ASYMMETRIC INFORMATION IN THE LABOR MARKET: NEW EVIDENCE ON LAYOFFS, RECALLS, AND UNEMPLOYMENT

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Abstract

In the United States, many laid-off workers are recalled to their former employer. I develop an asymmetric information model of layoffs in which high productivity workers are more likely to be recalled and may choose to remain unemployed rather than accept a low-wage job. In this case, unemployment can serve as a signal of productivity, and unemployment duration may be positively related to post-laid-off wages even among workers who are not recalled. In contrast, since workers whose plant closed cannot be recalled, longer unemployment duration should not have a positive signaling benefit for such workers. Analysis of the data from the January 1988-1992 Displaced Workers Supplements to the Current Population Survey reveals that the wage/unemployment duration relation differs between the two groups in the predicted way, and finds evidence consistent with asymmetric information in the U.S. labor market.

KEYWORDS: permanently and temporarily laid-off workers, signaling, unemployment, and wages.
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INTRODUCTION

Many economists have analyzed the importance of asymmetric information in explaining labor market outcomes.[1] In particular, Gibbons and Katz (1991) developed and tested a model of adverse selection in the labor market. They argue that if employers have private information concerning employees' abilities and if they have discretion over whom to lay off, then the market infers that laid-off workers are *lower* productive ability workers. The authors argue that workers displaced due to plant closings, in contrast, do not suffer from such adverse inference because there is no discretion. They predict that wage losses associated with layoffs should be larger than wage losses associated with plant closings. They confirm this prediction using the 1984-1986 Displaced Workers Supplements to the Current Population Survey.

In their theoretical model, Gibbons and Katz do not allow for workers to return to their former employer, even though many laid-off workers in the U.S. are rehired by their former employer. Lilien (1980) uses BLS data to show that about three-quarters of the layoffs in U.S. manufacturing in the 1970s ended in rehire. Katz (1986) finds that this process is also widespread outside of manufacturing. Moreover, Anderson and Meyer (1994) calculate that 28% of turnover is temporary (defined as temporary layoffs plus recalls). Finally, the Mass Layoff Statistics program reports that "68% of employers reporting a layoff in the second quarter of 1998 indicated that they anticipated some type of recall. And that among all establishments expecting a recall, most employers expected to recall over one-half of the separated employees and to do so within six months."[2] Furthermore, much evidence points out that layoffs in the U.S. are counter-cyclical[3] and narrowly tied to firms' output demand fluctuations.[4]

In this paper, I show that taking into account the possibility of recalls has important implications for the study of both subsequent earnings and unemployment durations of laid-off workers in the U.S. I develop a theoretical model of asymmetric information that analyzes what happens to laid-off workers when some of these workers lose their job because of a demand contraction and may be recalled.[5] The model delivers predictions on earnings and unemployment durations for laid-off workers. I test the theory using 1988-1992 Displaced Workers Supplement to

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[1] Spence (1973), Akerlof (1976), Waldman (1984), Greenwald (1986).
[2] U.S. Bureau of Labor Statistics, October 1998.
[3] See Anderson and Meyer (1994) and Katz and Meyer (1990).
[4] In the early 1970's, Feldstein (1975) called attention to the importance of layoffs and rehires in response to fluctuations in firms' output demands.

the Current Population Survey and find evidence consistent with asymmetric information in the U.S. labor market. Other theories can also explain each of the predictions individually. However, I will argue that it is hard to reconcile the whole set of findings with any of these alternative models.

My theoretical model offers a new explanation for unemployment among laid-off workers: I find that *high* productive ability laid-off workers may *choose* unemployment over a low-paid job, even though they may not be recalled by the original employer.[6] My empirical work offers quantitative evidence consistent with this explanation and finds that the post-displacement earnings profiles of *permanently* laid-off workers differ from those of workers displaced through plant closings.

The main idea behind this paper is that when employers have discretion over whom to layoff, they *permanently* lay off their *lower*-ability workers. However, depending on their output demand, they may also lay off *higher*-ability ones, hoping to recall those who are still unemployed as soon as demand recovers. Workers know their ability but cannot observe their employers' output demand; laid-off workers thus infer their probability of being recalled. Prospective employers only observe workers' causes of job loss and workers' employment and unemployment histories. They infer that a laid-off worker who accepts a job right away is a lower-ability worker and thus offer him a low wage in his next job. However, if they observe that a laid-off worker is unemployed, they infer that he is a temporarily laid-off worker waiting to be recalled and offer him (relatively) higher wages in his next job. As such, higher-ability *laid-off* workers may choose unemployment over low-paid jobs. The separating equilibria of this model predict a *positive* relation between post-layoff wages and unemployment duration for *permanently* laid-off workers.

The relation between earnings changes and unemployment duration is determined by loss of human capital during unemployment, stigma, unobserved heterogeneity, and as this paper suggests, asymmetric information. Only the latter element combined with the high recall rate in the U.S. leads to a negative relation between earnings *losses* and unemployment duration for permanently laid-off workers. This predicted relationship provides a basis for testing the

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[5] This compliments the explanation of layoffs caused by seniority rules.

[6] Others have found similar theoretical results (McCormick, 1990; Ma-Weiss, 1993.) However, none of these papers treats the layoff-rehire process. Furthermore, they restrict themselves to a theoretical analysis. Ma and Weiss have testable predictions but they do not test them. Moreover, their predictions disagree

existence of asymmetric information in the U.S. labor market. I use workers displaced though plant closings to control for all unobserved heterogeneity not correlated with being a laid-off worker and with having a positive probability of being recalled. Since all workers lose their job when a plant closing occurs, I assume that nothing can be inferred about the workers' productive ability from observing their cause of displacement. I also assume that these workers cannot be rehired by their former employer. Using the 1988-1992 Displaced Workers Supplement, I find that conditional on not being recalled, laid-off workers who accept a job right away have relative *greater* earnings losses than those of (otherwise observationally equivalent) workers displaced through plant closings.[7] However, I find that this difference *declines* as unemployment duration lengthens. Finally, as predicted by this model I also find that permanently laid-off workers have longer expected unemployment duration than (otherwise observationally equivalent) workers displaced through plant closings.

Like Gibbons and Katz's paper, this paper finds evidence consistent with the existence of asymmetric information in the U.S. labor market. However, it differs from this earlier paper in many ways. At the theoretical level, this paper stresses the role of signaling productivity through unemployment among laid-off workers, whereas Gibbons and Katz's work focused on adverse selection in the labor market. The empirical predictions are also quite different: while their results are in terms of levels, mine focus on wage changes and unemployment duration.

This paper is organized as follows. The first section of this paper presents the theoretical model and analyzes the predictions of the separating equilibria. The second section shows empirical evidence consistent with these predictions.

THEORETICAL ANALYSIS

In the signaling model described below, high productivity laid-off workers are more likely to be recalled than low productivity laid-off workers. Thus, they may choose to remain unemployed rather than accept a low-wage job. If so, unemployment can serve as a signal of productivity. In this case, unemployment duration may be positively related to post-displacement wages even among workers who are not recalled. In contrast, since workers displaced through

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with the empirical findings. McCormick uses a quite different approach and does not have signaling in his model.

[7] This is the adverse selection result previously found by Gibbons and Katz (1991).

plant-closings cannot be recalled, longer unemployment spells should not have a positive signaling benefit for such workers.

I. THE MODEL

This is a three-period model. There are three types of workers: "high" productivity workers, H; "medium" productivity workers, M, and "low" productivity workers, L. I assume that there is a continuum of workers of each type. The cumulative distribution of all workers is normalized to 1. The proportion of workers who are "high" productivity workers (type H workers) is a, and the proportion of workers who are "medium" productivity workers (type M workers) is b, where $0<a<1$ and $0<b<1$. The productivity of a type H worker (respectively, M and L) is denoted by H (respectively, M and L) and $0<L<M<H$.

For notational simplicity, I assume that layoffs only occur at the end of period one and that there is no discounting between periods. Workers are expected lifetime income maximizers and firms maximize the present value of profits. Workers and firms are risk-neutral and there is a large finite number of firms. The structure of the game is as follows.

I.1. Firm-Specific Demand Fluctuations

Each firm faces its firm-specific product demand fluctuations. I assume that these fluctuations are independent events across time within a firm and across firms. With probability p, a firm-specific demand is high; with probability $(1-p)$, it is low. These probabilities are exogenous and time-invariant.

The marginal productivity of a given worker varies with his firm's demand fluctuations. If the firm-specific demand is high, his productivity is $Y_t(A) = A+ F$ for all t = 1,2, and 3, where A is the worker's (time-invariant) productivity, and F is a constant such that $F > 0$ and represents the increase in the worker's productivity when the firm faces a high demand. I normalize the increase in productivity, F, to zero when the firm-specific demand is low.

I assume that $F < Min\left\{ p[H-M]+C, \frac{(1-a-b+pb)}{(1-a)}[M-L]+C \right\}$. Without this assumption, all workers would be bid-off by prospective employers when the former employer's demand is low.[8]

I assume that in each period, at least two firms (not including the former employer) have high firm-specific demands.

I.2. Information Structure

Given the observable characteristics of a worker, all firms initially share the beliefs that there are three types of workers. After one period, the worker's type is revealed to his current employer, but not to the other firms. Workers know their type.

At the end of each period, employers observe their own demand for the next period. However, they do not observe other firms' demands nor do they observe their own demand two periods ahead.[9] Workers cannot observe firms' specific demands.

Prospective employers observe the workers' causes of displacement and their employment history. Yet, they cannot observe what fraction of workers has been laid-off from one specific firm. Thus, prospective employers cannot infer whether a firm has a high or low demand.

I.3. Contracting Possibilities

I assume that neither contingent nor long-term contracts are possible. Employers are restricted to single period, non-contingent wage offers. Since output is not observable by prospective employers (and thus by a court), contracts contingent on output or long-term contracts cannot be enforced.

Finally, I assume that if a worker accepts a new job, he is precluded from receiving a future recall offer from his previous job.[10] This assumption is consistent with the U.S. empirical evidence.[11]

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[8] The Appendix 2 shows why this assumption is needed.

[9] The idea behind this assumption is that the employer has more information on his local product market than anyone else.

[10] This assumption could be endogenized into the model. Note that in this model, the former employer recalls a worker only because he pays him the market wage (i.e., a wage below the worker's productivity). If a worker accepts a new offer, then two employers would know his productivity, and the former employer would no longer get a rent from recalling this worker (assuming that current employer makes the last offer). Moreover, if I assume that there is a cost of making an offer, it would no longer be optimal for the former employer to recall an employee who is already working for a new employer.
I could also assume that there is a cost from hiring someone that may be recalled. The market would then offer an even lower wages to laid-off workers, and those laid-off workers who think that they will be recalled would have a higher incentive to wait unemployed.

I.4. Cost of Losing a Worker

I assume that when an employer loses an employee, he incurs a cost, C, where C is a constant and $C > 0$. One can think of this cost as a severance pay that the employer must give to laid-off workers, or as the cost that the employer incurs of having a job position vacant when a worker is bid away by another firm. Without this assumption, an employer may choose to layoff workers in order to recall them later at a considerably lower wage.

I also assume that the cost of losing a worker is the same independent of who initiated the separation. If having workers bid-off were cheaper then laying them off, we would not observe layoffs in the labor market. Yet, layoffs do occur. Thus, there must be a cost associated with offering low wages to those workers the employer does not want to keep.[12]

Finally, I assume that $C < F$. Without this assumption, the current employer can afford to retain all workers for the following period.

I.5. Unemployment

Usually, these types of models do not generate unemployment.[13] However, the empirical evidence points out that there is always some level of unemployment. I assume that with time-invariant probability q, a displaced worker searches for a job and with probability $(1-q)$, the displaced worker does not look for a job (e.g., he may be sick, taking a break, etc.).

Notice that q is independent of the cause of displacement and the worker's type. The way in which I generate unemployment is completely random and does not allow the market to infer anything about the worker's productive ability. I do so because I want to analyze the effects of the

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[11] Katz (1986) points out that this does not hold only when laid-off workers accept a new potentially *temporary* job. Furthermore, given the importance of the layoff-rehire process in the U.S. labor market, without this assumption, recalls would only be possible if workers quit to return to the original employer. However, they would then be recognize as "quitters" and if they were to be laid off again, the prospective employers would be cautious in hiring a worker who might leave as soon as he is recalled by his original employer.

[12] A possible explanation is that it is generally bad for workers' morale to offer very low wages. Moreover, this strategy creates uncertainty for the employer since not all workers might choose to leave despite the low wages being offered.

[13] This occurs because when a worker is displaced, he enters a secondhand market and gets offered a wage equal to the expected productivity of those workers who belong to that market.

Figure 1: The timing of the game.

Period One

Workers work.	Ability and next period demand are revealed to the employer.	Employer may lay off some workers.	Market observes workers employment status and offers them a job.	Laid-off workers who get a market offer choose to accept it or reject it.	
				Employer observes market wage to non-laid-off workers and offers them a wage.	Non-laid-off workers choose the highest offer.

Period Two

Workers work or are unemployed.	Ability and next period demand are revealed to the employer	Former employer may recall some unemployed laid-off workers.	Market observes workers' employment status and offers them a job.	Non-recalled laid-off workers who get a market offer choose to accept it or reject it.	
				Employer observes market wage to employed workers and offers them a wage.	Employed workers choose the highest offer.

Period Three

Workers work or are unemployed. They retire at the end of the period.

layoff-rehire process on unemployment and post-displacement earnings net of any negative duration dependence from unemployment.[14]

Workers and employers know the population parameters: *p, a, b, q, L, M, H, F, and C.*

I.6. Timing (see Figure 1)

Workers enter the labor force at the beginning of period one. At that point in time, they are assumed to look identical to potential employers. They are hired into an entry-level market and work over the course of period one.

At the end of period one, the employer observes his workers' output and his next period demand. Then he decides whether or not to lay off a worker. Following a layoff, prospective employers observe that some workers were laid off, and they simultaneously offer some of them a second-period wage.[15] Laid-off workers simultaneously choose between accepting the highest wage offered (randomizing in case of a tie) or rejecting the offer and remaining unemployed for one period, in which case some of them might be recalled.[16] If the worker is unemployed, his current income is zero. The wage offered to those workers who are not laid-off is set in the following manner. First, prospective employers observe that the worker was not laid off, and they simultaneously offer him a second-period wage. Then, the current employer observes these offers and makes his own second-period wage offer to his workers. Finally, the worker chooses the highest of the wages offered (choosing the current employer's offer in case of a tie).

During period two, workers work for their original employer, for their new employer, or they are unemployed. They are differentiated on the basis of their actions at the end of period one (see Figure 2).

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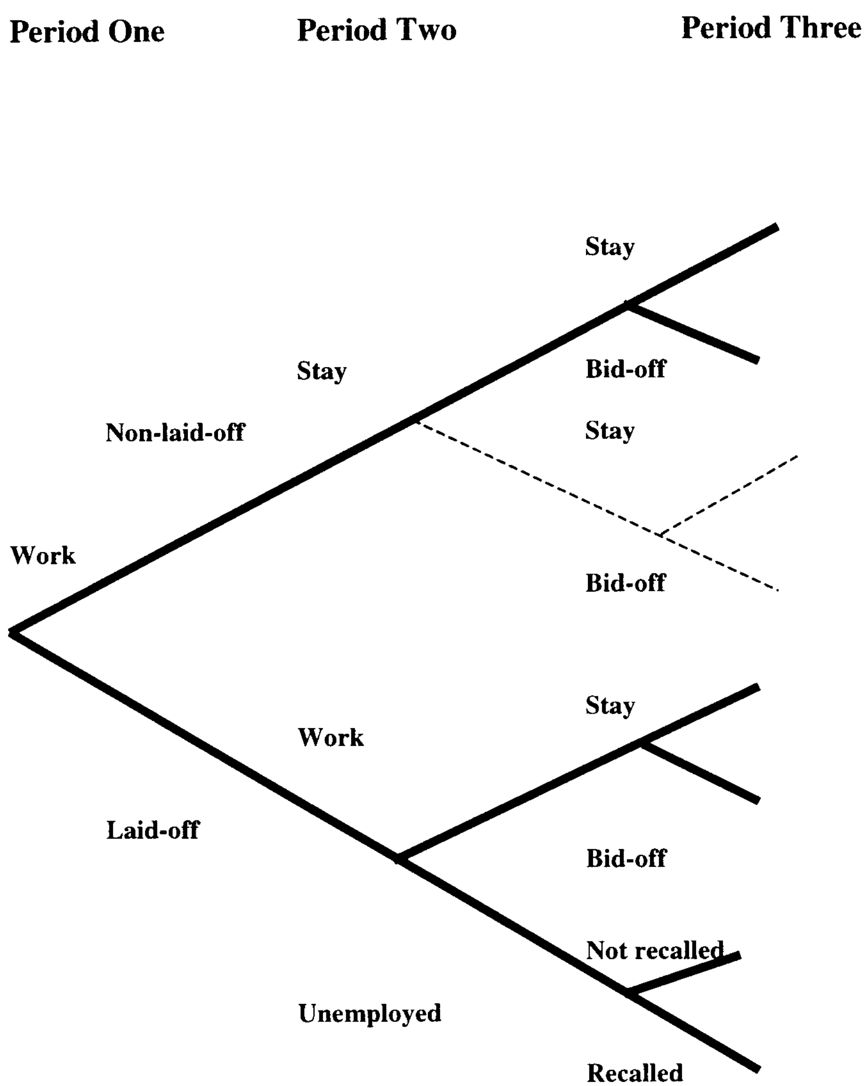
[14] While it is true that some form of "frictional unemployment" is essential for the fully-separating equilibrium (see proposition 1), the form it takes is inconsequential. For instance, involuntary unemployment could be generated endogenously if there is firm heterogeneity (in which some firms' technologies are extremely sensitive to workers' productive ability so that hiring a low productivity worker results in a net loss) and a job search mechanism. However, that approach makes it difficult to differentiate signaling motives for unemployment from better understood reasons which stem the demand side.

[15] Some workers will not search for a job and thus will not get an offer. However, in this model all workers who receive an offer will receive at least two offers from *high*-demand prospective employers. This greatly simplifies the analysis and avoids dealing with mixed strategy equilibrium.

[16] One might ask why some laid-off workers might be recalled. As will become clear below, if the former employer's demand recovers, private information on the workers' productivity and relatively low market wages explains why he recalls some higher productivity laid-off workers.

Figure 2: Three-period model.



At the end of period two, the former employer may choose to recall some of his laid-off workers who are still unemployed.[17] Then, prospective employers observe that some laid-off workers are not recalled and they simultaneously offer some of them a wage. Since no recalls occurs after the end of period two, those workers who receive a market offer accept the highest wage offered (randomizing in case of a tie). Non-displaced workers either remain with their employer, or are bid-off by a new employer. The wage setting game for these workers is the same as the one described above for the non-laid-off workers.

Workers work over the course of period three and retire at its end.

The purpose of this paper is to analyze how the recall-expectation affects labor market outcomes in an asymmetric information model. Therefore, I focus on the equilibria in which the employer lays off and recalls workers.[18] I show below that given certain value of parameters, the employer chooses the following layoff and recall rules: he lays off his lowest productive ability workers (i.e., his L-type workers) if he observes a high second period demand; yet, he lays off both his low and medium productive ability workers (L- and M-type workers) if he observes a low second period demand. The employer recalls those M-type workers who are still unemployed if his demand recovers at the end of period two. Workers know their type and infer their probability of recall. Thus, in the separating equilibria, M-type laid-off workers choose to remain unemployed. Prospective employers cannot observe the workers' productive ability, but they observe their causes of displacement and their length of initial unemployment spell. Thus, if they observe that a worker is laid-off, they infer that he is a low-productive-ability worker, and offer him a low post-displacement wage. Yet, if prospective employers observe that a laid-off worker remains unemployed, they infer that he is a higher productive ability *laid-off* worker and offer him (relatively) higher wages.

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[17] In this model, prospective employers cannot distinguish between recalled workers and workers who never left their employer. So, they cannot offer a separate second-period wage to recalled workers.

[18] There are many equilibria in this model, one of which has no laid-off workers. I could rule out such equilibrium by assuming that the cost of having a worker bidden off by a prospective employer is an epsilon higher than that of laying him off. Although this assumption is questionable in certain countries (e.g., Spain), it is not unreasonable in the U.S. The cost of laying off a worker are relatively low in the U.S., whereas the cost of losing a worker can be considerably high due to the uncertainty tied to an unexpected loss of an employee.

There are two main differences between this paper and related models: firm-specific demand fluctuations and the existence of recalls. In addition to lay off workers because of their low productivity, the employer also lays off workers because of demand shocks. However, if demand recovers, he recalls those workers who were displaced due to a contraction of the demand and who are still unemployed. In equilibrium, the employer only recalls M-type workers who are still unemployed. He will never recall L-type workers. Thus, there are two types of laid-off workers in this model: those who are permanently laid-off (i.e., L-type workers), and those who are (possibly) temporarily laid-off (M-type workers).[19] The latter have higher productivity than the former, and have a positive (not equal to one) probability of being recalled.

Finally, I only consider spot contracts in this model because the evidence shows that the employer usually does not commit to rehiring a specific worker.[20] Furthermore, when asked, workers do not know for certain whether they will be recalled or not. This, added to the fact that output is not observable by a court, leads me to only consider this type of contract.

II. EQUILIBRIUM WAGES

II.1. Notation

Let $V^f(t,h,m,l)$ denote the wage offered by the f^{th} prospective employer at the end of period $(t-1)$ to those workers with employment history h, given the probability of rejecting a new job for permanently laid-off workers (L-type workers), l, and for temporarily laid-off workers (M-type workers), m, where $t=1,2,3$. I define the market wage offered to these workers as $V^*(t,h,m,l) = Max_f\{\, V^f(t,h,m,l)\,\}$.

Let $W(t,h,m,l)$ denote the wage offered by the current employer at the end of period $(t-1)$ to those workers with employment history h, given the probability of rejecting a new job for L-type workers, l, and for M-type workers, m, where $t=2,3$.

Let $A(t,h,m,l)$ denote the expected productive ability of workers in a low-demand firm with employment history h at the end of period $(t-1)$, given the probability of rejecting a new job for L-type workers, l, and for M-type workers, m, where $t=1,2,3$.

[19] Temporarily laid-off workers are *ex-ante* temporarily laid-off workers. Although they lost their job due to a demand contraction, not all of them will be recalled to their former employer, and thus some of them will end up being permanently displaced, *ex-post*.

For expository purposes, I use capital letters to denote quantities or employment history, and small letters to denote probabilities.

All proofs are in an Appendix available from the author upon request.

II.2. The Equilibrium Concept

A perfect Bayesian equilibrium in this model is a set of functions $m^*(V(t,h,m,l),W(t,h,m,l))$, $l^*(V(t,h,m,l),W(t,h,m,l))$, $V^*(t,h,m,l)$, $W^*(t,h,m,l)$ such that:

1. All laid-off workers choose the optimal unemployment rule $m(V,W)$ or $l(V,W)$ depending on their type given that the other laid-off workers also behave optimally, given the optimal layoff, bid-off and recall rules, and given the wages offered by prospective employers V^* and by the former employer W^*.
2. All current employers choose the optimal layoff, bid-off, and recall rules and equilibrium wages W given prospective employers' wage offers V^*, and given laid-off workers' optimal unemployment rule: $m^*(V,W)$ and $l^*(V,W)$.
3. All prospective employers offer an optimal wage to workers in an entering market and to workers they want to bid off, V, given their beliefs on these workers' productivity types; given the laid-off workers' optimal unemployment rule $m^*(V,W)$ and $l^*(V,W)$; and given the current employer's optimal equilibrium wage W^* and layoff, bid-off, and recall rules.
4. The beliefs of prospective employers are derived by Bayes' Rule in all information sets that are reached given the current employer's equilibrium strategy W^*; given the layoff, bid-off and recall rules; and given the laid-off workers' unemployment rule $m^*(V,W)$ and $l^*(V,W)$.

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[20] Philip L. Martin explains in his book Labor Displacement and Public Policy that "*Unemployment statistics do not include information on how long the lay-off is expected to last. Even if they did, expectations may be misleading because the lay-off intentions change.*"

II.3. Equilibrium Strategies

To construct the equilibrium, I work backwards.

II.3.1. The Current Employer

At the end of period two, a current employer makes two decisions: which of his workers he wants to retain, and which of his laid-off workers (if any) he wants to recall. The employer maximizes profits using his private information on the productivity of his workers and on his next period demand. He retains an employee only if the worker's productivity plus the cost of losing a worker, C, is greater than the market wage. To retain an employee, the employer only needs to offer him the competitive wage. If the employee is not worth keeping, the firm offers him a wage of zero.[21]

If the worker has been with the employer for two periods, the current employer's equilibrium strategy with the workers he wishes to retain takes the following form:

If his firm-specific demand is *high*:

$$W(3,S\text{-}S,m^*,l^*) = \begin{cases} M+F & \text{if } A+C \geq M \\ 0 & \text{if } A+C < M, \end{cases}$$

If his firm-specific demand is *low:*

$$W(3,S\text{-}S,m^*,l^*) = \begin{cases} M+F & \text{if } A+C \geq M+F \\ 0 & \text{if } A+C < M+F, \end{cases}$$

where the employment history, $S\text{-}S$, denotes that the worker has *stayed* with the initial employer during the first two periods. To retain a worker, the current employer only needs to pay a wage, $W(3,S\text{-}S,m^*,l^*)$, equal to the market wage, $M+F$, offered to those workers who are bid off by prospective employers.

If the worker has been with the current employer for only the second period, he is a laid-off worker who obtained a new job at the end of period one (see Figure 2). The current employer's equilibrium strategy is similar to the one described above, although now the market wage is $L+F$.

When asked, laid-off workers usually have an idea of how likely they are to be rehired by their former employer. However, they do not know for certain whether or not they will be recalled. To capture this uncertainty, Condition 1 places restriction on the relative magnitude of the firm-specific shock.[22]

Condition 1: Let $F > [M - A^*(3, L\text{-}U, m^*, l^*)]$.

Thus, at the end of period two, if the former employer observes that his third-period demand is high, he recalls all of his laid-off workers who are still unemployed if their productive ability satisfies $A+F \geq V^*(3, L\text{-}U, m^*, l^*)$, where $V^*(3, L\text{-}U, m^*, l^*)$ is the wage offered at the end of period two by prospective employers to those laid-off workers who have been unemployed during period two. However, if the worker's productivity satisfies $A+F < V^*(3, L\text{-}U, m^*, l^*)$ when the former employer's third period demand is *high* (or $A < V^*(3, L\text{-}U, m^*, l^*)$ when the former employer's third period demand is *low*), then the employer's best response is to not recall the worker. Since the market cannot distinguish between laid-off workers who will and will not be recalled, the employer only needs to offer those workers he wants to recall a wage equal to the market wage: $V^*(3, L\text{-}U, m^*, l^*)$. I show below that this wage, $V^*(3, L\text{-}U, m^*, l^*)$, is a weighted average of the productive ability of the two types of laid-off workers who are unemployed during period two (*L*- and *M*-types) in a *high* demand firm. Thus, if demand recovers, the former employer's best response is to only recall his *M*-type workers who are still unemployed. The employer recalls previous employees because he only needs to pay them $V^*(3, L\text{-}U, m^*, l^*)$, a wage below their productive ability, and because of his informational advantage.

At the end of period one, the current employer observes his worker's type and his next period demand. Then, he decides whether or not to lay off a worker. The employer's laid-off rule is to layoff a worker if his productive ability satisfies $A < M - C$ when the employer observes a high second period demand or $A < M + F - C$ when his demand is low. Given the above described layoff rule, prospective employers infer that those workers who are not laid-off are either *M*- or *H*-type workers. Thus, the current employer's equilibrium strategy with the workers he wishes to retain at the end of period one is similar to the one described earlier. He offers those workers he wishes to

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[21] By offering the worker a wage below the market wage, the firm would also get rid of him.
[22] Provided that the high-firm-specific productivity increases, *F*, satisfies condition 1, the former employer does not recall his *M* type workers when he observes that his third-period demand is *low*. Notice that this assumption on *F* is also consistent with the fact that in this model, due to perfect competition and demand fluctuations, employers only hire workers when they observe that their next period demand is *high*.

retain a wage equal to $M+F$.

At the end of period one, the employer is indifferent between the two ways he can rid himself of L-type workers: he can lay them off, or he can induce them to quit by offering less than the market wage. Yet, he *chooses* to lay off his M-type workers if he observes that his next period demand is *low*. This is so because by laying them off, he may recall them later at a low wage. Yet, if he loses them to a new employer, he will incur the cost of losing these workers and will not be able to hire them later when demand recovers. The existence of recalls and firm-specific demand fluctuations generates an incentive for the current employer to layoff higher productivity workers in order to recall them when output demand recovers. To avoid a situation where the employer lays off some or all of his H-type workers in order to rehire them later at a wage considerably lower than their productivity, I need the following proposition.

Proposition 1. The necessary and sufficient conditions for a Nash Equilibrium in which the current employer chooses to layoff L-type workers if his second period demand is high and L- and M-type workers if his second period demand is low are:

$$\begin{aligned} C > &[qk+(1-q)]\{p[H+F-V^*(3,L-U,m,l)]+(1-p)[H-V^*(3,L-U,m,l)]\} \\ &-[H-M-F]-p[H-M]-(1-p)[H-M-F] \end{aligned} \tag{1}$$

where k is the probability that type H laid-off workers choose to reject a second period market wage at the end of period one, in the out-of-equilibrium action where the current employer lays off a type H worker.

And that:

$$C > [qm+(1-q)][M+F-V^*(3,L-U,m,l)] \tag{2}$$

where m is the probability that M-type laid-off workers choose to reject a second period market wage at the end of period one, and where V(3,L-U,m,l) is also a function of p, q, a, b, m, l, L, and M.*

The current employer has an informational advantage with respect to the market, thus he could layoff workers in order to recall them later at a much lower wage. Inequalities (1) and (2) put a lower bound to the cost of loosing a worker, so that the initial employer will not layoff workers in order to exploit them later. Provided that inequalities (1) and (2) hold and that the high-demand-firm-specific productivity increase, *F,* satisfies that $F > [M-A^*(3,L-U, m^*,l^*)]$, the employer's optimal layoff rule is to lay off *L*-type workers when demand is high and to lay off *L*- and *M*-type workers when demand is low. If the employer chooses this rule, then the market's conjectures I assumed above are correct and I have accurately constructed the second and third period equilibrium wages for non-laid-off workers.

II.3.2. Prospective Employers

In equilibrium, prospective employers know that the firm will play the best responses just derived. In order to compute the optimal wage offer, prospective employers also have to conjecture about the layoff rule used by the current employer at the end of period one. Suppose that prospective employers believe that when the former employer observes that his second period demand is high, he lays off all of his *L*-type workers. However, if the current employer observes a low second period demand, he lays off both his *L*- and *M*-type workers. Given this conjecture about the layoff rule used by the current employer, prospective employers infer that those workers who are not laid-off are either *M*- or *H*-type workers. Bertrand wage competition among prospective employers bids up the market wage offered to workers until the present value of expected profits on the workers it attracts with this offer is zero in each of the secondhand markets or entering markets. Thus, given the current employer's equilibrium strategies and the worker's equilibrium strategies, prospective employers offer new employees a third period wage, $V^*(3,h,m^*,l^*)$, such that $V^*(3,h,m^*,l^*)=A(3,h,m^*,l^*)+F$ given the worker's employment history, *h*, and where $A(3,h,m^*,l^*)+F$ denotes the productivity of the workers he attracts when he observes a high third period demand. In the Appendix, I show that the above responses characterize the Nash Equilibrium determining the unique third period wage for workers given their employment histories.

At the end of the first period, prospective employers offer laid-off workers a second period wage, $V^*(2,L,m^*,l^*)$, such that the net present value of profits they will make on these workers is zero. Thus, $V^*(2,L,m^*,l^*)$ is such that:

$$V(2,L,m^*,l^*)+P(stays\ \ end\ \ period\ \ 2\,|\,2,L-W,m^*,l^*)[L+F]$$
$$+P(leaves\ \ end\ \ period\ \ 2\,|\,2,L-W,m^*,l^*)C=$$
$$A^*(2,L,m^*,l^*)+F+P(stays\ \ end\ \ period\ \ 2\,|\,2,L-W,m^*,l^*)A^*(3,L-W,m^*,l^*)$$
$$P(period\ \ 3\ \ demand\ \ is\ \ high\ \ and\ \ worker\ \ stays\ \ end\ \ period\ \ 2\,|\,2,L-W,m^*,l^*)F$$

where the employment history *L-W* denotes that the worker was *laid-off* at the end of period one and *working* for the new employer during period two.

The LHS term of the above expression is the expected cost the new employer will incur on the laid-off workers he hires. Similarly, the RHS is the expected productivity the employer will obtain from these workers.

At the beginning of the first period, information is symmetric but imperfect. Prospective employers simultaneously offer the entering cohort a wage $V^*(1,E,m^*,l^*)$, where E denotes "*Entering cohort*." Bertrand competition bids up this wage until the expected profits on the workers it attracts is zero. Thus, the wage equals the expected productive ability of the entering cohort plus the expected gains the employer will earn on these workers, given that they stay with him in the future or given that he might recall them at the end of the third period, net of the expected losses he will incur if they leave at the end of period one or two. Thus, prospective employers offer new employees a first period wage, $V^*(1,E,m^*,l^*)$, such that:

$$V(1,E,m^*,l^*)+\sum_{t=2}^{3}P(stays\ \ end\ \ period\ \ (t-1)\,|\,(t-1),S,m^*,l^*)[M+F]$$
$$+\sum_{t=2}^{3}P(leaves\ \ end\ \ period\ \ (t-1)\,|\,(t-1),S,m^*,l^*)C$$
$$+P(recalled\ \ end\ \ period\ \ 2\,|\,2,L-U,m^*,l^*)V^*(3,L-U,m^*,l^*)$$
$$=[(1-a-b)L+bM+aH]+F$$
$$+\sum_{t=2}^{3}P(stays\ \ end\ \ period\ \ (t-1)\,|\,(t-1),S,m^*,l^*)A^*(t,S,m^*,l^*)+$$
$$\sum_{t=2}^{3}P(period\ \ t\ \ demand\ \ is\ \ high\ \ and\ \ worker\ \ stays\ \ end\ \ period\ \ (t-1)\,|\,(t-1),S,m^*,l^*)F$$
$$+P(recalled\ \ end\ \ period\ \ 2\,|\,2,L-U,m^*,l^*)[M+F]$$

where the employment history S denotes that the worker *stayed* with the initial employer during period *(t-1)*, the employment history *L-U* denotes that the worker was *laid-off* at the end of period one and *unemployed* during period two, and where *t=2,3.*

The LHS term of the above expression is the expected costs the employer will incur on the new workers he hires, given their employment histories. Similarly, the RHS is the expected productivity the employer will obtain from these workers.
[See Greenwald (1986) for a more complete explanation of wage setting in a sequence of markets with adverse selection.]

II.3.3. Laid-off Workers

There are two types of laid-off workers: *permanently* laid-off workers (*L*-type workers) and (possibly) *temporarily* laid-off workers (*M*-type workers) in this model. The former are never recalled, whereas the latter are recalled with positive probability if they remain unemployed during period two. Workers know their type.

If a worker is not recalled at the end of period two, he will not be recalled. Thus, displaced workers accept the highest wage offered by prospective employers at the end of period two.

In this model, with probability *(1-q)*, a displaced worker does not search for a job. At the end of period one, those laid-off workers who search for a job receive a re-employment offer. They then decide whether to accept that offer or to reject it, and wait unemployed for one period. They choose the strategy that maximizes their present value of earnings given their type, given that the other type is also optimally behaving, and given the market's optimal wage to laid-off workers.

A temporarily laid-off worker (a type *M* worker) chooses the strategy that maximizes his present value of earnings (PVE):

$$Max\{[p+(1-p)q]V^*(3,L-U,m,l^*),V(2,L,m,l^*)+V^*(3,L-W,m,l^*)\},$$

where *L-U* denotes the employment history *"Laid-off-Unemployed"* at the end of period two, *L* denotes the employment history *"Layoff"* at the end of period one, and *L-W* denotes the employment history *"Laid-off-Working"* at the end of period two. The first term is the PVE of temporarily laid-off workers who are for one period unemployed; the second term is the PVE of temporarily laid-off workers who accept the re-employment wage right away. l^* is the optimal probability of rejecting a new job for permanently displaced laid-off workers.

Permanently laid-off workers solve the following optimization problem:

$$Max\{qV*(3,L-U,m^*,l),V(2,L,m^*,l)+V*(3,L-W,m^*,l)\},$$

where *L-U* denotes the employment history *"Layoff-Unemployed"* at the end of period two, *L* denotes the employment history *"Layoff"* at the end of period one, and *L-W* denotes the employment history *"Layoff-Working"* at the end of period two. The first term is the PVE of permanently laid-off workers who are unemployed for one period; the second term is the PVE of permanently laid-off workers who accept the re-employment wage right away.

The major difference between these two types of workers is that temporarily laid-off workers have a higher probability of being recalled at the end of period two than permanently laid-off workers. Thus, they have a higher probability of getting a third period job, and a lower cost of remaining unemployed during period two than that of permanently laid-off workers.

II.4. Characterization of the Equilibria with Voluntary Unemployment

In this model, there are five possible perfect Bayesian equilibria. Four of them involve some *voluntary* unemployment (i.e., some laid-off workers who are offered a new job at the end of period one choose to reject it.) This occurs because accepting a second period job is a worse signal than being unemployed for one period. These perfect Bayesian equilibria are: all laid-off workers who receive a second period job offer reject it; all temporarily laid-off workers and some permanently laid-off workers who receive a second period job offer reject it; and only temporarily laid-off workers who receive a second period job offer reject it. These are, respectively pooling, semi-separating and fully-separating perfect Bayesian equilibria. For a given value of parameters, these equilibria are mutually exclusive. There is also a fourth class of perfect Bayesian equilibrium in which some temporarily laid-off workers who receive a second period job offer reject it. However, this last equilibrium is an unsatisfactory one. These are the only possible equilibria with *voluntary* unemployment; that is, it is never an equilibrium for permanently laid-off workers to choose unemployment while temporarily laid-off workers choose low-paid jobs.

There is also an equilibrium where there is no voluntary unemployment (i.e., the cost of being unemployed one period surpasses the signaling gains.) Thus, all laid-off workers who are offered a second period job accept it. However, given certain value of the parameters, this equilibrium fails to satisfy the Cho-Kreps intuitive criterion. Therefore, the outcome equilibrium that satisfies the intuitive criterion must be one with *voluntary* unemployment. Furthermore, for a given value of parameters, the equilibrium outcome is *unique.*

The following theorem characterizes all equilibria in which some or all workers choose unemployment in the second period:

Theorem 1. The necessary condition for a perfect Bayesian equilibrium in which some workers choose to wait unemployed is:

$$\frac{2[L+F]-(1-p)C}{V*(3,L-U,1,0)} \leq [p+(1-p)q] \tag{3}$$

The maximum expected gains a worker receives from waiting unemployed is $[p+(1-p)q]\ V*(3,L-U,1,0)$. On the other hand, the minimum cost of refusing a job at the end of period one is $2[L+F]-(1-p)C$. Hence, when (3) does not hold, the minimum cost of choosing unemployment will be higher than the maximum potential expected benefit.

The sufficient conditions for a perfect Bayesian equilibrium are:

There is a perfect Bayesian pooling equilibrium in which both types of laid-off workers reject the second period job when:

$$\frac{2[L+F]-(1-p)C}{V*(3,L-U,1,1)} \leq q \tag{4}$$

There is a perfect Bayesian equilibrium in which all temporary layoffs wait unemployed, and a proportion, λ, of permanently laid-off workers who are offered jobs in period two rejects this offer, while all other workers (that get an offer) accept it when:

$$\frac{2[L+F]-(1-p)C}{V*(3,L-U,1,0)} \leq q \leq \frac{2[L+F]-(1-p)C}{V*(3,L-U,1,1)} \tag{5}$$

and λ is given by the (unique) solution to the following equation

$$\frac{2[L+F]-(1-p)C}{V*(3,L-U,1,\lambda)} = q \tag{6}$$

There is a perfect Bayesian equilibrium in which all temporarily laid-off workers who receive a second period offer reject it and all permanently laid-off workers accept it when

$$\frac{2[L+F]-(1-p)C}{V*(3,L-U,1,0)} \leq [p+(1-p)q] \tag{7}$$

$$\frac{2[L+F]-(1-p)C}{V*(3,L-U,1,0)} > q \tag{8}$$

and $p>0$ and $q<1$.[23]

Due to informational asymmetries and to the existence of recalls among laid-off workers, accepting a job right away is sufficiently damaging to the future employment prospects of a laid-off worker that he may choose unemployment even if there is no disutility from work. Yet, since only the M-type laid-off workers may be recalled, they have higher probability of getting hired at the end of period two than L-type workers and thus, they have higher incentives to signal their ability through unemployment. When condition (4) holds, all laid-off workers choose to reject the second period job. When conditions (5) and (6) hold, all M-type workers and a fraction λ of L-type workers choose to reject the second period job. Finally, when conditions (7) and (8) hold, all temporarily laid-off workers (i.e., M-type workers) choose to reject a second period job offer, whereas all permanently laid-off workers (i.e. L-type workers) accept it. [24] In the Appendix, I give values of the parameters for which a fully-separating equilibrium exists.

Under condition (3), I can also construct another hybrid equilibrium. However, I find this equilibrium to be unsatisfactory.

There is a perfect Bayesian equilibrium in which all permanently laid-off workers who receive a second period offer accept it, and a proportion ξ of temporarily laid-off workers who

[23] Without the condition $p > 0$, the probability of being recalled would be zero for everyone (including temporarily laid-off workers). The condition $q < 1$ is only needed in the three period model. When $q= 1$, there is no involuntary unemployment. Thus, the probability of being offered a job if you choose to wait unemployed for one period is the same for both types of laid-off workers. A peculiarity of the three-period model is that both types earn the same present value of earnings if they choose to wait unemployed. Thus, in the three period model, when $q = 1$, the equilibrium where one type has a greater incentive to wait unemployed then the other type is not a possible equilibrium.

[24] Notice that in the fully separating equilibrium, the types are not fully identified: the market infers that all laid-off workers who accept a second period job are L-type workers. However, the market cannot infer that all of those laid-off workers who are unemployed for one period are M-type workers. This is caused by the existence of a market friction, namely the *involuntary* unemployment, determined by q.

receive a second period offer reject it while all the other workers accept it when

$$\frac{2[L+F]-(1-p)C}{V^*(3,L-U,1,0)} \leq [p+(1-p)q] \leq \frac{2[L+F]-(1-p)C}{V^*(3,L-U,0,0)} \tag{9}$$

and ξ is given by the (unique) solution to:

$$\frac{V^*(2,L,\xi,0)+L+F}{V^*(3,L-U,\xi,0)} = [p+(1-p)q] \tag{10}$$

I consider this equilibrium to be unsatisfactory. Suppose that if fewer than ξ of temporarily laid-off workers choose to wait unemployed, then the expected productivity of workers accepting a market offer at the end of period one would exceed $V^*(2,L, \xi,0)+ L+F$, and the market wage offered to unemployed laid-off workers would be smaller than $V^*(3,L-U, \xi, 0)$. Thus, more temporarily laid-off workers would accept job offers at the end of period one, and the equilibrium would not be sustained. Conversely, if more than ξ choose to reject market offers at the end of the first period, the average productivity of laid-off workers who accept the second period job would be less than $V^*(2,L, \xi,0)+ V^*(3,L-W, \xi,0)$, and $V^*(3,L-U, \xi, 0)$ would be greater. Thus, it seems unlikely that an economy would ever converge to this equilibrium. Notice that the other hybrid equilibrium does not have this instability problem.[25]

Finally, there is never an equilibrium where permanently laid-off workers choose to wait unemployed and temporarily laid-off workers accept the second period market job offer.

II.5. Equilibrium with No Voluntary Unemployment

In this model, the equilibrium in which there is no voluntary unemployment is also possible. However, under certain conditions, this equilibrium fails to satisfy the Cho-Kreps intuitive criterion.

Theorem 2. There is always a perfect Bayesian equilibrium in which there is no voluntary unemployment.

Under certain conditions, the equilibrium in Theorem 2 fails to satisfy the intuitive criterion. The intuitive criterion in this model is as follows: starting from an equilibrium in which there is no voluntary unemployment, a worker choosing to wait unemployed is implicitly making the following statement: "I must have a positive probability of being recalled because those workers with no probability of being recalled would not choose unemployment, even if employers believed that only the high productivity laid-off workers choose unemployment."

Theorem 3. The equilibrium with no voluntary unemployment described in Theorem 2 fails to satisfy the intuitive criterion if and only if:

$$q < \frac{V^*(2,L,0,0)+L+F}{V^*(3,L-U,1,0)} \leq [p+(1-p)q] \tag{11}$$

and if $p > 0$ *and* $q < 1$.

Theorem 4. All equilibrium with some voluntary unemployment satisfy the intuitive criterion.

Corollary 1. If (11) holds, the outcome equilibrium that satisfies the intuitive criterion is unique and must be one with voluntary unemployment.

III. PREDICTIONS

The three-period model that generates the following predictions was chosen for its tractability and is only meant to be illustrative. However, these predictions would persist if the horizon were extended to *N* periods.

Proposition 2: In the separating equilibria, the re-employment wages of permanently laid-off workers who accept jobs at the end of period one are lower than those of observationally equivalent permanently laid-off workers who are unemployed during the second period.

The relation between wage rate of displaced workers and unemployment duration is

[25] If the fraction of permanently laid-off workers who rejected the offer increased (or decreased), this would lead to lower (or higher) earnings for those that wait unemployed. Thus, is would bring these workers back to the postulated distribution of actions.

determined by many factors. Among them are unobserved heterogeneity, loss of human capital, stigma, and as this paper points outs asymmetric information. Most of these factors imply a negative relation between wages and length of unemployment. However, combining the high recall rates in the U.S. and asymmetric information leads to a positive relation between wages and length of unemployment.[26] This allows me to test for the existence of asymmetric information in the U.S. labor market. To control for the effects on earnings and duration not associated with being adversely selected (the "lemons" effect) and with having a positive probability of recall, I use workers displaced through plant-closings. Because all workers lose their job when a plant closes, I assume that nothing can be inferred on their productive ability by observing their causes of displacement. Moreover since the plant closes, I assume that they cannot be recalled. The former assumption implies that there is no adverse selection amongst these workers. Moreover since these workers are not recalled, they have no incentive to signal their productivity through unemployment.[27] Thus, in this model, the expected productive ability of workers displaced through plant closings is independent of their unemployment duration and equals the expected productive ability of the entering cohort: $aH+bM+(1-a-b)L$.[28]

This model also yields a similar prediction to Gibbons and Katz's (1991) main result.

Proposition 3: The re-employment wage of workers permanently displaced through layoffs who immediately accept jobs is lower than otherwise observationally equivalent workers displaced through plant closings.

In this model, competition among employers and symmetric but imperfect information before period one yield a single first-period wage, $V^*(1,E,m^*,l^*)$, for all workers. Thus,

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[26] Adapting the model to incorporate the negative effect of unemployment on earnings would not change the main prediction of this model, namely that asymmetric information and the high probability of recall generate an incentive for laid-off workers to signal through unemployment their productivity.
[27] The construction of the equilibrium for workers displaced through plant closings is available from the author upon request. The equilibrium wages for workers displaced through plant closings can be found in the Appendix.
[28] Because there is a finite number of periods, and since entry-level wages are set in a competitive manner, under certain conditions the re-employment wage for workers displaced through plant closings could fall with unemployment duration. However, the expected ability and the present value of earnings of workers

combining these predictions yields the following result: *at displacement, laid-off workers who take new jobs right away have larger wage losses than otherwise equivalent workers displaced through plant closings, but this difference declines as unemployment duration lengthens.* In my empirical model, I consider wage changes as well as re-employment wages.

Like Gibbons and Katz's paper, this paper tests whether there is any asymmetric information in the U.S. labor market. However, the papers drastically differ in substantial and important ways. At the theoretical level, Gibbons and Katz test a model of "adverse selection in the labor market," whereas I test a model of "signaling through unemployment." They find that there is a "lemons-effect" associated with being a laid-off worker and thus that the wage loss associated with a layoff is greater than that associated with a plant closing. Their result is therefore in terms of levels (see Figure 3). By allowing for the possibility of recall, I find that this differential declines as the initial unemployment spell lengthens, and thus, my empirical result is in terms of slopes. In Figure 4, I show the new contribution of this paper: I find that the wage loss/unemployment duration relationship differs by cause of displacement.[29]

Finally, this model predicts that, conditional on not being recalled, laid-off workers should have a longer unemployment duration than that of (observationally equivalent) workers displaced through plant closings. Others have found this result.[30] Katz attributed this result to the recall-expectation explanation: higher recall expectations are likely to reduce the new-job-finding rate of workers. Because laid-off workers are more likely to think they may be recalled to their pre-unemployment jobs than are workers displaced through plant closings, this recall-expectation effect should be greater among the former. This also occurs in this model. However, due to asymmetric information, there are other reasons that explain why laid-off workers may have more incentives to wait unemployed than workers displaced through plant closings. First, in the separating equilibria, there is a positive inference associated with "long-term" unemployed laid-off workers that does not occur when the cause of displacement is plant closing. Second, due to the initial "lemons-effect," laid-off workers have lower opportunity costs of being unemployed than workers displaced due to plant closings.

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displaced through plant closings should not change with unemployment duration in a model with an indefinite number of periods.

[29] Note, however, that the model does not predict that the earnings profiles converge (as shown in Figure 4). The profiles could cross over each other or could asymptote toward each other depending on the expected productivity of laid-off workers and of workers displaced through plant closings.

Figure 3: Gibbons and Katz's (1991) results for permanently displaced workers.

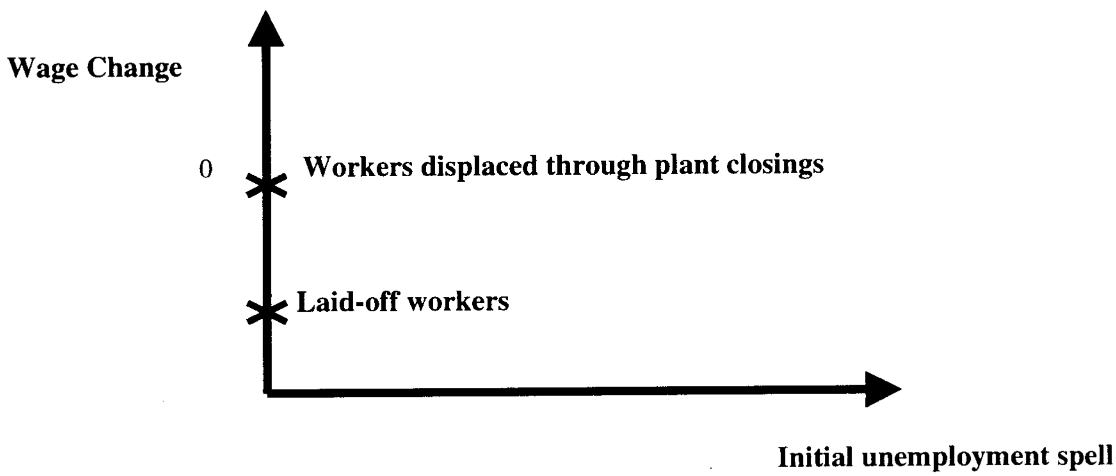
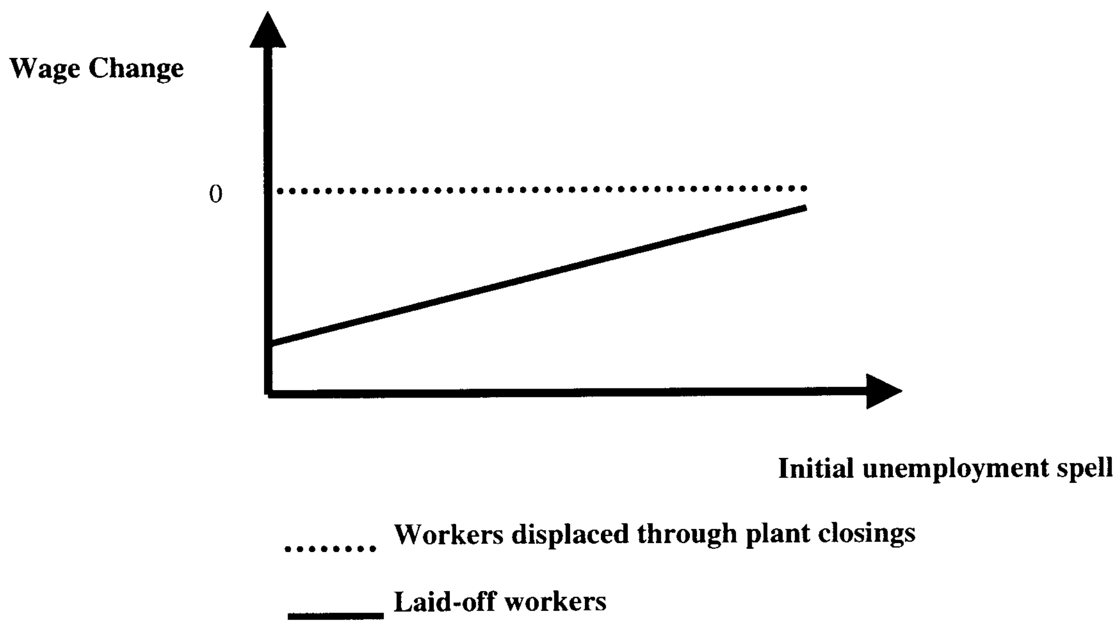


Figure 4: After introducing temporary layoffs, earnings and initial unemployment spell this result for permanently displaced workers.



All of the above predictions are hard to reconcile with alternative theories. For instance, a search model may predict the positive relation between post-displacement wages and unemployment duration since those workers with higher reservation wages search longer. However, those workers with higher post-displacement reservation wages should also have higher pre-displacement wages. Thus, such model would not generate the predicted relationship between wage losses and unemployment duration.[31] Alternatively, a symmetric-information firm-specific human capital model would require many additional assumptions to generate these predictions. Imperfect information at the beginning of the worker's career, and wage rigidity would be needed so that pre-displacement wages do not differ by cause of displacement, and the employer cannot reduce the worker's wage even if he is paid above his productivity, respectively. Moreover, additional assumptions on the relation between firm-specific and general human capital would be required so that the laid-off workers prefer the expected earnings of a potential future recall to the realized earnings from a present new job.

EMPIRICAL ANALYSIS

In this section, I provide evidence on the wages and unemployment duration of permanently displaced male workers[32] using data from January 1988, 1990, and 1992 from the "Displaced Workers Supplement (DWS)" to the "Current Population Survey (CPS)."[33] The theoretical model analyzes how the possibility of recall affects labor market outcomes for laid-off workers in an asymmetric information framework. The model delivers predictions for those laid-off workers who do *not* return to the original employer. Therefore, this section is restricted to

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[30] Katz (1986) and Katz and Meyer (1990).

[31] Moreover, a search model would need to explain the differential search activity between laid-off workers and workers displaced through plant closing.

[32] Like Gibbons and Katz, I focus on males displaced from full-time jobs in an attempt to identify a sample of workers with strong attachments to the labor force.

[33] I do not use the survey years 1984 and 1986 because they did not contain the variable "*initial* unemployment spell." For the 1986 supplement, I can obtain this variable for the sub-sample of workers who have only had one job since displacement. For consistency purposes, I did not include this sub-sample in this paper, but the results are very similar if the 1986 sub-sample is included. I do not use survey years after 1992 because, starting in 1994, the BLS decided to make some changes in the DWS questionnaire. Instead of asking "In the past five years, have you lost or left a job because of a plant closing, an employer going out of business, a layoff from which you were not recalled, or other similar reasons?," the BLS asked the same question referring only to the last three years from the survey date. Also, in 1994, there was an error in the supplement and the "initial unemployment spell" variable was not collected for all displaced workers who were re-employed at the survey date.

workers who were permanently displaced, (i.e., who were *not* rehired by their former employer.) After controlling for a pre-displacement worker's observable characteristics and for pre-displacement industry and occupation, I examine how the change in wages, the pre-displacement wage, and the post-displacement wage[34] vary with the cause of displacement, with the length of the initial unemployment spell, and with the interaction between length of initial unemployment and cause of displacement.

I. DATA DESCRIPTION

I examine a pooled sample of male workers between the ages of 20 and 61 who were *permanently displaced* from a private-sector, full-time, non-agricultural job because of a plant closing, slack work, or a position or shift abolished.[35] I use permanently displaced workers in an attempt to identify a sample of workers who do not return to their previous jobs (and similar wages).[36] I classify as laid-off workers those displaced because of slack work, or a position or shift that was eliminated.[37] Workers displaced from construction jobs were eliminated from the sample because it is difficult to formulate an appropriate definition of permanent displacement from a construction job. For most of this section, the sample is restricted to those individuals who were re-employed in wage-and-salary employment at the survey date[38] and who had re-employment earnings of at least $40 a week.[39] Later, I address the potential sample biases that may arise from using the DWS and from the fact that I exclude from the sample the workers who are not re-employed at the survey date.

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[34] The measure of pre-displacement wages is the usual weekly earnings before deductions the worker earned at his job before he got displaced. The measure of post-displacement wages is the usual weekly earnings at his current job (i.e., the job he holds at survey date.) Unfortunately, neither the pre-displacement hourly wage nor the pre-displacement hours worked are available in the 1988, 1990 and 1992 DWS.

[35] Agricultural workers tend to have a large number of jobs with a pronounced seasonal pattern.

[36] Katz and Meyer (1990) find that the post-displacement hourly earnings of workers with unemployment spells ending in recall are similar to their pre-displacement hourly earnings. They use a sample of unemployment insurance recipients from Missouri and Pennsylvania covering unemployment spells during the 1979-1981 period.

[37] If a worker lost more than one job in the 5 years prior to the survey, the survey questions refer to the lost job he or she had held the longest.

[38] The DWS does not provide current earnings information for those workers who entered self-employment.

[39] If I include workers who earn less than $40 per week, the results do not change much.

The restriction that data on all required variables be available leaves a sample of 1,664 workers displaced through plant closings and 1,522 permanently laid-off workers. Basic descriptive statistics for my sample of permanently displaced workers are presented in Table 1.1. Workers displaced through plant closings have, on average, significantly longer pre-displacement tenure (1.75 more years) than laid-off workers do. This suggests that seniority rules may be important in the layoff decision process. Furthermore, workers displaced through plant closings have, on average, a significantly higher probability of finding a new job without an intervening unemployment spell (17.06 % do not suffer unemployment compared to only 9.52 % of the sample of workers displaced through layoffs) and shorter (but not statistically significant) initial spells of unemployment (1.02 fewer weeks) than workers displaced by layoffs. Since unemployment duration usually rises with pre-displacement tenure, the fact that laid-off workers have similar unemployment spells as workers displaced through plant-closings, despite their smaller tenure suggest that they may have a greater incentive to wait unemployed than workers displaced through plant closings. Finally, workers displaced through plant closings are older, more experienced, more non-white workers, and a lower fraction of them are in white-collar occupation jobs.

The earnings loss for the typical displaced worker is substantial: being displaced reduces the earnings of the "average" worker by $86.68 per week (or $4,057.54 per year).[40] I find that the mean loss in the log of real weekly earnings for workers displaced through layoffs (-.18) is significantly greater than the one experienced by workers displaced through plant closings (-.13). Since much evidence indicates that the earnings losses of displaced workers rise substantially with pre-displacement tenure,[41] the fact that workers displaced through plant closings have smaller earnings losses than workers displaced through layoffs, despite their higher average pre-displacement tenure, suggests that a "lemon effect" may be operating.

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[40] The average pre-displacement deflated weekly earnings for the sample is $557.4424.

[41] Podgursky and Swaim (1987), Kletzer (1989), and Topel (1991) give evidence of this.

II. EARNINGS EQUATION

II.1. Specification

I examine how the weekly earnings losses vary with the first order interaction between cause of displacement and different length of initial unemployment spells. I assume that prospective employers know the workers' employment history.

My model predicts that laid-off workers with a short initial unemployment spell should have greater wage losses than similar workers displaced through plant closings. But that this difference should decline as unemployment duration lengthens. Yet, the model does not help in determining at what point of the initial unemployment spell the change in slope occurs. I would expect the positive signaling effect associated with laid-off workers to be stronger among those workers who are hired by a new employer around the time they would have expected to be recalled (but were not). This occurs because prospective employers are more likely to believe that these workers are *temporarily* laid-off workers who were not recalled. In the United States, most recalls occur within eight weeks and almost none occur after twenty-six weeks of displacement.[42] Thus, I look at the interaction of being a laid-off worker and several unemployment dummies: being unemployed between one and four weeks, between five and twelve weeks, between thirteen and twenty-six weeks, and more than twenty-six weeks. I also have dummy variables for experiencing more than twenty-six weeks and for no unemployment spell at all. This specification was chosen because of its economic sense, however, the results were robust to many changes in the specification and independent of how the week dummies were chosen.[43]

The regression equation is:

$$Yi = \gamma + \beta_1 L_i + \sum_{j=2}^{5} \alpha_j D_i^j + \sum_{f=2}^{5} \beta_j Z_i^f + X_i^{'}\delta + \xi_i \qquad (12)$$

Where Y_i is change in log real weekly earnings for worker *i* for $i=1,...N$,

L_i is a dummy for cause of displacement (L_i = 1 if the worker is laid off, and 0 if the worker is displaced through plant closings);

[42] See Katz (1986).

[43] Alternative specifications can be found in the Appendix.

D^2_i is a dummy for initial length of joblessness ($D^2_i = 1$ if the worker's initial length of joblessness is one to four weeks long, and 0 elsewhere);

D^3_i is a dummy for initial length of joblessness ($D^3_i = 1$ if the worker's initial length of joblessness is five to twelve weeks long, and 0 elsewhere);

D^4_i is a dummy for initial length of joblessness ($D^4_i = 1$ if the worker's initial length of joblessness is thirteen to twenty-six weeks long, and 0 elsewhere);

D^5_i is a dummy for initial length of joblessness ($D^5_i = 1$ if the worker's initial length of joblessness is more than twenty-six weeks long, and 0 elsewhere);

Z^2_i is the interaction between the layoff dummy and D^2_i;

Z^3_i is the interaction between the layoff dummy and D^3_i;

Z^4_i is the interaction between the layoff dummy and D^4_i;

Z^5_i is the interaction between the layoff dummy and D^5_i;

X_i is a vector of observable pre-displacement characteristics.[44]

Besides controlling for workers' observable characteristics, I also control for workers' pre-displacement industry and occupation, region of displacement, year of displacement, and year of survey. These variables aim to control for macroeconomic and regional effects.

The key identifying assumption is that in the absence of the treatment β_1, β_2, β_3, β_4, and β_5 would be zero, or $E[\xi_i \mid L_i, Z_i^2, Z_i^3, Z_i^4, Z_i^5] = 0$.

II.2. Results

Using Gibbons and Katz specification (but different survey years), I find that workers displaced through layoffs experience around 5.6 percent greater wage losses than workers displaced through plant closings.[45] Like them, I find that this is explained by lower post-displacement earnings and by higher pre-displacement earnings.

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[44] The covariates are: a spline function in previous tenure (with breaks at 1, 2, 3, and 6 years); five dummies for education (one for less than twelve years completed; one for "twelve years completed;" one for "some college but less than four years of college completed;" one for "college degree but no graduate degree;" and one for "more than four years of college"); "three year of survey" dummies; "years since displacement" dummy; "eight year-of-displacement" dummies; "advance notification" dummy; "six previous-industry" dummies; "five previous-occupation" dummies; experience at survey date and its square; a "marital status in year *t*" dummy; a "non-white" dummy; and "four region" dummies.

[45] Using January 1984 and 1986 DWS, Gibbons and Katz find that workers displaced through layoffs experience 4 percent greater wage losses than workers displaced through plant closings.

The estimates of equation 12 can be found in Table 1.2. All regressions use the Huber/White estimator of variance. Workers displaced by a layoff who suffer at most one month of initial unemployment spell experience approximately 8.5 percent larger weekly earnings loss than do similar workers displaced through plant closings. This loss is caused by 11.1 percent relatively lower post-displacement earnings and by slightly higher (although not statistically significant) pre-displacement earnings. This model only predicts the former result. Although the coefficient on the layoff dummy is not individually statistically significant, I reject the null hypothesis that the coefficients on the layoff dummy, the length of initial joblessness spell dummies, and the interaction between the layoff dummy and the length of initial joblessness spell dummies are jointly equal to zero (H_0: $\beta_1=\alpha_2=\alpha_3=\alpha_4=\alpha_5=\beta_2=\beta_3=\beta_4=\beta_5=0$). Furthermore, I reject the null that the cumulative effect of being between one and four weeks unemployed on the weekly earnings losses is the same for laid-off workers than for workers displaced through plant closings (H_0: $\beta_1+\beta_2=0$). This result is explained by variation in the post-displacement wages and is consistent with a "lemons-effect" associated with being a laid-off worker with a short initial spell of joblessness. Finally, I reject the joint hypothesis that the effects of being a laid-off worker with at most one month unemployment are jointly equal to the effects of being at most one month unemployed for workers displaced through plant closings (H_0: $\beta_1=0$ and $\beta_1+\beta_2=0$).

However, this differential effect on weekly earnings losses for laid-off workers with respect to those workers displaced through plant closings *disappears* when workers experience more than a one-month spell of initial joblessness. I fail to reject the individual hypotheses that H_0: $\beta_1+\beta_3=0$ and H_0: $\beta_1+\beta_4=0$, respectively, and the joint hypothesis that H_0: $\beta_1+\beta_3=0$, $\beta_1+\beta_4=0$, and $\beta_1+\beta_5=0$. Laid-off workers with more than a one month spell of initial unemployment experience the *same* wage losses that observationally equivalent workers displaced through plant-closings experience. All of these results are explained by the post-displacement wages. Thus, I find that laid-off workers who take a job within one month of displacement have larger wage losses than otherwise observationally equivalent workers displaced through plant closings, but that this difference declines and disappears as the unemployment duration lengthens. These effects are perhaps stronger than they might appear for the following two reasons. First, some laid-off workers included in the sample could end up returning to their original employer[46] and thus they should have higher re-employment wages and shorter initial spells of joblessness than permanently displaced laid-off workers. Second, many of the layoffs in the sample are likely to be determined by strict seniority systems.[47]

The results in Table 1.2 also show that workers displaced through plant closings experience increasing wage losses as their initial unemployment spell lengthens. Others have found that workers who are unemployed longer (especially those exhausting unemployment insurance) tend to have larger wage losses than short-term unemployed workers.[48] Loss of human capital, stigma associated with being unemployed or decreases in the workers' reservation wage are some of the arguments that explain this negative relationship between unemployment duration and earnings of displaced workers. As I pointed out earlier, my theoretical work is not contrary to this evidence. Yet, my research finds that because of asymmetric information and the high recall rate in the U.S., post-displacement wages will be higher among those experiencing moderate unemployment duration than among those experiencing short unemployment duration.

The change in earnings equation seems to indicate that the stigma associated with being laid-off reappears when workers have been unemployed for more than twenty-six weeks.[49] This effect, were it driven by variation in the post-displacement earnings, would be a concern since it is not predicted by the theoretical model. However, one can see that it is driven by both higher pre-displacement earnings of laid-off workers and lower pre-displacement earnings of workers displaced through plant closings (see column 2 in Table 1.2.) Therefore, it seems that workers

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[46] "Displaced Workers Supplement" to the CPS is known to overstate what would be considered job displacement because some laid-off workers end up returning to their original employer after the survey date. This is despite the fact that workers entering my sample are re-employed at survey date and have answered "yes" to the question: "In the past 5 years, have you left or lost a job because of a plant closing, an employer going out of business, or a layoff from which you were *not* recalled, or other similar reasons?"
[47] The initial negative stigma should not apply for these workers since the employer does not have discretion over whom to layoff. Also, these workers are usually also recalled by seniority rules and therefore those who are more likely to accept a job right away are those with less seniority (but not necessarily lower productivity).
[48] Using a sample of unemployment insurance (UI) recipients from Missouri and Pennsylvania covering unemployment spells the 1979-1981 period, Katz and Meyer (1990) find that workers who exhausted their UI benefits experienced larger earnings losses than workers who did not exhaust their UI benefits.
[49] I reject the individual hypothesis that there is no differential effect between the earnings losses of laid-off workers and of workers displaced through plant closings when workers are displaced for more than half a year (H_0: $\beta_1+\beta_5=0$). However, I fail to reject the joint hypothesis that there is a differential effect between

displaced through plant closings with *long-term* unemployment (i.e., more than twenty-six weeks unemployed) are a poor control group.[50]

III. SENSITIVITY ANALYSIS

III.1. Robustness

The above results are robust to model specifications.[51] They are also robust to changes in the definition of the sample[52] and to various changes of the covariates.[53] I also re-run the regressions dropping some outliers (i.e., points (x_i, y_i) with corresponding large residual and/or with high leverage). The results are very robust in all the specifications and for all sub-samples.

III.2. Retrospection Bias

The CPS supplements are retrospective as respondents are asked to describe events that may have occurred up to five years in the past. This is a problem when the errors are not random, such as if a worker only recalls an especially traumatic or costly displacement that occurred four to five years ago. A priori, it is not clear whether this bias is worse for plant closings than for layoffs. For instance, if plant closings are more easy to remember than layoffs, and if they occur in more depressed areas, I would expect an upward bias on the coefficient on the layoff dummy (since plant closings in particular depressed areas would be over-represented), and an upward bias on the coefficient of the interaction between layoff and unemployment (because these plant-

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layoffs and plant closings from waiting more than one month unemployed (H_0: $\beta_1+\beta_3=0$, $\beta_1+\beta_4=0$, and $\beta_1+\beta_5=0$.)

[50] I reject the H_0: $\beta_1+\beta_K=0$ in the pre-displacement earnings equation. However, workers displaced through plant-closings with twenty –six weeks of unemployment or less are a good control group: I fail to reject that all the coefficient of interest are jointly equal to zero in the pre-displacement earnings equation (H_0: $\beta_1=\alpha_2=\alpha_3=\alpha_4=\alpha_5=\beta_2=\beta_3=\beta_4=\beta_5=0$), and that there is no differential effect between the layoffs and plant-closings (except for those displaced more than 26 weeks).

[51] In the Appendix, a table shows the results for different functional forms of unemployment duration. The results are in a spirit similar to previous results (especially those for post-displacement wages.) I also estimated some regressions with interactions with tenure. Higher pre-displacement tenure leads to greater wage losses. But there does not seem to be any effect of the interactions between tenure and initial unemployment spell and/or layoff dummy. Also, I have used different initial unemployment dummies (besides the ones shown above) and again the results are robust to the ones shown in the paper. Finally, the wage loss and post-displacement wage regressions shown in this paper do not control for pre-displacement wage. However, the results are in the same spirit as the ones presented here once I do so.

[52] I also included part-time workers, workers earning less than $40 a week, and public sector workers, respectively.

[53] I tried several definitions for some of the covariates. This did not change the results.

closings are more likely have long-term unemployment and lower re-employment wages if the area is still depressed.)[54] On the other hand, if particularly "traumatic" layoffs are remembered and over-represented, then I would expect a downward bias on the coefficient on the layoff dummy, and a downward bias on the coefficient of the interaction between being laid-off and unemployment duration. The former bias would be of concern. A different type of retrospective bias may emerge if respondents do not accurately recall the exact date of their layoff or the length of the initial duration of unemployment. For instance, if (especially non-traumatized) laid-off workers understated the length of time unemployed in earlier years, this would cause a downward bias on the coefficients on the interaction between being a laid-off worker and the initial spell of unemployment dummies.

Looking at the raw data, I find that many more layoffs are reported in the 1988 (respectively, 1990) survey than in the 1990 (respectively, 1992) survey, while the analogous comparison of plant closings reported at the three survey dates reveals a much smaller difference.[55] Yet, looking at tenure means, it is unclear whether the retrospection bias is worse for layoffs or for plant closings.[56] If anything, one could say that particularly "traumatic" layoffs are more likely to be remembered.

I take two approaches in analyzing the dimension of this problem. First, I re-estimate the equations dropping the first and second earliest year from each DWS, respectively. The results are very similar to the ones previously found and it is unclear whether the retrospection bias is

[54] Assuming that labor supply is constant.

[55] In my sample (including those not re-employed at survey date), the layoffs reported in the 1988 DWS are 230, 256, and 353 for 1985-7, respectively, while those reported in the 1990 DWS are 122, 173, and 148 for the same years, and those reported in the 1992 DWS are 113 for 1987. The plant closings reported in the 1988 DWS are 282, 248, and 244 for 1985-87, respectively, while those reported in the 1990 are 194, 206, and 222 for the same years, and those reported in the 1992 DWS are 201 for 1987. Similarly, the layoffs reported in the 1990 DWS are 144 and 306 for 1988-89, respectively, while those reported in the 1992 DWS are 137 and 216. The plant closings reported in the 1990 DWS are 196 and 204 for 1988-89, respectively, while those reported in the DWS 1992 are 200 and 256 for the same years.

[56] The average tenure reported by laid-off workers in the 1988 DWS are 4.39 (5.81), 4.19 (5.50), and 3.56 (6.04) -standard errors are in parenthesis- for 1985-87, respectively, while those reported in the 1990 DWS are 4.40 (5.37), 4.79 (5.98), and 5.03 (6.08) for the same years, and those reported in the 1992 DWS are 6.16 (7.14) for 1987. The average tenure reported for workers displaced through plant closings are in the 1988 DWS are 7.32 (9.00), 7.44 (8.26), and 6.31 (7.86) for 1985-87, respectively, while those reported in the 1990 are 6.97 (7.30), 7.54 (8.60), and 5.28 (6.77) for the same years, and those reported in the 1992 DWS are 7.25 (7.64) for 1987. Similarly, the layoffs reported in the 1990 DWS are 4.02 (5.47) and 3.57 (5.03) for 1988-89, respectively, while those reported in the 1992 DWS are 4.78 (6.74) and 4.47 (5.97).

worse for layoffs or for plant closings. An alternative approach is to generate five dummies for each year-since-displacement.[57] I should expect a monotonic pattern of the coefficients on these five dummies if the retrospection bias was large, yet I do not observe any increasing or decreasing pattern. Rather, a typical pattern is that the strongest effects are in the first, fourth, and fifth years.[58]

III.3. Sample Selection Bias

Since the above estimations are on a sample of displaced workers who were re-employed at the survey date, the estimates may potentially reflect sample-selection bias since some of the workers have not had much time to find a new good job match. To probe the importance of this problem, I re-estimate the equations using a sample of workers who were displaced at least a year before survey date as these workers should have had plenty of time to find a new job. The results are in the spirit of the previous findings. There is a "lemons-effect" associated with short-term unemployment that dies out after three weeks of the initial unemployment spell. [59]

Finally, in a previous version of this paper, I used an alternative data set: the Panel Study of Income Dynamics (PSID), waves XIII to XXIV. The PSID is a longitudinal survey that allows to follow household heads over time. Its longitudinal characteristic considerably reduces the possibility of a retrospection bias or the "inclusion of temporarily laid-off workers" bias. Its drawback is that it produces rather small samples of dislocated workers. The results using the PSID are very much in the style of those found in this paper: laid-off workers who accept a new job right away experience higher wage losses than similar workers displaced through plant closings, however this differential in the wage loss decreases as the workers' unemployment duration lengthens.[60]

The plant closings reported in the 1990 DWS are 7.13 (8.38) and 5.27 (6.87) for 1988-9, respectively, while those reported in the DWS 1992 are 5.12 (6.15) and 6.29 (7.66) for the same years.

[57] For simplicity purposes, I have used a similar specification to the ones presented above, but with only one dummy for the initial unemployment spell (equal to one if the worker experienced more than three weeks of unemployment).

[58] My regressions include dummies for displacement on the RHS. Thus, this pattern is not picking up the fact that 1983, 1984, and 1989 were "bad" economic years.

[59] Yet, the individual coefficients are not as strong in all the specifications.

[60] With the PSID, I use the wage the worker receives three years after re-employment as the post-displacement wage. By doing this, I avoid capturing effects of temporary jobs and short-term bad matches.

IV. UNEMPLOYMENT DURATION AND CAUSE OF DISPLACEMENT

The theoretical model also predicts, conditional on not being recalled, that laid-off workers have longer unemployment duration than workers displaced through plant closings.

In Tables 1.1, I find that among permanently displaced workers who were re-employed at a survey date, workers displaced through plant closings have shorter average initial unemployment spells than workers displaced through layoffs.[61] In order to see if this holds after controlling for observable characteristics, I analyze the duration of initial spells of joblessness for this sample using formal hazard-model techniques. I parameterize the hazard rate (i.e., the escape rate from joblessness) using a Weibull specification. The hazard rate for individual *i* at time *t* is specified as:

$$h_i(t) = \frac{\Pr ob.\ \ of\ \ escaping\ \ between\ \ times\ \ t\ \ and\ \ t+\Delta t}{(\Delta t)(\Pr ob.\ \ of\ \ escaping\ \ after\ \ time\ \ t)}$$
$$= h_0(t)e^{X_i\beta}$$

where $h_0(t) = t^{\frac{1}{(\alpha-1)}}$. X_i is a vector of time-invariant covariates[62] for individual *i,* and β is a vector of parameters. Table 1.3 presents maximum-likelihood estimates of Weibull duration models for the initial spell of joblessness following displacement for my DWS sample.[63] I present the results in the following regression form:

$$\ln(Y_i) = \beta^* X_i + \xi_i$$

where ξ has an extreme value distribution scaled by σ and β^* = - $\sigma\beta$. In this form, β^* can be interpreted as the effects of the covariates on the expected log duration of joblessness.

I find that workers permanently displaced by layoffs have longer initial unemployment spells than do those displaced by plant closings. Laid-off workers in the DWS have a 91% ($e^{.649}$)

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[61] This difference is not statistically significant.

[62] The covariates used with the DWS are: five dummies for education (one for "less than twelve years completed"; one for "twelve years completed"; one for "some college but less than four years of college completed"; on for "college degree but no graduate studies"; and one for "more than four years of college"); three "year of survey" dummies; eight "year-of-displacement" dummies; "advance notification" dummy; six "previous-industry" dummies; five "previous-occupation" dummies; experience at survey date and its square; a pre-displacement marital status" dummy; a "non-white" dummy; and four "region" dummies.

[63] The variable that measures "weeks of joblessness since displacement" is top-coded at 99. I treat initial spells of joblessness top-coded at 99 as being censored at 99 weeks.

longer initial unemployment spell than do those workers displaced through plant closings. Column (2) shows the DWS estimates using only workers who are re-employed at the survey date. I also find that workers with longer pre-displacement tenure have a higher initial spell of joblessness. The results from DWS are robust to changes in the covariates and to changes in the sub-samples.[64]

CONCLUSION

In the United States, many laid-off workers are recalled to their original employer. If employers have discretion over whom to recall, high productivity workers are more likely to be recalled and they may choose to remain unemployed rather than to accept a low-wage job. If so, unemployment can serve as a signal of productivity. In this case, unemployment duration may be positively related to post-displacement wages even among workers who are not recalled. In contrast, since workers displaced through plant closings cannot be recalled, longer unemployment duration should not have a positive signaling benefit for such workers. Analysis of the 1988-1992 Displaced Workers Supplements to the Current Population Survey reveals that the wage/unemployment duration relation differs between the two groups in the predicted way. The evidence is also consistent with the other two predictions of the theoretical model regarding wage loss *at displacement* and unemployment duration of laid-off workers relative to workers displaced through plant closings.

This paper is a step forward towards testing the importance of asymmetric information in the labor market. It is important to note that the standard search model would not generate these results. In such a model, workers choose unemployment until they are offered a wage at least as large as their reservation wage. Thus, such a model could generate a positive relationship between unemployment duration and re-employment wages.[65] However, we should expect those workers with high reservation wages after displacement to also have higher reservation wages before displacement. Therefore, a search model alone would *not* generate the empirical results in terms of wage losses which is exactly what this asymmetric information model predicts. Moreover, a symmetric-

[64] Moreover, the results found using the PSID were consistent with those found using the DWS.
[65] It is not clear how a search model would generate a different search intensity for laid-off workers than for workers displaced through plant-closings, and thus imply different re-employment earnings profiles. How search intensity varies by cause of displacement is an interesting topic with controversial results (Clark and Summers (1979) and Katz and Meyer (1990).

information model would need many additional assumptions to generate these predictions. For instance, a symmetric information firm-specific human capital model would require imperfect information at the beginnings of the worker's career to insure that pre-displacement wages do not differ by cause of displacement. Moreover, wage rigidity would be needed so that the employer cannot reduce the worker's wages even if he is paid above the worker's productivity. Finally, additional assumptions on the relation between firm- and general-specific human capital would be required so that laid-off workers prefer the expected earnings of a potential future recall to the realized earnings from a present job.

Most importantly, this model has driven the motivation for a new empirical finding regarding laid-off workers. Among workers who are laid-off and who do not return to their former employers, there is an increasing earnings profile: those who obtain jobs between one and three months of unemployment have higher earnings than those with short–term unemployment.

Table 1.1. Descriptive statistics for displaced workers using the DWS (1988-90-92), males re-employed at survey date.

	Means		
		Reason of Displacement	
Variables	Entire Sample	Plant Closing	Layoff
Layoff = 1	47.77%	0%	100%
Previous tenure in years	5.24	6.08	4.33
	(6.44)	(6.99)	(5.65)
Change in log real weekly earnings	-.155	-.133	-.180
	(.514)	(.492)	(.537)
Log of previous weekly earnings	6.167	6.156	6.179
	(.560)	(.555)	(.565)
Log of current weekly earnings	6.011	6.022	5.998
	(.578)	(.551)	(.606)
Length of unemployment in weeks	13.86	13.37	14.39
	(18.65)	(19.06)	(18.18)
No unemployment after displacement = 1	13.46%	17.06%	9.52%
Advance notice = 1	51.55%	59.25%	43.13%
Current education in years	12.93	12.68	13.20
	(2.39)	(2.41)	(2.35)
Current (age-education-6)	17.84	18.61	16.99
	(10.30)	(10.40)	(10.11)
White collar in previous job = 1	42.15%	39.66%	44.91%
Previous job in manufacturing = 1	42.59%	42.30%	42.87%
Current age	36.77	37.29	36.20
	(10.14)	(10.10)	(10.16)
Currently married = 1	68.58%	69.89%	67.14%
Non white = 1	10.35%	11.23%	9.39%
N	3,186	1,664	1,522

Note.- Standard deviations are in parenthesis. All weekly wages are deflated by the gross domestic product (GDP) deflator (base year = 1992). The white-collar sample consists of workers whose pre-displacement occupations were in the managerial and professional specialties or in the technical, sales and administrative support specialties.

Table 1.2. Earnings equation with five length of displacement dummies using the DWS (1988-90-92), males re-employed at survey date.

	Dependent variables*		
N = 3,186	Weekly earnings Change (1)	Pre-displacement Earnings (2)	Post-displacement Earnings (3)
One-to-four weeks unemployed: α_2	-.008	-.016	-.024
	(.032)	(.034)	(.035)
Five-to-twelve weeks unemployed: α_3	-.116*	.007	-.108*
	(.036)	(.036)	(.038)
Thirteen-to-twenty-six weeks unemployed: α_4	-.157*	-.023	-.180*
	(.038)	(.038)	(.042)
More than twenty-six weeks unemployed: α_5	-.146*	-.070	-.216*
	(.045)	(.041)	(.043)
Layoff Dummy : β_1	-.073	.021	-.052
	(.048)	(.045)	(.053)
Layoff dummy	-.012	-.046	-.059
x One-to-four weeks unemployed: β_2	(.056)	(.053)	(.062)
Layoff dummy	.121*	-.023	.098
x Five-to-twelve weeks unemployed: β_3	(.058)	(.054)	(.064)
Layoff dummy	.053	.035	.089
x Thirteen-to-twenty-six weeks unemployed: β_4	(.062)	(.057)	(.067)
Layoff dummy	-.037	.105	.067
x More than twenty-six weeks unemployed: β_5	(.075)	(.064)	(.072)
R-squared	.1032	.3781	.2850
H_0: $\beta_1=\alpha_2=\alpha_3=\alpha_4=\alpha_5=\beta_2=\beta_3=\beta_4=\beta_5=0$	F(9, 3139)=6.67	F(9, 3139)=1.73	F(9, 3139)=6.62
H_0: $\beta_1+\beta_2=0$	F(1, 3139)=7.60	F(1, 3139)=0.71	F(1, 3139)=12.31
H_0: $\beta_1+\beta_3=0$	F(1, 3139)=2.01	F(1, 3139)=0.00	F(1, 3139)=1.65
H_0: $\beta_1+\beta_4=0$	F(1, 3139)=.26	F(1, 3139)=2.43	F(1, 3139)=.78
H_0: $\beta_1+\beta_5=0$	F(1, 3139)=3.83	F(1, 3139)=7.88	F(1, 3139)=.09
H_0: $\beta_1=0$, $\beta_1+\beta_2=0$	F(2, 3139)=4.80	F(2, 3139)=0.48	F(2, 3139)=6.60
H_0: $\beta_1+\beta_3=0$, $\beta_1+\beta_4=0$, $\beta_1+\beta_5=0$	F(2, 3139)=2.13	F(2, 3139)=3.46	F(2, 3139)=.81
H_0: $\beta_2=\beta_3=\beta_4=\beta_5$	F(3, 3139)=3.73	F(3, 3139)=3.22	F(3, 3139)=4.71

Note: The number in parentheses are standard errors. All regressions use the White estimator of variance. The covariates are: a spline function in previous tenure (with breaks at 1, 2, 3, and 6 years); five dummies for education (one for less than twelve years completed; one for "twelve years completed;" one for "some college but less than four years of college completed;" one for "college degree but no graduate degree;" and one for "more than four years of college"); "three year of survey" dummies; "years since displacement" dummy; "eight year-of-displacement" dummies; "advance notification" dummy; "six previous-industry" dummies; "five previous-occupation" dummies; experience at survey date and its square; a "marital status in year *t*" dummy; a "non-white" dummy; and "four region" dummies.

♣ Dependent variable: col. 1 = log(current earnings/previous earnings); col. 2 = log (previous earnings deflated by GDP deflator); and col. 3 = log(current earnings deflated by GDP deflator).

* Statistically significant at 5% level.

Table 1.3. Effect of selected variables on the duration of the first spell of joblessness following displacement using the DWS (1988-90-92) and the PSID (1980 to 1991), males.
Dependent variable = Log (month of joblessness)
Weibull duration model specification

Sample	DWS (all displaced workers)	DWS (only those re-employed at survey date)
	N=6,140	N=4,883
Layoff = 1	.649*	.117*
	(.102)	(.031)
Previous tenure in years	.061*	.085*
	(.009)	(.028)
Log of previous real weekly (or hourly for PSID sample) earnings	-.432*	.016
	(.098)	(.002)
Weibull scale parameter (σ)	3.371	1.028
Log likelihood	-14,965.251	-7,713.830

Note.- Earnings are deflated by GDP deflator. The number in parentheses is standard errors.
The covariates are: five dummies for education (one for "less than twelve years completed"; one "for twelve years completed"; one for "some college but less than four years of college completed"; one for "college degree but no graduate degree"; and one for "more than four years of college"); three "year of survey" dummies, eight "year-of-displacement" dummies; "advance notification" dummy; six "previous-industry" dummies, five "previous-occupation" dummies; experience at survey date and its square; a "pre-displacement marital status" dummy; a non-white dummy; and four region dummies.
* Statistically significant at 5% level.

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APPENDIX OF "ASYMMETRIC INFORMATION IN THE LABOR MARKET: NEW EVIDENCE ON LAYOFFS, RECALLS, AND UNEMPLOYMENT."

APPENDIX 1

Proof of Proposition 1.

Inequalities (1) and (2) are necessary and sufficient conditions for a Nash equilibrium in which the current employer chooses to layoff L type workers if his second period demand is high and L and M type workers if his second period demand is low.

First, I show sufficiency.

Inequality (1) can be rewritten as follows:

$$[H-M-F]+p[H-M]+(1-p)[H-M-F]>$$
$$-C+[qk+(1-q)]\{p[H+F-V^*(3,L-U,m,l)]+(1-p)[H-V^*(3,L-U,m,l)]\} \quad (13)$$

where the LHS of inequality (13) denotes the expected profits the current employer earns if he does not layoff a type H worker at the end of period one, when he observes a low second period demand. The RHS of inequality (13) denotes the expected profits the current employer earns if he lays off a type H worker at the end of period one. Equation (2) can be rewritten as follows:

$$-(1-p)C>-C+p[qm+(1-q)][M+F-V^*(3,L-U,m,l)] \quad (14)$$

where the LHS of inequality (14) is the expected profits the current employer earns if he does not layoff a type M worker at the end of period one, when he observes a high second period demand. The RHS of inequality (14) is the expected profits the current employer earns if he lays off a type M worker at the end of period one.

Since I assumed that the high-demand firm-specific productivity increase, F, satisfies $M+F\leq H$, where H (resp. $M+F$) is the productivity of type H (resp. type M) worker at a *low*-demand firm (resp. *high*-demand firm), and since the wage offered to unemployed laid-off workers ($V^*(3,L-U, m^*,l^*)$) is a weighted average of the productivity of unemployed laid-off workers in high-demand firms (i.e., L and M type workers), then I have $V^*(3,L-U, m^*,l^*)\leq M+F\leq H$. Suppose that, in the out-of equilibrium action where the current employer lays off a type H worker, he offers him a wage of $V^*(3,L-U, m^*,l^*)$ at the end of period two. Then, in the out-of equilibrium action where the employer would layoff a type H worker, his best response would be to recall this worker, independently of his third-period demand. Inequality (13) says that the current employer would choose not to layoff a type H worker at the end of period one if his second period demand were *low*. Since the expected profits the employer makes on those workers he does not lay off are higher when his second period demand is *high*, inequality (13) also implies that it is a best response for the current employer not to layoff a type *H* worker at the end of period one when he observes a *high* second period demand.

Provided that Condition 1 holds, the former employer chooses to recall a type *M* worker only if his third-period demand recovers. Suppose the former employer offers those unemployed *M* type workers he recalls a wage of $V^*(3,L\text{-}U, m^*,l^*)$. Then, inequality (14) says that the current employer would choose to not layoff a type *M* worker at the end of period one if his next period demand were *high.*

It is straightforward to verify that the conditions above are not only sufficient but also necessary.

APPENDIX 2

Below I show that it is optimal for prospective employers to offer a wage $V(3,S\text{-}S,m,l)=M+F$ *to workers who stayed with their employer for two periods. The proof for the optimal third wage for workers with other employment histories is similar and thus omitted.*[1]

First, I show that it is optimal for prospective employers to offer a wage $V(3,S\text{-}S,m,l)=M+F$.

If a prospective employer, *f*, offers a wage $w^f<M+F$, then since other prospective employers are offering $V^*(3,S\text{-}S,m,l)=M+F$, the employer fails to hire the worker and $E[\pi^f]=0$.

Supposing that $M+F<w^f\leq M+F+C$, then given the response of the current employer and the optimal layoff rule and since, by assumption, $H>M+F$, the new employer only hires *M*-type workers if the current employer's third period demand is low and $E[\pi^f]=M+F-w^f<0$.

Supposing that $M+F+C<w^f\leq H+C$, then given the response of the current employer and the optimal layoff rule, the new employer hires *M*-type workers independently of the current employer's third period demand, and $E[\pi^f]=M+F-w^f<0$. Supposing that $H+C<w^f\leq H+F+C$, then given the response of the current employer and the optimal layoff rule, the new employer hires *M* type workers, independently of the current employer's demand, and *H* type workers when the current employer's third period demand is low and

$E[\pi^f] = pM + (1-p)\left\{\frac{pb}{a+b}M + \left[\frac{a}{a+b}p + (1-p)\right]H\right\} + F - w^f < 0$. Notice that for

$E[\pi^f]<0$, I need the high-firm-specific productivity increase, *F*, to be sufficiently small. This condition is not binding because of the condition that implies that $W(2,S,m,l)=M+F$ is an equilibrium wage.[2]

Supposing that $H+C+F<w^f$, then given the response of the current employer and the optimal layoff rule, he hires *M*- and H-type workers, independently of the current employer's third-period demand, and $E[\pi^f] = \frac{pb}{a+b}M + \left[\frac{a}{a+b}p + (1-p)\right]H + F - w^f < 0$.

Thus, it is optimal for prospective employers to offer $V(3,S\text{-}S,m,l)=M+F$.

Second, I show that the response function of the current employer is optimal.

Remember that the current employer's best response is to offer a wage, $W(3,S\text{-}S,m^*,l^*)$ such that:

$W(3,S\text{-}S,m^*,l^*) =$ $V^*(3,S\text{-}S,m^*,l^*)$	if	$A+C+F \geq V^*(3,S\text{-}S,m^*,l^*)$ when his third-demand is *high;*
0	if	$A+C+F < V^*(3,S\text{-}S,m^*,l^*)$ when his third-demand is *high;*
$V^*(3,S\text{-}S,m^*,l^*)$	if	$A+C \geq V^*(3,S\text{-}S,m^*,l^*)$ when his third-demand is *low; and*
0	if	$A+C < V^*(3,S\text{-}S,m^*,l^*)$ when his third-demand is *low.*

Thus, his profits on worker *j* are $\pi=\mathrm{Max}\{A^j - V^*(3,S\text{-}S,m^*,l^*),-C\}$.

If he reduces $W(3,S\text{-}S,m^*,l^*)$, he will loose worker *j*. Thus, the above mentioned wage response is optimal, and the resulting wage is a Nash Equilibrium wage.

APPENDIX 3

Definitions of market wages offered to laid-off workers

1. Third-period wage offered to laid-off workers when both types chose unemployment:

$$V^*(3,L-U,1,1) = \frac{(1-a-b+bp)}{(1-a-b+bp)+b(1-p)^2}L + \frac{b(1-p)^2}{(1-a-b+bp)+b(1-p)^2}M + F$$

2. Third-period wage offered to laid-off workers when only M type workers chose unemployment:

---

[1] In this case, the condition on high-demand-firm-specific productivity increase is not binding because of the condition that guaranties that the third-period wage offered to workers displaced through plant-closings is $V^*(3,PC\text{-}W,m^*,l^*)=L+F$, which is $F < \frac{(1-a-b+pb)}{(1-a)}[M-L]+C$.

[2] This condition is $F<p[H-M]+C$. The proof that $W^*(2,S,m,l)=M+F$ is an equilibrium wage is very similar to this proof and thus is omitted.

$$V^*(3,L-U,1,0)=\frac{(1-q)(1-a-b+bp)}{(1-q)(1-a-b+bp)+b(1-p)^2}L+\frac{b(1-p)^2}{(1-q)(1-a-b+bp)+b(1-p)^2}M+F$$

3. Third-period wage offered to laid-off workers when all laid-off workers chose to work during the first period:

$$V^*(3,L-U,0,0)=\frac{(1-a-b+bp)}{(1-a-b+bp)+b(1-p)^2}L+\frac{b(1-p)^2}{(1-a-b+bp)+b(1-p)^2}M+F$$

4. Second-period wage offered to laid-off workers when no one chooses unemployment:

$$V^*(2,L\text{ - }W,0,0)=\left\{\frac{(1-a-b+bp)}{(1-a-b+bp)+(1-p)b}L+\frac{(1-p)b}{(1-a-b+bp)+(1-p)b}M+F\right\}+G^*(2,L-W,0,0)$$

$$G^*(2,L-W,0,0)=\left\{\begin{array}{l} p\dfrac{(1-p)b}{(1-a-b+bp)+(1-p)b}[M-L] \\ +(1-p)\dfrac{(1-p)\beta}{(1-a-b+bp)+(1-p)b}[M-L-F] \\ -(1-p)\dfrac{(1-a-b+bp)}{(1-a-b+bp)+(1-p)b}C \end{array}\right\}$$

APPENDIX 4

Proof of Theorem 1.

Proof that condition (3) is necessary.

Supposing that there is an equilibrium in which some workers prefer to wait unemployed rather than to accept the job right away, then:

$[p+(1-p)\,m]V^*(3,L\text{-}U,m,l)\geq V^*(2,L\,,m,l)+\ V^*(3,L\text{-}W,\ m,l)$ (15)

$lV^*(3,L\text{-}U,m,l)\geq V^*(2,L\,,m,l)+\ V^*(3,L\text{-}W,\ m,l)$ (16)

By definition of $V^*(3,L\text{-}U,m,l)$, I know that $V^*(3,L\text{-}U,m,l)\leq V^*(3,L\text{-}U,1,0)$. By definition of $V^*(2,\ L\,,m,\ l)+\ V^*(3,L\text{-}W,m,l)$, I know that $V^*(2,L\,,m,l)+V^*(3,L\text{-}W,\ m,l)\geq\ V^*(2,L\,,1,\ 0)+\ V^*(3,L\text{-}W,\ 1,\ 0)=2[L+F]-(1-p)C$.

Moreover, since $1>m\geq l$, then $p+(1-p)m>l$. This and (3) yield

$[p+(1-p)q]\ V^*(3,L\text{-}U,1,0)\geq lV^*(3,LU,10)\geq V^*(2,L,m,l)\ +\ V^*(3,L\text{-}W,\ m,l)\geq 2[L+F]-(1-p)C$

and hence inequality (3) follows.

Proof that there is a perfect Bayesian pooling equilibrium in which both types of laid-off workers reject the second period job.

Notice that (4) implies:

$$[p+(1-p)q]\ V^*(3,L-U,1,1) \geq 2[L+F]-(1-p)C. \qquad (17)$$

Suppose that prospective employers offer $V^*(3,L-U,1,1)$ to laid-off workers who were unemployed during period two, and $2[L+F]-(1-p)C$ to laid-off workers who accept a job in period two. Inequalities (4) and (17) say that both types of laid-off workers who get a market job offer at the end of period one choose to reject it and to wait one period unemployed. Supposing that all laid-off workers choose to wait unemployed one period, and observing an out-of-equilibrium employment history of accepting a second-period job by a worker, it is possible that prospective employers believe that they were observing a permanently laid-off worker type. Those beliefs would lead them to offer that worker the following earnings: $2[L+F]-(1-p)C$.

Proof that there is a perfect Bayesian equilibrium in which all temporary layoffs wait unemployed and a proportion λ of permanently laid-off workers who earns offered a job in period two, rejects this offer, while all other workers (who receive an offer) accept it. Suppose (5) is true. Since, from (5), $V^*(3,L-U,1,\lambda)$ ranges from $V^*(3,L-U,1,0)$ to $V^*(3,L-U,1,1)$ and is continuous, there must exist a $\lambda \in [0,1]$ that satisfies (5). Since $q \leq [p + (1-p)\, q]$, I have from (6) that

$$\frac{2[L+F]-(1-p)C}{V^*(3,L-U,1,\lambda)} \leq [p+(1-p)q] \qquad (18)$$

Reordering expression (6) and (15), and recalling that

$$V^*(2,L,1,0)+ V^*(3,L-W,1,0)= 2[L+F]-(1-p)C\,,$$

it is easy to see that they say the following: if prospective employers offer $V^*(3,L-U,1,\lambda)$ to laid-off workers who are unemployed one period and $V^*(2,L,1,0)+L+F$ to laid-off workers who accept the second-period job offer, temporarily laid-off workers will strictly prefer to reject the offer while the permanently laid-off type will be indifferent between rejecting the second period job offer or accepting it. Supposing that all temporarily laid-off workers and a fraction λ of permanently laid-off workers who receive a market job offer at the end of period one reject it, and that all other permanently laid-off workers (who receive an offer) accept it, then prospective employers will offer a wage of $V^*(3,L-U,1,\lambda)$ to laid-off workers who wait one period unemployed and an income of $2[L+F]-(1-p)C$ to workers who accept the second period job. Therefore, the strategies described in the lemma are the equilibrium strategies.

Proof that there is a perfect Bayesian equilibrium in which all temporarily laid-off *workers who receive a second period offer reject it and all permanently laid-off workers accept it.* Expressions (7) and (8) say that if prospective employers offer a wage of *V*(3,L-U,1, 0)* to laid-off workers who are unemployed one period, and an income of *V*(2,L ,1,0)+L+F* to laid-off workers who accept the re-employment wage at the end of period one, then it is optimal for temporarily laid-off workers to reject the second period job offer and for permanently laid-off workers to accept it. Given these workers' equilibrium strategies, prospective employers choose a wage of *V*(3,L-U,1,0)* for laid-off workers who are unemployed during the second period and a wage of *V*(2,L ,1,0)=L+F-(1-p)C* for laid-off workers who work during the second period. Thus, the strategies just described are equilibrium strategies.

The proof that there is a perfect Bayesian equilibrium in which all permanently laid-off workers and some temporarily laid-off workers choose to accept the second period job offered is similar to that of the other hybrid equilibrium described above, and thus omitted.

APPENDIX 5

Example of a fully separating equilibrium.

Suppose that the fraction of *M*-type workers is *b=.5,* and the fraction of *H*-type workers is *a=.25*, and that the productivity of a type *H* worker is 100 units, of a type *M* worker is 30 units, and of a type *L* worker is 8 units. Let us also suppose that the high demand firm-specific productivity increase *F,* is 10 units and the cost of losing a worker *C* is 5 units. Given these parameter values, a fully-separating equilibrium exists if the following four conditions are satisfied:

Condition 1 guaranties that the above wages are equilibrium wages:

1. $p > \frac{1}{14}$

Conditions 2 guaranties that *M*-type workers are not laid-off if the current employer's demand is high:

2. $17(1-q)(.5+p) < 5(1-p)^2$

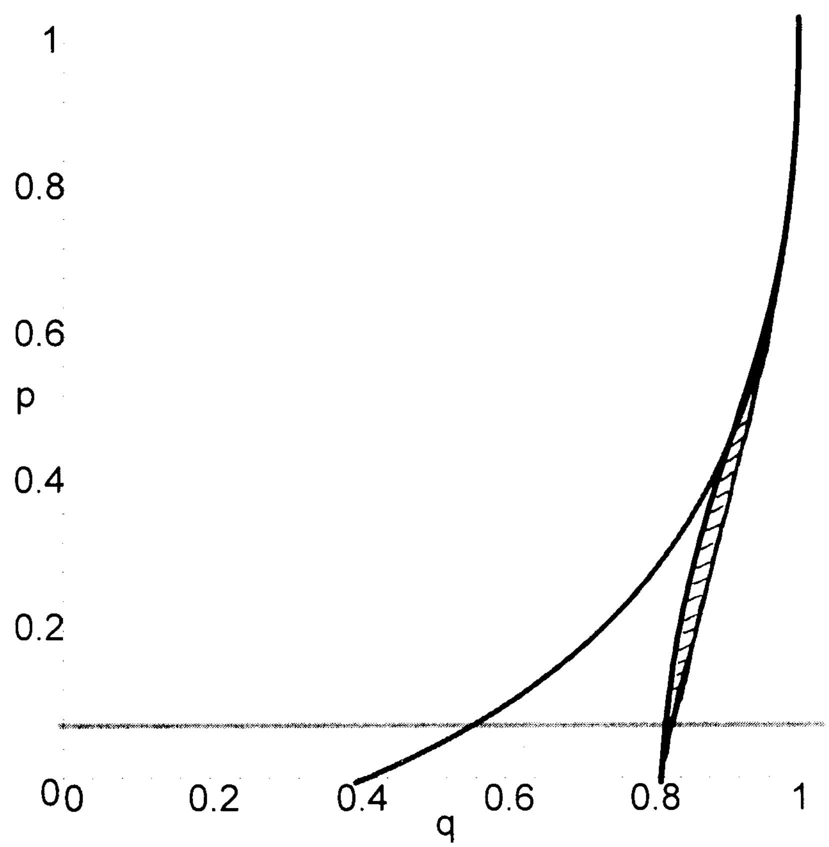
Finally, condition 3 implies that temporarily laid-off workers reject the second period job offered, and condition 4 implies that permanently laid-off workers accept the second period job:

3. $(1-q)(.5+p)[13p+18(1-p)q-31]+(1-p)^2[35p+40(1-p)q-31] \geq 0$

4. $(1-q)(.5+p)[18q-5p-31]+(1-p)^2[40q-5q-31] \leq 0$

In Figure 5, the shaded area shows values of *q* and *p* for which a fully-separating equilibrium

Figure 5: Example of a fully-separating equilibrium.



Fully-separating equilibrium exists in shaded area exists.

APPENDIX 6

Proof of Theorem 2.

Proof that there is always a perfect Bayesian equilibrium in which there is no voluntary unemployment.

First, I need to show that: $V^*(2,L,0,0)+L+F>V^*(3,L-U,0,0)$ (19)

Given the definition of $V^*(3,L-U,0,0)$, when (19) holds the following is also true:

$$G^*(2,L,0,0)+L+F>0 \tag{20}$$

Since $C<F$, *by assumption, and since* $p>0$, *simplifying* $G^*(2,L,0,0)+L+F$ *gives you inequality (20).*

Since $V^*(2,L,0,0)+L+F\geq V^*(3,L-U,0,0)$, I have:

$$V^*(2,L,0,0)+L+F\geq [p+(1-p)q]V^*(3,L-U,0,0) \tag{21}$$

$$V^*(2,L,0,0)+L+F\geq pV^*(3,L-U,0,0) \tag{22}$$

Suppose the market wages are $V^*(2,L,0,0)+L+F$ for laid-off workers who accept a job at the end of period one, and $V^*(3,L-U,0,0)$ for laid-off workers who are unemployed for one period. Then, inequalities (21) and (22) say that (both types of) laid-off workers choose to accept the market job offer at the end of period one. Since all laid-off workers accept the job offer at the end of period one, firms will offer them an income of $V^*(2,L,0,0)+L+F$. It is consistent for prospective employers to believe that if they observe a laid-off worker unemployed during period two, this worker is randomly selected from the pool of laid-off workers. Thus, they offer him a wage $V(3,L-U,0,0)$. Given these wages, the workers' optimal strategies are the ones just described.

APPENDIX 7

Proof of Theorem 3.

Proof that the equilibrium with no voluntary unemployment described in Theorem 2 fails to satisfy the intuitive criterion.

I first show that (11) is sufficient. Inequality (11) can be rewritten

$$V^*(2,L,0,0)+L+F\leq [p+(1-p)q]\ V^*(3,L-U,1,0) \tag{23}$$

and

$$V^*(2,L,0,0)+L+F>\ q\ V^*(3,L-U,1,0) \tag{24}$$

Inequality (24) implies that it is an out-of-equilibrium strategy for a permanently laid-off worker to reject a second-period job, whereas inequality (23) implies that it is not an out-of-equilibrium strategy for a temporarily laid-off worker to reject a second-period job. Thus, if a laid-off worker chooses to wait unemployed, he must be a temporarily laid-off worker. Inequality (23) implies that the equilibrium with no voluntary unemployment fails to satisfy the intuitive criterion.

Inequality (11) is not only a sufficient condition, but also a necessary one. If $V^*(2,L,0,0)+L+F > q\,V^*(3,L-U,1,0)$, then a permanently laid-off worker would not benefit from waiting unemployed one period even when by doing so he would be identified as an M-type laid-off worker. And if $V^*(2,L,0,0)+L+F \leq [p+(1-p)q]V^*(3,L-U,1,0)$ then it would be optimal for a temporarily laid-off worker to reject a second-period offer and wait unemployed one period.

APPENDIX 8

Proof of Theorem 4.

Proof that all equilibrium with some voluntary unemployment satisfy the intuitive criterion.

Since the separating and the two hybrid equilibria do not involve an unreached information set, they satisfy the intuitive criterion. I only need to show that the equilibrium in which all laid-off workers choose to wait unemployed for one period satisfies the intuitive criterion. The only way the intuitive criterion would rule out the equilibrium where everyone chooses to wait unemployed would be if, when observing an out-of-equilibrium action from a worker, prospective employers would believe this worker was temporarily laid-off. However, temporarily laid-off workers have a positive probability of being recalled, this restriction on prospective employers' beliefs is not possible. Thus, when prospective employers observe a worker accepting a second-period offer, they believe that he is a permanently laid-off worker. This will dissuade workers from accepting an offer at the end of period one. □

APPENDIX 9

Proof of Corollary 1.

Proof that if (11) holds, the outcome equilibria that satisfy the intuitive criterion is unique and must be one with voluntary unemployment.

Inequality (11) does not contradict any of the conditions in Theorem 1. Together with Theorems 3 and 4, I know that an equilibrium that satisfies the intuitive criterion must be one with voluntary unemployment. However, I ruled out one of the equilibrium because it did not seem reasonable. Because the other equilibria in Theorem 1 are mutually exclusive, the conclusion follows.

APPENDIX 10

Equilibrium wages for workers displaced through plant closings.

$W^*(3,PC\text{-}U,m^*,l^*)=V^*(3,PC\text{-}U,m^*,l^*)=aH+bM+(1\text{-}a\text{-}b)L+F$

where *PC-U* denotes *Plant-Closing-Unemployed* at the end of period two; and

$V^*(3,PC\text{-}W,m^*,l^*)=L+F$

where *PC-W* denotes *Plant-Closing-Worked* at the end of period two; and

$$V^*(2,PC,m^*,l^*)=[aH+bM+(1-a-b)L]+F$$
$$+P\left(period\ \ 3\ \ demand\ \ is\ \ high\ \ and\ \ worker\ \ stays\ \ end\ \ period\ \ 2|2,PC,m^*,l^*\right)\left[A^*(3,PC-W,m^*,l^*)-L\right]$$
$$+P\left(period\ \ 3\ \ demand\ \ is\ \ low\ \ and\ \ worker\ \ stays\ \ end\ \ period\ \ 2|2,PC,m^*,l^*\right)\left[A^*(3,PC-W,m^*,l^*)-L-F\right]$$
$$-P\left(leaves\ \ end\ \ period\ \ 2|2,PC,m^*,l^*\right)C$$

where *PC* denotes *Plant-Closing* at the end of period one; and *PC-W* denotes *Plant Closing Worked* at the end of period two.

APPENDIX 11

Proof of Proposition 2.

Proof that in the fully-separating equilibria, the re-employment wages of permanently displaced laid-off workers who accept a job at the end of period one are lower than that of observationally equivalent permanently displaced laid-off workers who are unemployed during one period.

Re-ordering equation (7) I have that:

$$2[L+F]-(1-p)C\leq[p+(1-p)q]\ V^*(3,L\text{-}U,1,0). \tag{25}$$

Since $V^*(2,L,1,0)=L+F-(1-p)C$, and $[p+(1-p)q]<1$ and $L>0$ and $F>0$, equation (25) implies that:

$$V^*(2,L,1,0)<2[L+F]-(1-p)C\leq[p+(1-p)q]\ V^*(3,L\text{-}U,1,0)< V^*(3,L\text{-}U,1,0) \tag{26}$$

Inequality (26) says that in the fully-separating equilibrium, the re-employment wage of *permanently displaced* laid-off workers who are unemployed for one period is greater than that of laid-off workers who accept the re-employment wage at the end of period one.

The proof that in the semi-separating equilibrium, the re-employment wages of permanently displaced laid-off workers who accept a job at the end of period one are lower than that of observationally equivalent permanently displaced laid-off workers who are unemployed during one period, is similar to the one described above and thus, omitted.

APPENDIX 12

Proof of Proposition 3.

Proof that at displacement, the re-employment wage of workers displaced through layoffs is lower than that of otherwise observationally equivalent workers displaced through plant closings.

In this model, entry level wages are such that the expected discounted profits the new employer will receive from the employees he hires are zero. Thus,

V(2,L,m,l)= A*(2,L,m,l)+P(stays end of period 2|laid-off)[A*(3,L-W,m,l)-V*(3,L-W,m,l)]- P(leaves end of period 2|laid-off)C*

and

V(2,PC,m,l)= A*(2,PC,m,l)+P(stays end of period 2|plant-closing)[A*(3,PC-W,m,l)-V*(3,PC-W,m,l)]- P(leaves end of period 2|plant-closing)C*

where *P(leaves end of period 2|laid-off)=(1-p)P(A=L|laid-off)* (respectively, *P(leaves end of period 2|laid-off)=(1-p)P(A=L|plant-closing)*) denotes the conditional probability of being a *L* type worker given that you were laid-off at the end of period one and hired by a prospective employer (respectively, given that you were displaced through a plant-closing and hired by a prospective employer at the end of period one).

Whether the new employer hired a laid-off worker or a worker displaced through plant closing at the end of period one, in equilibrium, if his demand falls in period three, he loses all of his *L*-type workers. The odds of having an *L*-type worker if the new employer hired laid-off workers at the end of period one, *P(A=L|laid-off)*, is higher than the odds of having a *L*-type worker if he hired a worker displaced through plant closing *P(A=L|plant-closing)*. Thus:

P(leaves end of period 2|laid-off)>P(leaves end of period 2|plant-closing)

And since *P(stays end of period 2|laid-off)=1- P(leaves end of period 2|laid-off)* (and the same holds for plant-closings), I have that

P(stays end of period 2|laid-off)<P(stays end of period 2|plant-closing)

It is easy to see that the second-period (respectively, third-period) expected productivity of workers displaced through plant closings at the end of period one, *A*(2,PC,m,l)*, (respectively, of workers displaced through plant closings at the end of period one who stayed with the new employer during period two and three, A**(3,PC-W,m,l)*) is *higher* than the second-period (respectively, third-period) expected productivity of *permanently* laid-off workers who accept the re-employment wage at the end of period one, *A*(2,L,m,l)*, (respectively, of *permanently* laid-off workers who accept the re-employment wage at the end of period one and stay with the new employer during periods two and three, *A*(3,L-W,m,l)*). Since *V*(3,PC-W,m,l)=L+F*, which is also the third-period wage offered to workers displaced through layoffs, $V^*(3,L\text{-}W,m,l)$.[3] Thus, the re-employment wage of workers displaced through plant closings, $V^*(2,PC,m,l)$, is greater than that of workers displaced through layoffs, $V^*(2,L,m,l)$.

[3] This is due to adverse selection and to the fact that there is a discrete number of types of workers. In the third period, the market knows that given the current employer's best response, it can only bid-off those workers whose productivity plus the cost of losing a worker, C, is below the market wage. Thus, the market offers a wage equal to $L+F$, and bids off L-type workers when the current employer's demand is low.

APPENDIX 13

Table 13.1.
Gibbons and Katz (1991) earnings equation using the DWS (1988-90-92), males re-employed at survey date.

	Dependent variables♣		
N = 3,186	Weekly earnings Change (1)	Pre-displacement Earnings (2)	Post-displacement Earnings (3)
Layoff	-.056*	.024	-.032
	(.018)	(.016)	(.018)
R-squared	.0870	.3750	.2721

Note: The number in parentheses are standard errors. All regressions use the White estimator of variance. The covariates are: a spline function in previous tenure (with breaks at 1, 2, 3, and 6 years); five dummies for education (one for "less than twelve years completed"; one for "twelve years completed" one for "some college but less than four years of college completed"; one for "college degree but no graduate degree"; and one for "more than four years of college"); eight "year-of-displacement" dummies; "advance notification" dummy; six "previous-industry" dummies; five "previous-occupation" dummies; experience at survey date and its square; a pre-displacement marital statues" dummy; a "non-white" dummy; and four region dummies. Columns (1) and (3) also include three "year of survey" dummies; and a "years since displacement" variable.

♣ Dependent variable: col. 1 = log(current earnings/previous earnings); col. 2 = log (previous earnings deflated by GDP deflator); and col. 3 = log(current earnings deflated by GDP deflator)

* Statistically significant at 5% level.

Table 13.2.

Earnings equation with ten length of displacement dummies using the DWS (1988-90-92), males re-employed at survey date.

	Dependent variables*		
N = 3,186	Weekly earnings Change (1)	Pre-displacement Earnings (2)	Post-displacement Earnings (3)
One week unemployed: α_2	-.014	-.018	-.033
	(.040)	(.041)	(.045)
Two weeks unemployed: α_3	.025	-.018	.007
	(.048)	(.049)	(.047)
Three weeks unemployed: α_4	-.012	.047	.035
	(.056)	(.061)	(.062)
Four weeks unemployed: α_5	-.035	-.046	-.082
	(.045)	(.047)	(.047)
Five-to-eight weeks unemployed: α_6	-.127*	.026	-.101*
	(.043)	(.042)	(.043)
Nine-to-twelve weeks unemployed: α_7	-.103*	-.015	-.119*
	(.045)	(.044)	(.049)
Thirteen-to-twenty-six weeks unemployed: α_8	-.157*	-.023	-.180*
	(.038)	(.038)	(.042)
Twenty-seven-to-fifty-two weeks unemployed: α_9	-.106*	-.066	-.173*
	(.047)	(.041)	(.045)
More than Fifty-two weeks unemployed: α_{10}	-.282*	-.084	-.366*
	(.093)	(.081)	(.080)
Layoff Dummy : β_1	-.072	.021	-.051
	(.048)	(.045)	(.053)
One week unemployed: β_2	-.069	-.004	-.073
	(.076)	(.067)	(.084)
Two weeks unemployed: β_3	-.032	-.022	-.055
	(.072)	(.072)	(.077)
Three weeks unemployed: β_4	-.093	-.131	-.225
	(.088)	(.084)	(.093)
Four weeks unemployed: β_5	.141	-.067	.073
	(.076)	(.072)	(.079)
Five-to-eight weeks unemployed: β_6	.144*	-.047	.097
	(.066)	(.061)	(.071)
Nine-to-twelve weeks unemployed: β_7	.090	.009	.100
	(.068)	(.063)	(.076)
Thirteen-to-twenty-six weeks unemployed: β_8	.053	.036	.089
	(.063)	(.057)	(.067)
Twenty-seven-to-fifty-two weeks unemployed: β_9	-.069	.107	.037
	(.082)	(.068)	(.077)
More than Fifty-two weeks unemployed: β_{10}	-.065	.100	.165
	(.123)	(.106)	(.116)

Table 13.3.

Test of hypothesis from earnings equation with ten length of displacement dummies using the DWS (1988-90-92), males re-employed at survey date.

	Dependent variables		
N = 3,186	Weekly earnings Change	Pre-displacement Earnings	Post-displacement Earnings
R-squared	.1089	.3793	.2894
H_0: $\beta_1=\alpha_2=\alpha_3=\alpha_4=\alpha_5=\alpha_6=\alpha_7=\alpha_8=\alpha_9=\alpha_{10}=\beta_2=\beta_3=\beta_4=\beta_5=\beta_6=\beta_7=\beta_8=\beta_9=\beta_{10}=0$	F(19,3129)=3.98	F(19,3129)=1.14	F(9,3129)=3.97
H_0: $\beta_1+\beta_2=0$	F(1,3129)=5.66	F(1,3129)=.12	F(1,3129)=3.71
H_0: $\beta_1+\beta_3=0$	F(1,3129)=3.66	F(1,3129)=.00	F(1,3129)=3.75
H_0: $\beta_1+\beta_4=0$	F(1,3129)=4.99	F(1,3129)=2.37	F(1,3129)=13.25
H_0: $\beta_1+\beta_5=0$	F(1,3129)=1.27	F(1,3129)=.64	F(1,3129)=.14
H_0: $\beta_1+\beta_6=0$	F(1,3129)=2.41	F(1,3129)=.38	F(1,3129)=.91
H_0: $\beta_1+\beta_7=0$	F(1,3129)=.13	F(1,3129)=.46	F(1,3129)=.81
H_0: $\beta_1+\beta_8=0$	F(1,3129)=.23	F(1,3129)=2.42	F(1,3129)=.84
H_0: $\beta_1+\beta_9=0$	F(1,3129)=4.66	F(1,3129)=6.24	F(1,3129)=.06
H_0: $\beta_1+\beta_{10}=0$	F(1,3129)=.00	F(1,3129)=1.59	F(1,3129)=1.20
H_0: $\beta_1=0$, $\beta_1+\beta_2=0$, $\beta_1+\beta_3=0$, $\beta_1+\beta_4=0$	F(4,3129)=3.99	F(4,3129)=.67	F(4,3129)=5.43
H_0: $\beta_1+\beta_5=0$, $\beta_1+\beta_6=0$, $\beta_1+\beta_7=0$, $\beta_1+\beta_8=0$, $\beta_1+\beta_9=0$, $\beta_1+\beta_{10}=0$	F(6,3129)=1.50	F(6,3129)=1.97	F(6,3129)=.64
H_0: $\beta_2=\beta_3=\beta_4$, $\beta_5=\beta_6=\beta_7=\beta_8=\beta_9=\beta_{10}$	F(7,3129)=1.33	F(7,3129)=1.56	F(7,3129)=.72
H_0: $\beta_2=\beta_3=\beta_4=\beta_5=\beta_6=\beta_7=\beta_8=\beta_9=\beta_{10}$	F(8,3129)=2.60	F(8,3129)=1.58	F(8,3129)=3.00

Note: The numbers in parentheses are standard errors. All regressions use the Huber/White estimator of variance. The covariates are: a spline function in previous tenure (with breaks at 1, 2, 3, and 6 years); five dummies for education (one for less than twelve years completed; one for "twelve years completed;" one for "some college but less than four years of college completed;" one for "college degree but no graduate degree;" and one for "more than four years of college"); "three year of survey" dummies; "years since displacement" dummy; "eight year-of-displacement" dummies; "advance notification" dummy; "six previous-industry" dummies; "five previous-occupation" dummies; experience at survey date and its square; a "marital status in year *t*" dummy; a "non-white" dummy; and "four region" dummies. Column (2) does not include the three "year of survey" dummies and a"years since displacement" variable.
Dependent variable: col. 1 = log(current earnings/previous earnings); col. 2 = log (previous earnings deflated by GDP deflator); and col. 3 = log(current earnings deflated by GDP deflator) .
* Statistically significant at 5% level.

Table 13.4.

Earnings equation using the DWS (1988-90-92), males re-employed at survey date.

	Dependent variables♣		
N = 3,186	Weekly earnings Change (1)	Pre-displacement Earnings (2)	Post-displacement Earnings (3)
Layoff	-.0386	.0240	-.0507*
	(.0229)	(.0166)	(.0231)
Duration of Initial Unemployment Spell	-.0034*		-.0044*
	(.0008)		(.0007)
Layoff x Duration of Initial Unemployment Spell	-.0006		.0020
	(.0012)		(.0011)
R-squared	.1016	.3750	.2851
Layoff	-.0453	.0240	-.0680*
	(.0274)	(.0166)	(.0275)
Duration of Initial Unemployment Spell	-.0064*		-.0084
	(.0020)		(.0019)
(Duration of Initial Unemployment Spell)^2	.00005		.00007
	(.00003)		(.00003)
Layoff x Duration of Initial Unemployment Spell	.0010		.0057
	(.0030)		(.0029)
(Layoff x Duration of Initial Unemployment Spell)^2	-.00003		-.00006
	(.00005)		(.00004)
R-squared	.4913	.3750	.2861
Layoff	-.039	.011	-.059*
	(.029)	(.021)	(.023)
Tenure	-.014*	.016*	.003
	(.002)	(.001)	(.002)
Layoff x Tenure	.0001	.001	.0005
	(.003)	(.002)	(.0044)
Duration of Initial Unemployment Spell	-.003*		-.004*
	(.001)		(.001)
Duration of Initial Unemployment Spell x Tenure	.000009		-.00005
	(.00009)		(.0001)
Layoff x Duration of Initial Unemployment Spell	.00008		.002
	(.001)		(.001)
Layoff x Duration of Initial Unemployment Spell x Tenure	-.00011		-.00010
	(.00014)		(.00016)
R-squared	.1012		.2764

Note: The numbers in parentheses are standard errors. All regressions use the White estimator of variance. The covariates are: a spline function in previous tenure (with breaks at 1, 2, 3, and 6 years); five dummies for education (one for less than twelve years completed; one for "twelve years completed;" one for "some college but less than four years of college completed;" one for "college degree but no graduate degree;" and one for "more than four years of college"); "three year of survey" dummies; "years since displacement" dummy; "eight year-of-displacement" dummies; "advance notification" dummy; "six previous-industry" dummies; "five previous-occupation" dummies; experience at survey date and its square; a "marital status in year *t*" dummy; a "non-white" dummy; and "four region" dummies. Column (2) does not include the three "year of survey" dummies; and a "years since displacement" variable.

♣ Dependent variable: col. 1 = log(current earnings/previous earnings); col. 2 = log (previous earnings deflated by GDP deflator); and col. 3 = log(current earnings deflated by GDP deflator).

* Statistically significant at 5% level.