of zero. All plants that are not the new incumbent receive a payoff of zero and die. Workers have time-separable linear utility over wages and plants maximize expected future profits. Workers and plants share discount factor $\rho \geq \max\{1-\delta, 1-d\}$ Therefore, the objectives are:

$$\text{Workers} \qquad \mathbf{E}[\sum_{t=0}^{\infty} \rho^t w_{it}]$$

$$\text{Plants} \qquad \mathbf{E}_i \sum_{t=0}^{\infty} \rho^t \left[y_i - w_{it}\right]$$

Information A worker's ability is her private information. An incumbent newly matched with a worker from non-employment observes whether the worker is a new entrant or has been displaced. Each period during a match, the incumbent learns the worker's ability with probability μ. Poaching plants that meet the worker are informed of all information of the incumbent with probability ν and with probability $1-\nu$, they have no information on the worker or the action of the incumbent.[10] All poaching plants have the same information about a worker in a given period. The incumbent does not observe the action of the poaching plants or whether they are informed. The worker observes all actions, information, and states.

Timing The timing for a worker with incumbent prior p, poaching prior p^*, and contract w is as follows.

1. **Nature**

[10] Since poachers only live a single period, there is no "memory" of poachers

- **Worker Death, Birth**: Measure δ die, replaced by entrants
- **Exogenous Displacement (Shut Down):** worker labeled unemployed with exogenous probability d.

2. **Incumbent**

- **Learning:** probability μ learns the worker's type.
- **Fires:** Incumbents choose whether to fire workers $F(p', w) = 1$.
- **Incumbent wage offers**: raise $w' > w$ or remain at $w' = w$.

3. **Poachers**

- **Poachers' wage offers**: a contract $w^*(p^*)$.

4. **Workers**

- **Employed Workers Choose an Offer**
- **New entrants & displaced matched to vacancies**

Figure 1: Timing

Nature	Incumbent(p) $w' \in [w, \bar{w}]$	Poacher(p^*) $w^* \in [\underline{w}, \bar{w}]$	Worker $Q \in \{0, 1\}$
T			**T+1**
1. Death prob=δ 2. Exog SD prob $=d$ label unemp. p^u	1. Learning μ learn $p' \in 0, 1$ 2. Fires: $F(p') \in \{0, 1\}$ 3. Inc Offer: $w'(w, p') \in [w, \bar{w}]$	1. Information ν Informed $p^* = p$ $1 - \nu$ Uninf $p^* = p^{uninf}$ 2. Poacher Offers: $w^*(p^*)$	$Q = 0$: Incumbent $w' = w'(p, w)$ $p' = B(p, w'(p, w))$ $Q = 1$: Poacher $w' = w^*(p^*)$ $p' = B^*(p^*, w^*)$ Other plants die

Beliefs and Strategies Incumbents and poachers have priors over a worker's type and each others' types and actions. Priors over worker type are p and p^*, a probability the worker is of the high type. An incumbent newly matched with a new entrant has rational prior $p = \pi$ according to the population distribution. An incumbent newly matched with a displaced worker has prior $p = p^u$, the proportion of unemployed that are high type. Informed poachers have prior $p^* = p$ and uniformed poachers have prior $p^* = p^{uninf}$. The incumbent's prior over the poachers' type and action is a joint probability distribution $q_p(p^*, w^*)$. The poachers' prior over the incumbent's type, standing wage contract, and action is a joint probability distribution $q^*_{p^*}(p, w; w')$. [11]

The plant whose offer the worker accepts has a posterior belief about the worker's type based on their prior and the worker's action. Denote the Bayesian posterior as $B(p, w)$ for the incumbent if the worker stays and $B^*(p^*, w^*)$ for the poaching plant if the worker quits.

Strategies are a mapping of priors P and the standing contract W to actions A. Eliminating redundant state variables, pure strategies can be defined as:

$$
\begin{array}{rll}
\text{Incumbent} & w'(p, w) \in [w, w_{max}]; & F(p, w) \in \{0, 1\} \\
\text{Poachers} & w^*(p^*, \underline{w}) \in [\underline{w}, w_{max}] & \\
\text{Worker} & Q(p, w, p^*) \in \{0, 1\} &
\end{array}
$$

Value Functions and Strategies **Employed Worker**: Consider worker of ability $i \in \{L, H\}$ with contract w, incumbent belief p, and poachers' belief p^*. Given other players' strategies $\{w'(p, w), w^*(p^*), F(p, w)\}$, the worker chooses quit strategy $Q_i(p, w, p^*)$ to

[11] Note both objects depend on the plants' own types.

maximize the value function:[12]

$$V_i(p,w,p^*) = \max_{Q\in[0,1]} w' \quad +\rho[(1-\mu)(\mathbf{E}_{p'^*}[V_i(B(p',w'),w',p'^*)|B(p',w')] + \mu\bar{V}_i(w'))]$$
$$+d\rho\mathbf{E}_{p'^*}[V_i(p^u,w(p^u),p'^*)|p^u]$$

subject to

$$(p',w') = \begin{cases} (p,w), & \text{if Q=0;} \\ (p^*,w^*), & \text{if Q=1.} \end{cases}$$

$$\mathbf{E}[p'^*|B(p',w')] = \quad \{B(p',w') \quad \text{with pr} \quad \nu; \quad p^{uninf} \quad \text{with pr} \quad 1-\nu\}$$

$$\bar{V}_i(w) = (1-F(\delta_i))\mathbf{E}_{p'^*}[V_i(\delta_i,w,p'^*)|\delta_i] + F(\delta_i)\mathbf{E}_{p'^*}[V_i(p^u,w(p^u),p'^*)|p^u]$$

The first line gives the expected value of choosing a wage and prior pair (p',w') from the choices of incumbent: (p,w) and poacher: (p^*,w^*). The continuation value depends on whether the new incumbent learns next period. With probability $(1-\mu)$ the new incumbent does not learn her type, but may update it's belief giving a Bayesian posterior $B(p',w')$ [13]. The expectation over the poacher's information p^* includes the probability ν they become informed of the incumbent's information. If the new incumbent learns the worker's type the continuation value is $\bar{V}_i(w)$, a function of firing strategy $F(p')=1$.The second line is exogenous shut-down to unemployment. Then the new incumbent's belief, p^u is the probability an unemployed worker is the high type.

Incumbent: Denote $p_l = (1-p)$ and $p_h = p$. Given other players' strategies, the

[12] I assume an equilibrium exists where agents play pure strategies and later verify the unique equilibrium is a pure strategy equilibrium

[13] The worker's quit strategy may reveal information about her type

incumbent chooses strategies $w'(p,w)$ and $F(p)$ to solve:

$$\Omega(p,w) = \max_{w'(p,w)\geq w} \underbrace{\sum_{i=l,h} p_i[\nu(1-Q_i(p,w',w^*(p))) + (1-\nu)(1-Q_i(p,w',w^*(p_e)))]}_{\text{Probability the Worker Accepts the Offer}} \times$$

$$\underbrace{[y(B(p,w')) - w' + \rho\mu\bar{\Omega}(B(p,w'),w') + \rho(1-\mu)\Omega(B(p,w'),w')]}_{\text{Expected Profits Conditional on the Worker Accepting}}$$

Wage offer strategy $w'(p,w)$ is chosen considering the probability the worker stays given the offer and the expected future profits conditional on the worker staying. The incumbent collects zero if they choose to fire the worker. Firing strategy $F(p,w)$ enters into the value after learning, $\bar{\Omega}$:

$$\begin{aligned}\bar{\Omega}(B(p,w'),w') = \max_{F\in\{0,1\}} \; & (1-F(1,w))B(p,w')\Omega(1,w) \\ & +(1-F(0,w))(1-B(p,w'))\Omega(0,w)\end{aligned}$$

Poachers: Bertrand competition among the poachers yields the worker the total expected surplus. This implies $w^*(p^*)$ solves $\Omega(p^*, w^*(p^*)) = 0$

Definition of a Symmetric Perfect Bayesian Equilibrium An equilibrium Φ is a set of pure strategies $\{w, w^*, F, Q\}$, posterior beliefs $\{B(p,w), B^*(p^*,w^*)\}$, and a stationary distribution $\lambda(p,w)$ with support Ψ such that, given exogenous objects $\Theta = \{y_l, y_h, \pi, \mu, \nu, \delta, d, \rho\}$:

- Strategies are sequentially rational given Ψ:
- Priors are consistent with equilibrium distribution $\lambda(p,w)$
- Posteriors are Bayesian where possible.[14]

  Off path: $B(p,w) = lim_{\epsilon\to 0}Q_{i\epsilon}$ where $Q_{i\epsilon} \in [\epsilon, 1-\epsilon]$

[14] I define off-path beliefs as the limit of the workers' forced mixed strategies. However, this equilibrium can be supported by many off-path beliefs and satisfies other equilibrium refinements including Cho-Kreps

- Stationary distribution $\lambda(p, w)$ is consistent with strategies.

4 Characterization of the Equilibrium

There is a unique pure strategy equilibrium characterized by two key features: (1) workers' strategies are independent of type; and (2) the uninformed poacher wage equals the minimum informed poacher wage in the economy.[15]

Proposition 4.1. *The worker's policy is independent of her type (i): $Q_h(p, w, w^*) = Q_l(p, w, w^*)$ for all $(p, w, w^*) \in \bar{\Psi} \times \bar{\Psi}$. Proof: Appendix.*

The intuition for this result is that it is costless for low types to mimic high types. This is because the only type-dependent payoff for the low type occurs when the incumbent learns her type. This payoff is independent of her past actions and the rate at which this learning happens is exogenous.

Since $Q(p, w, w^*)$ is independent of workers' true types, workers actions do not convey information about their type. This implies incumbents' posterior update equals the prior, but poachers may still learn about the incumbents' information conditioning on the fact the worker accepted their offer. The result is a finite set of beliefs in the economy: a worker poached by an uninformed poacher, a new entrant, an unemployed worker, and the high type worker.[16]

Although the environment is dynamic, the problem for an incumbent is static before and

Intuitive Criterion, Sequential Equilbrium as Kreps and Wilson, and is the limit of Control Cost equilibria as Selton.

[15]These results apply to any number of finite worker ability types

[16] To avoid no lay-offs, assume that $y_l < 0$ and so low workers are fired when the employer learns their type. Also, let y_h be sufficiently large such that $F(\delta_h) = 0$.

after the arrival of full information. Therefore wages only change when information changes. This reduces the problem to solving for the set of unique wages corresponding to the finite set of beliefs in the economy, for both poachers and incumbents.

Lemma 4.2. *$w'(p,w) \leq w^{uninf} \leq w^*(p)$ for all $w \leq w^{uninf}$ and any $p \in \mathcal{P}$, and $w'(p,w) < w^{uninf} \leq w^*(p)$ if $\mu \in (0,1)$ and $\nu \in [0,1)$.*

Wages and turnover are characterized as follows. First, the incumbent always pays less than the informed poachers. This is obvious, since poachers Bertrand compete yielding zero profits. It also implies that incumbents will lose the worker when outsiders learn. Second, the incumbent pays the minimum wage to keep the worker from switching to the uninformed poacher, *if the standing contract does not prohibit it*:[17] This means the incumbent keeps the worker from the uniformed poachers, earning positive profits until the poachers become informed and the worker switches. What is less obvious is that the wage required to keep the worker is strictly less than the uniformed poacher wage.[18] Algebra on the worker's problem shows that these wages are:

$$\text{Before Learning} \quad (p \in \{p^u, \pi\}): \quad \underline{w}(p) = \frac{(1-(1-\nu)\rho)w^*(p^{uninf}) - \nu\rho w^*(p)}{1-\rho}$$

$$\text{After Learning} \quad (p = 1) \quad \underline{w}(1) = \frac{(1-(1-\mu)(1-\nu)\rho)w^*(p^{uninf}) - (1-\mu)\rho\nu y_h}{1-(1-\mu)\rho}$$

These wages are *less* than the uninformed poacher wage because when a worker quits she destroys the information of the incumbent. She loses the opportunity for this information to spread to poachers and bring her higher future offers. An interesting result is that the worker considers these future offers and may forgo an offer from an uninformed poacher, even if it

[17]Sequential rationality implies the incumbent will not mix between beating and failing to beat an uninformed poacher. One strategy will always dominate the other in the continuation at a given node.

[18]With the exception being when $\nu = 1$ and learning is public. Then all plants earn zero profits and the incumbent is indifferent between any wage offer up to the worker's expected productivity.

is higher than her current wage. The strength of this effect is tempered by the likelihood of meeting an informed poacher ν. When ν is large the likelihood of meeting an informed poacher is large and therefore the asset value (value beyond the flow wage) of remaining with the incumbent is large. Thus, the gap between the incumbent wage and uninformed poacher wage is increasing in ν. The high type with an incumbent who has learned her type, $(p = 1)$ also takes into consideration the speed of learning μ. The asset value of remaining with the incumbent is decreasing in μ. For example, if $\mu = 1$ learning is immediate, all employers are the same, and the incumbent pays the uninformed wage.[19]

Consistent with the above, the workers' strategy is to only quit to informed poachers, as is characteristic in an asymmetric information (lemons) problem.[20] The worker's full quit strategy is:

$$Q(p, w, p^*) = \begin{cases} 0, & \text{if } p^* = p^{uninf}; \\ 1, & \text{if } p^* = p \text{ and } p > p^u. \end{cases}$$

The final strategy to characterize is the wage offer by the uninformed poacher. It is defined by Bertrand Competition and the posterior $B^*(p^{uninf})$ if the worker accepts. Since no worker will ever accept, the belief is defined as the limit of forced mixed strategies. In this case, the only posterior that can provide zero profits is $B^*(p^{uninf}) = p^u$, the lowest incumbent prior in the economy.[21] This gives a wage strategy:

$$w^*(p^{uninf}) = y_h - \frac{[1 - (1 - \nu)\rho](1 - p^u)(y_h - y_l)}{1 - \rho[(1 - \nu) - p^u)\mu]}$$

[19] More discussion in section 5

[20] The exception is when the worker is hired from unemployment and incumbent prior is p^u. This is the lowest prior in the economy, and the uninformed poachers offer $w^{uninf} = w(p^u)$ to satisfy the notion of sequential equilibrium with respect to workers' quit strategy. In this case, the worker is indifferent and by the proposition above, the worker chooses to stay.

[21] The assumption that the worker's outside option is to quit to unemployment gives this same value.

The proposition below shows the equilibrium satisfying the above equations exists and is unique. It generalizes the key result that the uninformed poacher belief equals the minimum informed poacher belief in the economy.

Proposition 4.3. *If $\mu \in (0,1)$ and $\nu \in (0,1)$, there exists a unique $\Psi(\Theta)$ that satisfies the equilibrium conditions and refinement and it is characterized by $p^{uninf} = \underline{p} \in \mathcal{P}$ such that $p \geq \underline{p}$ for all $p \in \mathcal{P}$.*

Discussion The equilibrium consists of six distinct wages that are ever paid: the wage of a new entrant w^{ne}, the wage of a worker hired from unemployment w^{u}, the wage of a worker after her employer learns she is high type w^{h} and the wages of workers who are poached before the incumbent has learned her type w^{*ne} and after w^{*h}. These wages combined with worker quit strategies qualitatively match the three stylized facts of the data. First, all unemployed workers experience short term wage losses. This is because the wage of a worker hired from unemployment w^{u} is the lowest wage in the economy. This result depends upon plants having no information about the reason for unemployment. Second, high type workers' wages recover. This requires not only the incumbent plant to learn the worker is the high type, but also information to spread to an informed poacher who will offer a higher wage. Third, low type worker's wages do not recover, and they are fired again. When the incumbent learns the worker is low type, she is fired and never has wage recovery to a new entrant wage they started at. An example of the wage and belief paths of a high ability and low ability worker can be seen in Figure 5 on page 36.

5 Comparative Statics

A main distinction of this work is that it is flexible in the speed of employer learning and the speed of diffusion of information to outside potential employers. Figure 6 on page 37 show the effects of these parameters on wages. I will now describe how these parameters are key for determining the size of the information surplus and how it is split between worker and employer.

5.1 Speed of Employer Learning (μ)

The speed of employer learning affects equilibrium wages through two channels: the incumbent's monopsony power over private information and the composition of the pool of unemployed. As employer learning becomes fast (μ approaches 1), the incumbent's monopsony power over information falls. Consider $\mu = 1$, then a new employer is identical to the current employer and there are no information rents. This increases the worker's share of the information surplus. The second effect of fast employer learning is that low type workers are fired more often. This increases the proportion of unemployed that are low type and implies the wages of re-hired unemployed workers fall. This causes the wage offer of the uninformed poacher to fall. As a result, the minimum wage required to keep a worker from quitting to an uninformed poacher falls. These two effects work in the same direction to lower wages for displaced workers, but have ambiguous effect on new entrants. The dynamic effects are that exogenously displaced high types have faster recoveries and low types experience more displacements.

5.2 Speed of Diffusion of Information to Potential Employers (ν)

The likelihood a poacher is informed affects equilibrium wages by changing the worker's asset value of employment with an incumbent that has positive private information about her. As the spread of incumbent information to outside employers becomes fast (ν approaches 1), the worker receives high wage offers from informed poachers more quickly. This increases the worker's asset value of remaining with incumbent to preserve the incumbent's positive information until poachers become informed. This increase in the asset value of employment lowers the flow wage required to keep a worker. The effect on a worker is unambiguous: when poachers are more likely to be informed, wages start lower, but growth is faster. The effect on plant profits is ambiguous, they capture a larger share of the rents from private information but for a shorter period of time. Flexibility in how fast information diffuses adds interesting results compared to the discrete case $\nu \in \{0, 1\}$. In these cases, the worker never has incentive to change employers. If $\nu = 1$, then information is public and the worker receives the full information surplus. If $\nu = 0$, information is private and the incumbent receives the full information surplus.

6 Quantitative Macroeconomic Model

In the remaining sections of this paper I extend the basic model to include transitory general productivity (skill) loss, the major alternative theory of wage losses following unemployment. I then embed the model in an equilibrium unemployment Mortensen and Pissarides (1994) search framework to endogenize the entry of vacant plants and analyze the effect of these mechanisms on macroeconomic outcomes.[22]

[22] Tractability of alternative extensions benefits from maintaining a pooling equilibrium in workers' strategies. Such extensions include adding static decisions of the worker or plant. For example, a choice between

6.1 Adding Human Capital

I add (general) skill accumulation and loss in the style of Ljungqvist and Sargent (1998). Workers' skills are public information and increase a worker's productivity on any job. Workers start life unskilled ($s = 0$). During each period of employment they become skilled ($s = 1$) with probability γ. If a skilled worker becomes unemployed, regardless of cause, she becomes unskilled with probability τ. I assume all workers always produce positive output, but an unskilled low type worker's output is below the opportunity cost of the firm of hiring a new worker.[23] Thus the low type is profitable if she is skilled, but unprofitable if she is unskilled and will be fired. Denote the output of worker of ability $i \in \{l, h\}$ and skills $s \in \{0, 1\}$ as y_{is} with the following ordering assumed to hold: $y_{l0} < y_{h0} < y_{l1} < y_{h1}$. The third component I add is that the worker's wage can be lowered if both parties agree. This prevents plants from offering workers wage contracts above the skilled low worker's value that would trigger a firing if she is discovered to be the low type. Instead, she will offer the plant to be paid a wage such that the plant earns arbitrarily small profits and accepts the offer.

6.2 Adding Search and Vacancy Posting

To assess the effect of employer information on aggregate unemployment, I now embed the model in a general equilibrium random search framework. Vacant plants choose whether to pay cost κ each period for a chance to meet a searching worker. Searching workers include the unemployed, new entrants, and employed workers who would be offered a higher wage by informed poachers. Each searching plant meets a single worker, but each worker may meet many searching plants. Search is random following the "urn-ball" formulation of Butters

different occupations with different speeds of learning, a one-time choice of investment in general or specific human capital, or adding a cost to obtain a signal about workers' ability before the start of the match.

[23]and wages must be weakly positive

(1977). The relevant probabilities a worker has m meetings conditional on u searching workers and v searching plants are:

$$r_{m=0}(u,v)=e^{-v/u} \qquad \text{Probability of meeting no plants}$$
$$r_{m=1}(u,v)=e^{-v/u}\frac{v}{u} \qquad \text{Probability of meeting one plant}$$
$$r_{m>1}(u,v)=(1-(e^{-v/u}(1+\frac{v}{u}))) \qquad \text{Probability of meeting more than one plant}$$

If a searching plant meets a worker, they observe the worker's employment status, skill level, and if another searching plant meets the worker in the same period. If plants meet an employed worker, they have a probability ν of being informed of the incumbent's information. If more than one plant meets a worker, the plants Bertrand compete and earn zero profits. If a single plant meets an worker, they offer a wage slightly above the incumbent wage and may earn profit.[24]

In this set-up, plants earn positive expected profits when they alone meet one of the following workers: a new entrant, an unemployed with high skills, and an employed worker who has not been competed over in her current skill/incumbent information state. Equilibrium in the search market is defined by zero expected profits for vacancy posting:

$$\mathbf{E}_{p,s,w}[e(p,s,w)(1-\nu)\Omega(p,s,w)+(1-e(p,s,w))\Omega(p,s,w)]\frac{r_{m=1}(u,v)u}{v}-\kappa=0$$

The expectation is over workers' type (p,s,w) is given by the stationary distribution $\Gamma(p,s,w)$ and $e(p,s,w)$ which specifies the proportion of workers of that type that are employed. Since these objects depend on ν and μ, equilibrium vacancies and unemployment also depend on ν and μ.

The main results of the simple model are maintained. The incumbent always chooses the lowest wage to beat two uninformed poachers. Characterizing the equilibrium requires

[24] For practical purposes, I will compute this as no change in wage for the worker, but it will be a case where a searching plant earns positive profit.

solving for a finite set of wages. The wages offered to unemployed workers are a function of the proportion of high ability unemployed workers of either skill level. This requires first solving for the stationary distributions of skill-ability combinations in the economy and the proportion of high types in unemployment at each skill level. [25]

6.3 Calibration

To measure the contribution of lost skills and information to the wage losses of displaced workers, I calibrate model parameters to moments dealing with worker tenure, multiple displacements, and wages. The time period is four weeks.[26] Three parameters are chosen directly. I normalize the output of the low type worker $y_l = 1$. I choose the worker death rate to give an average working life of 40 years $1 - \delta = 0.0021$. I choose discount rate $\rho = 0.99$ within the standard range. Since learning follows a poisson arrival rate, it is iid over workers and across experience groups and can be identified with single equations. I choose $\mu = 0.08$, the speed of employer learning, to match the 40% of workers fired with tenure greater than 1 year. I choose $\nu = 0.016$, the speed of information diffusion to outside employers, to match the tenure of direct employer to employer quitters of 5.1 years observed in the data.[27]

The next set of parameters are uniquely identified by equating a set of model flow equations to empirical flows, given a chosen value of the share of workers that are high ability: π.[28] These parameters are $[\hat{d} \quad d \quad \gamma \quad \tau]$ and the data moments in the table below. Parameter γ is the probability of skill growth, τ the probability of skill loss, d the probability of an

[25]These objects are explicitly written, along with the relevant value functions, in the Technical Appendix.

[26] This equals one-half the median duration of unemployment from the Bureau of Labor Statistics for 1976-1998 of 7.8 weeks.

[27]I choose tenure at second firing and later in life to avoid un-modeled idiosyncracy in the employment experiences of young workers.

[28]These equations do not require solving for wages. They are written in the appendix.

exogenous shut down, and $\hat{d}$ is the probability of exogenous displacement being labelled an individual "firing" in the data. [29] This leaves three parameters to be jointly estimated, π: the proportion of workers that are high ability; s: productivity gained from learning by doing on the job; and y_H: the productivity of the high type. These parameters are found through indirect inference. I produce model data for 3,000 individuals over 25 years and minimize the distance between statistics of the simulated data and statistics from the PSID sample. The first statistics are given by the same Mincer regression controlling for age, age-squared, displacement dummies, *and individual fixed effects* run on model data and the PSID. The remaining target statistic is wage growth from age 25 to 50.

Given all other parameters, a choice of $\kappa = 0.33$ gives an unemployment rate of 5%.

Results: Information Explains more of Unemployed Wage Loss than Productivity The complete list of parameter values and targets are shown in Figure 2 on page 34. The results show an estimate that eighteen-percent of the population is "low ability". This means eighteen-percent of new entrants are at risk of being fired if their employer learns their type before they gain skills. This risk is persistent. Low ability workers take longer to gain skills because sixty-percent of unskilled low ability workers are discovered and fired each year. This implies 7.14 years of experience necessary, on average, for a low ability worker to gain skills compared to just 2.8 for high ability workers.

Skills are acquired more quickly and loss less often in this model compared to several calibration of models following Ljungqvist and Sargent (1998) and also more quickly than the best fit of the model without ability.[30] If the model has skills only, they account for a 41%

[29] I estimate $\hat{d}$ because it is likely some workers are displaced individually for reasons independent of their own performance on the job.

[30] The Ljungqvist and Sargent (1998) literature gives different estimates for time to regain skills after unemployment. A median estimate is about 10 years

increase in life-time wages, take an average of five years to acquire, and are lost with a 90% probability if a worker becomes unemployed. Including both skills and ability in the model reduces the addition of skills to lifetime wage growth to twelve percent, reduces the time to acquire skills to 3.3 years, and reduces the probability of losing skills in unemployment to 25.9%. The important implication of the large difference between these estimates is that productivity loss following unemployment in the model including both skills and ability is less than 10% of a theory of skills alone.

I re-estimate the model with skills only and with ability only (Figure 7 on page 38) to show why both components are necessary to match the data.[31] A theory of skills alone does not produce persistent wage losses because skills are a transitory and can be reacquired. A theory with ability only gives the counterfactual that exogenously shut down workers have larger initial wages losses than fired low-ability workers.[32] Adding skills to the model corrects this problem by providing a way to imperfectly sort the pool of unemployed by ability. Skilled workers are more likely to be high-ability because high-ability workers are more likely to have been continuously employed to have gained skills. Exogenously shut down workers are more often skilled because skilled workers are never fired, and, because skills are positively correlated with ability, are rehired at higher wages than unskilled unemployed workers.

[31] In this exercise I choose parameters to best fit the initial wage losses of workers and life-cycle wage growth. Parameter values listed in the technical appendix.

[32] This also highlights the importance of the fixed effect in both the indirect inference and in the empirical regression. Including an individual fixed-effect requires a large deviation from life-time average wage to produce a large wage loss in the regression. Since exogenously displaced workers are of higher average ability than endogenously fired workers, they have higher pre-displacement wages. This means that if both groups are hired back at the same wage, the shutdown workers show a larger loss when individual fixed effects are included.

Model Fit To judge how well the model simulated data fits observed data in the PSID, I estimate the same regression on the simulated data as I did for the PSID sample in the evidence section. Graphical depictions are shown in Figure 8 on page 39. With respect to shut-down workers, the coefficients of the displacement dummies in the model-generated data lay within the 95-percent confidence interval of the displacement dummies in the wage regression. Note the time to recovery was not targeted in the calibration. This match is one success of the model. With respect to fired workers, the model underpredicts the long term wage losses. The model accounts for 71% of the present discounted value of the wage losses of fired workers. This is a marked improvement over Davis and von Wachter (2011) estimates of 0.05 to 0.2% in a standard Moretensen-Pissarides model and 25% for the job ladder model of Burgess and Turon (2010).[33] Finally, the model predicts workers ever fired will experience an average of 5.3 firings in 25 years. The PSID average is 4.63 over the sample period, but suffers from attrition.

Comparative Statics: Speed of Learning, Worker Flows and Wage Dispersion Figure 9 on page 40 shows the effects of changes in speed of employer learning (μ) and speed of information diffusion to potential employers (ν) on equilibrium unemployment.[34] The speed of incumbent learning has no significant effect on the unemployment rate. This appears to be a consequence of equilibrium wage adjustment. The speed of information diffusion to potential employers has a significant and non-monotone effect on unemployment.

[33] I use a discount of $\beta = .95$ just as Davis and von Wachter (2011). For comparability, the empirical estimates of wage losses from unemployment in their sample is 1.4-2.8 years of earnings over 20 years. The estimates from my sample are 1.48 years of earnings over 16 years, but do not include periods of zero earnings.

[34] To predict the quantitative effects of information on unemployment, I modify the parameters from the calibration to match a period length of 8 weeks.[35] I choose $\kappa = 0.33$ to give an unemployment rate of 5% for these baseline parameters.

For high values of ν, poachers are more likely to be informed about incumbent's information and to have opportunities to poach employed workers. Poaching employed workers is more profitable than poaching unemployed because of selection. For low values of ν poachers are less likely to be informed and more likely to hire the unemployed. This negative effect on profits is more than offset by the fact that once a worker is hired they are less likely to be poached again in the future. This increases expected profits by increasing the match duration. Higher expected profits, for both high and low values of ν, increases entry of vacant plants and lowers unemployment. Neither positive effects on profits are strong for middle values of ν, leading to fewer vacancies and higher unemployment rates.[36]

7 Conclusion

This paper provided a theory of how information available about workers' productivities affects the joint process determining fires, quits, and wage paths. I built this theory into a search and matching framework and showed it can quantitatively replicate the diverging wage and employment patterns following employer transitions for different reasons. In particular, it can account for 71% of the large and persistent wage losses of workers who change employers through an unemployment spell, whereas the best fit with skills alone captures less than 25% of wage losses. I conclude employer learning about workers' abilities drives long-term wages losses after unemployment, but estimates show skill loss does affect about a quarter of all displaced workers. Simply stated, lost reputation and lost skills are both important for displaced workers' initial wage losses, but selection is the cause of the permanent

[36]These results hold when other parameters of the model are fixed to the calibration targeting my PSID sample. Future research can illustrate how these results are affected by alternative parameterizations of the model.

scars.

My results suggest information frictions have a quantitatively important effect on the macroeconomy. In particular, the speed of information diffusion to potential employers has a large and non-monotone effect on aggregate unemployment. Since the framework developed in this paper provides implications for the Macroeconomy, it is a tool to quantitatively analyze labor market policies in light of the information frictions presented. For example, how could firing restrictions or retraining programs affect unemployment and welfare? On a broader horizon, the model can provide predictions to examine how much changes in employer information has contributed to evolving trends of worker turnover, life-cycle wage profiles, and inequality.

A Appendix

A.1 Regression Analysis

Following Jacobson et al. (1992), the effect of employer change at time $t-n$ on current wages w_t of individual i is captured by β_n in this regression:

$$ln(w_{it}) = \gamma_1 exp_{it} + \gamma_2 exp_{it}^2 + \sum_{n=-1}^{15} \beta_n D_{nit} + \delta_t + \alpha_i + \epsilon_{it}$$

The dependent variable is the natural logarithm of hourly earnings. The independent variables include a quadratic of experience, D_{it}^n a dummy variable that captures employer change in year $t-n$, year dummy δ_t and individual fixed effects α_i. The employer change variable D_{it}^n includes dummies for one year prior to employer change, the year of the change, and each of the first through sixteenth years following the change (ie: $n \in \{-1, 0, 1, 2, ..., 15, 16\}$). I follow sample selection similarly to Barnette and Michaud (2010) to construct a panel from the PSID covering years 1976-1998. [37]

A.2 Proofs

Proposition A.1. $Q_h(p, w, w^*) = Q_l(p, w, w^*)$ *for all* $(w, w^*) \in \bar{\Psi} \times \bar{\Psi}$

Proof. Case 1: $w \geq w^*(p)$. The definition of off path beliefs implies $Q_i(p, w^*(p), w^*(p)) = 0$ maximizes informed poacher offers. Quit policies to uninformed poachers satisfy:

$$\begin{aligned}
\text{High Type:} \quad & \max\{[\rho(1-\mu)]^{-1}[(1-\mu)w^*(p_e) + \mu\frac{(1-\nu)w^*(p_e) + \nu\rho\bar{V}^H}{\rho(1-\nu)})], \\
& [\rho(1-\mu)]^{-1}[(1-\mu)w^*(p) + \mu\frac{(1-\nu)w^*(p) + \nu\rho\bar{V}^H}{\rho(1-\nu)})]\} \\
\text{Low Type:} \quad & \max\{[\rho(1-\mu)]^{-1}[(1-\mu)w^*(p_e)], \\
& [\rho(1-\mu)]^{-1}[(1-\mu)w^*(p)]\}
\end{aligned}$$

Where $\bar{V}^H = V(\delta_h, w^*(\delta_h))$. By Bertrand competition $\bar{V}$ is independent of history. By inspection, $Q_h(w^*(p), w^{unif})) = Q_l(w^*(p), w^{unif}) = 1$ if $w^*(p) > w^{unif}$.

[37] There are several important distinctions between this paper and that work, including the addition of workers who voluntarily quit to a new employer without an unemployment spell and information on tenure patterns for all groups.

Case 2: $w < w^*(p)$. Trivially, if $p < p^*$ both quit: $Q_h = Q_l = 1$ If $p^* > p$ policies satisfy:

$$\begin{aligned}
\text{High Type:} \quad & \max\{c_1[(1-\mu)w^*(p_e) + \mu\frac{(1-\nu)w^*(p_e)+\nu\rho\bar{V}^H}{\rho(1-\nu)})], \\
& c_1c_2\nu[(1-\mu)w^*(p) + \mu\frac{(1-\nu)w^*(p)+\nu\rho\bar{V}^H}{\rho(1-\nu)})] \\
& + \quad c_2(1-\nu)[(1-\mu)\underline{w} + \mu\frac{(1-\nu)\underline{w}+\nu\rho\bar{V}^H}{\rho(1-\nu)})]\} \\
\text{Low Type:} \quad & \max\{c_1(1-\mu)w^*(p_e), \\
& c_1c_2\nu(1-\mu)w^*(p) \\
& + \quad c_2(1-\nu)(1-\mu)\underline{w}\} \\
c_1 = [1-\rho(1-\mu)]^{-1} & \qquad c_2 = [1-\rho(1-\nu)(1-\mu)]^{-1}
\end{aligned}$$

$Q_l(p, w, w^*(p^*)) = 1 \iff c_1(1-\mu)w^*(p^*) > c_1c_2\nu(1-\mu)w^*(p) + c_2(1-\nu)(1-\mu)w \iff c_1[(1-\mu)w^*(p^*)+\mu\frac{(1-\nu)w^*(p^*)+\nu\rho\bar{V}^H}{\rho(1-\nu)})] > c_1c_2\nu[(1-\mu)w^*(p)+\mu\frac{(1-\nu)w^*(p)+\nu\rho\bar{V}^H}{\rho(1-\nu)})]+c_2(1-\nu)[(1-\mu)w + \mu\frac{(1-\nu w+\nu\rho\bar{V}^H}{\rho(1-\nu)})] \iff Q_h(p, w, w^*(p^*)) = 1$ [38] □

Proposition A.2. *If $\mu \in (0,1)$ and $\nu \in (0,1)$, there exists a unique $\Psi(\Theta)$ satisfying equilibrium conditions. It is characterized by $p^{uninf} = \underline{p} \in \mathcal{P}$ such that $p \geq \underline{p}$ for all $p \in \mathcal{P}$.*

Proof. Given $\mu \in (0,1)$ and $\nu \in (0,1)$, $\underline{p} \leq p$ for all $p \in \mathcal{P}$ and proof by contradiction need only consider $p^{uninf} > \underline{p}$. Suppose $p^{uninf} > \underline{p}$. Let $\tilde{\mathcal{P}} \subset \mathcal{P}$ such that $w'(\tilde{p}, \underline{w}) < \underline{w}(\tilde{p})$ for all $\tilde{p} \in \tilde{\mathcal{P}}$. Then, by definition of $B(p^{uninf}, w^*(p^{uninf}))$, $p^{uninf} > \underline{p}$ implies $\tilde{\mathcal{P}} \backslash \underline{p} \neq \emptyset$. Define $\tilde{p}_{max} \in \tilde{\mathcal{P}}$ such that $\tilde{p}_{max} \geq \tilde{p}$ for all $\tilde{p} \in \tilde{\mathcal{P}}$. By equation 4.2, if $p \in \mathcal{P}$ and $p < \tilde{p}_{max}$, then $p \in \tilde{\mathcal{P}}$. Then, by definition of $B(p^{uninf}, w^*(p^{uninf}))$, $\tilde{p}_{max} > p^{uninf}$. But also by equation 4.2, $\tilde{p}_{max} > p^{uninf} \Rightarrow w'(\tilde{p}_{max}, \underline{w}) > \underline{w}(\tilde{p}_{max}) \Rightarrow \tilde{p}_{max} \notin \tilde{\mathcal{P}} \rightarrow\leftarrow$. □

[38]Further, the cost of deviation is greater for the high type. Thus, this equilibrium satisfied the control costs refinement.

A.3 Calibration Equations

Model flow equations to equate to data to solve for parameters $\hat{d}, d, \tau, \gamma$. (1)Fired EU Flow Rate[39]

$$\tilde{F} = \hat{d} + \mu\lambda_{l0}$$

(2) Shut down EU Flow Rate: d

(3) Model proportion fired again the next year:

$$\tilde{FF} = \hat{d} + \frac{\lambda_{l1}\mu\tau + \mu(1+\mu)\lambda_{l0}}{1+\mu\lambda_{l0}}$$

(4) Model proportion displaced by shutdown and fired within two years:

$$\tilde{SDF} = F + \mu\tau\lambda_1$$

(5)Model definition of stationary distribution λ:

$$\lambda_{l0}(1-\mu-\delta-d-\hat{d}) = \lambda(1,2)(\delta+\tau(d+\hat{d}))$$
$$\lambda_{l1} = 1-\pi-\lambda_{l0}$$

This system reduces to the following functions of π, pre-defined parameters, and data moments:

$$\begin{aligned}
\lambda_{l0} &= \frac{EUFlowRate - d}{\mu} \\
\hat{d} &= d - SDRate \\
1-\gamma &= \frac{\hat{SDF}}{\mu\lambda_{l0}}\left[\frac{FF - SDF}{2\hat{FF} + \mu\hat{SDF}}\right] \\
\tau &= \delta\left[\gamma\frac{FF - SDF}{\hat{FF} + (1+\mu)\hat{SDF}} - (1-\delta)d\right]^{-1} \\
1-\pi &= \lambda_{l0}\left(1 + \frac{\gamma}{\delta + (1-\delta)d\tau}\right)
\end{aligned}$$

[39] In this specification I estimating that $\hat{d}$ of EU flows labelled "individually fired or laid off" in the PSID are actually independent of ability and labeled exogenous in the model PSID do not report if they were selected based on their ability, it is best to estimate this.

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A.4 Figures

Calibrated Parameters			
Parameter	Value	Target (PSID)	Value
Speed of Learning μ	0.6	Prop Fired > 1yr tenure	0.4
Prob. Poacher Informed ν	0.18	Tnre at Quit age>30	5.1 yrs
Worker Death $1-\delta$	0.0025	Av working years	40
Discount Rate ρ	0.95	Standard	
Low Ability Output yL	1	Normalization	
Exogenous Shut Down d	0.0071	Flow Equation System	
Exogenous Firing $\hat{d}$	0.0121	Flow Equation System	
Skill Growth Prob γ	0.3528	Flow Equation System	
Skill Loss Prob τ	0.2590	Flow Equation System	
Flow Equation System: Data Moments			
Annual Proportion Fired	0.023	Annual Proportion Shut Down	0.0071
Prop. fired yr after a firing	0.21	Prop. fired yr after Shut Down	0.04

Jointly Estimated Parameters		
Parameter	Value	
High Ability Output y_H	1.31	
Prop High Ability π	0.82	
Skilled Productivity s	0.05	
Targets	PSID Statistic	Model Simulation Statistic
Av. 25 year log(wage) Growth	0.287	0.3295
Coef. Year after Firing Dummy	-0.162	-0.168
Coef. Year after Shut Down Dummy	-0.119	-.115

Figure 2: Model Parametrization

Figure 3: Wage Dynamics of Job Changers

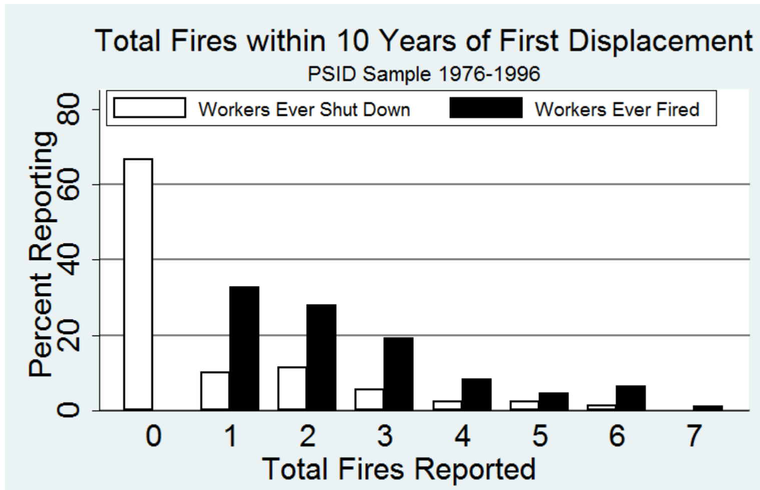


Figure 4: Repeat Unemployment Spells of Job Changers

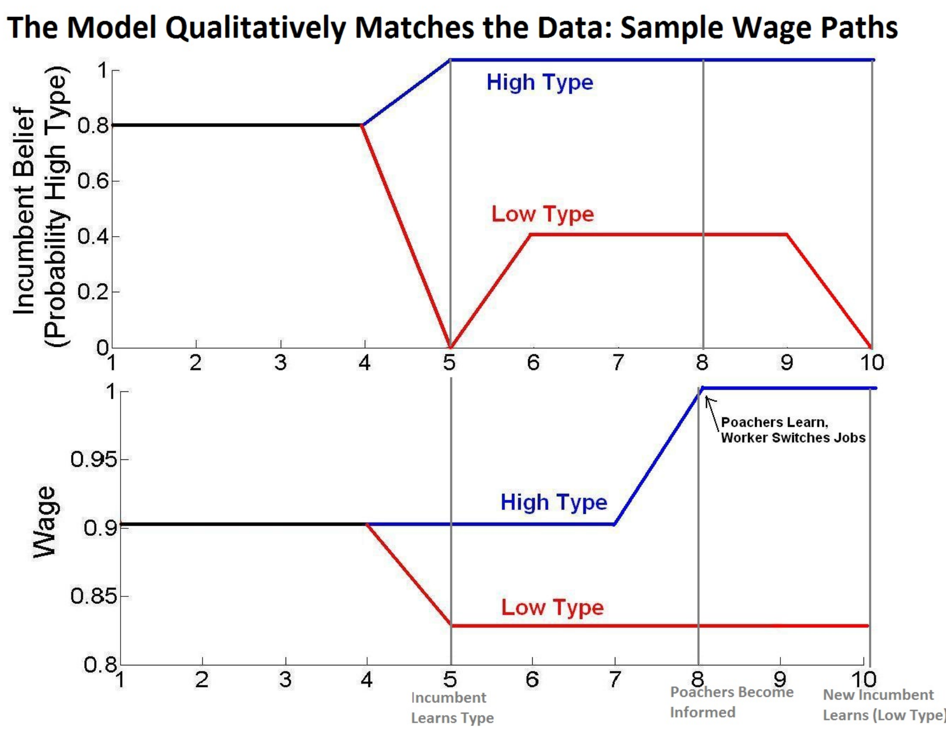


Figure 5: Example of Wage and Belief Paths in the Model

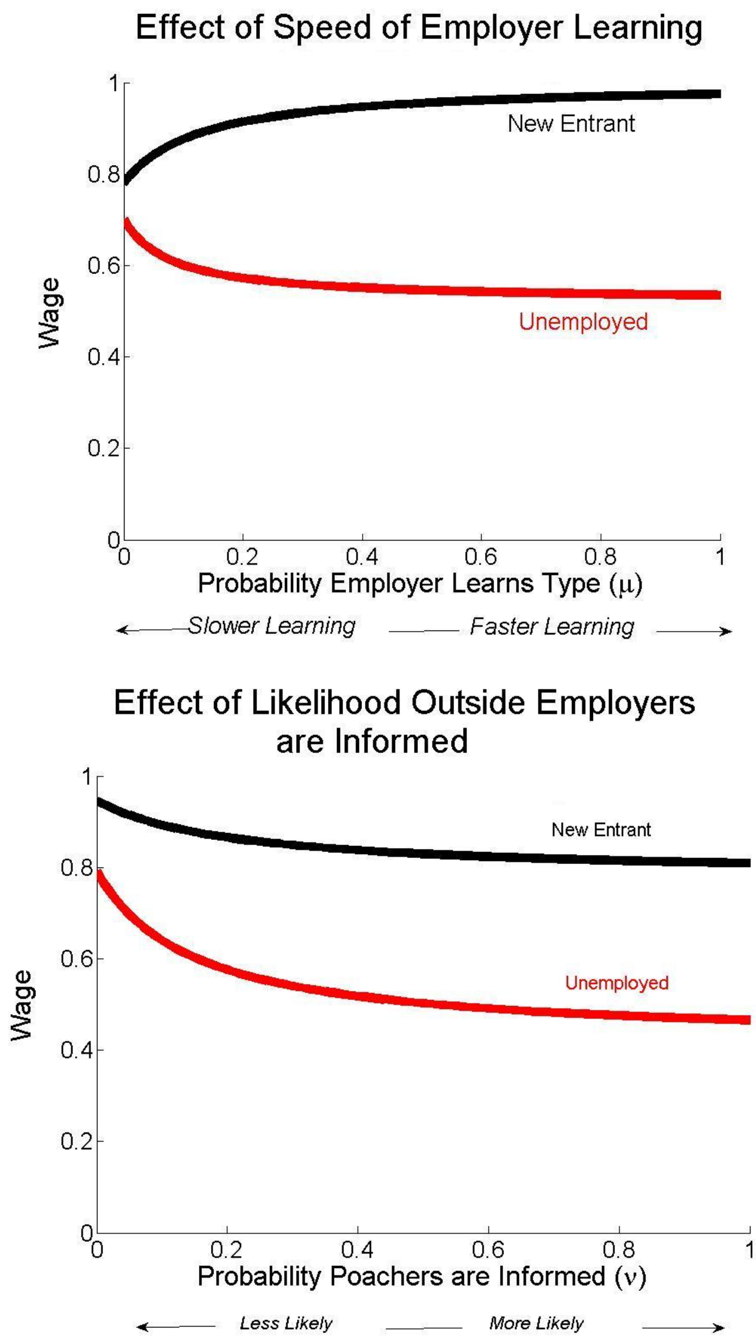


Figure 6: Comparative Statics: Speed and Asymmetry of Employer Learning

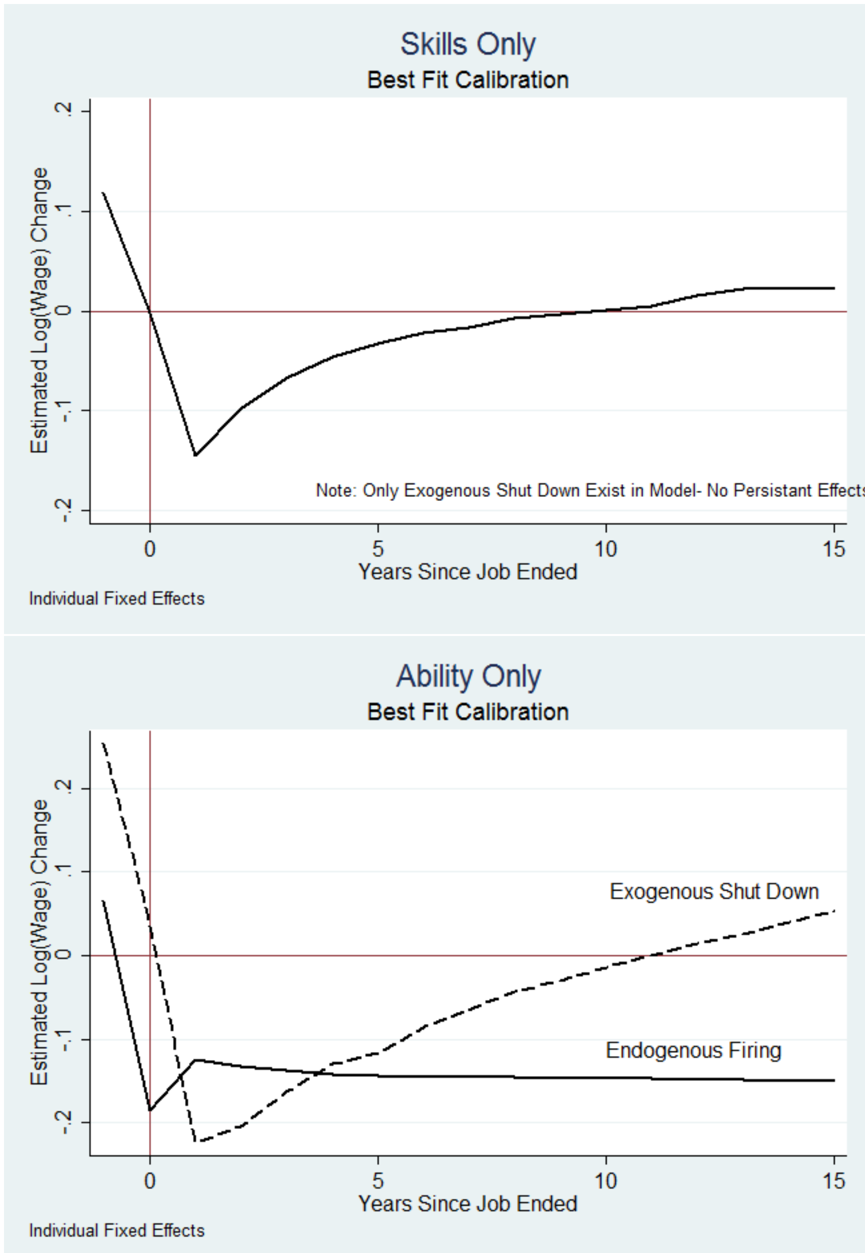
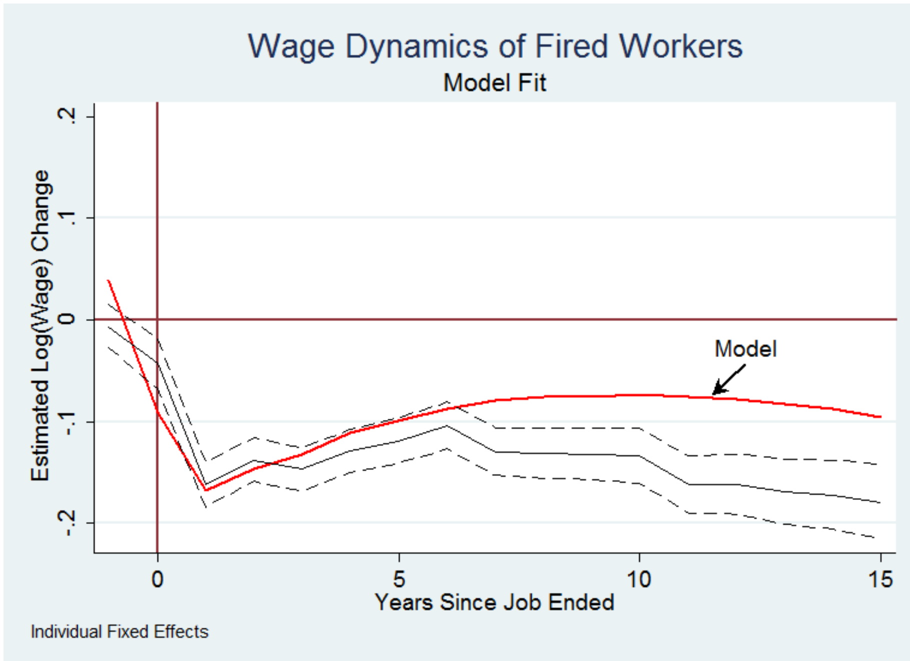


Figure 7: Counterfactuals: Model with Skills Only, Model with Ability Only



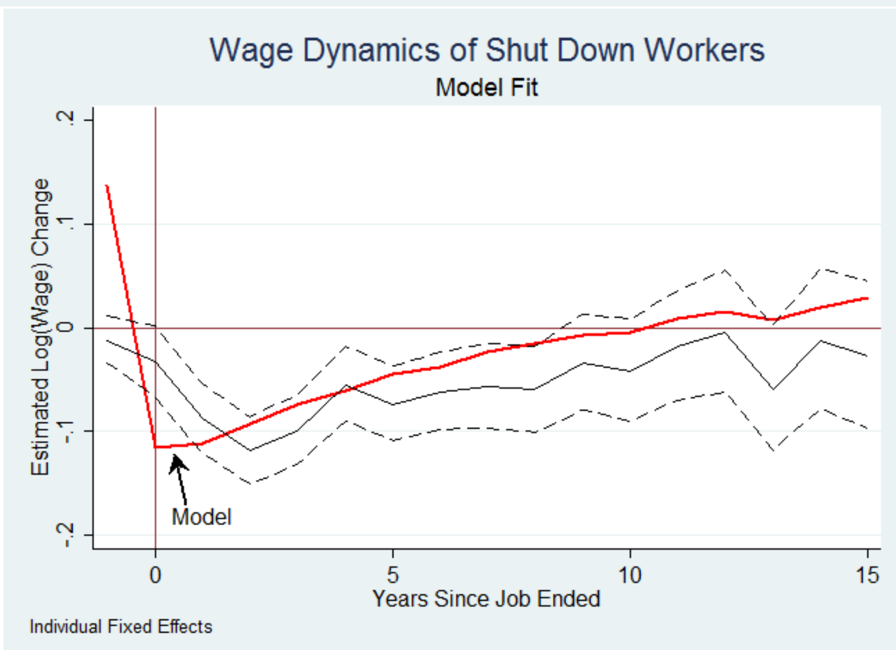


Figure 8: Regression Coefficients of Model and Observed Data

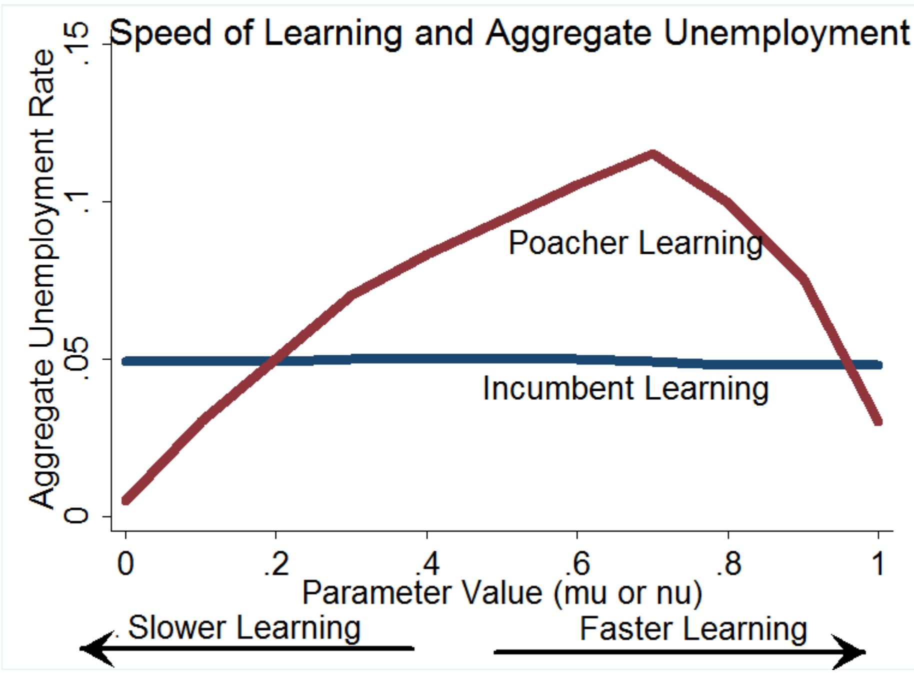


Figure 9: The speed of potential employer learning has a non-monotone effect on unemployment.