A Model of Separation Costs, Negative Shocks, and Layoffs

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July 2008

JEL Codes: J63, J65

Abstract: What happens to workers' wages after an "involuntary" separation from a firm? While the current presumption may be that wages fall, empirical estimates show that otherwise identical workers have experienced negative, zero, or positive wage changes. This paper presents a model of imperfect labor markets that illustrates how separation costs and local labor market conditions could potentially explain the wide variation in empirical results without appealing to multiple equilibria. Separation costs prevent efficient labor turnovers. This loss is mitigated when laid-off workers are compensated by severance pay in times of temporary negative shocks or mild recession. As a result, economic conditions determine whether workers are worse off or better off financially after being involuntarily displaced.

The authors thank David Bressoud, Daniel Hamermesh, Peter Orazem, and Margaret Stevens for very helpful discussion and comments. The authors also thank the Keck Foundation for financial support.

Introduction

The question of what happens to workers who are laid off remains an important policy issue. Numerous empirical studies suggest that workers tend to experience declining wages prior to being laid off and that workers are generally worse off (in the sense that they earn persistently lower wages) after being laid off. Prominent U.S. studies include Kuhn and Sweetman (1999), Hamermesh (1989), Marcal (2001), Stevens (1995), Davis and Haltiwanger (1992), Ruhm (1991a and 1991b), Antel (1986), de la Rica (1995), Addison and Portugal (1989), Gibbons and Katz (1991), and Jacobson, LaLonde, and Sullivan (1993a and 1993b). Notable non-U.S. studies include Burda and Mertens (2001), Couch (2001), Doiron (1995), and Eliason and Storrie (2006). These studies provide several possible explanations for wage loss: loss of specific human capital, search cost, signaling effects, loss of wage premiums, and seniority.

Although these studies seem to either be consistent with or have formed the conventional wisdom that wages are lower after being laid off, empirical results suggest that many workers have different experiences. For example, Abbring et al. (2002) find that U.S. workers are neither better nor worse off following displacement in 1996. They also find that workers are better off after being displaced in the Netherlands. Bender et al. (2002) find wage losses of less than 1 per cent in France and Germany. Ruhm (1987) studied the variance of the post-displacement wages and finds a great disparity: even for the unstable 1969-1975 period in the United States, around 40% of the workers are better off after involuntarily leaving their jobs.

Our goal in this paper is to present a model that can explain these varied results. This paper develops a theoretical model that illustrates how the external economic conditions at the time of being laid off can generate a type of hysteresis in worker wages. In the presence of an adjustment cost that is borne by the worker in the event of a voluntary (that is, a worker-initiated) separation, being laid off could generate three possible outcomes: lower, equal, or higher post-displacement wages. We then show how these outcomes depend on the local economic conditions (in time and space) at the time of displacement. Workers who are displaced during locally bad economic times can earn significantly and persistently lower wages after displacement. Workers who are displaced in good times, however, can actually be much better off.

These results clearly beg the question of why these workers who are better off do not voluntarily leave their jobs and take jobs with higher wages. In our model, this result is explained by the presence of a cost to the worker from changing jobs. When workers voluntarily change jobs, they bear this cost. The adjustment cost in essence "traps" the worker into a current job and induces the worker to forego other, higher-paying opportunities. Our model therefore also contributes to the similar, but separate, "job lock" literature.[1] This literature identifies job characteristics, such as health insurance, that would reduce job mobility by increasing the cost to workers from moving. The costs identified in this literature can be considered a sub-set of factors that could be included in our moving cost. Empirical estimates suggest “job lock” reduces mobility by 20% to 40%. Although a few authors such as Monheit and Cooper (1994) and Berger, Black and Scott (2004) question the magnitude of the effect, most[2] agree that these adjustment costs reduce voluntary worker turnover. Our model generates the same result, and shows how this empirically-relevant phenomenon can affect post-displacement wages.

[1] Gruber and Madrian (2002) provide an excellent review of this literature.
[2] Examples include Madrian (1994), Adams (2004), Sanz-de-Galdeano (2006), and Gilleskie and Lutz (2002).

The second stylized fact captured by our model is the prevalence of severance payments. When workers are laid off, the firm bears the adjustment cost in the form of severance payments to the worker. Severance payments are extremely common world-wide and hold either by law or convention. The prevalence of these severance payments is consistent with the idea that there is some cost from switching jobs that is imposed on the worker when the firm releases the worker and that, as the one initiating the change, the firm should bear that cost.[3] Displaced workers are compensated for this cost and are then able and willing to take higher-paying jobs.

The presence of higher paying jobs, however, depends on the local economic conditions that are generally ignored by empirical studies of displacement. In Table 1 we add the local unemployment rate at the time of displacement, the long-run average unemployment rate, and the trend pattern of unemployment to the empirical results found in several prominent studies. This heuristic comparison seems to suggest a negative correlation between the local unemployment rate and the post-displacement wage changes reported in these studies. In the U.S. labor market, estimates of wage losses are highest when unemployment is high (PA, 1984; MA, 1986). When the market is favorable (for example, during 1996-1998), there are insignificant penalties for being laid off. International experience shows in countries with high separation costs (France and Germany) displaced workers tend to lose little if not gain. If a worker is displaced when unemployment is falling, workers also seem to lose less.

For intuitive reasons, most displacement studies focus on periods of significant, wide-spread displacement events in which large-scale plant closures are common. For

[3] In our model, even if we assume that government agency bears the cost, the result will be the same.

example, perhaps the best-known paper in this area, Jacobson, LaLonde, and Sullivan (1993a, henceforth JLS), uses data from Pennsylvania during the peak of very poor economic conditions (see Figure 1, 1980-1985). Although they studied the wage disparity between workers who experienced mass against non-mass layoffs, they do not mention the local market conditions as a possible explanation for their results. In fact, aside from Howland and Peterson (1988), Herz (1990), and Farber (1997), most empirical studies do not account for local labor market conditions.

Local labor market conditions matter because layoffs occur at a non-negligible rate even during booming periods (Davis and Haltiwanger 1992, Davis and Haltiwanger 1999, Helwig 2001). Negative shocks (whether industry-specific or firm-specific), are common in the dynamic modern economy. Although the net rate of job creation is mild, the double-digit rates of job creation and job destruction clearly indicate that layoffs are common both in good and bad times (Davis, Haltiwanger and Schuh, 1996). Given these results, the lack of a formal theoretical analysis of post-displacement wages is surprising.

The model that we develop takes a modest step in this direction by merging two notable studies: McLaughlin (1991) and Stevens (1994). McLaughlin differentiates *quits* (worker-initiated "voluntary" separations) from *layoffs* (firm-initiated "involuntary" separations).[4] We incorporate these definitions and a separation cost into Stevens' (1994) labor market model. Unlike our paper, her focus is on worker training. Her basic model, however, is based on imperfect labor-market competition, which we feel is a more realistic representation than perfect competition and therefore well-suited for this exercise.

Furthermore, her model (and ours) is a model of one-sided search. Several important recent papers highlight the virtues of two-sided search models. One key

[4] These are different from *firings*, which are the result of poor worker performance.

difference between one-sided and two-sided search models is that two-sided search models generally give rise to multiple equilibria, while one-sided search models generally produce a single equilibrium (e.g. Burdett and Wright 1998, Mailath et al. 2000). The result that some people gain and others lose might not be surprising in a model that is likely to generate multiple equilibria. On the other hand, our one-sided search model has the advantages of both relative simplicity and (usually) generating clear predictions about the link between local labor market conditions and post-displacement worker wages.

Our paper presents these results in seven remaining sections. First, we specify the model and formalize definitions. In section 2, we calculate the expected returns to workers and the relevant probabilities. In section 3, we calculate and discuss the effects of four key parameters on the initial results of the model: worker productivity, the adjustment cost, the output price, and the number of firms. In section 4, we derive and discuss the conditions under which workers are better off following a local (negative) economic shock. In section 5, we analyze the implications of a firm-specific price shock. In section 6, we analyze plant closings. We conclude in the final section.

1. A Model of Separation Cost, Wage and Labor Turnover

The goal of this section is to develop a model that illustrates how workers' wages change after separating from the firm. The main features of the model include imperfect competition in the labor market and separation that is costly to the worker. Imperfect competition implies that workers' skills are valued by a limited number of firms in the market (although this number may be large). The separation cost is borne by the worker if the worker voluntarily separates from the firm, but is shifted to the firm when the worker involuntarily leaves the firm due to layoffs through a payment to the worker by the firm (a severance payment).[5]

1.1. The Workers and the Firm

We begin with the assumption that there are many firms and many workers in the labor market. The firms are subject to independent productivity shocks that affect the value of the match between the worker and the firm. As a result, firms are heterogeneous in the sense that they have different values for workers.

The marginal productivity of workers is constant in the sense that the productivity of any worker in any firm is unaffected by the number of other workers employed in that firm. Workers, then, do not compete for jobs. Instead, firms compete for workers in a "Bertrand" manner.

Although the marginal productivity of workers is not affected by the number of workers in the firm, workers differ in their productivity, which is a function of their educational level, training, and working experience (to some degree, location can represent these factors). Without loss of generality, we can then focus on a representative worker. The realized marginal productivity of a representative worker at each firm is described by the vector $\boldsymbol{v} = (v_0, v_1, v_2, \ldots, v_n)$ where v_i is the realized productivity of the worker at the firm $\boldsymbol{i}$. The realized productivity of the worker at firm i is composed of two components: a general component and a firm-specific component. The general

[5] The fact that the severance payments are established either by law or convention differentiates our model somewhat from the implicit contract literature (e.g. Rosen 1985) that might suggest that workers may have different post-displacement wages due to *a priori* beliefs about displacement probabilities and compensating contracts. To the extent that these severance payments are established by law or convention, they are less subject to the kinds of individual variation implied by implicit contracts. Furthermore, as Rosen (1985) points out, contracts increase employment volatility and pre-displacement wages might incorporate the risk of layoff. Nevertheless, exploring our question in the scope of implicit contracts may be a fruitful area for future research.

component is simply the expected value of worker's productivity, ***m*** and is equal in all firms: E (v_i) = $m\,\forall i$ in (1, 2, 3, …, n). The specific component comes from independent and identically-distributed shocks represented by random variables ϵ_i, for i = 0, … , n with mean zero, support [– 1, 1][6] and continuous distribution and density function *F(.)* and *f(.)*. Then: $\boldsymbol{v} = (m+\epsilon_0, m+\epsilon_1, m+\epsilon_2,\dots m+\epsilon_i \dots, m+\epsilon_n)$.

To model labor market competition, we make two assumptions: (1) the productivity vector ***v*** is revealed to the worker at zero cost, and (2) a firm does not know about the worker's productivity at other firms, but once this information is revealed to the firm, it can be verified at zero cost. The first assumption implies that the worker is fully aware of all the outside offers (the search cost is fixed, zero, and occurs with replacement). The second assumption implies that the firm will offer the worker a wage equal to the worker's marginal revenue product (MRP) in any period (t): $W_t = MRP_t = (m+\epsilon_i)*p_t$.

1.2. Timing

The model has three periods. We assume that period 1 represents equilibrium in the sense that workers are well-matched; i.e. there is no incentive for any worker to change jobs or for any firm to adjust wages. In period 1, the whole industry is stable. At the beginning of the period 2, a negative generalized price shock occurs. We initially model this shock as a fall in the product price p_t for every firm. Labor turnover takes place and labor market reaches equilibrium by the end of each period. We are interested in wages (especially for laid-off workers) by the end of period 2. As noted above, the main analysis begins in period 1, which is in a state of equilibrium. To formally illustrate

[6] The support is consistent with the reality that that variance in wages is bounded.

the returns to the three worker types, however, it is helpful to include period 0 (an additional period prior to period 1). At the beginning of period 0, we assume workers are randomly assigned to firms.

1.3. Labor Market Turnover

Labor turnover can be classified into three categories: firings, quits, and layoffs. Firings are separations that are due to poor performance or malfeasance by the worker. We assume that there are no firings. To define quits and layoffs, we turn to McLaughlin (1991). McLaughlin defines quits as separations that occur when the worker receives a higher outside offer that the firm refuses to match. Layoffs occur when the worker refuses the firm-initiated wage cut. Both quits and layoffs are efficient.

In the event of a negative shock, a firm may realize that the worker's marginal revenue product is less than the predetermined wage (W > MRP), motivating the firm to initiate a wage cut in order to meet the lower MRP. If the worker refuses this wage cut, then the worker is laid off.

If switching jobs is costless, the worker in firm 0 will initiate a wage raise when the worker receives an outside offer that is higher than her current wage (that is $W_0 < \text{Max}\{MRP_i\}$). Not willing to pay a wage above the worker's MRP, the firm refuses to pay the higher wage and the worker quits.

1.4. Separation cost

Switching jobs may not be costless. There is a significant literature on the empirical relevance of adjustment costs to firms (Hamermesh, 1993). Meanwhile, there may be significant relocation, learning, psychic, and other adjustment costs to workers that arise from changing jobs. We therefore assume that, from the worker's point of view, it is costly to switch jobs. Without proper compensation workers can get "trapped": workers would prefer not to incur the cost associated with changing jobs. Denote **C** as the monetized value of the separation cost that the worker experiences when separating from the firm: when a worker separates, either through a quit or a layoff, the worker experiences a cost C.[7] To simplify our analysis, we define C as a certain multiple of the output price: $\mathbf{C_t = p_t * A}$. **A** is the real (de-monetized) value of separation cost, which we treat as exogenous. Linking the separation cost to the output price makes the separation cost proportional to the worker's wage, which reflects the fact that higher-paid workers may incur higher separation costs.

The separation cost affects workers' behavior. Realizing the existence of the separation cost, a worker quits only when his new outside wage offer is higher than the sum of his current wage and the separation cost; $W_0 + C < \text{Max}[W_i]$. Otherwise the worker stays. In the presence of the separation cost, first-period equilibrium may be characterized by some workers who are not matched to the highest-valuing firms. That is, some workers may have a higher outside offer, but stay due to the separation cost C. They belong to the category such that, $W_0 < \max [W_i] < W_0 + C$, which is inefficient in the sense that some workers are not matched to the firm that would value them the most.

1.5. Output Market

[7] To mitigate these costs, firms, either by custom or law, often compensate workers who separate involuntarily from firms. Firms do not offer severance payments to workers who quit, since workers voluntarily leave their jobs in the case of a quit.

At time t, all firms in the industry produce homogeneous outputs and sell them at the same price p_t. The output price p is a function of the tariff level $\boldsymbol{\tau}$ and the macroeconomic conditions (e.g aggregate demand), inversely indexed by u_t.[8] Then $\mathbf{p_t = p(\boldsymbol{\tau}_t,} u_t\mathbf{)}$. We assume that a higher tariff and better macroeconomic conditions increase the output price and vice versa. Then $\partial p_t / \partial \tau_t > 0$ and $\partial p_t / \partial u_t < 0$.

2. Effect of a General Negative Shock

We assume that there are two kinds of negative shocks that may lead to worker displacement: general shocks and firm-specific shocks. Examples of general shocks include recession, a fall in aggregate demand, or a drop in tariffs that affects the industry-specific output price. Examples of firm-specific shocks may include poor management, loss of a business partner, or an idiosyncratic response to a general shock. We analyze the general shock in sections 2 through 4 and then analyze the firm-specific shock in section 5.

2.1 Decision Rules

A negative general shock causes the output price to fall from p_1 to p_2 at the beginning of period 2, causing the worker's MRP to fall below her wage. The firms will initiate a wage cut so the adjusted wage equals the new MRP. If the worker is matched to her most productive firm in period 1, then she will accept the wage cut and stay. If the worker was prevented from efficient turnover by the separation cost in period 1, however, then in period 2 she will refuse the wage cut, get laid off, receive the severance payment, and

[8] For example, u_t may represent the unemployment rate, which would be a useful proxy for macroeconomic conditions.

work for her most productive firm. Although it might not be in the firm's best interest to lay off workers because it has to pay for the separation cost, the firm is unable to identify the worker that will refuse the wage cut because the firm lacks information about the complete productivity vector ***v***.

2.2 Wage Effects of Displacement

To illustrate how equilibrium is reached we look back to period 0 when workers are randomly assigned to firms. This assumption is useful simply to help illustrate the initial equilibrium of the model and does not affect the results. From period 0 on, labor market turnover occurs. In order to identify the effects of displacement on wages, we first identify three groups of workers by their status in period 0: Quitters, Trapped, and Stayers. Quitters are workers for whom $p_1 (m+\epsilon_0) + C < p_1(m+\epsilon_{max})$. These workers are able to change jobs prior to the first period. Their outside offer is higher than the sum of their current wage and the separation cost, so they quit. Since we assume that period 1 starts in equilibrium, we assume these workers had already quit and moved and, therefore, start period 1 matched with their most productive firm. As a result, after the negative shock, these workers will accept the wage cut and stay.[9]

Trapped workers are those who fall into the group characterized by $p_1(m+\epsilon_0) < p_1(m+\epsilon_{max}) < p_1(m+\epsilon_0) + C$. That is, the separation cost prevents these workers from quitting in period 1, but in period 2 they are laid off. They would have been more productive at some other firm, but the real separation cost is greater than the difference in productivity. Facing a wage cut in period 2 and compensation from the firm

[9] In other words, the set of quitters in periods 1 and 2 is empty. Anyone who would have quit did so before period 1, leaving no quitters for the first and second periods..

for the separation cost, the worker is able to switch jobs at zero cost. He will certainly get laid off and work for his most productive firm. In other words, the trapped workers are also the workers who are laid off (displaced).

"Stayers" are workers characterized by $p_1(m+\epsilon_0) > p_1(m+\epsilon_{max})$. That is, the worker is matched to the most productive firm in period 0. Through period 1 and period 2, he will not switch jobs. Table 2 contains a summary of these three cases. Denote the wage offer from firm 0 at time t as $W_{0t} = p_t (m+\epsilon_0)$, and the highest wage offer from other firms as $V_t = p_t (m + \epsilon_{max})$.

The expected return to a representative worker is the sum of the expected returns in each state (stayers, trapped, and quitters) times the probability of being in each state. Denote the wages paid with W_{it} (*t* is the time period 0,1,2 and *i* represents the firm), and the three states with **a** (quitters) , **b** (trapped) , and **c** (stayers). Since we define ϵ_0 as a random variable with mean zero, probability density function *f(.)* and cumulative distribution function *F(.)*, it follows for the random variable $\epsilon_{max} = \max \{\epsilon_1, \epsilon_2, \ldots \epsilon_n\}$, the corresponding CDF and PDF are $F_n(.) = F(.)^n$ and $f_n(.) = nf(.)F(.)^{n-1}$. Algebraic manipulation generates several results (details are in the Appendix) that provide the foundation of the paper.

First, we calculate the expected returns to a representative worker in period 1 (R_1):

(1) Return to the worker in period 1:

$R_1 = E[R_1|\mathbf{a}]*\Pr[\mathbf{a}] + E[R_1|\mathbf{b}]*\Pr[\mathbf{b}] + E[R_1|\mathbf{c}]*\Pr[\mathbf{c}]$

$R_1 = E[V_1 - C \mid \mathbf{a}]*\Pr[\mathbf{a}] + E[W_{01} \mid \mathbf{b}]*\Pr[\mathbf{b}] + E[W_{01} \mid \mathbf{c}]*\Pr[\mathbf{c}]$

$$R_1 = E[V_1 - C \mid a]\Pr[a] + E[W_{01} \mid b \cup c]\Pr[b \cup c]$$

Then, applying the appropriate distribution functions generates

Result 1: $$R_1 = p_1(m+1) - \int_{-1}^{1} p_1 F(y) F_n(y+A)dy$$

Next, we calculate the expected returns to a representative worker in period 2.

(2) Return to the worker in period 2:

R_2 = E[R_2 |**a**]*Pr[**a**] + E[R_2|**b**]*Pr[**b**] + E[R_2 |**c**]*Pr[**c**]

R_2 = E [V_2| a]*Pr [a] + E [V_2| b]*Pr [b] + E [W_{02} | c]*Pr [c]

$$R_2 = E[V_2 \mid a \cup b]\Pr[a \cup b] + E[W_{02} \mid c]\Pr[c]$$

Result 2: $$R_2 = p_2(m+1) - \int_{-1}^{1} p_2 F(y) F_n(y)dy$$

Since a key element of the model is the separation cost, it is helpful to calculate the expected returns to a representative worker in period 1 in the absence of a separation cost.

(3) Return to worker in period 1 if there is no separation cost:

I_1 = E [V_1 | a]*Pr [a] + E [V_1| b]*Pr [b] + E [W_{01} | c]*Pr [c]

$$I_1 = E[V_1 \mid a \cup b]\Pr[a \cup b] + E[W_{01} \mid c]\Pr[c]$$

Result 3: $$I_1 = p_1(m+1) - \int_{-1}^{1} p_1 F(y) F_n(y)dy$$

Results (1) and (3) can be combined to calculate the efficiency loss due to the separation cost.

(4) Efficiency loss due to the separation cost C: X = $I_1 - R_1$

Result 4: $$X = I_1 - R_1 = \int_{-1}^{1} p_1 F(x)[F_n(x+A) - F_n(x)]dx$$

This efficiency loss will play a key role in the analysis that follows. The subsequent analysis requires two additional key results. The first is the probability of being laid off.

(5) Probability of being laid off: Pr [layoff] = Pr [b] = Pr [$\epsilon_0 < \epsilon_{max} < \epsilon_0 + A$]

Result 5: $$\Pr[layoff] = \int_{-1}^{1} f(x)\{F_n(x+A) - F_n(x)\}dx$$

Result (5) can then be used to calculate the probability that a worker is better off conditional on being laid off. [10]

(6) Probability of being better off given the worker is laid off:

Pr [Better-off | Layoff] = $\frac{\Pr[BetterOff \ \& \ Layoff]}{\Pr[Layoff]} = \frac{\Pr[BetterOff \cap b]}{\Pr[b]}$

Condition that worker is better off: $p_1 (m+\epsilon_0) < p_2 (m+\epsilon_{max})$.

Then Pr [Better-off | Layoff] = $\frac{\Pr[Better-off \cap b]}{\Pr[b]}$, which leads to

Result 6: Pr [Better-off | Layoff] = $\frac{\int_{-1}^{1} f(x)\{F_n(x+A) - F_n(\frac{p_1}{p_2}x + \frac{p_1 - p_2}{p_2}m)\}dx}{\int_{-1}^{1} f(x)\{F_n(x+A) - F_n(x)\}dx}$

Since we are interested in the change in wages after being laid-off, the last result calculates the return to workers who are laid off.

(7) Return to the laid-off workers:

E [R_2|Layoff] =E [$p_2 (m+\epsilon_{max})$ | layoff] = $\frac{E[R_2 \mid layoff]\Pr[layoff]}{\Pr[layoff]}$

E [R_2|Layoff] = $\frac{E[R_2 \mid b]\Pr[b]}{\Pr[b]}$.

Result 7: $$R[layoff] = \frac{\int_{-1}^{1} p_2(m+x) f(x)\{F_n(x+A) - F_n(x)\}dx}{\int_{-1}^{1} f(x)\{F_n(x+A) - F_n(x)\}dx}$$

Results 1-7 above provide the foundation of the model. In the next section, we consider how these results vary with the key exogenous variables in the model.

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[10] Alternatively $\Pr[layoff] = -\int_{-1}^{1} F(x)\{\log F(x+A) * F_n(x+A) - \log F(x) * F_n(x)\}dx$

3. Dependence of returns on the parameters (*m*, *A*, p_t, *n*)

3.1. The average marginal product, *m*

The parameter ***m*** represents the expected value of worker's marginal productivity in real terms. One way to think about variation in ***m*** would be to let ***m*** capture regional differences. In this model, it simply shifts the distribution of values in vector ***v*** up or down for all (n+1) firms.

Proposition* 1** As the average product ***m increases, **i)** the return to all workers increases and the marginal benefit of a one-unit increase in ***m*** is equal to the output price per unit in that period; **ii)** the efficiency loss in period 0 does not change; **iii)** the probability of being laid off is not affected; i**v)** the return to laid-off worker increases; **v)** the probability of being better off given the worker is laid off after the shock is decreasing.

Proof:

i) $\frac{\partial R_1}{\partial m} = \frac{\partial I_1}{\partial m} = p_1 > 0$; $\quad \frac{\partial R_2}{\partial m} = p_2 > 0$;

ii) $\frac{\partial X}{\partial m} = 0$

iii) $\frac{\partial \Pr[layoff]}{\partial m} = 0$

iv) $$\frac{\partial R[layoff]}{\partial m} = \frac{\int_{-1}^{1} p_2 f(x)\{F_n(x+A) - F_n(x)\}dx}{\int_{-1}^{1} f(x)\{F_n(x+A) - F_n(x)\}dx} = p_2 > 0$$

v) $$\frac{\partial \Pr[betterOff \mid layoff]}{\partial m} = \frac{\partial}{\partial m} \frac{\int_{-1}^{1} f(x)\{F_n(x+A) - F_n(\frac{p_1}{p_2}x + \frac{p_1 - p_2}{p_2}m)\}dx}{\int_{-1}^{1} f(x)\{F_n(x+A) - F_n(x)\}dx}$$

$$\frac{\partial \Pr[BetterOff \mid Layoff]}{\partial m} = -\frac{\int_{-1}^{1} \frac{p_1 - p_2}{p_2} f(x) f_n(\frac{p_1}{p_2} x + \frac{p_1 - p_2}{p_2} m) dx}{\int_{-1}^{1} f(x)\{F_n(x+A) - F_n(x)\} dx} < 0 \quad \square$$

Parts ii and iii of this proposition imply that the existence of the efficiency loss (due to the separation cost) is not affected by the level of ***m***. In Part iv the returns to the laid off worker are higher simply because they are more productive. That is, their wages are higher before and after the shock than less-productive workers. Given that result, Part v, which states that the probability of being better off after the shock is falling in ***m***, seems to be counter-intuitive. The difference is the frame of reference. Part iv compares more productive workers to less productive workers. Part v compares more productive workers before the shock to the same workers after the shock. In part v, the higher ***m*** is, the more severe the damage $(p_1 - p_2)m$ the price shock will cause to the worker, reducing the chance that they will be better off after the shock. In other words, more productive workers potentially have more to lose from being laid off.

3.2. The "real value" of the separation cost A

In practice, the separation cost is taken to have a monetary value. Workers care about the real, rather than the nominal, value of this separation cost. Therefore, we perform the analysis using the real value of the separation cost, which is the nominal value of the separation cost divided by the price level.

***Proposition* 2** When the real separation cost **A** increases, **i)** the return to the worker decreases when the separation cost exists (in period 1); **ii)** the return to the worker does not change when firm 0 pays the separation cost to the worker; **iii)** the efficiency loss increases; **iv)** the probability of being laid off increases; **v)** the probability of being better off given the worker is laid off increases.

Proof:

i). $\frac{\partial R_1}{\partial A} = -\int_{-1}^{1} p_1 F(y) f_n(x+A)dy < 0$

ii). $\frac{\partial R_2}{\partial A} = 0$; $\frac{\partial I_1}{\partial A} = 0$

iii). $\frac{\partial X}{\partial A} = \int_{-1}^{1} p_0 F(y) f_n(y+A)dy > 0$

Together, parts i, ii, and iii of Proposition 2 illustrate the inefficiency introduced by the separation cost. The separation cost makes workers worse off, but the payment to the workers by the firm effectively compensates the workers for the loss. This is consistent with the widespread practice of severance payments. Nevertheless, as the cost increases, the efficiency loss increases.

iv). $\frac{\partial \Pr[layoff]}{\partial A} = \int_{-1}^{1} f(x) f_n(x+A)dx > 0$

Figure 2 is a Mathematica® generated plot Pr[layoff] against the number of firms when the separation costs are 0.5, 0.8, 1, 1.2, and 1.4 respectively, given that the random variables are uniformly distributed. We can see that as A increases, the whole probability curve shifts up.

v). Applying the quotient rule generates this result:

$$\frac{\partial \Pr[BetterOff \mid Layoff\,]}{\partial A} = \frac{\int_{-1}^{1} f(x) f_n(x+A)dx * (\int_{-1}^{1} f(x)\{F_n(\frac{p_1}{p_2}x + \frac{p_1 - p_2}{p_2}m) - F_n(x)\}dx}{(\int_{-1}^{1} f(x)\{F_n(x+A) - F_n(x)\}dx)^2} > 0$$

□

Together, results iii, iv, and v of proposition 2 illustrate the inefficiency introduced by the separation cost. The presence of the separation cost reduces the worker's incentive to correct bad matches on their own: workers are less likely to quit. Furthermore, it increases the probability of layoffs, which are more likely as match quality falls, and increases the probability that workers are better off after being laid off.

3.3. The product prices before and after shocks: p_1 and p_2

***Proposition* 3.a.** As the product price increases **i)** the return to the worker in respective period increases; **ii)** the efficiency loss increases in period 0; **iii)** the probability of being laid off does not change; **iv)** the return to the laid-off worker increases.

Proof

i) $\frac{\partial R_1}{\partial p_1} = (m+1) - \int_{-1}^{1} \{F(y)F_n(x+A)\}dy > 0$

$$\frac{\partial R_2}{\partial p_2} = (m+1) - \int_{-1}^{1} F(y)F_n(y)dy > 0$$

$$\frac{\partial I_1}{\partial p_1} = (m+1) - \int_{-1}^{1} F(y)F_n(y)dy > 0$$

ii). $\frac{\partial (I_1 - R_1)}{\partial p_1} = \int_{-1}^{1} F(y)[F_n(x+A) - F_n(y)]dy > 0$

iii). $\frac{\partial \Pr[layoff]}{\partial p_1} = \frac{\partial \Pr[layoff]}{\partial p_2} = 0$

iv). $\frac{\partial R[layoff]}{\partial p_2} = \frac{\int_{-1}^{1} (m+x) f(x)\{F_n(x+A) - F_n(x)\}dx}{\int_{-1}^{1} f(x)\{F_n(x+A) - F_n(x)\}dx} > 0$

***Proposition* 3.b. i)** As the pre-shock product price $\mathbf{p_1}$ increases, the probability of being better off given the worker is laid off decreases; **ii)** As the post-shock product price $\mathbf{p_2}$ falls (that is, the shock is more severe), the probability of being better off given the worker is laid off falls.

Proof

i). $\frac{\partial \Pr[BetterOff \mid Layoff]}{\partial p_1} = \frac{\partial}{\partial p_1}\left(\frac{\int_{-1}^{1} f(x)\{F_n(x+A) - F_n(\frac{x+m}{p_2} p_1 - m)\}dx}{\int_{-1}^{1} f(x)\{F_n(x+A) - F_n(x)\}dx}\right)$

$$\frac{\partial \Pr[BetterOff \mid Layoff]}{\partial p_1} = \frac{-\int_{-1}^{1} \frac{x+m}{p_2} f(x) f_n(\frac{x+m}{p_2} p_1 - m)\}dx}{\int_{-1}^{1} f(x)\{F_n(x+A) - F_n(x)\}dx} < 0$$

ii). $\frac{\partial \Pr[BetterOff \mid Layoff]}{\partial p_2} = \frac{\partial}{\partial p_2}\left(\frac{\int_{-1}^{1} f(x)\{F_n(x+A) - F_n(\frac{p_1}{p_2} x + \frac{p_1 - p_2}{p_2} m)\}dx}{\int_{-1}^{1} f(x)\{F_n(x+A) - F_n(x)\}dx}\right)$

$$\frac{\partial \Pr[BetterOff \mid Layoff]}{\partial p_2} = \frac{\int_{-1}^{1} f(x)[-\frac{p_1(x+m)}{p_2{}^2}] * [-f_n(\frac{p_1}{p_2}(x+m) - m)]dx}{\int_{-1}^{1} f(x)\{F_n(x+A) - F_n(x)\}dx}$$

$$= \frac{\int_{-1}^{1} f(x) \frac{p_1(x+m)}{p_2{}^2} * f_n(\frac{p_1}{p_2}(x+m) - m)dx}{\int_{-1}^{1} f(x)\{F_n(x+A) - F_n(x)\}dx} > 0$$

The higher the post-shock price, the more likely that the worker will be better off after being laid off. It is important to remember at this point that these product prices apply to all firms. A "bad" shock that affects all firms increases the likelihood that workers will be worse off, which is reminiscent of the JLS study of Pennsylvania during a recession.

□

Part i) and ii) of Proposition 3.b are two sides of the same coin: the greater (the more negative) the price shock is, the more likely that the laid-off worker is going to be worse off.   This is a very intuitive result that illustrates how the post-displacement experience depends on economic conditions.

3.4. The number of firms in the market, *n*

The amount of economic activity at one place may be characterized by the number of firms, ***n.*** In a model of imperfect labor market competition (e.g. Stevens 1994), the number of firms plays a very important role. When there is only one firm, the firm has monopsony power over wages. As the number of firms increases, so does labor market competition, and the power that any given firm has over wages falls. This competition causes wages to increase as the number of firms increases.

Proposition **4.a.** As the number of firms in the industry ***n*** increases, the returns to the worker increase.

Proof

$$\frac{\partial R_1}{\partial n} = -\int_{-1}^{1} p_1 \log[F(x+A)] * F(y) F_n(x+A) dy > 0$$

$$\frac{\partial I_1}{\partial n} = -\int_{-1}^{1} p_0 \log[F(y)] * F(y) F_n(y) dy > 0$$

$$\frac{\partial R_2}{\partial n} = -\int_{-1}^{1} p_1 \log[F(y)] * F(y) F_n(y) dy > 0$$

□

If we investigate the wage an average worker will get in the industry at place j, then it seems that the amount of economic activity (the number of firms) matters in the sense that increasing the number of firms will increase the worker's pay. If we study the laid off group, however, many things are unclear. Specifically, the direct effects (derivatives) with respect to *n* are difficult to sign. We can, however, determine the signs of the second derivatives: the effects of the other exogenous variables on the effect that *n* has on our endogenous variables.

Proposition 4.b The marginal returns on *n* to X and Pr [layoff] decreases in A for *n* sufficiently large.

Proof

$$\frac{\partial X}{\partial n} = \int_{-1}^{1} p_1 F(x)[\log[F(x+A)] F_n(x+A) - \log[F(x)] F_n(x)] dx$$

$$\frac{\partial \Pr[layoff]}{\partial n} = \int_{-1}^{1} f(x) \{\log[F(x+A)] F_n(x+A) - \log[F(x)] F_n(x)\} dx$$ [11]

[11] Alternatively, $\frac{\partial \Pr[layoff]}{\partial n} = -\int_{-1}^{1} F(x)\{\log^2 F(x+A) * F_n(x+A) - \log^2 F(x) * F_n(x)\} dx$.

$\frac{\partial X}{\partial n}$ and $\frac{\partial \Pr[layoff]}{\partial n}$ are of the similar form:

$$G(A,n) = \int_{-1}^{1} M\{\log[F(x+A)]F_n(x+A) - \log[F(x)]F_n(x)\}dx \text{ where M > 0}$$

$$\frac{\partial}{\partial A}G(A,N) = \frac{\partial}{\partial A}\int_{-1}^{1} M\{\log[F(x+A)]F_n(x+A) - \log[F(x)]F_n(x)\}dx$$

$$\frac{\partial}{\partial A}G(A,N) = \int_{-1}^{1} Mf(x+A)F(x+A)^{n-1}\cdot(1+n\log[F(x+A)])dx$$

It follows that there exists an integer **N** such that $\frac{\partial^2(X)}{\partial n \partial A} < 0$ and $\frac{\partial^2 \Pr[layoff]}{\partial n \partial A} < 0$ for all ***n*** > **N** (see **Proposition 4.d**).

***Proposition* 4.c** As $n \rightarrow +\infty$, **i)** For A that is greater than the range of the random variable ϵ_i, the efficiency loss approaches some fixed positive value and the probability of being laid off approaches 1; **ii)** For A that is less than the range of the support of the random variable, the efficiency loss and the probability that the worker gets laid off approach some fixed value depending on F(.) and A. Furthermore, $\frac{d}{dA}\lim_{n\rightarrow+\infty}\Pr[layoff] > 0$ and $\frac{d}{dA}\lim_{n\rightarrow+\infty} X > 0$

Proof

i) If A > 2, then Min{x + A} > 1, x+A>1 for all x in [-1,1], implying that $F_n(x+A) = 1$.

We also know that $\lim_{n\rightarrow+\infty} F_n(x) = \begin{cases} 0 & x < 1 \\ 1 & x = 1 \end{cases}$

$$\lim_{n\to+\infty} X = \lim_{n\to+\infty} \int_{-1}^{1} p_1 F(x)[F_n(x+A) - F_n(x)]dx$$
$$= \lim_{n\to+\infty} \int_{-1}^{1} p_1 F(x)(1 - F_n(x))dx$$
$$= \lim_{\substack{n\to+\infty \\ \varepsilon\to 0^+}} (\int_{-1}^{1-\varepsilon} p_1 F(x)(1 - F_n(x))dx + \int_{1-\varepsilon}^{1} p_1 F(x)(1 - F_n(x))dx)$$
$$= \int_{-1}^{1-\varepsilon} p_1 F(x)dx + \int_{1-\varepsilon}^{1} p_1 F(x)(1-1)dx$$
$$= \int_{-1}^{1} p_1 F(x)dx$$

$$\lim_{n\to+\infty} \Pr[layoff] = \lim_{n\to+\infty} \int_{-1}^{1} f(x)\{F_n(x+A) - F_n(x)\}dx$$
$$= \lim_{\substack{n\to+\infty \\ \varepsilon\to 0^+}} \int_{-1}^{1-\varepsilon} f(x)[1 - F_n(x)]dx + \lim_{\substack{n\to+\infty \\ \varepsilon\to 0^+}} \int_{1-\varepsilon}^{1} f(x)[1 - F_n(x)]dx$$
$$= \int_{-1}^{1} f(x) * [1-0]dx = 1$$

To illustrate this result, Figure 3a plots Pr [layoff] against the number of outside offers with A = 2.5, given the random variable is normal distributed with mean 0 and standard deviation 0.5. As ***n*** increases, the probability of being laid off increases.

ii) If 0 < A < 2, then $\lim_{n\to+\infty} F_n(x+A) = 0$ for $x < 1 - A$ & $\lim_{n\to+\infty} F_n(x) = 0$

$$\lim_{n\to+\infty} X = \lim_{n\to+\infty} \int_{-1}^{1} p_1 F(x)[F_n(x+A) - F_n(x)]dx$$
$$= \lim_{n\to+\infty} [\int_{-1}^{1-A} p_1 F(x)[F_n(x+A) - F_n(x)]dx + \int_{1-A}^{1} p_1 F(x)[F_n(x+A) - F_n(x)]dx]$$
$$= 0 + \int_{1-A}^{1} p_1 F(x)[1 - \lim_{n\to+\infty} F_n(x)]dx$$
$$= \int_{1-A}^{1} p_1 F(x)dx$$

$$\frac{d}{dA} \lim_{n\to+\infty} X = \frac{d}{dA} \int_{1-A}^{1} p_1 F(x)dx > 0$$

$$\lim_{n\to+\infty} \Pr[layoff] = \lim_{n\to+\infty} [\int_{-1}^{1-A} f(x)\{F_n(x+A) - F_n(x)\}dx + \int_{1-A}^{1} f(x)\{F_n(x+A) - F_n(x)\}dx]$$
$$= \int_{-1}^{1-A} f(x)\{0-0\}dx + \lim_{n\to+\infty} \int_{1-A}^{1} f(x)\{1 - F_n(x)\}dx$$
$$= \int_{1-A}^{1} f(x)dx = F(1) - F(1-A) = 1 - F(1-A)$$

Furthermore, $\dfrac{d}{dA}\{1-F(1-A)\} = f(1-A) > 0$

To illustrate this result, Figure 3b contains a plot of Pr [layoff] against the number of outside offers with A = 0.7, given that the random variable is normally distributed with mean 0 and standard deviation 0.3.

***Proposition* 4.d** There exists a $N \in \aleph$ such that $\frac{\partial \Pr[layoff]}{\partial n} < 0$ and $\frac{\partial X}{\partial n} < 0$ when n > N.

Proof: $\Pr[layoff] = \int_{-1}^{1} f(x)\{F_n(x+A) - F_n(x)\}dx$

$$\frac{\partial \Pr[layoff]}{\partial n} = \int_{-1}^{1} f(x)[\log[F(x+A)]F_n(x+A) - \log[F(x)]F_n(x)]dx$$

Let $\phi(x,n) = \log[F(x)]F_n(x)$,

$$\frac{\partial \phi}{\partial x} = (1 + n\log[F(x)])f(x)F(x)^{n-1}$$

The Archimedean principle implies that there exists some integer **N** such that for all n > **N**, $n\{-\log F(x)\} > 1$, which is equivalent to $[1 + n\log F(x)] < 0$. Thus, there always exists a natural number **N** such that $\dfrac{\partial \Pr[layoff]}{\partial n} < 0$ for all n > N. That means that the probability of layoff will eventually decrease as the number of firms gets bigger.

Figure 3c plots Pr [layoff] against the number of the firm when the separation costs are 0.1, 0.5, 1, 1.5 and 2 respectively. We use a normally distributed random variable with mean 0 and standard deviation 0.5 to do the simulation. The intuition behind this result is that increasing the number of firms will increase the probability that the worker is well-matched initially. The main implication of this result would be seen in cross-country comparisons, as adjustment costs would likely be similar within a given country. Conditional on the same shock, countries with higher adjustment costs may be more likely to experience layoffs in areas with greater economic activity.

4. When does getting laid off make you better off?

We are now prepared to identify the conditions under which workers would be better off following displacement. The worker in a particular industry at certain place is better off after the negative shock if and only if $R_2 > R_1$ because we use the wage (represented here as R) as the sole measure of the worker's welfare.[12] The condition $R_2 > R_1$ is equivalent to

$$p_1\{(m+1) - \int_{-1}^{1} F(y)F_n(y+A)dy\} < p_2\{(m+1) - \int_{-1}^{1} F(y)F_n(y)dy\}$$

$$p_2 > p_1 \frac{(m+1) - \int_{-1}^{1} F(y)F_n(y+A)dy}{(m+1) - \int_{-1}^{1} F(y)F_n(y)dy}$$

Let $\omega = \frac{(m+1) - \int_{-1}^{1} F(y)F_n(y+A)dy}{(m+1) - \int_{-1}^{1} F(y)F_n(y)dy}$ and we know that $0 \le \omega \le 1$.

We therefore know that whether or not the worker is better off or worse off depends on how bad the negative price shock is. As long as p_2 is above ω p_1, the worker is going to be better off. As ω increases, the worker is more vulnerable to negative price shock. In other words, if the price shock affects all firms, and it is not too large, then the chance that the worker will be better off after moving is higher. The intuition for this is

[12] There are two important points to make about this assumption. First, we fully recognize that we are not measuring utility and, therefore, we may be missing factors for which there may be compensating differentials. Second, however, most studies in this literature use the wage as at least the primary, if not the only, measure of worker well-being. In other words, our problematic use of the wage as a measure of worker well-being is consistent with the literature.

also straightforward: a worker is more likely to be able to find a firm paying higher wages if the other firms did not experience "too great" of a price shock.

Proposition **5** Let ω(m, A, n) represent the vulnerability in response to negative shocks. Then the following conditions hold:

i) $\frac{\partial \omega}{\partial m} > 0$, $\frac{\partial^2 \omega}{\partial m^2} < 0$, $\frac{\partial^2 \omega}{\partial m \partial A} > 0$, and

ii) $\frac{\partial \omega}{\partial A} < 0$, $\frac{\partial^2 \omega}{\partial A \partial m} > 0$.

Proof

i). $$\frac{\partial \omega}{\partial m} = \frac{[(m+1) - \int_{-1}^{1} F(y) F_n(y) dy] - [(m+1) - \int_{-1}^{1} F(y) F_n(y+A) dy]}{[(m+1) - \int_{-1}^{1} F(y) F_n(y) dy]^2}$$

$$\frac{\partial \omega}{\partial m} = \frac{\int_{-1}^{1} F(y)[F_n(y+A) - F_n(y)] dy}{[(m+1) - \int_{-1}^{1} F(y) F_n(y) dy]^2} > 0$$

$$\frac{\partial^2 \omega}{\partial m^2} = -\frac{2\int_{-1}^{1} F(y)[F_n(y+A) - F_n(y)] dy}{[(m+1) - \int_{-1}^{1} F(y) F_n(y) dy]^3} < 0$$

ii). $$\frac{\partial \omega}{\partial A} = \frac{-\int_{-1}^{1} F(y) f_n(y+A) dy}{(m+1) - \int_{-1}^{1} F(y) F_n(y) dy} < 0$$

$$\frac{\partial^2 \omega}{\partial m \partial A} > 0$$ (Obvious.)

□

In places where the workers' productivity (***m***) is high, the workers are more vulnerable to price shocks. The intuition behind this is simply that high-wage workers have more to lose from being displaced. On the other hand, in places where the separation cost is high, the workers are less vulnerable to negative price shocks. In other words, higher adjustment costs mitigate the risk of economic fluctuations for workers at the cost of economic efficiency.

5. Implications of firm-specific price shock

Davis, Haltiwanger, and Schuh (1996) show that, during both bad and good times, firms are constantly expanding and contracting. Up to this point we have assumed that a given price shock affects all firms because all firms charge the same price in the output market. If there is variation in firm-specific prices, then firms may be susceptible to firm-specific price shocks. Examples include deals that are made or fail or even very specific trade agreements that affect prices of a very limited number of firms within broadly-defined industries. In this case, the output price that firm i charges at time t can be represented as $p_{t,i} = F(\tau_t, u_t, \sigma_i)$ where σ_i is firm-specific shock that affects firm ***i*** . $p_{t,i} = \pi_t + \pi_i$ where π_t is the economy and industry wide component and π_i is the firm specific shock. We now consider a particular example in which

(i) $\Delta\pi_t = 0$ and $\Delta\pi_i < 0$ for firm 0; and

(ii) $\Delta\pi_j = 0$ for all other firms $j \neq i$.

In these conditions, firm ***0*** gets a negative firm specific shock that results in the fall of the price of its output from p_1 to p_2, while all the other firms can still sell their product at the price p_1. Only firm ***0*** will lower its worker's wages to the new level $p_2(m + \epsilon_0)$ while all the other firms pay worker at the same rate as before. Then the worker in firm ***0*** will stay as long as $p_2(m + \epsilon_i) > p_1(m + \epsilon_{max})$, and they will be laid off only if $p_2(m + \epsilon_i) < p_1(m + \epsilon_{max})$. In this case, people in condition **b** will definitely be better off because they get paid at $p_1(m + \epsilon_{max})$ instead of $p_2(m + \epsilon_i)$ or $p_1(m + \epsilon_i)$. People in condition c, however, will vary. Some of them will choose to be laid off while others will accept the new wage and stay. The condition for workers in group **c** to be laid off is $p_2(m + \epsilon_0) < p_1(m + \epsilon_{max}) < p_1(m + \epsilon_1)$. For this sub-group, before the price falls, the worker already works for the firm where they had the highest productivity (firm 0). After the shock, they work for a firm in which they had the second highest productivity but highest marginal revenue product (productivity times price). As a result, they will be worse off than before they were laid off, and better off than if they had experienced an industry-wide shock.

Displaced workers are better off iff

$p_1(m+\epsilon_{max}) < p_1(m+\epsilon_1) + C$, and (ii) $p_2(m + \epsilon_i) < p_1(m + \epsilon_{max})$.

The probability that the worker gets laid off given the shock is firm specific:

$$\Pr[layoff \mid Firm - Specific] = \iint\limits_{x+A>y>\frac{p_2}{p_1}x-\frac{p_1-p_2}{p_1}m} f(x) f_n(y) dxdy$$

$$= \int_{-1}^{1} f(x)\{F_n(x+A) - F_n(\frac{p_2}{p_1}x - \frac{p_1 - p_2}{p_1}m)\}dx$$

Since $\Pr[layoff \mid industry - wide] = \int_{-1}^{1} f(x)\{F_n(x+A) - F_n(x)\}dx$, it follows that

$\Pr[layoff \mid Firm - Specific\ shock] > \Pr[layoff \mid industry - wide\ shock]$. As a result, the negative firm-specific price shock will create a larger scale (at the firm level), but less frustrating, layoff than the negative industry-wide price shock. In other words, if workers are in a region in which overall economic conditions are good, but their particular firm experiences a negative shock, then they are much more likely to experience positive post-displacement wages.

6. Plant Closings

In Sections 1 through 5, we assume that before and after the negative price shock, no firms close down. That analysis is important because it helps us to focus on the role of separation cost and general economic conditions. In reality, however, facing severe economic hardships, firms shut down. That means in period 2, the number of firms falls from **n** to **n'.** If there is no shock, the wage the worker should have been paid is

$$R' = p_1(m + 1 - \int_{-1}^{1} F(y)F_n(y + A)dy)$$

It follows immediately from previous steps that $\frac{\partial R'}{\partial P} > 0$, $\frac{\partial R'}{\partial A} < 0$ and $\frac{\partial R'}{\partial n} > 0$. If P, A, and n change simultaneously, then $dR' = \frac{\partial R'}{\partial P}dp + \frac{\partial R'}{\partial A}dA + \frac{\partial R'}{\partial n}dn$.[13]

[13] Where dA = -A. From period 1 to period 2, separation cost is compensated by means of severance payment. So separation cost decreases from A to 0.

Since n' < n, then $\frac{\partial R'}{\partial n} dn = \frac{\partial R'}{\partial n}(n' - n) < 0$. As a result, in bad years or severe localized shocks (with many plant closings), workers are more likely to be worse off. This is again consistent with JLS.

Another approach would be to use notation similar to that used in section two. Facing decline in number of firms from n to n', the worker is better off iff

$$p_1\{(m+1) - \int_{-1}^{1} F(y)F_n(y+A)dy\} < p_2\{(m+1) - \int_{-1}^{1} F(y)F_{n'}(y)dy\}$$, which implies

$$p_2 > p_1 \frac{(m+1) - \int_{-1}^{1} F(y)F_n(y+A)dy}{(m+1) - \int_{-1}^{1} F(y)F_{n'}(y)dy}.$$

Let $\varpi = \frac{(m+1) - \int_{-1}^{1} F(y)F_n(y+A)dy}{(m+1) - \int_{-1}^{1} F(y)F_{n'}(y)dy}$. We know that $0 \le \omega \le 1$. Then,

$$\frac{\partial \varpi}{\partial n'} = \int_{-1}^{1} F(y) * \log(F(y)) * F_{n'}(y)dy * \frac{(m+1) - \int_{-1}^{1} F(y)F_n(y+A)dy}{[(m+1) - \int_{-1}^{1} F(y)F_{n'}(y)dy]^2} < 0.$$

As n' decreases, then ϖ increases and the worker is more vulnerable to the price shocks.

7. Conclusions

Empirical estimates of wages after displacement vary widely, and there has been little theoretic work that attempts to explain this dispersion. This paper presents a model of imperfect competition that illustrates how local labor market conditions may affect post-displacement wages. In particular, this paper identifies the conditions in which workers may be better off following an involuntary separation from their firm, and also identifies conditions in which workers would be worse off.

A very heuristic review of the economic conditions surrounding the displacement events found in leading studies suggests a pattern that seems to be consistent with our results. Perhaps the leading paper in this literature, JLS, studies the effects of displacement on workers in Pennsylvania during a national recession. To the extent that these conditions are analogous to a large general shock in our model, their finding of negative post-displacement wages is expected. On the other hand, studies of displacement in the United States during better economic conditions, such as Helwig (2001) find no significant effect of displacement on wages. Furthermore, studies that directly contrast different economic conditions at the time and place of displacement (e.g. Kaplan, Martinez, and Robertson 2005) find patterns of post-displacement wages that are consistent with the predictions of our model: workers laid off in good times or areas with more economic activity are more likely to have higher post-displacement wages.

As intuitive as the results of this model may be, they contrast with the conventional wisdom that seems to be that displacement experiences are negative for workers. One possible reason for this is that, with a few notable exceptions, local economic conditions at the time of displacement have received relatively little attention in the empirical displacement literature, and even less in formal theoretic models. Our results suggest that a study that specifically compares the results of previous studies with local economic conditions would be valuable, and future studies of the effects of displacement should consider the possible influence of local labor market conditions.

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APPENDIX

1. Derivation of return to the worker in period 1

$R_1 = E[R_1 |\mathbf{a}]*\Pr[\mathbf{a}] + E[R_1 |\mathbf{b}]*\Pr[\mathbf{b}] + E[R_1 |\mathbf{c}]*\Pr[\mathbf{c}]$

$$R_1 = E[V_1 - C \mid a]\Pr[a] + E[W_{01} \mid b \cup c]\Pr[b \cup c]$$

$$R_1 = \iint_{p(m+x)+C<(m+y)p} (p_1(m+y) - C) f(x) f_n(y) dydx + \iint_{p(m+x)+C>(m+y)p} p_1(m+x) f(x) f_n(y) dxdy$$

$$R_1 = \int_{-1}^{1} (p_1(m+y-A)F(y-A) f_n(y)dy + \int_{-1}^{1} p_1(m+x) f(x)F_n(x+A)dx$$

Change of variables: let y – A = x

Then $R_1 = \int_{-1-A}^{1-A} (p_1(m+x)F(x) f_n(x+A)dx + \int_{-1}^{1} p_1(m+x) f(x)F_n(x+A)dx$

$$R_1 = -\int_{1-A}^{1} p_0(m+x)F(x) f_n(x+A)dx + \int_{-1}^{1} p_1(m+x)\{F(x) f_n(x+A) + f(x)F_n(x+A)\}dx$$

$$R_1 = -\int_{1-A}^{1} p_1(m+x)F(x)nf(x+A)F(x+A)^n dx + \int_{-1}^{1} p_1(m+x)\frac{d}{dx}\{F(x)F_n(x+A)\}dx$$

Since f(x+A) = 0 for all x in [1-A, 1], then

$$R_1 = \int_{-1}^{1} p_1(m+x)\frac{d}{dx}\{F(x)F_n(x+A)\}dx$$

$$R_1 = p_1(m+x)F(x)F_n(x+A)\,|_{-1}^{1} - \int_{-1}^{1} p_1\{F(x)F_n(x+A)\}dx$$

$$R_1 = p_1(m+1) - \int_{-1}^{1} p_1 F(y)F_n(y+A)dy$$

2. Derivation of return to worker in the second period

$R_2 = E[R_2 |\mathbf{a}]*\Pr[\mathbf{a}] + E[R_2 |\mathbf{b}]*\Pr[\mathbf{b}] + E[R_2 |\mathbf{c}]*\Pr[\mathbf{c}]$

$R_2 = E\,[V_2 \mid a\,]*\Pr\,[a] + E\,[V_2 \mid b\,]*\Pr\,[b] + E\,[W_{02} \mid c]*\Pr\,[c]$

$$R_2 = E[V_2 \mid a \cup b]\Pr[a \cup b] + E[W_{02} \mid c]\Pr[c]$$

$$R_2 = \iint_{p(m+x)<(m+y)p} p_2(m+y) f(x) f_n(y) dydx + \iint_{(m+y)p<(m+x)p} p_2(m+x) f(x) f_n(y) dxdy$$

$$R_2 = \iint_{x<y} p_2(m+y) f(x) f_n(y) dydx + \iint_{y<x} p_2(m+x) f(x) f_n(y) dxdy$$

$$R_2 = \int_{-1}^{1} p_2(m+y) F(y) f_n(y) dy + \int_{-1}^{1} p_2(m+x) f(x) F_n(x) dx$$

$$R_2 = \int_{-1}^{1} p_2(m+y) \frac{d}{dy}[F(y)F_n(y)] dy$$

$$R_2 = p_2(m+y)[F(y)F_n(y)]|_{-1}^{1} - \int_{-1}^{1} p_2 F(y) F_n(y) dy$$

$$R_2 = p_2(m+1) - \int_{-1}^{1} p_2 F(y) F_n(y) dy$$

3. Derivation of the probability of being laid off

$$P[layoff] = \iint_{p(m+x)+C>(m+y)p>(m+x)p} f(x) f_n(y) dxdy = \iint_{x+A>y>x} f(x) f_n(y) dxdy$$

$$= \int_{-1}^{1} f(x)\{F_n(x+A) - F_n(x)\} dx$$

4. Derivation of Pr[Better-Off | Layoff]

Pr [Better-off | Layoff] = $\frac{\Pr[BetterOff \ \& \ Layoff]}{\Pr[Layoff]}$

$$P[layoff] = \int_{-1}^{1} f(x)\{F_n(x+A) - F_n(x)\} dx$$

$$\Pr[layoff \ \& \ betteroff] = \iint_{\{p(m+x)+C>(m+y)p>(m+x)p\} \cap \{(m+x)p_1<(m+y)p_2\}} f(x) f_n(y) dxdy = \iint_{\{x+A>y>x\} \cap \{y>\frac{p_1}{p_2}x + \frac{p_1-p_2}{p_2}m\}} f(x) f_n(y) dxdy$$

(a) When $\frac{p_1}{p_2}x + \frac{p_1-p_2}{p_2}m > x + A$ for all x in [-1, 1], $\Pr[layoff \ \& \ betteroff] = 0$

This condition holds when $\frac{p_1-p_2}{p_2}x + \frac{p_1-p_2}{p_2}m > A$ for all x in [-1, 1]

That is the same as $\frac{p_1-p_2}{p_2}(m-1) > A$

$$p_2 < p_1 \frac{m-1}{A+m-1}$$

(b)When $\frac{p_1}{p_2}x + \frac{p_1-p_2}{p_2}m < Min\{x + A, 1\}$ for some x in [-1, 1], That is $p_2 \geq p_1 \frac{m-1}{A+m-1}$ $\Pr[layoff \ \& \ betteroff] > 0$

$$\Pr[layoff \ \& \ betteroff] = \iint_{\min\{1, x+A\} > y > \frac{p_1}{p_2}x + \frac{p_1 - p_2}{p_2}m} f(x) f_n(y) dx dy$$

Let $\beta = \frac{m-1}{A+m-1}$

Then $\frac{\partial \beta}{\partial m} = \frac{\partial}{\partial m}[1 - \frac{A}{A+m-1}] = -\frac{-A}{(A+m-1)^2} = \frac{A}{(A+m-1)^2}$,which means as ***m*** increases, β increases as well, so the laid-off worker is more likely to be worse off.

5. Return to the laid-off worker

$$E[R \mid Layoff]\Pr[layoff] = \iint_{p(m+x)+C > (m+y)p > (m+x)p} p_2(m+y) f(x) f_n(y) dx dy$$

$$= \iint_{x+A > y > x} p_2(m+y) f(x) f_n(y) dx dy$$

$$= \int_{-1}^{1} p_2(m+x) f(x)\{F_n(x+A) - F_n(x)\} dx$$

$$P[layoff] = \iint_{p(m+x)+C > (m+y)p > (m+x)p} f(x) f_n(y) dx dy = \iint_{x+A > y > x} f(x) f_n(y) dx dy$$

$$= \int_{-1}^{1} f(x)\{F_n(x+A) - F_n(x)\} dx$$

$$E[R \mid Layoff] = \frac{\iint_{x+A > y > x} p_2(m+y) f(x) f_n(y) dx dy}{\iint_{x+A > y > x} f(x) f_n(y) dx dy} = \frac{\int_{-1}^{1} p_2(m+x) f(x)\{F_n(x+A) - F_n(x)\} dx}{\int_{-1}^{1} f(x)\{F_n(x+A) - F_n(x)\} dx}$$

Table 1: Unemployment Rates (UE)
and Post-Displacement Wage Change

Authors(Year)	Time	Place	Earning Changes	UE @ Layoffs	Mean UE (1980-2000)	UE Trend
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Menezes-Filho(2004)	1993-1995	Sao Paolo Brazil	Lose 20%	6%	5.29%	Upward
Doiron(1995)	1981-1986	Canada	Lose 16%	10.37	9.35	Peak
Bender et al.(2002)	1984-1989	France	Positive Gain	10.05	9.84	Peak
Abbring et al.(2002)	1986-1990	Netherlands (LFS data)	Gain 10%	6.84	6.22	Downward
Orazem, Vodopivec & Wu (2005)	1990-1993	Slovenia	2/3 no jobs, yet average gain of 16.5%	6.68	7.69[14]	Upward
Bender et al.(2002)	1984-1990	Germany	<1% decrease	7.56	7.03	Downward
Couch (2001)	1988-1996	Germany	Lose 6.50%	6.8	7.03	U-Shape
Helwig(2001)	1997-1998	USA	0%	4.7	6.4	Downward
Gibbons & Katz (1991)	1984-1986	USA	Lose 16%	7.23	6.4	Downward
Abbring et al.(2002)	1996	USA(DWS)	0%	5.4	6.4	Downward
Ruhm (1987)	1969-1975	USA(PSID)	40% gain 10%	5.57	6.4	N-Shape
Ruhm (1991a)	1971-1975	USA(PSID)	Lose 13%	6.1	6.4	U-Shape
Kodrzycki(2007)	1992-1994	MA, USA	Lose 11%-17%	7.46	6.4	Peak
Jacobson, LaLonde, and Topel (1993a)	1982-1984	PA, USA	Lose 25%	10.67	6.40	Peak

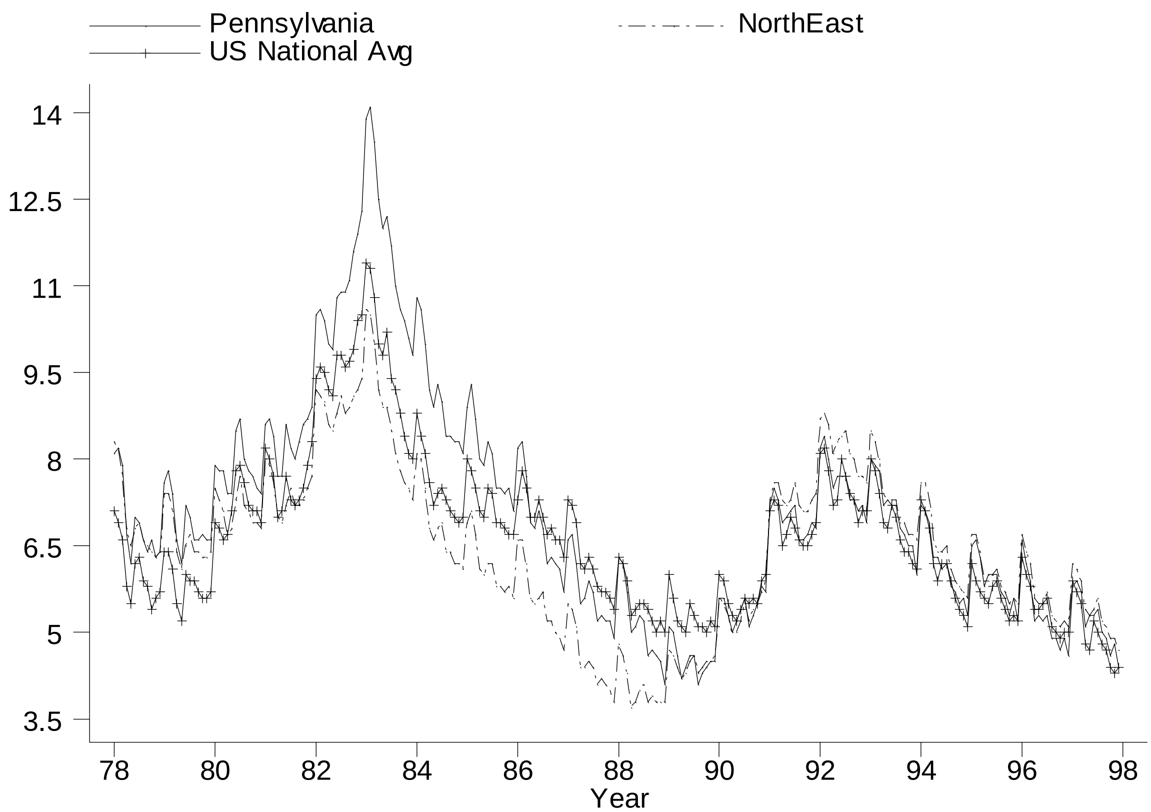
Notes: Columns 2-4 are from the studies listed in column 1. Columns 5-7 are added by the authors for comparison.
Source: IMF Financial Statistics

[14] For Slovenia, we took the average unemployment rate between 1990 and 2000

Table 2: Summary of Three Worker Types

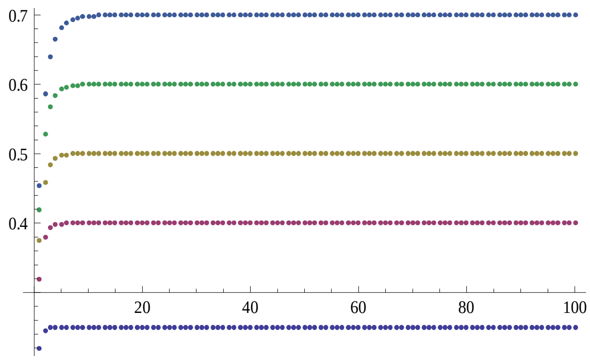
	Period 0	Condition	Period 1	Period 2
(a)	Jobs randomly	$\epsilon_{max} > \epsilon_0 + A$	**Quit**	Stay anyway
(b)	assigned to	$\epsilon_0 < \epsilon_{max} < \epsilon_0 + A$	Stay due to C	**Layoff**
(c)	workers	$\epsilon_{max} < \epsilon_0$	Stay anyway	Stay anyway

Figure 1: United States Unemployment Rates
Pennsylvania, Census North East, USA Average



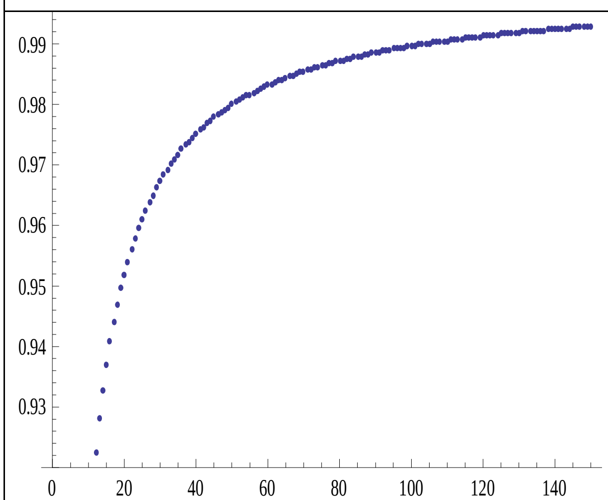
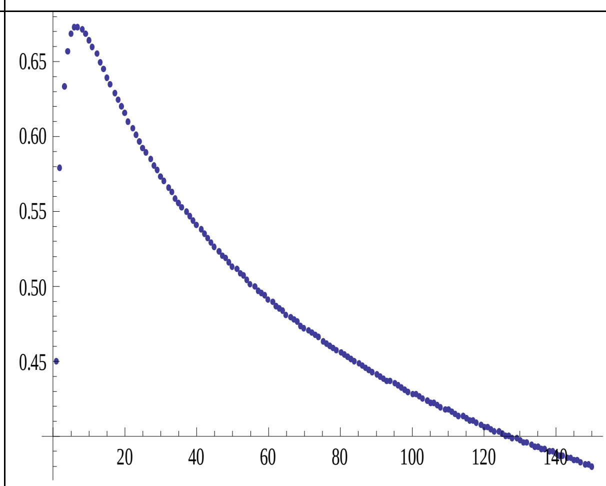
Source: Constructed by authors using data from the U.S. Bureau of Labor Statistics (www.bls.gov).

Figure 2: Probability of Layoff
as a Function of Number of Firms and Real Adjustment Cost



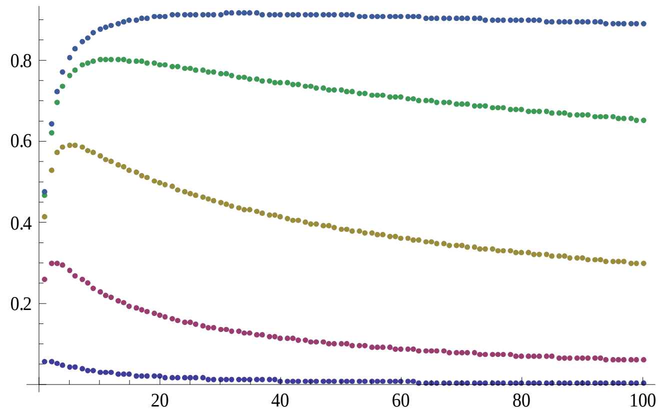
Notes: The various lines represent the different levels of adjustment costs in a simulation of the model in Mathematica ®. The x-axis plots the number of firms and the lines represent separation costs of 0.5, 0.8, 1, 1.2, and 1.4 from the bottom to the top respectively, given that the random variables are uniformly distributed. As A increases, the whole probability curve shifts up.

Figure 3: Layoff Probability the number of firms

Figure 3a: The probability of layoff as a function of the number of firms when A is large (greater than the range of the support of the wage difference)	Figure 3b: The probability of layoff as a function of the number of firms with A is small (smaller than the range of the support of the wage difference)
	

Notes: The effect of the number of firms on the probability of layoff critically depends on the size of the adjustment cost. Figure 3a plots Pr [layoff] against the number of outside offers with A = 2.5, given that the random variable is normal distributed with mean 0 and standard deviation 0.5. Figure 3b plots plot of Pr [layoff] against the number of outside offers with A = 0.7, given that the random variable is normal distributed with mean 0 and standard deviation 0.3.

Figure 3c: The probability of layoff as a function of the number of firms for a range of As



Notes: This figure plots Pr [layoff] against the number of the firm when the separation costs are 0.1, 0.5, 1, 1.5 and 2 respectively. We use a normally distributed random variable with mean 0, standard deviation 0.5 to do the simulation. Increasing the number of firms always decreases the probability that a worker gets laid off eventually because the probability that a worker is initially well-matched increases with the number of firms.