

Job Search with Recall and Reneging

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This paper studies a model of job search with two novel decisions related to anti-competitive practices by firms and other parties in the labor market. First, instead of making an exploding offer requiring an immediate decision, a firm may allow a worker to recall its offer within a period of time. Second, after accepting an offer, a worker may renege on it before the job starts. The model suggests that the two decisions are related to each other, and a small cost of reneging is critical for the coexistence of exploding offers, recall, and reneging. Policies that discourage workers from reneging could induce firms to make more exploding offers with lower wages, contradicting other policies for exploding offers and reducing the value of job search for workers.

KEYWORDS. Job search, recall, reneging, wages.

JEL CLASSIFICATION. C72, C73, C78, J31, J41, J64.

1. INTRODUCTION

This paper studies a model of job search with two novel features related to anti-competitive practices by firms and other parties in the labor market. The first is recall, referring to the case where a firm gives a worker some time to consider its offer and thus a chance to receive another offer for comparison. This is in contrast to exploding offers, which are defined by Roth (2015) as “take-it-or-leave-it offers of such short duration that they didn’t leave enough time for another firm to jump in and compete for the same candidate, or for a candidate to get another offer for comparison”. The second feature studied in this paper is reneging, referring to the case where a worker reneges on an accepted offer before the job starts.

The two features are prominent in the job market for graduating students. Cortés et al. (2023) surveyed recent graduates from Boston University’s Questrom School of Business about their search for the first job after college. Over 40% of their offers required a decision within a week, while about 10% gave them more than four weeks to make a decision. This suggests that both exploding offers and offers with recall are made by firms in the same market. Moreover, 10.6% of respondents reneged on an offer, and the typical respondent believed that over a quarter of their peers had reneged on an offer. This suggests that reneging is neither rare nor unexpected.

The two features are related. Abera (2022) finds that pressure from an exploding offer’s deadline is a major reason a graduating student may accept the offer first and

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I thank Xiaoming Cai, Chao He, Qingmin Liu, Xincheng Qiu, Leeat Yariv, and three anonymous referees for helpful comments. All errors are mine.

renege on it later. Meanwhile, universities often have policies that discourage employers from making exploding offers ([Stanford University, 2025](#)) and punish their students for renegeing, e.g., by marking it on a student's academic transcript and cutting alumni privileges ([Harvard Business School, 2025](#)).

This paper endogenizes recall and renegeing and evaluates relevant policies. I provide conditions for an equilibrium where exploding offers and offers with recall coexist with each other as well as renegeing, and characterize the impact of university policies that raise the cost of renegeing for their students on the job market.

In the absence of a direct cost for making an exploding offer (vs an offer with recall), there are always some exploding offers that are optimal for firms in my model. Despite this disadvantage, I show that offers with recall are also optimal under three conditions, and the equilibrium features both types of offers and renegeing.

The first condition is that a new job cannot start immediately, e.g., students on the job market cannot start working before graduation. This makes the environment non-stationary, and it gives firms an opportunity to act (post vacancies, meet workers and make offers) early, e.g., months before graduation, in which case they may find it optimal to give workers some time to consider their offers. The condition also gives workers an opportunity to accept an early offer and renege on it later before the job starts. In comparison, standard search-theoretic models of the labor market assume a stationary environment where a new job could start immediately after a firm meets a worker ([Rogerson et al., 2005](#)). This leaves workers with no time to renege on an accepted offer and makes it optimal for firms to make only exploding offers.

The second condition is that the match surplus (i.e., the value of the match between a firm and a worker minus the sum of their values from being unmatched) is relatively large. This is necessary to induce firms to act early. Otherwise, firms may find it optimal to either not enter the market or enter it only at the last minute when new jobs can start immediately, in which case firms make only exploding offers and workers have no time to renege on an accepted offer before the job starts. This is similar to [Guo \(2024\)](#), where I study how firms post vacancies sequentially in a nonstationary environment by ignoring both the difference between the two types of offers and a worker's decision to renege on an accepted offer.

The last and most important condition is that the cost for a worker to renege on an accepted offer is relatively small. If workers have to pay a (strictly positive) cost to renege on an accepted offer, they would only do so after receiving another offer that is sufficiently better. Consequently, accepting an exploding offer means that a worker may have to reject subsequent offers that are slightly better. This makes exploding offers less attractive for workers than offers with recall, *ceteris paribus*. In response, workers demand higher wages for exploding offers than comparable offers with recall. On the other hand, as long as an exploding offer is acceptable for workers in the first place, it is more attractive for firms than a comparable offer with recall, because the former allows a firm to hire a worker with a higher probability. Consequently, firms are willing to attach a higher wage to an exploding offer than a comparable offer with recall. Together, the cost of renegeing makes the option to recall an offer valuable for workers and costly for firms. As long as the two sides could agree on a price, it is optimal for some firms to offer

the option in exchange for a lower wage. As the cost of renegeing increases, the maximum wage at which a firm is willing to make an offer with recall could drop below a worker's reservation wage. Consequently, it is optimal for firms to make offers with recall that are acceptable to workers only when the cost of renegeing is relatively small.

By making exploding offers more attractive for firms, a larger cost of renegeing also induces more firms to jump the gun (Roth and Xing, 1994) and act early. With fewer firms looking for workers later in the process, there is a smaller chance that a worker with an early offer could receive another offer. This reduces the intertemporal wage competition faced by early-acting firms and, in turn, their wage offers. Although lower wages could induce more firms to enter the market and raise the job finding probability for workers, when the cost of renegeing is sufficiently large so that wage offers are close to workers' reservation wages, the negative effect on wages dominates the positive effect on the job finding probability. In this case, an increase in the cost of renegeing reduces the value of job search for workers.

Together, the model suggests that recall and renegeing are closely related to each other: a small cost of renegeing is critical for firms to make offers with recall, while a large cost of renegeing could induce firms to make more exploding offers and reduce the value of job search for workers. University policies that discourage students from renegeing could induce employers to make more exploding offers, contradicting policies that discourage employers from doing that. Moreover, students on the job market could benefit from policies that reduce the cost of renegeing, e.g., the announcement by the [American Finance Association \(2022\)](#) that exploding offers accepted before a certain date are not binding for rookie job seekers.

A number of studies assume exogenously that workers could recall some offers received previously (Carrillo-Tudela et al., 2011, Wolthoff, 2014, Carrillo-Tudela and Smith, 2017, Gautier and Moraga-González, 2018). I am not aware of a model of endogenous recall and renegeing in the literature, including studies of the job market for graduating students (Roth and Xing, 1994, Cortés et al., 2023, Guo, 2024). In the product market, Armstrong and Zhou (2016) show that an exploding offer could be a seller's optimal strategy to deter a buyer from searching for lower prices; Janssen and Williams (2024) show that uncertainty about product quality could lead consumers to buy a product first and return it later. This paper studies the interaction between recall and renegeing in a labor market, where exploding offers are the default choice and there is no uncertainty about match quality.

Substantively, this paper contributes to an emerging literature on the equilibrium effects of anti-competitive practices by employers in the labor market, including non-compete agreements (Gottfries and Jarosch, 2026a) and no-poach agreements (Gottfries and Jarosch, 2026b). Similar to these practices, exploding offers limit a worker's ability to leverage outside opportunities and thus suppress wage competition and wages market-wide. In particular, both noncompetes in Gottfries and Jarosch (2026a) and exploding offers in this paper create costs for workers who want to respond to outside offers, both generate compensating differentials, and both can restore the Diamond (1971) paradox.

One key difference is that offer types are endogenous in this paper, where firms are homogeneous and face the same technology, but exogenous in Gottfries and Jarosch

(2026a), where a legal technology to implement and enforce noncompetes is available to some firms but not others. Similarly, [Gottfries and Jarosch \(2026b\)](#) assume that a cartel of firms could commit not to hire each other's workers, which allows them to make different wage offers than other firms outside the cartel. Moreover, this paper shows that anti-competitive practices by employers could result from and respond to actions by a third party, e.g., universities in the job market for graduating students.

The next section presents the model. Section 3 characterizes the main equilibrium with recall and reneging. Section 4 characterizes other equilibria and the impact of the cost of reneging. Section 5 discusses implications and extensions.

2. THE MODEL

There are three periods. All actions take place in the first two periods. The last period is only used to distribute payoffs from actions in the first two periods. For simplicity, the first two periods are assumed to have the same length. In the job market for graduating students, one can think of the first two periods as the last two months or weeks before graduation, and the last period as the life after graduation.

There are two types of agents: workers and firms. The measure of workers is normalized to 1. The measure of firms is determined endogenously through free entry. All workers are homogeneous and unemployed at the beginning of the first period. Firms are also homogeneous, and they could post vacancies, meet workers and make job offers in each of the first two periods. However, new jobs can only start at the beginning of the third period. In particular, a worker who accepts an offer in the first period cannot work or be paid until the beginning of the third period. All agents are risk neutral, and they use the same discount factor $\rho \in (0, 1)$.

At the beginning of each of the first two periods, a firm could enter the market by posting a vacancy. The cost of a vacancy per period is $c > 0$. In posting a vacancy, a firm also chooses a wage w that will be paid to the worker upon hiring one. If a firm chooses to post a vacancy in the first period, it also has to choose whether to make an offer with or without recall after meeting a worker. An offer without recall, also referred to as an exploding offer, expires by the end of the first period. Consequently, a worker who receives an offer without recall in the first period has to either accept or reject it by the end of the period. An offer with recall allows a worker to hold on to it without a decision until the end of the second period. Offers received in the second period have to be either accepted or rejected by the end of the period.

Let v_{1E} be the measure of vacancies posted in the first period where the firm chooses to make an exploding offer upon meeting a worker, v_{1R} be the measure of vacancies posted in the first period where the firm chooses to make an offer with recall, and v_2 be the measure of vacancies posted in the second period. Similarly, let F_{1E} be the cumulative distribution of wages across vacancies making exploding offers, F_{1R} be the cumulative distribution of wages across vacancies making offers with recall, and F_2 be the cumulative distribution of wages across vacancies in the second period. Finally, let $\mathcal{F}_i$ be the support of F_i for $i \in \{1E, 1R, 2\}$, and $v_1 = v_{1E} + v_{1R}$ be the total measure of vacancies posted in the first period.

There is no search cost for workers, and all workers search with the same intensity in each of the first two periods. A worker (vacancy) could meet at most one vacancy (worker) and receive (make) at most one offer in each of the first two periods, so that each worker could receive up to two offers in the first two periods. I relax these assumptions and discuss their implications in the working paper (Guo, 2026).

Workers with two offers by the end of the second period have to reject one of them, or renege on it if the offer was accepted in the first period. Rejecting an offer is free, but a worker has to pay a cost $\kappa > 0$ in order to renege on an offer accepted in the first period for another one received in the second period. In addition to financial costs, if any, κ also includes the psychological cost of being viewed negatively by peers and, in the case of graduating students, the alma mater.

Meetings between workers and vacancies occur randomly in each of the first two periods. In particular, whether a vacancy intends to make an offer with or without recall does not affect its probability of meeting a worker, and $\frac{v_1 E}{v_1}$ ($\frac{v_1 R}{v_1}$) is the conditional probability of receiving an exploding offer (an offer with recall) for a worker who meets a vacancy in the first period.

Let λ_s be the probability that a vacancy meets a worker in period $s \in \{1, 2\}$, and μ_s be the probability that a worker meets a vacancy. Following the literature, λ_s and μ_s are assumed to be monotonic functions of labor market tightness, defined as the number of vacancies v_s per unemployed worker. Since the measure of workers is normalized to 1, labor market tightness is equal to the measure of vacancies v_s .

ASSUMPTION 1. *For any $s \in \{1, 2\}$, $\lambda_s = \lambda(v_s)$, $\mu_s = \mu(v_s)$, $\frac{\partial \lambda(v_s)}{\partial v_s} < 0$, $\frac{\partial \mu(v_s)}{\partial v_s} > 0$, $\lim_{v_s \downarrow 0} \lambda(v_s) = \lim_{v_s \uparrow +\infty} \mu(v_s) = 1$, and $\lim_{v_s \uparrow +\infty} \lambda(v_s) = \lim_{v_s \downarrow 0} \mu(v_s) = 0$.*

I use the notations λ_s and μ_s in most cases, and use $\lambda(v_s)$ and $\mu(v_s)$ when it is useful to make the dependence clear.

The final payoff for each agent is distributed in the third period. For a firm, the payoff of not being able to hire a worker is normalized to 0, and the payoff of hiring a worker at wage w is $J(w)$. For a worker, the payoff of staying unemployed is U , and the payoff of being hired at wage w is $W(w)$.

ASSUMPTION 2. *$\frac{\partial J(w)}{\partial w} < 0$, $\lim_{w \uparrow +\infty} J(w) = -\infty$, $\frac{\partial W(w)}{\partial w} > 0$, and there exists a reservation wage $R > 0$ such that $W(R) = U$.*

An example of the payoff functions is provided in the working paper (Guo, 2026). For notational simplicity, I assume the cost of renegeing κ is paid in the third period and measured in the same unit as $J(w)$, $W(w)$ and U . This is equivalent to assuming that the cost is $\rho\kappa$ and has to be paid in the second period. Moreover, I assume that a worker does not have to pay a cost to renege on an accepted offer for unemployment. This assumption is innocuous, because the choice is never optimal in the model.

2.1 Workers' Problems

A worker maximizes his/her payoff by choosing whether to accept an offer, if there is one, and which one to accept if there are two offers. The decision is straightforward in most cases.

First, under Assumption 2, an offer with wage w is acceptable by the end of the second period if and only if $w \geq R$. That is, R is the reservation wage in the second period irrespective of when an offer is received and whether it has a recall option or not. In equilibrium, we must have $w \geq R$ for any $w \in \mathcal{F}_i$ and $i \in \{1E, 1R, 2\}$.

Second, if a worker has two offers above the reservation wage R , including an offer with recall from the first period and another offer from the second period, the worker would accept the one with a higher wage and reject the other.

Third, if a worker has two offers above the reservation wage R , including an exploding offer with wage w accepted in the first period and another offer with wage w' received in the second period, the worker would renege on the former and accept the latter if and only if $W(w') - \kappa \geq W(w)$. This is equivalent to $w' \geq R_w$, where R_w is defined by

$$W(R_w) = W(w) + \kappa$$

Because $\kappa > 0$ and $W(w)$ is strictly increasing in w , we have $R_w > w$, i.e., a worker would renege on an accepted offer only when the new offer is sufficiently better.

The only nontrivial decision for a worker is whether to accept an exploding offer in the first period. If the offer is rejected and the worker enters the second period without an offer, the value is

$$N = \rho[\mu_2 E_{F_2} \max\{W(w), U\} + (1 - \mu_2)U]$$

The discount factor ρ appears because all payoffs are distributed in the third period. With probability μ_2 , the worker receives an offer with wage w drawn from F_2 , the wage offer distribution in the second period. The worker could either accept the offer and receive a payoff $W(w)$, or reject it and receive a payoff U . E_{F_2} is the expectation with respect to the wage offer distribution F_2 . With probability $1 - \mu_2$, the worker receives no offer and stays unemployed with payoff U .

On the other hand, if a worker accepts an exploding offer with wage w_1 in the first period, the value at the start of the second period is

$$A(w_1) = \rho[\mu_2 E_{F_2} \max\{W(w) - \kappa, W(w_1), U\} + (1 - \mu_2) \max\{W(w_1), U\}]$$

With probability μ_2 , the worker receives a new offer with wage w drawn from the distribution F_2 in the second period. The worker could either accept the new offer and renege on the offer accepted in the first period, the payoff of which is $W(w) - \kappa$, or keep the accepted offer by rejecting the new offer, the payoff of which is $W(w_1)$, or stay unemployed by discarding both offers, the payoff of which is U . With probability $1 - \mu_2$, the worker receives no offer in the second period. In this case, the worker could either enter the next period with the accepted offer and payoff $W(w_1)$, or discard the accepted offer and stay unemployed with payoff U .

A worker accepts an exploding offer with w_1 if and only if $A(w_1) \geq N$. Because $W(w)$ is strictly increasing in w , and $W(R) = U$, $A(w_1)$ is strictly increasing in w_1 as long as $w_1 \geq R$, which is true for any exploding offer in equilibrium. Let R_1 be defined by

$$A(R_1) = N \quad (1)$$

An exploding offer is accepted if and only if its wage is greater than R_1 . That is, R_1 is the reservation wage for exploding offers in the first period.

We must have $w \geq R_1$ for any $w \in \mathcal{F}_{1E}$ in equilibrium. With $\kappa > 0$, $R_1 < R$ implies $W(R_1) < U$ and $A(R_1) < N$. Consequently, we must have $R_1 \geq R$ in equilibrium, i.e., the reservation wage is (weakly) decreasing over the first two periods.

2.2 Firms' Problems

A firm maximizes its profit by choosing whether to post a vacancy, and if so, which one of the three types of vacancies to post and the associated wage. For simplicity, I use the wage support to indicate the type of a vacancy and offer, e.g., a vacancy with $w \in \mathcal{F}_{1E}$ represents a vacancy posted in the first period which makes an exploding offer with wage w upon meeting a worker.

The expected value of posting a vacancy with $w \in \mathcal{F}_{1E}$ is

$$V_{1E}(w) = -c + \rho^2 \lambda_1 \{1 - \mu_2 [1 - F_2(R_w)]\} J(w) \quad (2)$$

where c is the cost in the first period, and the second term is the expected benefit. The effective discount factor is ρ^2 , because the benefit $J(w)$ only materializes in the third period after the vacancy is filled by the end of the second period. In order to be filled, the vacancy has to meet a worker in the first period, the probability of which is λ_1 , and win the competition against another firm if the worker receives an offer from that firm in the second period. Since μ_2 is the probability that a worker meets a vacancy and receives an offer in the second period, and F_2 is the wage offer distribution in the second period, the probability that a worker receives an offer with wage greater than R_w in the second period is $\mu_2 [1 - F_2(R_w)]$. This is also the probability that a worker who accepts an offer with $w \in \mathcal{F}_{1E}$ in the first period will renege on the offer in the second period. Consequently, the term in the curly brackets is the probability that a vacancy with $w \in \mathcal{F}_{1E}$ is filled by the end of the second period conditional on meeting a worker in the first period.

Similarly, the expected value of posting a vacancy with $w \in \mathcal{F}_{1R}$ is

$$V_{1R}(w) = -c + \rho^2 \lambda_1 \{1 - \mu_2 [1 - F_2(w)]\} J(w) \quad (3)$$

The only difference from equation (2) is that, in order to win the competition against an offer with recall received in the first period whose wage is w , the offer in the second period has to have a wage greater than w instead of R_w .

Finally, the expected value of posting a vacancy with $w \in \mathcal{F}_2$ is

$$V_2(w) = -c + \rho \lambda_2 \left\{ 1 - \mu_1 \frac{v_{1E}}{v_1} [1 - F_{1E}(R_w^-)] - \mu_1 \frac{v_{1R}}{v_1} [1 - F_{1R}(w)] \right\} J(w) \quad (4)$$

Now that we are in the second period, the potential payoff $J(w)$ is discounted by ρ instead of ρ^2 , and the probability of meeting a worker is λ_2 instead of λ_1 . Conditional on meeting a worker, there are two cases where a firm cannot fill a vacancy with $w \in \mathcal{F}_2$. First, the worker has an offer with recall from the first period, and the wage of that offer is greater than w . The probability of this event is $\mu_1 \frac{v_{1R}}{v_1} [1 - F_{1R}(w)]$. Second, with probability $\mu_1 \frac{v_{1E}}{v_1} [1 - F_{1E}(R_w^-)]$, the worker accepted an exploding offer in the first period with a wage greater than R_w^- , which is the inverse of R_w defined as

$$W(R_w^-) = W(w) - \kappa$$

By construction, we have $R_{R_w^-} = R_{R_w^-}^- = w$. Because $\kappa > 0$ and $W(w)$ is strictly increasing in w , we have $R_w^- < w < R_w$ for any w .

2.3 The Equilibrium

With free entry, I define the equilibrium of the market as follows.

DEFINITION 1. An equilibrium of the market is a tuple $(R_1, v_{1E}, v_{1R}, v_2, F_{1E}, F_{1R}, F_2)$, where R_1 is given by equation (1), and firms' choices satisfy profit-maximization and free-entry conditions, i.e., $V_i(w) = \max_{w'} V_i(w') = 0$ for any $w \in \mathcal{F}_i$ and $i \in \{1E, 1R, 2\}$.

Because firms may or may not post each of the 3 types of vacancies, there are 8 potential types of equilibria: (1) $v_{1E} = v_{1R} = v_2 = 0$, (2) $v_{1E} > 0$ and $v_{1R} = v_2 = 0$, (3) $v_{1R} > 0$ and $v_{1E} = v_2 = 0$, (4) $v_2 > 0$ and $v_{1E} = v_{1R} = 0$, (5) $v_{1E}v_{1R} > 0$ and $v_2 = 0$, (6) $v_{1E}v_2 > 0$ and $v_{1R} = 0$, (7) $v_{1R}v_2 > 0$ and $v_{1E} = 0$, and (8) $v_{1E}v_{1R}v_2 > 0$.

PROPOSITION 1. *The model has no equilibrium with $v_{1E} = 0$ and $v_{1R} > 0$.*

This rules out cases (3) and (7) listed above. The proof is in the [Appendix](#). The idea is to show that, if such an equilibrium exists, a firm could make a profit by posting a different vacancy. A companion idea for the existence of an equilibrium is that no firm could make a profit by posting a different vacancy. Both ideas are used to establish other results described later, whose proofs are also in the [Appendix](#).

One interpretation of the proposition is that $v_1 > 0$ implies $v_{1E} > 0$, i.e., as long as it is optimal for some firms to enter the market in the first period, it is optimal for some of them to make exploding offers. Intuitively, with a strictly positive cost of reneging, as long as an exploding offer is acceptable in the first period, it is more likely to be accepted by the end of the second period than a comparable offer with the same wage and a recall option. Consequently, firms prefer exploding offers over offers with recall, *ceteris paribus*, and they make no offers with recall without exploding offers. This explains the dominance of exploding offers in many labor markets, and why firms may not make offers with recall even when they are encouraged to do so. Despite this disadvantage, the next section shows that offers with recall could coexist with exploding offers under certain conditions.

3. THE EQUILIBRIUM WITH RECALL AND RENEGING

This section studies the equilibrium with $v_{1E}v_{1R}v_2 > 0$. This is the only equilibrium with both recall and renegeing. I start by characterizing its properties, and then show its existence and uniqueness.

LEMMA 1. *In any equilibrium with $v_{1E}v_{1R}v_2 > 0$, $\mathcal{F}_{1R} \subseteq [R, R_1]$.*

Because R_1 is a worker's reservation wage for exploding offers in the first period, and $w \geq R_1$ for any $w \in \mathcal{F}_{1E}$, the lemma implies that wages of exploding offers must be greater than wages of offers with recall. Given the cost of renegeing, a worker is less likely to renege on an exploding offer accepted in the first period than to reject an offer with the same wage and a recall option. Consequently, a vacancy with an exploding offer is more likely to be filled by the end of the second period than a vacancy offering the same wage and a recall option. To make firms indifferent between the two types of vacancies, those with recall must provide firms with higher values after being filled, as measured by larger $J(w)$ and lower wages. On the other hand, because workers value the option to recall an offer, they are willing to take it for a lower wage.

LEMMA 2. *In any equilibrium with $v_{1E}v_{1R}v_2 > 0$, let $\bar{w}$ be the supremum of $\mathcal{F}_{1E}$, and $\pi = \frac{v_{1R}}{v_1}$ be the share of vacancies making offers with recall in the first period, we have $\bar{w} > R_1 > R$ and*

$$F_{1E}(w) = \frac{1}{(1-\pi)\mu_1} \frac{J(R_{\bar{w}})}{J(R_w)} + 1 - \frac{1}{(1-\pi)\mu_1} \text{ for } w \in [R_1, \bar{w}] \quad (5)$$

$$F_{1R}(w) = \frac{1-\mu_1+\pi\mu_1}{\pi\mu_1} \frac{J(R_1)}{J(w)} - \frac{1-\mu_1}{\pi\mu_1} \text{ for } w \in [R, R_1] \quad (6)$$

$$F_2(w) = \begin{cases} \frac{1}{\mu_2} \frac{J(\bar{w})}{J(w)} + 1 - \frac{1}{\mu_2} & \text{for } w \in [R, R_1] \\ \frac{1}{\mu_2} \frac{J(\bar{w})}{J(R_{\bar{w}})} + 1 - \frac{1}{\mu_2} & \text{for } w \in [R_{R_1}, R_{\bar{w}}] \end{cases} \quad (7)$$

$$\max\{\rho\lambda_2(1-\mu_1), \rho^2\lambda_1(1-\mu_2)\}J(R) = c \quad (8)$$

$$\rho\lambda_2(1-\mu_1+\pi\mu_1)J(R_1) = c \quad (9)$$

$$\rho^2\lambda_1J(\bar{w}) = c \quad (10)$$

$$\rho\lambda_2J(R_{\bar{w}}) = c \quad (11)$$

Because a worker could receive an offer in each of the first two periods, there is intertemporal wage competition between vacancies posted in the two periods. Similar to the model by [Burdett and Judd \(1983\)](#) and its applications in the labor market ([Wolthoff, 2014](#), [Gautier and Moraga-González, 2018](#), [Guo, 2025b](#)), the possibility that a worker could receive multiple offers implies wage dispersion ($\bar{w} > R_1 > R$) even with homogeneous workers and homogeneous firms. Different from those models, where there is one price/wage distribution with no mass point, there are three different wage offer distributions (F_{1E} , F_{1R} and F_2) and at least one mass point in my model.

Specifically, due to the intertemporal wage competition, equation (7) shows that the wage support in the second period has two segments. The first segment, $[R, R_1]$, is the same as the support for F_{1R} , because vacancies in this segment only attempt to compete with vacancies making offers with recall in the first period. The second segment, $[R_{R_1}, R_{\bar{w}}]$, is a transformation of the support for F_{1E} , because vacancies in this segment also compete with vacancies making exploding offers in the first period. The transformation is necessary because the competition involves the cost of reneging.

Because of the transformation, the two segments of $\mathcal{F}_2$ are not connected with each other, i.e., there is no vacancy with $w \in (R_1, R_{R_1})$ in the second period. This gap is possible because R_1 is a mass point for F_{1E} . Specifically, since $\bar{w} > R_1$ and $J(w)$ is strictly decreasing in w , equation (5) implies $F_{1E}(R_1) > 0$, i.e., there is a mass of vacancies making exploding offers with wage R_1 in the first period. The mass makes a firm in the second period indifferent between a vacancy with wage R_1 and an alternative vacancy with a wage slightly above R_{R_1} , because the latter allows the firm to win the competition against the mass of exploding offers with wage R_1 at the cost of a higher wage.

A mass point at R_1 is possible because a worker could receive at most one offer in each period, so that the mass of exploding offers with wage R_1 in the first period do not have to compete against each other. For the same reason, I show in the proof of Lemma 2 that R could also be a mass point for either F_{1R} or F_2 , but not both, and whether it is a mass point for F_{1R} or F_2 depends on the two arguments in the max operator in equation (8): (a) If the first argument is strictly larger than the second, R is a mass point for F_2 but not F_{1R} ; (b) If the second argument is strictly larger than the first, R is a mass point for F_{1R} but not F_2 ; (c) If they are equal to each other, R is not a mass point for either. Due to the intertemporal wage competition, there is no other mass point for any of the three wage distributions.

The left panel of Figure 1 illustrates the three wage offer distributions (F_{1E} , F_{1R} and F_2) using the example described in the working paper ([Guo, 2026](#)). In this example, we have $F_2(R) > F_{1R}(R) = 0$, so that R is a mass point for F_2 but not F_{1R} .

Using the same example, the right panel plots (1) the distribution of wages across all vacancies posted in the first two periods given by

$$F(w) = \frac{v_{1E}F_{1E}(w) + v_{1R}F_{1R}(w) + v_2F_2(w)}{v_1 + v_2}$$

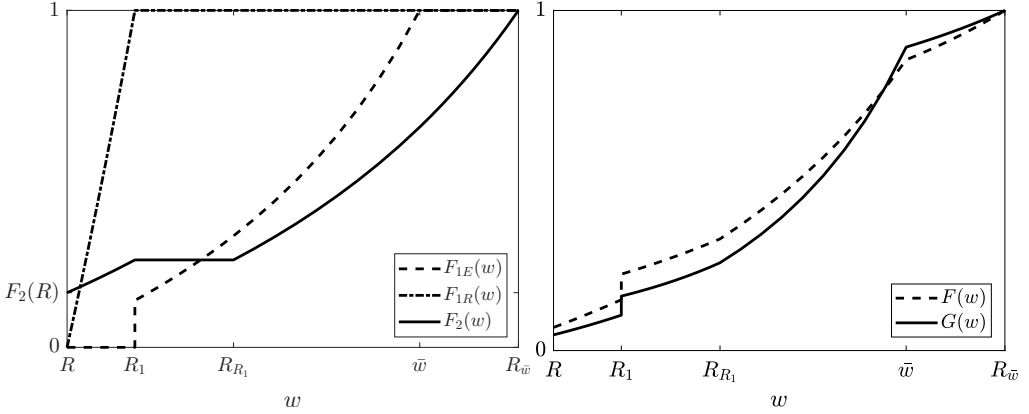


FIGURE 1. An Illustration of the Wage Distributions

and (2) the distribution of wages accepted by the end of the second period given by

$$G(w) = \frac{1}{P} \{ \mu_1(1 - \pi)F_{1E}(w)[1 - \mu_2 + \mu_2F_2(R_w)] + \mu_1\pi F_{1R}(w)[1 - \mu_2 + \mu_2F_2(w)] + (1 - \mu_1)\mu_2F_2(w) \}$$

where $P = \mu_1 + \mu_2 - \mu_1\mu_2$ is the job finding probability. Both distributions (F and G) have two mass points, one at the bottom (R) and the other in the middle (R_1). This is consistent with the empirical evidence (Dube et al., 2025). Moreover, there is a region where $G(w) > F(w)$. This is different from existing models of equilibrium wage dispersion (Burdett and Mortensen, 1998, Wolthoff, 2014, Gautier and Moraga-González, 2018, Guo, 2025b, 2024), where the distribution of accepted wages first-order stochastically dominates the distribution of wage offers, i.e., $G(w) \leq F(w)$ for all w . In those models, workers with multiple job opportunities always choose the one with a higher wage. In contrast, because renegeing is costly in our model, a worker who has accepted an exploding offer in the first period may reject another offer with a higher wage in the second period. This creates a chance for $G(w) > F(w)$ at some w . Both the size of the region for $G(w) > F(w)$ and the degree of bunching at the two reservation wages (R and R_1) depend on the cost of renegeing.

3.1 Existence and Uniqueness

With Lemma 2, equation (1) can be rewritten as

$$\int_R^{R_1} \frac{J(\bar{w})}{J(w)} dW(w) - [1 - \frac{J(\bar{w})}{J(R_1)}] \kappa = 0 \quad (12)$$

which, together with equations (8) to (11), determines $(R_1, v_{1E}, v_{1R}, v_2, \bar{w})$. With them, we could obtain (F_{1E}, F_{1R}, F_2) from equations (5) to (7).

This completes the characterization of the equilibrium with $v_{1E}v_{1R}v_2 > 0$. To show its existence and uniqueness, I start with some definitions.

DEFINITION 2. For any $J(R) > \frac{c}{\rho^2}$, let $\lambda_1^{J(R)} = \frac{c}{\rho^2 J(R)}$, $v_1^{J(R)}$ be the value of v_1 such that $\lambda_1 = \lambda_1^{J(R)}$, i.e., $\lambda(v_1^{J(R)}) = \lambda_1^{J(R)}$, and $\mu_1^{J(R)} = \mu(v_1^{J(R)})$.

It is worth noting that the reservation wage R is an exogenous parameter determined by $W(R) = U$. Because $J(R)$ is also an exogenous parameter, so are $\lambda_1^{J(R)}$, $v_1^{J(R)}$ and $\mu_1^{J(R)}$. Moreover, $J(R)$ a measure of the match surplus, i.e., the value of a firm-worker match minus the sum of their values from being unmatched. In addition to the reservation wage R , the match surplus $J(R)$ could vary with other factors, e.g, productivity of a firm-worker match. For the following analysis, it is useful to think about the variation in $J(R)$ as coming from productivity. Finally, R_R and $J(R_R)$ are also exogenous parameters. Given the payoffs $W(w)$, U and $J(w)$, the cost of renegeing κ is the only parameter that affects R_R and $J(R_R)$. For the following analysis, it is useful to think about the variation in R_R and $J(R_R)$ as coming from κ .

PROPOSITION 2. *The equilibrium with $v_{1E}v_{1R}v_2 > 0$ is unique if it exists, and it exists if and only if $J(R) > \frac{c}{\rho^2}$ and*

$$J(R_R) > \max\left\{\frac{c}{\rho}, (1 - \mu_1^{J(R)})J(R)\right\}. \quad (13)$$

The condition $J(R) > \frac{c}{\rho^2}$ implies that the equilibrium with $v_{1E}v_{1R}v_2 > 0$ exists only when the match surplus is relatively large. Since $J(R_R)$ is decreasing in the cost of renegeing κ , inequality (13) implies that the equilibrium with $v_{1E}v_{1R}v_2 > 0$ exists only when the cost of renegeing is small.

As long as $J(R) > \frac{c}{\rho^2}$, the equilibrium with $v_{1E}v_{1R}v_2 > 0$ always exists for some $\kappa > 0$. To see this, note that $\kappa = 0$ implies $R_R = R$ such that

$$J(R_R) = J(R) > \max\left\{\frac{c}{\rho}, (1 - \mu_1^{J(R)})J(R)\right\}$$

where the inequality follows from $J(R) > \frac{c}{\rho^2} > \frac{c}{\rho}$ and $\mu_1^{J(R)} \in (0, 1)$. This implies that inequality (13) always holds for $\kappa = 0$. Because $J(R_R)$ is continuous in κ , the inequality also holds for some $\kappa > 0$.

4. OTHER EQUILIBRIA AND THE COST OF RENEGING

To understand why the two conditions in Proposition 2 are necessary, this section shows what happens when they fail. The comparison also illustrates how equilibrium outcomes respond to the match surplus $J(R)$ and the cost of renegeing κ .

PROPOSITION 3. *There are four cases when conditions in Proposition 2 fail*

- (i) *If $J(R) \leq \frac{c}{\rho}$, the model has a unique equilibrium with $v_{1E} = v_{1R} = v_2 = 0$;*
- (ii) *If $J(R) \in (\frac{c}{\rho}, \frac{c}{\rho^2}]$, the model has a unique equilibrium with $v_{1E} = v_{1R} = 0$, a finite $v_2 > 0$ given by $\rho\lambda(v_2)J(R) = c$, and $\mathcal{F}_2 = \{R\}$;*

- (iii) If $J(R) > \frac{c}{\rho^2}$ and $J(R_R) \leq \max\{\frac{c}{\rho}, (1 - \mu_1^{J(R)})J(R)\} = (1 - \mu_1^{J(R)})J(R)$, the model has a unique equilibrium with $v_{1R} = 0$, $v_{1E} = v_1^{J(R)} > 0$, a finite $v_2 > 0$ given by $\rho\lambda(v_2)(1 - \mu_1^{J(R)})J(R) = c$, $\mathcal{F}_{1E} = \mathcal{F}_2 = \{R\}$, and $R_1 = R$.
- (iv) If $J(R) > \frac{c}{\rho^2}$ and $J(R_R) \leq \max\{\frac{c}{\rho}, (1 - \mu_1^{J(R)})J(R)\} = \frac{c}{\rho}$, the model has a continuum of equilibria with $v_2 = 0$, $v_1 = v_1^{J(R)} > 0$, $\pi \in [0, 1 - \frac{\rho J(R) - c}{\rho \mu_1^{J(R)} J(R)}]$, $\mathcal{F}_{1E} = \{R\}$, $R_1 = R$, and $\mathcal{F}_{1R} = \{R\}$ if $\pi > 0$.

The first case implies that, when the match surplus is too small to cover the present discounted value of the vacancy cost in either period, i.e., $J(R) \leq \frac{c}{\rho}$, no vacancy will be posted, and the market collapses. The second case implies that, when the match surplus is modest, i.e., $J(R) \in (\frac{c}{\rho}, \frac{c}{\rho^2}]$, vacancies are only posted in the second period. Together with Proposition 2, these two cases imply that the match surplus $J(R)$ mainly affects the timing of vacancies. Intuitively, due to discounting $\rho \in (0, 1)$, the real cost of a vacancy is cheaper when it is paid later. Consequently, a larger match surplus $J(R)$ is necessary to induce firms to post vacancies in the first period.

The first two cases also show that, when the match surplus is too small for firms to post a vacancy in the first period, i.e., $J(R) \leq \frac{c}{\rho^2}$, the cost of renegeing κ has no effect on equilibrium outcomes. On the other hand, when the match surplus is large enough for firms to post a vacancy in the first period, i.e., $J(R) > \frac{c}{\rho^2}$, the cost of renegeing κ affects both the number and wages of each of the three types of vacancies.

Specifically, because a larger cost of renegeing makes exploding offers in the first period more valuable to firms than the other two types of offers, *ceteris paribus*, it is optimal for firms to post all three types of vacancies only when the cost of renegeing is relatively small, as shown by inequality (13) in Proposition 2. When the cost of renegeing is so large that inequality (13) fails, the expected value of a vacancy making an exploding offer in the first period dominates

- either the expected value of a vacancy making an offer with recall in the first period, so that $v_{1R} = 0$, as in the third case of Proposition 3;
- or the expected value of a vacancy in the second period, so that $v_2 = 0$, as in the last case of Proposition 3. To keep firms from posting vacancies in the second period, the number of vacancies making exploding offers in the first period must be sufficiently large, resulting in an upper bound for π (the share of vacancies making offers with recall). Otherwise, π could be any value between 0 and the upper bound, and it is the only variable not uniquely determined. When $\pi = 0$, only vacancies with exploding offers are posted by firms.

The two cases are separated by the comparison between the two arguments in the max operator on the right-hand side of inequality (13). Given other parameters, e.g., c , ρ and $J(R)$, $(1 - \mu_1^{J(R)})J(R) > \frac{c}{\rho}$ implies that $\mu_1^{J(R)}$ is relatively small, i.e., not many workers could receive an offer in the first period. This gives firms an opportunity to hire a worker by posting a vacancy in the second period, so that $v_2 > 0$. On the other hand,

$(1 - \mu_1^{J(R)})J(R) \leq \frac{c}{\rho}$ implies that $\mu_1^{J(R)}$ is relatively large, i.e., most workers could receive an offer in the first period. This leaves firms with little chance of hiring a worker in the second period, so that $v_2 = 0$.

There is no wage dispersion in any equilibrium in Proposition 3. More precisely, only the reservation wage R is offered by firms in the last three cases. In the second (last) case, vacancies are only posted in the second (first) period, so that a worker could receive at most one offer in the first two periods. With no wage competition from other firms, all firms post the reservation wage R . In the third case, vacancies are posted in both periods, so that a worker has a chance to receive one offer from each period. However, since the cost of reneging is sufficiently large, no worker would ever renege on an offer accepted in the first period for another offer in the second period. Consequently, there is no meaningful wage competition between vacancies posted in the two periods, and all firms post the reservation wage R .

Because workers are indifferent between unemployment and a job at the reservation wage R , they gain no value from job search in any equilibrium in Proposition 3. In comparison, in the equilibrium with $v_{1E}v_{1R}v_2 > 0$ characterized by Lemma 2, the expected value of job search is strictly positive for workers, because they have a strictly positive possibility of finding a job with $w > R$. Consequently, an increase in the cost of reneging reduces the expected value of job search for workers when it pushes the equilibrium with $v_{1E}v_{1R}v_2 > 0$ to any of the last two cases in Proposition 3.

By continuity, an increase in the cost of reneging could also reduce the expected value of job search for workers even when it is not large enough to push the equilibrium with $v_{1E}v_{1R}v_2 > 0$ to any of the last two cases in Proposition 3. This is mainly due to the negative effect of κ on wages, as shown below.

LEMMA 3. *When κ is small and the equilibrium features $v_{1E}v_{1R}v_2 > 0$, we have $\frac{\partial v_1}{\partial \kappa} > 0$, $\frac{\partial v_2}{\partial \kappa} < 0$, and $\frac{\partial \bar{w}}{\partial \kappa} < 0$.*

An increase in the cost of reneging raises the competitiveness of vacancies making exploding offers in the first period relative to vacancies in the second period. In response, firms post more vacancies in the first period and fewer vacancies in the second period, and they also lower the maximum wage $\bar{w}$ of exploding offers in the first period. Because the combined wage support for the two types of vacancies in the first period is $[R, \bar{w}]$, as a larger κ pushes $\bar{w}$ towards R , workers are less likely to receive high-wage offers, which reduces their expected value from job search.

$\frac{\partial v_1}{\partial \kappa} > 0$ implies $\frac{\partial v_{1E}}{\partial \kappa} > 0$ when $\frac{\partial v_{1R}}{\partial \kappa} < 0$, which is the case when the equilibrium with $v_{1E}v_{1R}v_2 > 0$ is pushed towards the third case in Proposition 3. This implies that raising the cost of reneging could induce firms to make more exploding offers, and university policies that discourage students from reneging could contradict and invalidate policies that discourage employers from making exploding offers.

Not all equilibrium outcomes are monotonic in the cost of reneging κ . In particular, R_1 , the reservation wage for exploding offers in the first period, may not be monotonic in κ . This is because κ has two effects. First, other things equal, κ has a negative effect

on $A(w)$, the expected value of accepting an exploding offer with wage w in the first period. Consequently, a higher reservation wage R_1 is needed for workers to be indifferent between $A(R_1)$ and N , the value of entering the second period without an offer. Second, with $\frac{\partial v_2}{\partial \kappa} < 0$, a larger κ could reduce the value of search in the second period. This in turn reduces the reservation wage R_1 in the first period. When the first effect dominates the second, R_1 will be increasing in κ . Otherwise, it will be decreasing. Since $R_1 \in (R, \bar{w})$ in any equilibrium with $v_{1E}v_{1R}v_2 > 0$, R_1 must be dropping towards R as an increase in κ pushes $\bar{w}$ closer to R , which happens when κ is relatively large so that the equilibrium with $v_{1E}v_{1R}v_2 > 0$ is close to one of the last two cases in Proposition 3. On the other hand, R_1 could be increasing in κ when κ is relatively small.

Because R_1 is the wage that separates the two types of vacancies in the first period, equation (9) implies $\frac{\partial \pi}{\partial R_1} > 0$, *ceteris paribus*. When R_1 is not monotonic, π , the share of vacancies making offers with recall in the first period, may not be monotonic in κ either. In particular, when κ is relatively large so that $J(R_R)$ is only slightly larger than $(1 - \mu_1^{J(R)})J(R) > \frac{c}{\rho}$, an increase in κ reduces π towards zero. On the other hand, when κ is close to zero, raising it could lead to a larger π .

I confirm these predictions using an example in the working paper (Guo, 2026). In the example, both R_1 and π are hump-shaped in κ , while both the rate of renegeing and the expected payoff for a worker are strictly decreasing in κ . On the other hand, the job finding probability, $P = \mu_1 + \mu_2 - \mu_1\mu_2$, is strictly increasing in κ , because a larger κ allows firms to post lower wages and more vacancies. This suggests that universities have an incentive to raise the cost of renegeing for their students if they care more about the job finding probability than the expected payoff of their students, the latter of which also accounts for wages. This would be the case if wages are harder to observe so that the job finding rate is used more prominently by universities to measure the success of their graduates.

5. IMPLICATIONS AND EXTENSIONS

The model in this paper illustrates how the recall decision by firms and the renegeing decision by workers are related to each other, and how policies for recall and renegeing could contradict each other.

The model has three other implications. The first is about the timing of job search. In a seminal paper, Roth and Xing (1994) show that uncertainty about worker quality could induce employers to jump the gun and make offers to college students months or even years before they graduate. With homogeneous workers and homogeneous firms, this paper shows that employers may jump the gun purely due to search frictions, and they are more likely to do so when the cost of renegeing is large (Lemma 3). When the cost of renegeing is sufficiently large, firms may post vacancies and make offers only in the first period (the last case in Proposition 3).

Second, when the cost of renegeing is too large for firms to make offers with recall, the possibility of multiple offers may not result in wage dispersion (the third case in Proposition 3). This is different from Burdett and Judd (1983) and its applications in the labor market (Wolthoff, 2014, Gautier and Moraga-González, 2018, Guo, 2025b), where

the possibility of multiple offers leads to wage dispersion under the assumption that a worker could recall all offers received within a period of time. The difference highlights the importance of endogenizing recall and reneging.

Finally, when the cost of reneging is small and firms make all three types of offers, the equilibrium wage distribution could have two mass points, including R at the bottom and R_1 in the middle (Proposition 2 and Lemma 2). This is qualitatively consistent with the observation that the empirical wage distribution has multiple mass points, including one at the statutory minimum wage and others at higher wage levels (Dube et al., 2025). In comparison, existing models of equilibrium wage/price dispersion have either no mass point (Burdett and Judd, 1983, Burdett and Mortensen, 1998) or a single mass point at the bottom (Guo, 2024).

A critical assumption of the model in this paper is that new jobs cannot start immediately after a firm meets a worker. This is a natural assumption for graduating students, and it may also apply to other job seekers who cannot start a new job immediately for different reasons. Wolthoff (2014) documents that employment transitions are highly clustered around the first day of each workweek/month. This suggests that a firm-worker meeting in the middle of a workweek/month may not result in a job until the beginning of the next workweek/month. After meeting a worker in the middle of a workweek/month, a firm has to choose whether to make an exploding offer requiring an immediate decision, or to make an offer with a recall option that allows the worker to hold on to the offer until the end of the workweek/month. After accepting an exploding offer in the middle of a workweek/month, a worker may receive another offer before starting the job in the next workweek/month, in which case the worker could choose whether to renege on the accepted offer. The example in the working paper (Guo, 2026) shows that the rate of reneging could be around 10% when each of the first two periods is as short as a week.

To highlight the main ideas, the model makes some simplifying assumptions, e.g., all new jobs have the same starting time, all workers search with the same intensity in each of the first two periods, and a firm (worker) could meet at most one worker (firm) and make (receive) at most one offer in each of the first two periods. I relax these assumptions in the working paper (Guo, 2026). Focusing on a single firm looking for a worker to start a new job in the third period, I show that, as long as the cost of reneging is strictly positive so that workers value the option to recall an offer, it could be optimal for the firm to make an offer with recall in the first period even if (1) a worker could adjust his/her search effort in the second period in response to offers received in the first period, and (2) the firm could meet multiple workers in the first period and each of those workers may have an offer from another firm.

Other extensions are left for future work, including

- Allowing firms to choose the length of the recall period. For example, if a firm decides to make an offer to a worker in the first period but a new job can only start in the fourth period, the firm could choose whether to require a decision by the end of the first, second, or third period. The model in this paper suggests that firms could offer a longer recall period in exchange for a lower wage.

- Introducing a cost for exploding offers. As mentioned previously, universities tend to discourage employers from making exploding offers. Assuming this has an effect on firms, we can extend the model by requiring firms to pay a direct cost for an exploding offer (as opposed to an offer with recall), and study the impact of this cost on equilibrium outcomes.
- Allowing for wage negotiation. The survey by [Cortés et al. \(2023\)](#) suggests that, among college graduates who accepted an offer before graduation, about 20% attempted to negotiate their offer with the employer, less than 10% secured an increase in total compensation through negotiations, and the two measures are not significantly related to the number of offers received by an individual. In comparison, [Hall and Krueger \(2012\)](#) and [Guo \(2025a\)](#) show that about one third of all workers bargained over pay before accepting their current or most recent job. This suggests that wage negotiation plays a minor role for graduating students. However, it is useful to study the impact of wage negotiation on recall and renegeing, especially when the model is applied to all workers.
- Introducing heterogeneity and uncertainty about match quality. With heterogeneity, we could study which firms are more likely to make offers with recall, which workers are more likely to renege on accepted offers, and which firms and workers are more likely to be affected by an increase in the cost of renegeing. With uncertainty about match quality, firms may have other reasons to make offers with recall. For example, [Antler \(2019\)](#) argues that, other things equal, a worker is more likely to accept an offer if he/she is a firm's first choice to fill a vacancy, either because the worker likes to be chosen first, or because being chosen first is a good signal for "the quality of the match, the likelihood of being respected and kindly treated in the new workplace and the chances of early promotion or dismissal". For similar reasons, a worker may care about whether he/she is a firm's only choice, and infer that he/she is more likely to be the only choice after receiving an offer with recall than an exploding offer. This could make workers more likely to accept offers with recall, and make firms more likely to offer them. The contribution of this paper is to show that, with a small cost of renegeing for workers, firms may make offers with recall even in the absence of additional benefits from heterogeneity and uncertainty.

APPENDIX: PROOFS

PROOF OF PROPOSITION 1. First, there is no equilibrium with $v_{1R} > 0$ and $v_{1E} = v_2 = 0$. Otherwise, equation (3) implies that $V_{1R}(w) = -c + \rho^2 \lambda_1 J(w)$ for any $w \in \mathcal{F}_{1R}$. Since $J(w)$ is strictly decreasing in w and $w \geq R$ for any $w \in \mathcal{F}_{1R}$, we have $\mathcal{F}_{1R} = \{R\}$. With free entry, equation (3) implies $V_{1R}(R) = -c + \rho^2 \lambda_1 J(R) = 0$ for some $\lambda_1 \in (0, 1)$, so that $J(R) > \frac{c}{\rho^2}$. In this case, a firm could make a strictly positive profit by posting a vacancy with $R + \varepsilon \in \mathcal{F}_2$ for any $\varepsilon > 0$ satisfying $J(R + \varepsilon) > \frac{c}{\rho}$.

To see this, note first that Assumption 1 implies $\lambda_2 \approx 1$ when $v_2 \approx 0$. With no other vacancy in the second period, a vacancy with $R + \varepsilon \in \mathcal{F}_2$ could always meet a worker.

Moreover, with $\varepsilon > 0$, a vacancy with $R + \varepsilon \in \mathcal{F}_2$ could win any competition from vacancies posted in the first period, so that an offer from the vacancy is always accepted, i.e., the term in the curly bracket in equation (4) is 1. Together, equation (4) implies $V_2(R + \varepsilon) \approx -c + \rho J(R + \varepsilon) > 0$, making it profitable for a firm to post a vacancy with $R + \varepsilon \in \mathcal{F}_2$. This contradicts the assumption that $v_2 = 0$.

Second, there is no equilibrium with $v_{1E} = 0$ and $v_{1R}v_2 > 0$. Otherwise, there must be a $w^{max} > R$ such that $\mathcal{F}_{1R} \setminus \{R\} = \mathcal{F}_2 \setminus \{R\} = (R, w^{max}]$. This claim is both part of Lemma 1 in Guo (2024) and part of Claim 3 in the proof of Lemma 2 below. It arises from the wage competition between vacancies posted in the two periods, which implies wage dispersion in the form of a common connected wage support whose infimum is the reservation wage.

Let w^N be defined as follows

$$W(w^N) = \mu_2 E_{F_2} \max\{W(w), U\} + (1 - \mu_2)U$$

where the right-hand side is the expected value of a worker who enters the second period without an offer. Consequently, w^N is the lowest wage that a worker is willing to accept in the first period if he/she has to give up the option to search in the second period. Because a worker could still search in the second period after accepting an exploding offer in the first period, we must have $R_1 \leq w^N$.

Moreover, because $W(w)$ is strictly increasing in w , and $W(R) = U$, we must have $w^N \in (R, w^{max})$ when $\mathcal{F}_2 \setminus \{R\} = (R, w^{max}]$. In this case, any firm could make a profit by posting a vacancy with $w \in \mathcal{F}_{1E}$ for any $w \in (w^N, w^{max})$. To see this, note that the offer will be accepted in the first period because $w > w^N \geq R_1$. Moreover, $\kappa > 0$ implies $R_w > w$ so that $F_2(R_w) > F_2(w)$ for any $w \in (w^N, w^{max})$. Consequently, equations (2) and (3) imply $V_{1E}(w) > V_{1R}(w) = 0$ for any $w \in (w^N, w^{max})$, contradicting the assumption that $v_{1E} = 0$. $\square$

PROOF OF LEMMA 1. In describing workers' problems, I have shown that $w \geq R$ for any $w \in \mathcal{F}_{1R}$. I now show that $w \leq R_1$ for any $w \in \mathcal{F}_{1R}$.

Suppose there exists a $w \in \mathcal{F}_{1R}$ such that $w > R_1$. By definition, $V_{1R}(w) = 0$. As $R_w > w$ and F_2 is non-decreasing, we also have $F_2(R_w) \geq F_2(w)$.

However, if $F_2(R_w) > F_2(w)$, equations (2) and (3) imply $V_{1E}(w) > V_{1R}(w) = 0$. Consequently, any firm posting $w \in \mathcal{F}_{1R}$ could make a profit by switching to $w \in \mathcal{F}_{1E}$. This contradicts the assumption that $w \in \mathcal{F}_{1R}$.

Similarly, if $F_2(R_w) = F_2(w)$, equations (2) and (3) imply $V_{1E}(w) = V_{1R}(w) = 0$. Since $R_w > w > R_1$, there exists a $w' \in (R_1, w)$ such that $R_{w'} \in (w, R_w)$. Because $F_2(R_w) = F_2(w)$, we have $F_2(R_{w'}) = F_2(R_w)$. Equation (2) implies $V_{1E}(w') > V_{1E}(w) = 0$, so that any firm posting $w \in \mathcal{F}_{1R}$ could make a profit by switching to $w' \in \mathcal{F}_{1E}$. This again contradicts the assumption that $w \in \mathcal{F}_{1R}$. $\square$

PROOF OF LEMMA 2. I break the lemma into a series of claims and prove them sequentially.

CLAIM 1. *In any equilibrium with $v_{1E}v_{1R}v_2 > 0$, F_{1E} has either no mass point or a single mass point at R_1 , F_{1R} has either no mass point or a single mass point at R , and F_2 has either no mass point or a single mass point at R . If R is a mass point for F_{1R} , then $R \notin \mathcal{F}_2$, and vice versa.*

I first show that F_{1R} has either no mass point or a single mass point at R . With $\mathcal{F}_{1R} \subseteq [R, R_1]$ from Lemma 1, I need to show that F_{1R} has no mass point in $(R, R_1]$.

Suppose F_{1R} has a mass point at $w \in (R, R_1]$. There must be an arbitrarily small $\epsilon \in (0, w - R]$ such that $w' \notin \mathcal{F}_2$ for any $w' \in [w - \epsilon, w]$. Otherwise, any firm posting $w' \in \mathcal{F}_2$ for some $w' \in [w - \epsilon, w]$ could make a profit by switching to $w + \epsilon \in \mathcal{F}_2$. This is profitable because, according to equation (4), the firm could now beat the mass of competing offers with $w \in \mathcal{F}_{1R}$, which leads to a discrete jump in the offer acceptance probability that outweighs the minimal decrease in the value of the job to the firm $J(w)$ that is continuous in w and thus ϵ .

However, if $w' \notin \mathcal{F}_2$ for any $w' \in [w - \epsilon, w]$, we have $F_2(w - \epsilon) = F_2(w)$, and any firm posting $w \in \mathcal{F}_{1R}$ could make a profit by switching to $w - \epsilon \in \mathcal{F}_{1R}$. This is profitable because, according to equation (3), the lower wage raises the value of the job to the firm without any effect on the offer acceptance probability.

Together, the arguments imply that F_{1R} cannot have a mass point at any $w > R$. Similar arguments work for F_{1E} at R_1 and F_2 at R .

If R is a mass point of F_{1R} , equation (4) implies that any firm posting $R \in \mathcal{F}_2$ could make a profit by switching to $R + \epsilon \in \mathcal{F}_2$ for $\epsilon > 0$ but arbitrarily small. This allows the firm to beat the mass of competing offers with $R \in \mathcal{F}_{1R}$, which leads to a discrete jump in the offer acceptance probability that outweighs the minimal decrease in the value of the job to the firm. As a result, we must have $R \notin \mathcal{F}_2$. The reverse can be proved similarly.

CLAIM 2. *In any equilibrium with $v_{1E}v_{1R}v_2 > 0$, if $\mathcal{F}_{1E}$ is not a singleton, it must be a connected set with R_1 as the infimum. Similarly, if $\mathcal{F}_{1R}$ is not a singleton, it must be a connected set with R as the infimum.*

If $\mathcal{F}_{1R}$ is neither a singleton nor connected, there must exist $\{w_1, w_2\} \subseteq [R, R_1]$ such that $w_1 < w_2$, $w_2 \in \mathcal{F}_{1R}$ and $F_{1R}(w_1) = F_{1R}(w_2)$. In this case, we must have $w \notin \mathcal{F}_2$ for any $w \in (w_1, w_2]$. Otherwise, because $F_{1R}(w) = F_{1R}(w_1)$ and $F_{1E}(R_w^-) = F_{1E}(R_{w_1}^-) = 0$, the latter of which is due to the fact that $R_{w_1}^- < R_w^- < R_1$, equation (4) implies that any firm posting $w \in \mathcal{F}_2$ for some $w \in (w_1, w_2]$ could make a profit by switching to $w_1 \in \mathcal{F}_2$. This is profitable because the lower wage raises the value of the job to the firm $J(w)$ without any effect on the offer acceptance probability. However, if $w \notin \mathcal{F}_2$ for any $w \in (w_1, w_2]$ such that $F_2(w_1) = F_2(w_2)$, equation (3) implies that any firm posting $w_2 \in \mathcal{F}_{1R}$ could make a profit by switching to $w_1 \in \mathcal{F}_{1R}$. This contradicts the assumption that $w_2 \in \mathcal{F}_{1R}$. Consequently, $\mathcal{F}_{1R}$ must be a connected set if it is not a singleton.

Let w_i be the infimum of $\mathcal{F}_{1R}$. If $w_i \neq R$, then $w_i \in (R, R_1]$. In this case, we must have $w \notin \mathcal{F}_2$ for any $w \in (R, w_i]$. Otherwise, because $F_{1R}(w) = F_{1R}(R) = F_{1E}(R_w^-) = F_{1E}(R_R^-) = 0$ for any $w \in (R, w_i]$, equation (4) implies that any firm posting $w \in \mathcal{F}_2$ for some $w \in (R, w_i]$ could make a profit by switching to $R \in \mathcal{F}_2$. This is profitable because

the lower wage raises the value of the job to the firm $J(w)$ without any effect on the offer acceptance probability. However, if $w \notin \mathcal{F}_2$ for any $w \in (R, w_i]$ such that $F_2(w_i) = F_2(R)$, equation (3) implies that any firm posting $w_i \in \mathcal{F}_{1R}$ (or slightly above w_i if the infimum is not in the support) could make a profit by switching to $R \in \mathcal{F}_{1R}$. This contradicts the definition that w_i is the infimum of $\mathcal{F}_{1R}$. Consequently, the infimum of $\mathcal{F}_{1R}$ must be R .

Similar arguments work for $\mathcal{F}_{1E}$ and R_1 .

CLAIM 3. *In any equilibrium with $v_{1E}v_{1R}v_2 > 0$, $\mathcal{F}_2 \cap (R, R_1] = \mathcal{F}_{1R} \setminus \{R\}$, $\mathcal{F}_2 \cap (R_R, +\infty) = \{R_w | w \in \mathcal{F}_{1E} \setminus \{R_1\}\}$, and $\mathcal{F}_2 \cap (R_1, R_{R_1})$ is empty.*

I first show that $\mathcal{F}_2 \cap (R_1, R_{R_1})$ is empty. For any $w \in (R_1, R_{R_1})$, because $F_{1R}(w) = F_{1R}(R_1) = 1$ and $F_{1E}(R_w^-) = F_{1E}(R_{R_1}^-) = 0$, equation (4) implies that any firm posting $w \in \mathcal{F}_2$ could make a profit by switching to $R_1 \in \mathcal{F}_2$. This is profitable because the lower wage raises the value of the job to the firm $J(w)$ without any effect on the offer acceptance probability. Consequently, $w \notin \mathcal{F}_2$ for any $w \in (R_1, R_{R_1})$, i.e., $\mathcal{F}_2 \cap (R_1, R_{R_1})$ is empty.

Next, I show that $\mathcal{F}_2 \cap (R, R_1] = \mathcal{F}_{1R} \setminus \{R\}$. I consider two cases. First, if $\mathcal{F}_{1R} \setminus \{R\}$ is empty, then $\mathcal{F}_2 \cap (R, R_1]$ must be empty. Otherwise, any firm posting $w \in \mathcal{F}_2$ for some $w \in (R, R_1]$ could make a profit by switching to $w' \in \mathcal{F}_2$ for any $w' \in (R, w)$. This is because $F_{1R}(w) = F_{1R}(w') = 1$ and $F_{1E}(R_w^-) = F_{1E}(R_{w'}^-) = 0$, which, according to equation (4), imply that switching to the lower wage $w' < w$ raises the value of the job to the firm $J(w)$ without any effect on the offer acceptance probability. Consequently, $w \notin \mathcal{F}_2$ for any $w \in (R, R_1]$, i.e., $\mathcal{F}_2 \cap (R, R_1]$ is empty.

Second, if $\mathcal{F}_{1R} \setminus \{R\}$ is not empty, then it must be connected. That is, for any $w_1 < w_2$, $\{w_1, w_2\} \subseteq \mathcal{F}_{1R} \setminus \{R\}$ implies $[w_1, w_2] \subseteq \mathcal{F}_{1R} \setminus \{R\}$. In this case, we must also have $[w_1, w_2] \subseteq \mathcal{F}_2$. Otherwise, there must be some $w_1 < w_2$ such that, for any $w \in [w_1, w_2]$, we have $w \in \mathcal{F}_{1R} \setminus \{R\}$ but $w \notin \mathcal{F}_2$. This is impossible because it implies $F_2(w_1) = F_2(w_2)$, which, according to equation (3), implies that any firm posting $w_2 \in \mathcal{F}_{1R}$ could make a profit by switching to $w_1 \in \mathcal{F}_{1R}$, contradicting the assumption that $w_2 \in \mathcal{F}_{1R}$. Because $[w_1, w_2] \subseteq \mathcal{F}_2$ for any $[w_1, w_2] \subseteq \mathcal{F}_{1R} \setminus \{R\}$, and $\mathcal{F}_{1R} \setminus \{R\} \subseteq (R, R_1]$, we have $\mathcal{F}_{1R} \setminus \{R\} \subseteq \mathcal{F}_2 \cap (R, R_1]$.

To show the reverse that $\mathcal{F}_{1R} \setminus \{R\} \supseteq \mathcal{F}_2 \cap (R, R_1]$, let w_1 and w_2 be the supremum of $\mathcal{F}_{1R} \setminus \{R\}$ and $\mathcal{F}_2 \cap (R, R_1]$, respectively. Because $\mathcal{F}_{1R} \setminus \{R\}$ is a connected set with R as the infimum, we have $w_2 > w_1$ if $\mathcal{F}_{1R} \setminus \{R\} \supsetneq \mathcal{F}_2 \cap (R, R_1]$ is false. As $w_1 > R$ is the supremum of $\mathcal{F}_{1R} \setminus \{R\}$, $w_2 > w_1$ implies $F_{1R}(w) = F_{1R}(w_1) = 1$ for any $w \in (w_1, w_2]$. Additionally, we have $F_{1E}(R_w^-) = F_{1E}(R_{w_1}^-) = 0$ for any $w \in (w_1, w_2]$ because $R_w^- < w < w_2 \leq R_1$. According to equation (4), the two equalities imply that any firm posting $w \in \mathcal{F}_2$ could make a profit by switching to $w_1 \in \mathcal{F}_2$. That is, we must have $w \notin \mathcal{F}_2$ for any $w \in (w_1, w_2]$, contradicting the definition that w_2 is the supremum of $\mathcal{F}_2 \cap (R, R_1]$. Consequently, we must have $\mathcal{F}_{1R} \setminus \{R\} \supseteq \mathcal{F}_2 \cap (R, R_1]$ and, in turn, $\mathcal{F}_2 \cap (R, R_1] = \mathcal{F}_{1R} \setminus \{R\}$.

Similar arguments imply that $\mathcal{F}_2 \cap (R_{R_1}, +\infty) = \{R_w | w \in \mathcal{F}_{1E} \setminus \{R_1\}\}$.

CLAIM 4. *In any equilibrium with $v_{1E}v_{1R}v_2 > 0$, R_1 is the supremum of $\mathcal{F}_{1R}$.*

Let w_{sup} be the supremum of $\mathcal{F}_{1R}$. If $w_{sup} \neq R_1$, then $w_{sup} \in [R, R_1)$, and $w \notin \mathcal{F}_2$ for any $w \in (w_{sup}, R_{R_1})$ such that $F_2(w_{sup}) = F_2(R_{R_1})$, which, according to equations (2) and (3), implies that any firm posting $R_1 \in \mathcal{F}_{1E}$ could make a profit by switching to $w_{sup} \in \mathcal{F}_{1R}$. This contradicts the claim that R_1 is the infimum of $\mathcal{F}_{1E}$. Consequently, the supremum of $\mathcal{F}_{1R}$ must be R_1 .

CLAIM 5. *In any equilibrium with $v_{1E}v_{1R}v_2 > 0$, R_1 is a mass point of F_{1E} , and $R_{R_1} \notin \mathcal{F}_2$.*

Suppose R_1 is not a mass point of F_{1E} . Because R_1 is the infimum of $\mathcal{F}_{1E}$, and $\mathcal{F}_2 \cap (R_{R_1}, +\infty) = \{R_w | w \in \mathcal{F}_{1E} \setminus \{R_1\}\}$, we have $F_{1E}(R_1) = 0$ and $R_{R_1} + \epsilon \in \mathcal{F}_2$ for $\epsilon > 0$ but arbitrarily small. However, because $F_{1R}(R_{R_1} + \epsilon) = F_{1R}(R_1) = 1$ and $\lim_{\epsilon \downarrow 0} F_{1E}(R_{R_1} + \epsilon) = F_{1E}(R_1) = 0 = F_{1E}(R_{R_1}^-)$, equation (4) implies that any firm posting $R_{R_1} + \epsilon \in \mathcal{F}_2$ could make a profit by switching to $R_1 \in \mathcal{F}_2$, contradicting the assumption that $R_{R_1} + \epsilon \in \mathcal{F}_2$. Consequently, R_1 is a mass point of F_{1E} .

Since R_1 is a mass point of F_{1E} , equation (4) implies that any firm posting $R_{R_1} \in \mathcal{F}_2$ could make a profit by switching to $R_{R_1} + \epsilon \in \mathcal{F}_2$ for $\epsilon > 0$ but arbitrarily small. This allows the firm to beat the mass of competing offers with $R_1 \in \mathcal{F}_{1E}$, which leads to a discrete jump in the offer acceptance probability that outweighs the minimal decrease in the value of the match to the firm. As a result, we must have $R_{R_1} \notin \mathcal{F}_2$.

CLAIM 6. *In any equilibrium with $v_{1E}v_{1R}v_2 > 0$, we must have $\bar{w} > R_1 > R$.*

First, we cannot have $\bar{w} = R_1 = R$. Otherwise, we would have $\mathcal{F}_{1E} = \mathcal{F}_{1R} = \mathcal{F}_2 = \{R\}$. Then any firm posting $R \in \mathcal{F}_{1R}$ could make a profit by switching to $R + \epsilon \in \mathcal{F}_{1R}$ for $\epsilon > 0$ but arbitrarily small, because it allows the firm to win the competition against all firms posting $R \in \mathcal{F}_2$.

Second, we cannot have $\bar{w} > R_1 = R$. Otherwise, we would have $\mathcal{F}_2 = \{R_w | w \in (R_1, \bar{w}]\}$. Consider a worker who accepts an offer with $R_1 \in \mathcal{F}_{1E}$ in the first period. There are two possibilities. (1) The worker receives no offer in the second period. With $R_1 = R$, the payoff in the third period is $W(R_1) = U$, so that the net benefit from accepting the offer with $R_1 \in \mathcal{F}_{1E}$ is zero. (2) The worker receives another offer in the second period. Because $w > R_{R_1}$ for any $w \in \mathcal{F}_2$, the optimal decision is to renege on the accepted offer for the new one, which involves a cost $\kappa > 0$ that can be avoided if the offer with $R_1 \in \mathcal{F}_{1E}$ was rejected in the first period. In sum, accepting an offer with $R_1 \in \mathcal{F}_{1E}$ is not an optimal choice, contradicting the definition of R_1 .

Finally, we cannot have $\bar{w} = R_1 > R$. Otherwise, we would have $\mathcal{F}_2 \setminus \{R\} \subseteq (R, R_1]$. In this case, accepting an offer with $R_1 \in \mathcal{F}_{1E}$ is strictly better than rejecting it, again contradicting the definition of R_1 .

With above claims about F_{1E} , F_{1R} and F_2 , we can use the profit-maximization and free-entry conditions to obtain their expressions as follows.

With profit maximization, we have $V_2(R_w) = V_2(R_{\bar{w}})$ for any $w \in (R_1, \bar{w}]$. Together with $F_{1E}(w) \leq F_{1E}(\bar{w}) = 1$ and $F_{1R}(R_w) = F_{1R}(R_{\bar{w}}) = 1$, this implies equation (5). Because F_{1E} is continuous from the right, the equation also holds at $w = R_1$.

Similarly, we have $V_2(w) = V_2(R_1)$ for any $w \in (R, R_1]$. Together with $F_{1E}(R_w^-) = F_{1E}(R_{R_1}^-) = 0$ and $F_{1R}(w) \leq F_{1R}(R_1) = 1$, this implies equation (6). Because F_{1R} is continuous from the right, the equation also holds at $w = R$.

For any $w \in (R_{R_1}, R_{\bar{w}}]$, we have $V_{1E}(R_w^-) = V_{1E}(\bar{w})$. Since $F_2(w) \leq F_2(R_{\bar{w}}) = 1$, this implies the second line of equation (7), which holds at $w = R_{R_1}$ because F_2 is continuous from the right. Because $\mathcal{F}_2 \cap (R_1, R_{R_1}]$ is empty, we have $F_2(R_1) = F_2(R_{R_1})$. Since $V_{1R}(w) = V_{1R}(R_1)$ for any $w \in (R, R_1]$, this implies the first line of equation (7), which holds at $w = R$ because F_2 is continuous from the right.

Because of free entry, we have $V_{1E}(\bar{w}) = 0$. Together with $F_2(R_{\bar{w}}) = 1$, this implies equation (10). Similarly, $V_2(R_{\bar{w}}) = 0$ and $F_{1E}(\bar{w}) = 1$ imply equation (11). Moreover, $V_2(R_1) = 0$, $F_{1R}(R_1) = 1$ and $F_{1E}(R_{R_1}^-) = 0$ imply equation (9).

Because $F_{1R}(R) \geq 0$, $F_2(R) \geq 0$ and $F_{1R}(R)F_2(R) = 0$, which is due to the last part of Claim 1, we have either $F_2(R) \geq F_{1R}(R) = 0$, which implies $\rho\lambda_2(1 - \mu_1)J(R) = c$ and $\lambda_2(1 - \mu_1) \geq \rho\lambda_1(1 - \mu_2)$, or $F_{1R}(R) \geq F_2(R) = 0$, which implies $\rho^2\lambda_1(1 - \mu_2)J(R) = c$ and $\rho\lambda_1(1 - \mu_2) \geq \lambda_2(1 - \mu_1)$. Together, the two cases imply equation (8). $\square$

PROOF OF PROPOSITION 2. First, because $J(w)$ is strictly decreasing in w , and $J(R) > \frac{c}{\rho^2}$, for any $\bar{w} > R$ where $J(\bar{w}) > \frac{c}{\rho^2}$, there is a unique $\lambda_1 \in (0, 1)$ that solves equation (10). Under Assumption 1, this uniquely pins down v_1 and μ_1 , where v_1 is strictly positive and finite and $\mu_1 \in (0, 1)$.

Second, because $J(w)$ is strictly decreasing in w , and $J(R_R) > \frac{c}{\rho}$, for any $\bar{w} > R$ where $J(R_{\bar{w}}) > \frac{c}{\rho}$, there is a unique $\lambda_2 \in (0, 1)$ that solves equation (11). Under Assumption 1, this uniquely pins down v_2 and μ_2 , where v_2 is strictly positive and finite and $\mu_2 \in (0, 1)$.

Third, because $J(w)$ is strictly decreasing in w , and $J(R) > \frac{c}{\rho^2}$, for any $\bar{w} > R$ where $J(\bar{w}) > 0$, as R_1 increases from R to $\bar{w}$, the left-hand side of equation (12) increases strictly from $-[1 - \frac{J(\bar{w})}{J(R)}]\kappa < 0$ to $\int_R^{\bar{w}} \frac{J(\bar{w})}{J(w)} dW(w) > 0$. Consequently, for any $\bar{w} > R$ where $J(\bar{w}) > 0$, there is a unique $R_1 \in (R, \bar{w})$ that solves equation (12).

Fourth, for any $\mu_1 \in (0, 1)$, $\lambda_2 \in (0, 1)$ and $J(R_1) > 0$, which is true for any $R_1 \in (R, \bar{w})$ and $J(\bar{w}) > 0$, as π increases from 0 to 1, the left-hand side of equation (9) increases strictly from $\rho\lambda_2(1 - \mu_1)J(R_1)$ to $\rho\lambda_2J(R_1)$. Because equation (8) implies $\rho\lambda_2(1 - \mu_1)J(R) \leq c$, and $J(R_1) < J(R)$ for any $R_1 \in (R, \bar{w})$, we have $\rho\lambda_2(1 - \mu_1)J(R_1) < c$. On the other hand, because $J(R_1) > J(R_{\bar{w}})$ for any $R_1 \in (R, \bar{w})$, equation (11) implies $\rho\lambda_2J(R_1) > c$. Consequently, for any $\mu_1 \in (0, 1)$, $\lambda_2 \in (0, 1)$ and $R_1 \in (R, \bar{w})$ where $J(\bar{w}) > 0$, there is a unique $\pi \in (0, 1)$ that solves equation (9). This pins down v_{1E} and v_{1R} , both of which are strictly positive and finite.

Together, the four arguments imply that, for any $\bar{w} > R$ where $J(\bar{w}) > \frac{c}{\rho^2}$ and $J(R_{\bar{w}}) > \frac{c}{\rho}$, $(v_{1E}, v_{1R}, v_2, R_1)$ are determined uniquely by equations (9) to (12). With this, $\bar{w}$ is determined uniquely by equation (8) if $J(R) > \frac{c}{\rho^2}$ and inequality (13) holds.

To see this, note that, under Assumptions 1 and 2, equation (10) implies v_1 is strictly decreasing in $\bar{w}$, equation (11) implies v_2 is strictly decreasing in $\bar{w}$, and the left-hand side of equation (8) is strictly decreasing in both v_1 and v_2 . Consequently, the left-hand side of equation (8) is strictly increasing in $\bar{w}$.

When $\bar{w} = R$ such that $\lambda_1 = \lambda_1^{J(R)}$ and $\mu_1 = \mu_1^{J(R)}$, the left-hand side of equation (8) is strictly less than the right-hand side if $J(R) > \frac{c}{\rho^2}$ and inequality (13) holds. As $\bar{w}$

increases, we could reach a point where either $\lambda_1 = 1$ or $\lambda_2 = 1$. If $\lambda_1 = 1$ such that $\mu_1 = 0$, the left-hand side of equation (8) is greater than $\rho\lambda_2 J(R) > \rho\lambda_2 J(R_{\bar{w}}) = c$. Otherwise, if $\lambda_2 = 1$ such that $\mu_2 = 0$, the left-hand side of equation (8) is greater than $\rho^2\lambda_1 J(R) > \rho^2\lambda_1 J(\bar{w}) = c$. The two cases (either $\lambda_1 = 1$ or $\lambda_2 = 1$) imply that, as $\bar{w}$ increases from R to a value where both $\lambda_1 \in (0, 1)$ and $\lambda_2 \in (0, 1)$, the left-hand side of equation (8) increases strictly from below the right-hand side to above it. Consequently, $\bar{w}$ is uniquely determined by equation (8) at a point where both $\lambda_1 \in (0, 1)$ and $\lambda_2 \in (0, 1)$. Accordingly, equation (10) implies $J(\bar{w}) > \frac{c}{\rho^2}$, and equation (11) implies $J(R_{\bar{w}}) > \frac{c}{\rho}$.

With $(v_{1E}, v_{1R}, v_2, R_1, \bar{w})$ determined uniquely by equations (8) to (12), (F_{1E}, F_{1R}, F_2) are determined uniquely by equations (5) to (7). $\square$

PROOF OF PROPOSITION 3. If a vacancy with $w \geq R$ in the first period could be filled with probability 1 by the end of the second period, its value would be $-c + \rho^2 J(w) \leq -c + \rho^2 J(R)$. Because Assumption 1 implies $\lambda_1 < 1$ for any $v_1 > 0$, no vacancy in the first period can be filled with probability 1. Consequently, the value of a vacancy with $w \geq R$ in the first period is strictly less than $-c + \rho^2 J(R)$, and no vacancy is posted in the first period if $J(R) \leq \frac{c}{\rho^2}$. The same argument implies that no vacancy is posted in the second period if $J(R) \leq \frac{c}{\rho}$. With $c > 0$ and $\rho \in (0, 1)$, we have $\frac{c}{\rho^2} > \frac{c}{\rho}$, so that no vacancy is posted in either period if $J(R) \leq \frac{c}{\rho}$. This proves the first case.

If $J(R) \in (\frac{c}{\rho}, \frac{c}{\rho^2}]$, vacancies can only be posted in the second period. With $v_1 = 0$, equation (4) implies $V_2(w) = -c + \rho\lambda(v_2)J(w)$ for any $w \geq R$. Since $J(w)$ is strictly decreasing in w , all vacancies in the second period offer the same reservation wage R , i.e., $\mathcal{F}_2 = \{R\}$. With free entry, we have $V_2(R) = -c + \rho\lambda(v_2)J(R) = 0$, which determines a unique and finite $v_2 > 0$. This proves the second case.

The last two cases result from the following three claims.

CLAIM 7. *If $J(R) > \frac{c}{\rho^2}$ and $J(R_R) \leq \max\{\frac{c}{\rho}, (1 - \mu_1^{J(R)})J(R)\}$, the equilibrium cannot be any of the following five cases: (1) $v_{1E} = 0$, $v_{1R} > 0$ and $v_2 = 0$, (2) $v_{1E} = 0$, $v_{1R} > 0$ and $v_2 > 0$, (3) $v_{1E}v_{1R}v_2 > 0$, (4) $v_{1E} = v_{1R} = v_2 = 0$ and (5) $v_{1E} = v_{1R} = 0$ and $v_2 > 0$.*

Since the first two cases are ruled out by Proposition 1, and the third case is ruled out by Proposition 2, we only need to rule out the last two cases.

If $v_{1E} = v_{1R} = 0$, equation (4) implies $V_2(R) = -c + \rho\lambda(v_2)J(R)$. With $J(R) > \frac{c}{\rho^2}$, $V_2(R)$ is strictly positive for some $v_2 > 0$. Consequently, it is optimal for firms to post a small number of vacancies offering the reservation wage R in the second period. This rules out the fourth case.

If $v_{1E} = v_{1R} = 0$ and $v_2 > 0$, it is optimal for all vacancies in the second period to offer the reservation wage R . In this case, equation (3) implies $V_{1R}(R + \varepsilon) = -c + \rho^2\lambda(v_1)J(R + \varepsilon)$ for any $\varepsilon > 0$. With $J(R) > \frac{c}{\rho^2}$ and $v_{1E} = 0$, $V_{1R}(R + \varepsilon)$ is strictly positive for some $v_{1R} > 0$ and $\varepsilon > 0$. Consequently, it is optimal for firms to post a small number of vacancies in the first period making offers with recall and a wage slightly higher than R . This contradicts the assumption that $v_{1R} = 0$.

CLAIM 8. *If $J(R) > \frac{c}{\rho^2}$ and $J(R_R) \leq \max\{\frac{c}{\rho}, (1 - \mu_1^{J(R)})J(R)\}$, an equilibrium with $v_{1R} = 0$ and $v_{1E}v_2 > 0$ exists if $(1 - \mu_1^{J(R)})J(R) > \frac{c}{\rho}$, and the equilibrium is uniquely determined*

by $v_{1E} = v_1^{J(R)} > 0$, a finite $v_2 > 0$ given by $\rho\lambda(v_2)(1 - \mu_1^{J(R)})J(R) = c$, $\mathcal{F}_{1E} = \mathcal{F}_2 = \{R\}$, and $R_1 = R$.

Let $\bar{w}$ be the supremum of $\mathcal{F}_{1E}$. In any equilibrium with $v_{1R} = 0$ and $v_{1E}v_2 > 0$, due to the wage competition between vacancies posted in the two periods, $\mathcal{F}_{1E}$ is continuous over $\mathcal{F}_{1E} \setminus \{R_1\} = (R_1, \bar{w}]$, and $\mathcal{F}_2$ is continuous over $\mathcal{F}_2 \setminus \{R\} = (R_{R_1}, R_{\bar{w}}]$. The proof is similar to those in Lemma 2.

Different from Lemma 2, where $v_{1E}v_{1R}v_2$ implies $\bar{w} > R_1 > R$, with $v_{1R} = 0$ and $v_{1E}v_2 > 0$, we must have $\bar{w} = R_1 = R$. First, if $R_1 > R$, any firm posting $R_1 \in \mathcal{F}_{1E}$ could make a strictly positive profit by switching to $R \in \mathcal{F}_{1E}$. This switch is profitable because it leads to a jump in $J(w)$ without any effect on the vacancy filling rate. Second, if $\bar{w} > R_1 = R$, then R cannot be the reservation wage in the first period, contradicting the definition of R_1 . The proof is omitted, because it is the same as the second case in the proof of Claim 6.

With $\bar{w} = R_1 = R$, we have $\mathcal{F}_{1E} = \mathcal{F}_2 = \{R\}$. $\mathcal{F}_{1E} = \{R\}$ implies $V_{1E}(R) = 0$. With $\mathcal{F}_2 = \{R\}$, equation (2) implies $\rho^2\lambda(v_1)J(R) = c$. Under Assumption 1 and Definition 2, this determines a unique and finite $v_1 = v_1^{J(R)} > 0$ as long as $J(R) > \frac{c}{\rho^2}$. With $v_{1R} = 0$, we have $v_{1E} = v_1 = v_1^{J(R)}$. Moreover, $v_1 = v_1^{J(R)}$ implies $\mu_1 = \mu_1^{J(R)}$.

Similarly, $\mathcal{F}_2 = \{R\}$ implies $V_2(R) = 0$. With $\mu_1 = \mu_1^{J(R)}$, equation (4) implies $\rho\lambda(v_2)(1 - \mu_1^{J(R)})J(R) = c$. This determines a unique and finite $v_2 > 0$ as long as $(1 - \mu_1^{J(R)})J(R) > \frac{c}{\rho}$.

With $\rho^2\lambda_1 J(R) = c$ and $\mathcal{F}_2 = \{R\}$, equation (3) implies $V_{1R}(w) < 0$ for any $w \geq R$, so that $v_{1R} = 0$. Moreover, equation (2) implies $V_{1E}(w) < 0$ for any $w > R$, so that $\mathcal{F}_{1E} = \{R\}$. In order for $\mathcal{F}_2 = \{R\}$, we need $V_2(w) < 0$ for any $w > R$. With $V_2(R) = 0$, $v_{1R} = 0$ and $\mathcal{F}_{1E} = \{R\}$, we only need to show $V_2(R_R + \varepsilon) < 0$ for any $\varepsilon > 0$. This is true if and only if $\rho\lambda(v_2)J(R_R) \leq c$. With $\rho\lambda(v_2)(1 - \mu_1^{J(R)})J(R) = c$, this is equivalent to $J(R_R) \leq (1 - \mu_1^{J(R)})J(R)$.

CLAIM 9. If $J(R) > \frac{c}{\rho^2}$ and $J(R_R) \leq \max\{\frac{c}{\rho}, (1 - \mu_1^{J(R)})J(R)\}$, an equilibrium with $v_{1E} > 0$ and $v_2 = 0$ exists if $(1 - \mu_1^{J(R)})J(R) \leq \frac{c}{\rho}$, and the equilibrium features $\mathcal{F}_{1E} = \{R\}$, $R_1 = R$, $v_1 = v_1^{J(R)} > 0$, $\pi \in [0, 1 - \frac{\rho J(R) - c}{\rho \mu_1^{J(R)} J(R)}]$, and $\mathcal{F}_{1R} = \{R\}$ if $\pi > 0$.

With $v_2 = 0$, it is optimal for all vacancies in the first period to offer the reservation wage R . Consequently,

- $v_{1E} > 0$ implies $\mathcal{F}_{1E} = \{R\}$, $R_1 = R$, and $V_{1E}(R) = 0$. With $v_2 = V_{1E}(R) = 0$, equation (2) and Definition 2 imply $v_1 = v_1^{J(R)} > 0$.
- If $v_{1R} > 0$, we must also have $\mathcal{F}_{1R} = \{R\}$ and $V_{1R}(R) = 0$. The latter places no additional restriction, because equations (2) and (3) imply that $V_{1R}(R) = 0$ as long as $v_2 = 0$ and $V_{1E}(R) = 0$.

In order for $v_2 = 0$, we must have $V_2(w) \leq 0$ for any w . With $\mathcal{F}_{1E} = \{R\}$ and $\mathcal{F}_{1R} = \{R\}$ if $v_{1R} > 0$, if a firm decides to post a vacancy in the second period, the optimal wage

is either $R + \varepsilon$ or $R_R + \varepsilon$ for some arbitrarily small $\varepsilon > 0$. Intuitively, posting a vacancy with $R + \varepsilon \in \mathcal{F}_2$ allows a firm to win the potential competition against any vacancy with $R \in \mathcal{F}_{1R}$, while posting a vacancy with $R_R + \varepsilon \in \mathcal{F}_2$ allows a firm to win the potential competition against any vacancy posted in the first period.

Consequently, $v_2 = 0$ implies $V_2(R + \varepsilon) < 0$ and $V_2(R_R + \varepsilon) < 0$ for any $\varepsilon > 0$ and $\lambda_2 \in [0, 1]$. With equation (4), the two inequalities imply $J(R_R) \leq \frac{c}{\rho}$ and

$$[1 - \mu_1^{J(R)} + \pi \mu_1^{J(R)}]J(R) \leq \frac{c}{\rho}$$

In order for the above inequality to hold for some $\pi \in [0, 1]$, we must have $(1 - \mu_1^{J(R)})J(R) \leq \frac{c}{\rho}$, so that $\pi \in [0, 1 - \frac{\rho J(R) - c}{\rho \mu_1^{J(R)} J(R)}]$. $\square$

PROOF OF LEMMA 3. If $\frac{\partial \bar{w}}{\partial \kappa} \geq 0$, then $\frac{\partial J(\bar{w})}{\partial \kappa} \leq 0$, and equation (10) implies $\frac{\partial \lambda_1}{\partial \kappa} \geq 0$. Moreover, $\frac{\partial \bar{w}}{\partial \kappa} \geq 0$ implies $\frac{\partial R_{\bar{w}}}{\partial \kappa} > 0$ and $\frac{\partial J(R_{\bar{w}})}{\partial \kappa} < 0$. With equation (11), we have $\frac{\partial \lambda_2}{\partial \kappa} > 0$. Under Assumption 1, $\frac{\partial \lambda_1}{\partial \kappa} \geq 0$ implies $\frac{\partial \mu_1}{\partial \kappa} \leq 0$, and $\frac{\partial \lambda_2}{\partial \kappa} > 0$ implies $\frac{\partial \mu_2}{\partial \kappa} < 0$. In this case, the left-hand side of equation (8) is strictly increasing in κ . Because the right-hand side of the equation is independent of κ , this cannot hold in equilibrium. Consequently, we must have $\frac{\partial \bar{w}}{\partial \kappa} < 0$.

With $\frac{\partial \bar{w}}{\partial \kappa} < 0$, we have $\frac{\partial J(\bar{w})}{\partial \kappa} > 0$, so that equation (10) implies $\frac{\partial \lambda_1}{\partial \kappa} < 0$, and Assumption 1 implies $\frac{\partial v_1}{\partial \kappa} > 0$ and $\frac{\partial \mu_1}{\partial \kappa} > 0$.

If $\frac{\partial v_2}{\partial \kappa} \geq 0$, we would have $\frac{\partial \lambda_2}{\partial \kappa} \leq 0$ and $\frac{\partial \mu_2}{\partial \kappa} \geq 0$, which, together with $\frac{\partial \lambda_1}{\partial \kappa} < 0$ and $\frac{\partial \mu_1}{\partial \kappa} > 0$, imply that the left-hand side of equation (8) is strictly decreasing in κ . Because the right-hand side of the equation is independent of κ , this cannot hold in equilibrium. Consequently, we must have $\frac{\partial v_2}{\partial \kappa} < 0$. $\square$

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Co-editor Pablo Kurlat handled this manuscript.