Wages and Labor Demand in an Individualistic Bargaining Model with Unemployment *

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Abstract

This paper considers a model where individual workers bargain with their employer so that their wages reflect the *ex post* marginal product of labor at the firm for which they work. If the firm must incur some costs in hiring labor, and workers are unable to pay for their jobs, this can imply the existence of involuntary unemployment even without search frictions. The result is that there exist changes in technology and in the character of product demand curves such that firms increase their employment while increasing their wages by less than they would if labor markets were competitive. The reason is simply that the reduction in the marginal product of labor exerts downwards pressure on wages. The model can also rationalize cyclical upgrading, where increases in labor demand lead certain workers to quit jobs that pay low wages in order to accept jobs at higher-paying firms.

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This paper studies some implications of assuming that workers earn rents that depend on their marginal product at the firm in which they work. In other words, I consider a model where a worker employed by a firm where the marginal product of labor is high earns more than a worker with the same reservation wage who happens to be employed at a firm where his marginal product is smaller. Similarly, employed workers may earn more than the amount which leaves unemployed workers indifferent between working and not working. Many investigators doubt the empirical validity of such models on the ground that they feel that individuals have numerous avenues for bidding down the rents earned by other workers.[1] If such avenues exist, one would expect the rents ultimately earned by all workers to be zero. Other investigators have argued that various frictions exist which prevent workers from bidding down rents. Among the frictions that can play this role one can mention costs of having potential employers meet potential employees[2] , liquidity constraints that prevent workers from earning less than a minimum amount at any time and the danger that firms will abscond with any payment that workers make up front to secure a high paying job.[3] Probably because it is so difficult to observe the complete set of exchanges between workers and their employers, no consensus exists on whether these frictions are important or not. If they are not, this paper is of little interest.

One reason to be interested in these frictions is that, as I show, they may be helpful in understanding the way real wages respond to changes in labor demand. It is often thought that business cycles are caused by changes in labor demand. However, while real wages are somewhat procyclical (see the survey by Abraham and Haltiwanger 1995) they do not seem to be procyclical enough to be consistent with market clearing wages and unchanged labor supply behavior. What I show in this paper is that the dependence of individual real wages on individual marginal products dampens the increase in real wages induced by increases in labor demand. The reason is unbelievably simple: it is that increases in employment induced by changes in labor demand tend to reduce the marginal product of labor.

[1]See, for example, Carmichael (1985).
[2]As in the search literature.
[3]These last two frictions are discussed, for example, in Shapiro and Stiglitz (1984).

This paper is not the first to analyze situations where workers bargain with firms in such a way that real wages depend on individual marginal products. An essentially identical assumption is made, for example, in Lindbeck and Snower (1987, 1988a). However, their analysis of the level of employment that results from this way of setting wages is flawed. They suppose that, when setting employment to maximize profits, firms take this wage as given. However, firms ought to take into account that increases in employment lower the wage that they will have to pay employees.[4]

This is done in an important paper by Stole and Zwiebel (1996). As in Weitzman (1985), they show that this dependence of wages on employment leads firms to "overhire" relative to what would be done by a firm that takes wages as given. In their model, however, workers can also pay directly for their jobs. This dissipates all rents so that workers end up earning their reservation wage. By contrast, I consider a variant in which workers cannot pay for their jobs and show that it can lead to involuntary unemployment. Increases in labor demand can then raise employment, and the key result follows.

This paper is also not the first to take the view that departures from perfect factor markets might explain the lack of pronounced procyclical movements in real wages. McDonald and Solow (1981) motivate their study of union bargaining in precisely this way. However, their model is one where workers have constant reservation wages. Thus, their conclusion that changes in labor demand have ambiguous effects on wages does not really demonstrate that their model has systematically less procyclical wages than a model with competitive labor markets.

An even more serious drawback of the McDonald and Solow (1981) analysis is that their economic rationale for wage restraint in the face of increased labor demand is not

[4]In his analysis of compensations systems where wages are indexed to prices, profits, or revenues, Weitzman (1985) lays great stress on this and concludes that these schemes create a strong desire for firms to hire more workers. Where Weitzman's (1985) analysis differs from mine is that he effectively assumes that the parameters of any compensation system, including his proposed methods of sharing income between firms and workers, adjust in the long run so that there is little or no unemployment. The economy is thus supposed to operate in a region where firms are perpetually short of their preferred number of workers. One contribution of this paper is thus to show that the assumption that wages decline whenever additional workers are hired does not necessarily lead to such low unemployment outcomes in the long run.

convincing. This restraint is a consequence of their assumption that unions care no more about the utility of currently employed workers than they do about the utility of unemployed members. The union may thus choose to take advantage of increases in labor demand by increasing the fraction of its members that are employed - rather than by increasing wages. This is a problematic assumption for unions, as emphasized by Blanchard and Summers (1986) and Lindbeck and Snower (1988b). It is more reasonable to imagine that unions care disproportionately about their employed members. One would then expect them to push for large wage increases when labor demand increases.

A bargaining framework somewhat related to that of McDonald and Solow (1981) is embedded in the vast literature on search that originates with Diamond (1982) and, especially, Pissarides (1987). In Pissarides (1987), the marginal product of each worker is independent of the number of workers and is thus equal to the average product.[5] This means that the model can be interpreted equally well as one where workers bargain as individuals or as one where they bargain collectively in a union. An additional consequence of the constancy of the marginal product of labor is that Nash bargaining between individual workers and firms would lead to full (efficient) employment if there were no search frictions. The same would be true if, instead of Nash bargaining, one gave either workers or firms the right to make take-it-or-leave-it offers. Thus, while this search-theoretic literature involves bargaining between firms and workers, the unemployment that it generates arises exclusively from the time it takes for workers and firms to find each other. By contrast, my approach to bargaining can lead to unemployment even if workers and firms can find each other instantaneously.

Worker rents also provide a foundation for unemployment in efficiency wage models. In Shapiro and Stiglitz (1984), these rents induce effort because workers who get caught shirking are fired and lose their rents during the period in which they remain unemployed. Unfortunately, as shown by Kimball (1994), this model generates quite procyclical real wages.

[5] For a paper that combines costly search with the assumption that the marginal product of labor is declining in the number of workers, see Bertola and Caballero (1994). They show that combining these two assumptions leads to the unfortunate consequence that firms which succeed in becoming large (by finding workers) tend to pay low wages. This need not be true here because firms can find their workers instantaneously.

The reason is that booms are periods where employment is high, unemployment is low, and thus dismissal leads to relatively short spells of unemployment. To keep the cost of shirking high, wages must be increased. In effect, this model has in common with the competitive labor market model that the main determinant of the wage is the state of the external labor market. In particular, a slack external labor market puts downwards pressure on wages. By contrast, this paper offers a quite different conception of the forces that keep wages in check. My emphasis is on the importance of *internal* competition by co-workers. When there are many of these, the worker is less essential and this reduces the wage. One advantage of giving at least some weight to this internal competition is that it can explain more easily why periods of high employment are not associated with high real wages.

The paper proceeds as follows. In the next section, I lay out the basic framework of the paper by considering a setting where perfectly competitive firms bargain with their workers after paying a setup cost that depends linearly on their total employment. This setup cost can, for example, be interpreted as either a hiring or a training cost. This section both provides conditions under which such firms operate at interior optima and explains the circumstances under which unemployment arises in equilibrium. Neither of these outcomes is an automatic consequence of my bargaining framework, though they do arise under plausible circumstances.

The next section consider the effects of technical progress on real wages and employment (in the case where there is initially some unemployment). Not surprisingly, the exact form of technical progress matters a great deal for the response of these two variables. Neutral progress simply raises wages without altering employment. However, it is possible for technical progress to take forms such that employment rises while real wages rise less. If technical progress reduces the importance of hiring and training costs relative to the value of total output, it can even induce reductions in real wages while employment expands.

Section 3 is devoted to analyzing versions of the model in which firms have market power because they face downwards sloping demand curves. The result of this lack of perfect competition is that, as stressed by Rotemberg and Woodford (1997), it is possible for every firm's labor demand to vary even if technological opportunities remain constant. As when factor markets are competitive, changes in the elasticity of demand facing the typical firm can have this effect in my model.[6] A flattening of firms' product demand curves can lead firms to hire more labor and, leaving aside the effect of this on workers' reservation wages, this reduces wages. Thus, the model allows for a mechanism that raises employment while raising real wages by less than would a comparable model with competitive labor markets.

The unemployed are not alone in appearing to experience discrete gains in booms. As emphasized by Akerlof, Rose and Yellen (1988), booms also coincide with attractive job changes for many previously employed individuals. Moreover, as Bils (1985) and Shin (1994) show, wage gains in booms are concentrated among such job movers.[7] This "cyclical upgrading" involves changes in industry for many workers. And, when a worker changes industry, her wage tends to rise whenever the industry to which she is moving pays higher wages on average than the industry in which she was originally employed.[8] This is part of the reason given by Bils and McLaughlin (1993) for rejecting their competitive model of cyclical upgrading.

Since the forces pushing for wage equalization are so weak in the model, it is ideally suited for explaining differences in wages across industries. This is shown in Section 4, where I also discuss some of the determinants of industry-specific wages. In particular, I provide some interpretations for the cross-industry differences in wages that have been observed in the data by Dickens and Katz (1987).

Section 5 is devoted to discussing cyclical upgrading. The model rationalizes this easily if workers differ in their productivity. In this case, all industries prefer workers with higher productivity even if more productive workers also have higher reservation wages.[9] The results is that sectors that pay higher wages *for a given level of worker characteristics* can also be expected to attract more productive workers. When a boom results from, say, a flattening of

[6]For analyses of the effects of changes in this elasticity when firms treat wages as given, see Bils (1989) and Gali (1994).

[7]Akerlof, Rose and Yellen (1988) argue that the nonpecuniary benefits of these moves are quite important as well.

[8]See Katz and Summers (1989).

[9]In the bargaining models of Shimer (1996) and Moscarini (1997) more productive workers are also preferred but only because their reservation wages are the same as those of less productive workers.

industry demand curves, high-wage sectors are thus able to induce highly productive workers working in lower-wage sectors to move. Consistent with the evidence on inter-industry wage differences, the increase in wage of these movers is only a fraction of the difference in average industry wages. Section 6 concludes.

1 The Basic Model with Perfect Competition

In this section, I introduce the basic mechanism that leads to involuntary unemployment. (While I use the term unemployment to capture the idea that these individuals want to work, the model involves no search so that these individuals can also be involuntarily out of the labor force.) I suppose that $\bar{L}$ workers are willing to work at a reservation wage of $\bar{W}$. Thus, involuntary unemployment exists if wages exceed $\bar{W}$ while employment is less than $\bar{L}$. In the symmetric equilibria I consider at first, all employed workers earn the same wage so that, when this wage exceeds $\bar{W}$, there is no question that the workers who are not working at this wage are involuntarily unemployed. This means, of course, that they are willing to pay to become employed. As I explained in the introduction, my analysis is of interest only in the case where such payments are restricted.

I start by supposing that all firms are symmetrical. By hiring L units of labor and K units of capital, firms can produce Y units of output according to the production function

$$Y = AF(L, K) \tag{1}$$

where F is homogeneous of degree one in L and K and A is a parameter which captures Hicks-neutral technical progress. To simplify the presentation, I start by assuming that the capital endowment K of each firm is fixed so that the firm chooses only L.

I suppose that, each period, the firm incurs an additional setup cost ΦL. A crucial assumption for the analysis is that firms do not begin bargaining with their L workers until they commit themselves to pay ΦL.[10] After these bargains are concluded, the employees

[10]Holden (1988) and Moene (1988) consider the analogous case of union bargaining where the firm sets employment before the union and the firm bargain over wages.

that remain produce output and this output is sold in a competitive market at an exogenous price P.

I suppose that bargaining is individualistic so that each firm bargains separately with each one of its employees. The outcome of this process obviously depends on the bargaining power of these parties. One case that deserves an extended treatment because it results from a game between workers and firms that is easy to describe gives all the bargaining power to the workers. Suppose, in particular, that all workers make simultaneous take-it-or-leave-it offers to their employer in which they promise to work if they get paid the wage that they individually demand and promise to leave otherwise. If any one employee left, the firm would lose PF_L. This means that, if all L employees offered to stay in exchange for a wage of $PAF_L(L, K)$ the firm would keep them all. The unique Nash equilibrium of the game among workers thus involves a wage of

$$W = \max[\bar{W}, PAF_L(L, K)] \tag{2}$$

where $\bar{W}$ is the workers' reservation wage.[11] If workers expect other workers to make this demand, they find this demand optimal because higher demands would be rejected.[12]

I also consider a generalization of (2) which can be interpreted as giving less bargaining power to the workers. The wage W is then

$$W = \bar{W} + \delta \max[0, PAF_L(L, K) - \bar{W}] \tag{3}$$

where δ is a parameter between zero and one. When δ equals one, we have the outcome that prevails when employees make take-it-or-leave-it offers. The case where δ is equal to zero can be interpreted as one where the employers have all the bargaining power. Intermediate values of δ are meant to capture situations where the bargaining power is more evenly divided. It is tempting to see the case where δ is equal to 0.5 as representing the Nash bargaining solution.

[11]Ignoring the reservation wage, this is also the wage assumed by Lindbeck and Snower (1987, 1988a).

[12]If an individual worker expects any other worker to demand more than this, it becomes optimal for the individual worker to demand a wage between PF_L and the wage demanded by this other worker. But, this leads the other worker to be let go. Thus (2) is also the only equilibrium when workers make their wage demands in sequence.

This interpretation is warranted if each worker-firm bargaining pair believes that the other workers bargaining with the firm will end up working (so that each bargaining worker is a marginal worker). A closely related way of modeling bargaining is to follow Stole and Zwiebel (1996) who look for stable configurations where no worker seeks to reopen negotiations with his employer under the assumption that, if these negotiations break down, the employer will have to bargain again with the remaining employees. I do not follow this approach in part because it is more complicated and in part because one key insight of their analysis - that employers "overhire" - extends to my model as well.

I now demonstrate that, even though workers sometimes obtain more than their "full" marginal product (i.e. inclusive of the setup cost), there are robust sets of circumstances where firms hire them in positive quantities. Assuming $PAF_L > \bar{W}$, the profits of a perfectly competitive firm with K units of capital are equal to

$$\pi = PAF(L, K) - \delta PAF_L L - (1 - \delta)\bar{W}L - \Phi L. \tag{4}$$

Maximizing this with respect to L, the first order condition for an interior solution is

$$(1 - \delta)AF_L - \delta LAF_{LL} - \frac{(1 - \delta)\bar{W} + \Phi}{P} = 0. \tag{5}$$

When δ is zero, this simply equates the full marginal product of labor $PAF_L - \Phi$ to the worker's reservation wage. But, for higher δ, different considerations come into play. To see this more clearly, focus on the case where δ is equal to one. Then, this equations says that $-PAF_{LL}L$ ought to be equal to Φ. The first of these terms is the benefit to the firm from hiring an additional worker and is equal to the reduction in the value of the marginal product of labor times the number of people employed. This is the extent to which the wage bill of existing employees is reduced by hiring an additional worker. This benefit is set equal to the cost of hiring an additional worker, which is Φ. The marginal product of labor plays no role in this case because, while the firm obtains this through additional production, it must also hand over this marginal product to the marginal employee it hires.

The homogeneity of degree 1 of F implies that F_{LL} is homogeneous of degree -1 in L

and K so that LF_{LL} depends only on the ratio K/L. Thus, assuming the equation has a solution, this solution gives the capital/labor ratio K/L as a function of Φ and $\bar{W}$.

Equation (5) has a unique, optimal solution if the profit function is everywhere concave, so that, for all L,

$$(1-\delta)F_{LL} - \delta\{F_{LL} + LF_{LLL}\} < 0. \tag{6}$$

while at the same time, the derivative of profits with respect to L satisfies the boundary conditions

$$\lim_{L\to 0} \frac{\partial \pi}{\partial L} > 0 \qquad \lim_{L\to\infty} \frac{\partial \pi}{\partial L} < 0. \tag{7}$$

These boundary conditions simply require that one evaluate the left hand side of (5) near zero and at infinity. One case that does not satisfy these conditions is when, as in Pissarides (1987) and the literature that follows him, the marginal product of labor is constant. There then exists a knife edge case where the firm is indifferent as to how many employees it hires. For lower reservation wages and less bargaining power for workers (the standard case in the literature) firms would like to hire infinitely many workers.[13] For higher reservation wages and more bargaining power for workers, zero employment is optimal.

If, on the other hand, F satisfies diminishing returns and conventional boundary properties (6) and (7) are satisfied as long as δ is sufficiently small. For large δ, these conditions pose different demands on production functions and, moreover, they may not be satisfied even when F takes the CES form. To see this, I consider explicitly the cases where F is given by

$$F(L,K) = (L^\gamma + dK^\gamma)^{1/\gamma}, \qquad d > 0, \gamma \leq 1 \tag{8}$$

as well as the limit where γ is zero so that

$$F(L,K) = L^\alpha K^{1-\alpha} \qquad 0 < \alpha < 1. \tag{9}$$

When γ is nonzero, the first order condition (5) is given by

$$(1-\delta)AL^{\gamma-1}(L^\gamma + dK^\gamma)^{\frac{1}{\gamma}-1} + \delta(1-\gamma)AL^{\gamma-1}dK^\gamma(L^\gamma + dK^\gamma)^{\frac{1}{\gamma}-2} - \frac{\Phi + (1-\delta)\bar{W}}{P} = 0. \tag{10}$$

[13]Search frictions then prevent the firm from doing so. Thus, these assumptions about bargaining and production functions essentially require that one assume that firms find it difficult to find workers.

or, using κ for the optimal value of K/L

$$(1-\delta)A(1+d\kappa^{\gamma})^{\frac{1}{\gamma}-1} + \delta(1-\gamma)dA\kappa^{\gamma}(1+d\kappa^{\gamma})^{\frac{1}{\gamma}-2} - \frac{\Phi + (1-\delta)\bar{W}}{P} = 0 \tag{11}$$

The boundary conditions (7) involve the limits of the left hand side of (11) when κ goes to either zero or infinity. The limit when κ tends to zero poses no problems. When γ is positive, κ^{γ} goes to zero in this limit so the left hand side of (11) is negative as long as $\bar{W}$ is not too small. When γ is negative, the limit as κ goes to zero of the first two terms is proportional to $\kappa^{1-\gamma}$. This is zero so that the expression in (11) also tends to a negative value. I now turn to the limit when L goes to zero and focus only on the case where δ is one (since the case where δ is small has already been dealt with). When γ is positive, the left hand side of (11) becomes arbitrarily large as L shrinks. On the other hand, when γ is negative, the second term in (10) goes to zero as L goes to zero so that the derivative of profits with respect to L is negative at this point. Thus, initially, the firm actually lowers its profits by hiring workers.

Now turn to the curvature condition (6). The term in curly brackets in (6) is now

$$(1-\gamma)dA\left(1+d\left(\frac{K}{L}\right)^{\gamma}\right)^{\frac{1}{\gamma}-3} L^{-\gamma-1}K^{\gamma}\left[(1-\gamma)d\left(\frac{K}{L}\right)^{\gamma}+\gamma\right]$$

When γ is positive, this is always positive so that (6) is satisfied even when δ equals one. When γ is negative, this is negative for sufficiently small values of L/K. It does become positive when $(\frac{L}{K})^{-\gamma}$ becomes larger than $\frac{-\gamma}{d(1-\gamma)}$. Thus, for negative γ, and δ sufficiently large, the marginal attraction of hiring additional workers actually rises from the point that the firm employs zero workers. This gives some hope that an interior solution continues to exist since, as we saw, the marginal attraction of hiring workers when L is close to zero is negative in this case.

Indeed, there are cases where γ is negative and δ is one where an interior solution is optimal. I have demonstrated this numerically in the case where A equals 1, Φ equals .05, d and K are equal to 1 and γ equals -.05. Profits then decline slightly as L is increased from zero, but reach their maximum when L equals about 2.7. At this optimum, both (5) and

(6) are satisfied. The possibility of constructing such examples will prove important below, when I discuss the effects of technical progress.

In the Cobb-Douglas case, the first order condition (5) is

$$A\alpha(1-\delta\alpha)\left(\frac{K}{L}\right)^{1-\alpha} - \frac{\Phi + (1-\delta)\bar{W}}{P} = 0. \tag{12}$$

It is immediately apparent that the left hand side, which gives the benefit of increasing L, is positive as L tends to zero, negative as L tends to infinity and globally declining in L. Thus the capital/labor ratio which solves this equation represents a global optimum with strictly positive employment. Using (3) the resulting wage is

$$W = \max\Big(\bar{W}, \frac{\Phi + (1-\delta)\bar{W}}{1-\delta\alpha}\Big) \tag{13}$$

and Φ must exceed $\delta(1-\alpha)\bar{W}$ to ensure that the wage is above the reservation wage.

This shows that an interior solution with positive employment obtains in many cases even if workers demand a wage that is higher than their full marginal product $PAF_L - \Phi$. At these optima, there is "overhiring" in the sense that firms that take wages as given would hire fewer employees at this wage. As in Stole and Zwiebel (1996) the reason for this overhiring is that the firm has an additional benefit from hiring workers, namely that doing so reduces the wages of other workers.[14]

So far, I have considered a single firm in isolation. I now discuss unemployment by considering the equilibrium outcome in a world populated by many such firms, all of which sell the same product. To carry out this analysis, I treat the number of firms and their capital as fixed. The aggregate capital stock is $\bar{K}$ while the maximum number of workers willing to work remains $\bar{L}$. Letting κ be the capital/labor ratio which solves (5) in the case where this interior solution is optimal, there exist unemployed workers if $\bar{K}/\bar{L}$ is smaller than κ. For there to be involuntary unemployment, the marginal product of labor with this capital/labor ratio must be larger than $\bar{W}$. It follows from (5) that this requires that Φ exceed some strictly

[14] An essentially identical effect is present in the union bargaining models of Holden (1988) and Moene (1988). There, hiring workers reduces the wage that emerges from the Nash bargaining that takes place *ex post* between the firm and its union. For a different benefit to overhiring, see Feinstein and Stein (1988).

positive lower bound (whose value in the Cobb-Douglas case is $\delta(1-\alpha)\bar{W}$) When Φ is zero, this first order condition actually implies that the marginal product of labor is smaller than $\bar{W}$.

If $\bar{K}/\bar{L} > \kappa$ instead, firms are constrained. They would like to hire more workers (to reduce their wages) than they are able to find. Since all workers are employed, changes in labor demand affect only wages in this case. For this reason, I focus my attention on the case where some workers are unemployed. It is worth stressing again that this unemployment would disappear if workers were able to bid for their jobs, as they can in the related model of Stole and Zwiebel (1996). Similarly, firms would cease being rationed if they could pay workers to start bargaining with them.

Since a positive Φ is required for involuntary unemployment to exist, a discussion of some alternative interpretations for this cost seems worthwhile. The simplest interpretation is that Φ is the cost of hiring a worker and that the length of the period is the length of time that the worker is expected to remain employed. Similarly, Φ can represent a cost of training each employee as long as firms must pay for this training (perhaps because employees cannot afford to pay for this training or because moral hazard would lead firms to extract such payments from employees without actually training them). Another possibility is that Φ is a cost to the firm of figuring out what a particular employee ought to do and that, once again, the firm must pay this cost after it has identified the employee but before the employee carries out any work. Thus, by the time the firm needs the employee to produce output, this cost is sunk; if the employee leaves at this point and the firm hires a substitute, Φ must be spent again.

It might be objected that these costs are only incurred at the beginning of relatively long relations with employees. The firm then ought to compare these initial costs to the present value of benefits that the employee generates. In the case where nothing ever changes, this makes essentially no difference to the analysis. The periods over which employees produce output can be much shorter than the period of employment as long as Φ is interpreted as the annuitized value of the initial cost where the annuitization is carried out over the period that the employee remains at the firm. To analyze the effect of short term changes in the environment under this alternative interpretation, an explicitly dynamic analysis would be ideal. The static analysis I carry out here, where each period is just like the one that came before it, is then just a first step to understanding the consequences of this type of bargaining. It is hoped that some of the lessons of the static analysis would remain valid even if the cost ΦL is nonrecurrent for existing employees. This would seem to be particularly likely if the environment changes in such a way that the present value of benefits from having an additional employee rises because, in this case, the firm would again have to compare these benefits to Φ. By contrast, declines in the expected present value of these benefits should not trigger employee dismissals until the expected present value of having an additional employee is equal to zero.[15]

There is a final interpretation, which requires a slight modification of the model without changing the results. This is to suppose that it costs nothing to find the employee, nor to figure out what a particular individual ought to do, nor to train him, but that the firm cannot replace the employee in the period that the employee leaves. Instead, there is a cost Φ which must be paid to reorganize production after an employee departs. In other words, a firm that planned on 100 employees and found itself with 99 would have to incur additional organizational costs to obtain the output it would have gotten from just hiring 99 in the first place. These reorganization costs could arise if employees were assigned specific tasks and if they had to be assigned new tasks whenever an employee left. In this alternate formulation, the output of the firm is $AF(L, K)$, but the employee demands a wage equal to $PAF_L + \Phi$ because this is the amount lost to the firm if the employee leaves. One advantage of this interpretation is that the length of the period is much shorter, it is the length of time over which an employee's departure upsets the firm's production plans.

[15]See Bentolilla and Bertola (1990) for an analysis of linear hiring and firing costs in a competitive labor market setting.

2 The Effect of Technical Progress

I now study the effect of technical progress while maintaining the assumption of perfect competition. Neutrality in technical progress involves not only an increase in A but also an equiproportional increase in the cost Φ. One might well expect Φ to increase in this way if it represented the cost of reorganizing production when an employee leaves the firm. As workers become more productive the losses in output when one of them departs presumably rise as well.

Equiproportional increases in A, Φ and $\bar{W}$ are simple to analyze in this model. Inspection of the first order condition (5) reveals that κ is unaffected by such a change. Given this unchanged capital/labor ratio, F_L is unaffected as well. Equation (3) then implies that real product wages rise in proportion to the increase in A, Φ and $\bar{W}$. Real wages rise less if, as stressed by Pissarides (1987), the reservation wage $\bar{W}$ rises by less. This is likely to be true in a competitive labor market as well, however.

A more striking contrast with the competitive labor market case emerges if Φ rises by less than A so that Φ/A declines. In this case, total factor productivity and labor's marginal product are increasing at a faster pace than A since the costs of training labor are not rising at the same time. Nonetheless, this more biased form of technical progress leads to smaller increases in wages. This can be seen from (5) since an increase in A that is not accompanied by an increase in Φ raises the left hand side of this expression by more. Since (6) ensures that this expression is declining in L, this means that L must rise by more in this case. However, a larger increase in L means a bigger decline in the marginal product of labor so that W must increase by less.

This raises the question of whether it is possible for wages to decline in response to an increase in A. It turns out that, when workers have sufficiently strong bargaining power, this is possible. To see this, consider the case where δ is equal to one and F has the CES form. The real product wage W/P is then equal to

$$\frac{W}{P} = A(1 + d\kappa^{\gamma})^{\frac{1}{\gamma}-1} \tag{14}$$

while the first order condition (11) can be written in the convenient form

$$(1-\gamma)dA(1+d\kappa^{\gamma})^{\frac{1}{\gamma}-1}\frac{\kappa^{\gamma}}{1+d\kappa^{\gamma}}-\frac{\Phi}{P}=0 \tag{15}$$

An increase in A without a corresponding increase in Φ/P reduces κ regardless of the value of γ. If, and only if γ is negative this reduces $\frac{\kappa^{\gamma}}{1+d\kappa^{\gamma}}$. Since (15) implies that $\frac{\kappa^{\gamma}}{1+d\kappa^{\gamma}}$ times the wage is proportional to Φ, this implies that the wage must fall. Thus technical progress that does not increase real training costs has the potential of reducing wages. Of course, this can only happen if there were sufficiently many unemployed workers at the initial equilibrium that the reduction in κ can be accommodated by hiring additional employees.

3 Movements in Wages with Imperfect Competition

With perfect competition, the demand for labor by a typical firm can only change if there is a change in the technology for producing output. As stressed in Rotemberg and Woodford (1997), the existence of imperfect competition creates a new source of aggregate changes in labor demand, namely changes in the markup of price over marginal cost. I now consider the effects of shocks that change this markup. For concreteness, I focus on the effects of changes in the demand elasticity facing monopolistically competitive firms as in Bils (1989) and Gali (1994). While I also sketch below why the results ought to apply in models of rigid prices, the extension to alternative models of cyclical markups is left for further research.

In this section, I assume that the demand for each good is a symmetric function of its own price and the prices of other goods. In order to sell the quantity Y, the typical firm must set a price such that

$$Y = D(P, \xi) \tag{16}$$

where ξ represents all other determinants of demand, including the price charged by other firms. At a symmetric equilibrium, ξ is the same for all firms. One key determinants of firm output is the inverse elasticity of demand $-\frac{Y/P}{dY/dP}$ which I denote by η and which must be between zero and one. Changes in this elasticity at the symmetric equilibrium cause changes in employment and real wages.

In the case of imperfect competition, it matters whether firms set prices before or after bargaining with their workers. Or, put differently, it matters whether prices can be changed after bargaining is complete or whether, instead, bargaining over wages can be reopened after prices are set. I study both these cases in turn.

3.1 Bargaining with Pre-determined Prices

I start with the case where prices are set by the time workers bargain with firms. Thus, the firm initially hires L workers, sets its price P and then the workers make their demands. As before, I cover in some depth the outcome when workers make take-it-or-leave it offers and then generalize this to the case where the wage is a linear combination of this wage and the workers' reservation wage.

To determine the equilibrium, one must work backwards from the time when, taking the wage offers as given, the firm decides how many of its initial L employees to keep. I suppose that all employees ask for the same W, though I show shortly that this is indeed what they will all do. Given that there is no reason to produce any more than $D(P, \xi)$ at this point, the firm then keeps $\tilde{L}$ workers to maximize

$$PAF(\tilde{L}, K) - W\tilde{L} - \Phi L \qquad \text{subject to} \qquad \tilde{L} \leq L \qquad \text{and} \qquad AF(\tilde{L}, K) \leq D(P, \xi)$$

with respect to $\tilde{L}$ taking L and P as given. This means that the firms starts by keeping the employees who offer to work for the lowest wage and keeps moving up this "wage offer curve" until either W is above PAF_L, or until the number of employees it has already decided to keep is equal to either L or the level L^* such that $F(L^*, K)$ is equal to $D(P, \xi)$. Thus, if L happens to be equal to this level L^*, the firm keeps all L employees if their wage offers are no greater than PAF_L. If L is lower than L^*, all employees are again retained if they offer to work for no more than PAF_L while, if L is higher then L^*, some employees are let go regardless of their wage offers.

I suppose that the employees do not know whether L is greater than or smaller than L^* but that, consistent with what firms do given this ignorance, the employees expect L to be no greater than L^*. Finally, I assume that employees know their marginal product as well as the pre-set price of the output so they know PAF_L. Given this knowledge and these beliefs, all L employees find it in their interest to set W equal to PAF_L if this exceeds $\bar{W}$ so that (2) is satisfied once again. [16]

Following the approach of the previous section, I thus generalize the wage setting equation and use (3) instead. Given that the firm knows employees will pick wages in this way, it chooses L to maximize (4) once again. Because P depends on L (via its dependence on Y) this now leads to the first order condition

$$(1-\delta)AF_L - \delta AF_{LL}L - \eta F_L\Big[\frac{Y - \delta AF_L L}{Y}\Big] - \frac{\Phi + (1-\delta)\bar{W}}{P} = 0 \tag{17}$$

In the case that η is sufficiently small, it is immediately apparent that the value of the left hand side of this expression in the limits where L goes to zero and infinity as well as the derivative of this expression with respect to L are essentially the same as in the perfectly competitive case. Thus, as long as η is small, the solution to this equation provides the optimal level of employment whenever the production function satisfies the condition which were needed for the first order condition to describe optimal employment under perfect competition. Since the term multiplying η in (17) also depends on the capital-labor ratio, the solution to this equation is again an optimal K/L which I denote by κ.

The left hand side of (17) falls when η increases. This implies that, if the second order conditions are satisfied (i.e. so that (6) holds locally at the optimal level of employment), increases in η lead to reductions in employment. Since η increases when the elasticity of demand falls, this means that an increase in the elasticity of demand leads to an increase in L.

[16] The most critical assumption for this result is that employees expect the firm to set L no greater than L^*. If employees expected L to exceed L^*, they would expect some employee offers to be rejected. This would induce them to lower their wage so as to retain their position in the firm. However, it is plausible to assume as I do that employees do not know the connection between L and L^*. This ignorance, by itself, eliminates the firm's incentive to set L above L^*. Given that the firm must pay Φ for the additional employees and that this cost leads to no other compensating revenue when the employees are let go, the only possible benefit of this extra hiring for the firm is to lower the wages that the employees demand. If employee ignorance eliminates this effect, the firm hires only L^* employees.

This result is analogous to the ones surveyed in Rotemberg and Woodford (1997) in which an increase in the elasticity of demand raises the demand for labor. The reason this occurs here is basically the same as the one discussed there: An increase in the elasticity of demand promotes hiring because the firm suffers a smaller price decline when it hires more people.

The effect of an increase of η on the real wage of factor L can be obtained by differentiating (3). Since F_L is decreasing in L, it follows immediately from this equation that an increase in employment which is unaccompanied by an increase in the reservation wage $\bar{W}$ leads to a reduction in L's real product wage. This suggests that, if this model where embedded in a general equilibrium model where $\bar{W}$ would be determined as well, real wages would probably be less procyclical with individualistic bargaining than with competitive labor markets. In the case of competitive labor markets, the wage would rise as fast as $\bar{W}$. The contrast is particularly extreme when workers have all the bargaining power so that δ equals one. Then, as long as there are sufficiently many unemployed workers to take up the slack, real wages fall unambiguously as output and employment rise. The reason is that workers are then paid their *ex post* marginal product and this falls when employment increases.

Very similar results are likely to obtain if, due to costs of changing prices, output prices are fixed when there is an increase in the quantity demanded. The firm's gain from hiring an additional worker when $\delta = 1$ is then $(-PAF_{LL}L - \Phi)$ and this is positive at a point where the first order condition (17) holds. Thus, at least in the neighborhood of this optimum, a firm with rigid prices responds to an increase in the quantity demanded by raising its employment and its output. As a result, the wage ought to fall once again.

3.2 Bargaining over the Marginal Revenue Product

An alternative formulation is to suppose that the firm can adjust its prices after concluding its bargain with the workers. This can be modeled by supposing that the period starts with the firm hiring L workers but that this is immediately followed by negotiations with workers. Prices are set thereafter.

This sub-section shows that the results are considerably more ambiguous in this setting. It is now quite possible that increases in η raise employment rather than lowering it. Moreover, even when increases in η lower employment, wages may fall rather than rise. While I provide examples where, for given $\bar{W}$, wages move in the opposite direction as employment, these examples are less robust.

I start again with the case where workers make take-it-or-leave it offers. Each worker now believes that her departure would lead the firm to raise its price so that the resulting price would clear the market with the lower amount supplied. Assuming this exceeds $\bar{W}$, she would thus demand her marginal revenue product

$$\frac{d(PY)}{dL} = AF_L(P + \frac{dP}{dY}Y) = PAF_L(1-\eta). \tag{18}$$

Since η is positive, this wage demand is more modest than the demand when workers treat prices as predetermined. This suggests that, particularly when workers have a great deal of bargaining power, the model with predetermined prices has the advantage that it lets workers make their demands when the firm's position is weaker. Since prices do remain fixed for some time in practice, workers would be expected to make their demands when they feel that their employer is unable to respond to their departure by rapidly raising its prices.

I once again generalize this wage setting equation and suppose that W is given by

$$W = \bar{W} + \delta \max[0, PAF_L(1-\eta) - \bar{W}]. \tag{19}$$

Thus, assuming the marginal revenue product exceeds the reservation wage, the firm chooses L to maximize

$$\pi^m = PAF(L,K) - \delta(1-\eta)PAF_L L - (1-\delta)\bar{W} - \Phi L. \tag{20}$$

which leads to the first order condition

$$(1-\delta)(1-\eta)AF_L - \delta(1-\eta)AF_{LL}L + \delta\frac{\eta(1-\eta)A^2F_L^2L}{Y} - \frac{(1-\delta)\bar{W}+\Phi}{P} = 0. \tag{21}$$

Once again, the boundary and curvature conditions required for an optimum of this form to exist are essentially the same as in the competitive case if η is small enough.

This version of the model leads to ambiguous effects of η on L. The reason is that the derivative of the left hand side of (21) with respect to η is

$$\delta L F_{LL} - (1-\delta)F_L + \delta(1-2\eta)\frac{F_L^2 L}{F}.$$

If this expression were negative the second order condition would ensure that L falls when η rises. However, while the first two terms are negative, the third is positive for small η. Moreover, the third term is larger in absolute value than the second if δ is sufficiently large and η is sufficiently small.

Even supposing that an increase in η lowers employment, it is no longer certain that this raises wages when $\bar{W}$ is unaffected. This can be seen by inspecting (19). This shows that, while it is still true that reductions in L raise wages, an increase in η reduces wages directly.

These two ambiguities are related. When η rises, the reduction in output that is caused by the departure of a worker induces a smaller revenue loss because the price rises more. Since the firm has less to lose from a worker's departure, the worker earns a lower wage. This reduction in wages, in turn, makes hiring workers more attractive. Thus, this effect tends to make employment rise when η rises.

It is thus possible to construct examples where increases in η raise employment while also lowering wages. In these examples, it is still the case that wages are countercyclical in the absence of any change in $\bar{W}$, though for a quite different reason than the one emphasized in the previous subsection. To show this, I now present such an example.

Suppose that δ equals one and that the production function is given by the Cobb-Douglas form (9). Assuming this exceeds $\bar{W}$, W is then

$$W = PA\alpha(1-\eta)\left(\frac{K}{L}\right)^{1-\alpha}$$

while the first order condition (21) becomes

$$AP\alpha(1-\eta)(1-\alpha+\alpha\eta)\left(\frac{K}{L}\right)^{1-\alpha} = \Phi.$$

The left hand side of this expression is the wage multiplied by $(1-\alpha+\alpha\eta)$. Since an increase in η must necessarily raise $(1-\alpha+\alpha\eta)$, it must lower the wage. It also lowers employment if $(1-\eta)(1-\alpha+\alpha\eta)$ falls. Differentiating this expression with respect to η, this fall in employment occurs if

$$2\alpha - 1 - \eta(1+\alpha) < 0.$$

With α equal to .67 (a common estimate of the labor share in the U.S.), the inverse elasticity of demand would have to exceed .2 (so that the elasticity of demand cannot be larger than 5). Otherwise, employment would rise when η rises.

One conclusion from this section on imperfect competition is that wages in particular jobs can fall when employment rises. Empirical examples of this have been observed, for example by Wilson (1997). Unless workers have all the bargaining power, however, the model does not necessarily imply that real wages are countercyclical. With δ less than one, real wages can be procyclical as long as procyclical movements in the reservation wage $\bar{W}/P$ are sufficiently large to offset the countercyclical movements in AF_L.

4 Multiple Sectors

As a prelude to modeling the wage changes of people who change jobs in booms, I now consider a setting where firms differ in their production and demand functions. My model of bargaining then implies that wages will generally differ across firms.[17] I show this in a slightly modified setting where firms can hire capital in an economy-wide market. I use this modified setting for two reasons. The first is that I want to avoid the unrealistic implication that two industries can have different real wages simply because they were exogenously endowed with different capital stocks. The second is that, by having an economy-wide market for capital, I ensure that the price of capital is the same in all industries. I can then use this price of capital as a numeraire in computing real wages in different industries.

I concentrate my attention on the outcome when δ equals one so that workers have all the bargaining power and, consistent with this, I study only the case where, if competition

[17]For a discussion of the inter-industry wage differences that result when the Shapley value is used to model bargaining inside the firm, see Rotemberg and Saloner (1986). For another model where bargaining leads wages to differ across jobs, see Acemoglu (1997).

is imperfect, prices are set before workers bargain with firms. What is different is that the firm now starts the period by hiring not only L units of labor but also K units of capital. I suppose that the cost of a unit of capital is exogenous to the firm and I denote it by R.

Thus, firms maximize

$$\pi = P(AF(L,K) - AF_L L) - \Phi L - RK \tag{22}$$

where P continues to be given by (16). There are now two first order conditions,

$$-AF_{LL}L - \eta AF_L\Big[\frac{F - F_L L}{F}\Big] - \frac{\Phi}{P} \;=\; 0 \tag{23}$$

$$AF_K - AF_{LK}L - \eta AF_K\Big[\frac{F - F_L L}{F}\Big] - \frac{R}{P} \;=\; 0. \tag{24}$$

The first of these equations is identical to (17) with δ set to one. I simplify this equation further by supposing that the setup cost Φ is proportional to P so that

$$\Phi = P\tilde{\Phi}. \tag{25}$$

This can be interpreted as saying that the costs take the form of purchases of goods produced by other firms which have the same production structure and the same structure of demand. With this assumption (23) becomes

$$-F_{LL}L - \eta F_L\Big[\frac{F - F_L L}{F}\Big] = \frac{\tilde{\Phi}}{A} \tag{26}$$

The benefit of assuming (25) is that (26) gives the equilibrium capital/labor κ as a function of purely technical considerations and this increases the analytical tractability of the model.[18] Two obvious determinants of κ are η and $\frac{\tilde{\Phi}}{A}$ and I use the notation $\kappa(\eta, \frac{\tilde{\Phi}}{A})$ for the function that relates κ to these two parameters. This function is increasing in both its arguments. To see this, note that because the second order conditions require that the left hand side of (26) be declining in L, it must be increasing in κ. Increases in η reduce the left hand side of this equation, while increases in $\frac{\tilde{\Phi}}{A}$ raise the right hand side. Thus, they

[18] I have also studied alternative specifications for Φ, including the assumption that this cost takes the form of reductions of the firm's own output, and obtained similar results using numerical methods.

must both be offset by increases in κ. These results recapitulate, in this simpler setting, the effects of η discussed in section 3.1 and the effects of technical progress discussed in section 2.

Equation (24) equates the benefit to the firm from having an extra unit of K to its cost R. This marginal benefit is less than the value of the marginal product PAF_K not only because of the monopolistic distortion but also because an increase in K raises the marginal product of labor and thereby raises the wage bill by $AF_{LK}L$. For these equations to constitute optima, I require additional boundary and curvature conditions. In particular, when η is small, $F_{KK} - LF_{KKL}$ must be negative while the limit of $F_K - F_{LK}L$ must be large as K goes to zero. These conditions are not very demanding, however.

Notice that my simplification regarding the cost Φ makes it possible to analyze the equilibrium recursively. Given the value of $\kappa(\eta, \frac{\tilde{\Phi}}{A})$ that solves (26), equation (24) gives the relative price R/P and total output can then be obtained from (16). The real wage in terms of K (which provides an economy-wide benchmark) and which I denote by ω is simply

$$\omega \equiv \frac{W}{R} = \frac{F_L}{F_K - F_{LK}L - \eta F_K \left[\frac{F - F_L L}{F}\right]}. \tag{27}$$

Since the right hand side of (27) depends on η and κ, I let $\omega(\eta, \kappa)$ denote the function that graphs this dependence. This function is increasing in its two arguments. An increase in κ raises the marginal product of labor while the second order conditions ensure that it reduces the value of the denominator on the right hand side of (27). The reason an increase in η raises ω for a given capital/labor ratio is that an increase in η reduces the marginal revenue product of capital even when all physical products are unchanged. Thus, just as in the case of competitive factor markets, it reduces the equilibrium value of R/P and this now raises W/R.

This means that an increase in η raises real wages (in terms of K) both directly and indirectly, through the resulting increase in κ. This result implies that firms that face steeper demand curves pay higher wages than do firms with flatter ones. While this is only a very particular mechanism that translates product market power into wages, the logic of the analysis suggests that other sources of market power should lead to higher wages as well. Collusion among oligopolists, in particular, can be expected to restrict output and employment and thus raise the marginal product of labor and the real wage. Thus, the model is broadly consistent with the finding of Katz and Summers (1989) that more concentrated industries pay higher real wages.

It is worth noting that, for simple functional forms, the magnitude of this effect can be substantial. To see this, consider the Cobb-Douglas production function (9). Equation (26) implies that

$$\alpha(1-\alpha)\kappa^{1-\alpha} = \frac{\tilde{\Phi}}{A} \tag{28}$$

whereas (27) becomes

$$\omega = \frac{\alpha(K/L)^{1-\alpha}}{(1-\alpha)^2(1-\eta)(K/L)^{-\alpha}}$$

Substituting for κ from (28), the real wage is

$$\omega = (1-\eta)^{\frac{2-\alpha}{\alpha-1}}\alpha^{\frac{\alpha}{\alpha-1}}(1-\alpha)^{\frac{3-2\alpha}{\alpha-1}}\left(\frac{\tilde{\Phi}}{A}\right)^{\frac{1}{1-\alpha}}$$

This means that the semi-elasticity of ω with respect to η evaluated at η equal to zero equals $\frac{2-\alpha}{\alpha-1}$. In effect, an increase in η from zero (the competitive value) to .01, (where a one percent increase in output requires a price reduction of one one-hundredth of a percent) raises real wages by four percent if α is equal to 2/3. This does not seem insignificant.

Katz and Summers (1989) also show that capital/labor ratios are cross-sectionally positively correlated with real wages. Since increases in η are associated with both higher capital/labor ratios and higher wages, this model also provides an interpretation for this finding. In addition, increases in $\frac{\tilde{\Phi}}{A}$ also raise real wages together with the capital/labor ratio. Other changes in the production function do not have this attribute, however. For example, an analysis of the equations above shows that increases in α have ambiguous effects on both the capital/labor ratio and the real wage.

Before closing this section, I want to briefly turn my attention to the level of firm profits. In particular, I wish to show that equilibrium profits are zero when η is zero while they are positive when η is positive. Given a constant return to scale production function, this is precisely what one would expect if factor markets were competitive. But, given that labor demands more than its full marginal product, this is of some interest. To see this, use (23) and (24) to substitute for Φ and R in (22) so that this equation can be rewritten as

$$\frac{\pi}{AP} = [F(L,K) - F_L L - F_K K] + L\{F_{LL}L + F_{LK}K\} + \eta(F_K K + F_L L)\Big(\frac{Y - AF_L L}{Y}\Big).$$

The homogeneity of F implies that both the term in square brackets and that in curly brackets equal zero, and the conclusion follows. This means that, just as when factor markets are competitive, free entry with a constant $\eta > 0$ leads to zero profits as long as there are fixed costs. For simplicity, however, I neglect entry in my analysis. It is worth stressing, however, that considerations of entry do not change the conclusion that differences in demand and in the production structure affect real wages in the presence of my form of individualistic bargaining.

5 Cyclical Upgrading

I now consider situations in which the inverse elasticity of demand η falls in two sectors whose wages are different. As in section 3.1, this means that the demand for labor rises in both industries and that, if there are a sufficiently large number of unemployed workers, employment rises in both. If the cost ΦL is independent of whether firms hire previously unemployed or previously employed workers there is no reason why workers previously employed in the low-wage sector could not find themselves upgraded to the high-wage sector. This provides only a very weak rationale for cyclical upgrading because even a very small cost advantage to recruiting from the unemployment pool would ensure that all new jobs would be filled by members of this pool.

The model provides a much firmer basis for expecting workers to move from low- to high-wage jobs when labor demand increases if one drops the assumption that all workers have the same productivity. Such an extension is particularly attractive in the context of discussing inter-industry wage differences because the leading alternative interpretation for these differences is that they are due to differences in the individual productivity of workers employed in different industries. One reason that Murphy and Topel (1990) give for preferring this alternative explanation is that, as also shown by Dickens and Katz (1987), the employees in industries with high wages also tend to have observable characteristics which connote high skill. It turns out that my model implies this as well. I show that, even if absolute differences in productivity do not confer any comparative advantage for working in any particular sector, high-wage sectors tend to hire more productive individuals. At the same time, high-wage sectors also pay wage premia to their workers, as suggested by the evidence of Gibbons, Katz and Lemieux (1997).

The reason high-wage sectors end up with more productive employees in my model is that all firms prefer to hire more productive employees.[19] In the absence of search frictions, this implies that more productive employees end up working for firms that pay larger wage premia (while unemployment is principally borne by relatively less productive employees). When the demand for labor expands in all sectors, high-wage sectors prefer to poach relatively more productive employees from the ranks of low-wage sectors. This is more attractive to them than hiring from the unemployment pool and is what creates cyclical upgrading in my model. The low-wage sectors must then replace their departing workers by recruiting from the unemployed. This is what Akerlof, Rose and Yellen (1988) term a "vacancy chain".

To see this formally, suppose that there are two types of workers (the extension to more types is straightforward) which differ in their productivity. There are $\bar{M}_1$ available workers of type 1 and $\bar{M}_2$ available workers of type 2. A firm that hires m_1 workers of type 1 and

[19] Similar results can be found in the search-theoretic models of Shimer (1996) and Moscarini (1997) but I emphasize a channel that operates even if more productive workers have commensurately higher reservation wages. Workers do not have all the bargaining power in Shimer (1996) and Moscarini (1997) so that wages equal an average of their productivity and of what they can expect to earn if the firm fails to hire them. Under their assumption that all reservation wages are the same, firms prefer to hire more productive employees. These reasons for preferring more productive workers would be just as relevant in my model as in theirs if I let wages be given by (3) and made their assumptions about $\bar{W}$. However, if reservation wages reflected productivity differences, or if workers had all the bargaining power, firms would be indifferent as to whom they hire in their setups.

m_2 workers of type 2 has a total effective labor input L given by

$$L = \rho_1 m_1 + \rho_2 m_2 \qquad\qquad \rho_1 > \rho_2$$

so that, without loss of generality I am assuming that type 1 workers contribute more effective units of labor. I simultaneously suppose that this firm incurs setup costs equal to $\Phi(m_1 + m_2)$. Thus, this cost does not depend on the composition of the firm's workforce and, in particular, is not higher if the firm hires more productive employees. This is an assumption that is central for the results that follow. It has a certain degree of plausibility in that the cost of finding, training or figuring out what "better" employees must do is not necessarily commensurate with their higher output (indeed it might be lower precisely because they are better).

Assuming this exceeds her reservation wage, an employee with productivity parameter ρ still demands her *ex post* marginal product which now equal ρPAF_L. Thus, profits from this collection of inputs are

$$P[AF(L, K) - AF_L L] - \Phi(m_1 + m_2) - RK \tag{29}$$

where P can depend on the level of output as before. Thus, the firm's marginal benefit from adding an employee with productivity ρ_i to its roster is

$$-\rho_i PA\Big[F_{LL}L + \eta F_L \frac{Y - F_L L}{Y}\Big] - \Phi. \tag{30}$$

If the firm is maximizing profits, the expression in (30) is nonnegative for all its employees and is nonpositive for any worker who is available to the firm but who has not been hired. One obvious feature of (30) is that, for given Y, L and K, it is lower for employees with lower values of ρ. Thus, the firm strictly prefers hiring more productive employees to hiring less productive employees.

This may seem surprising since the ability of employees to capture their entire marginal product as wages may seem to make all workers equivalent in a firm's eyes. However, while the ability of more productive employees to generate more sales has no direct effect on the desirability of hiring them because their wage is higher as well, there is another effect. This is that, for a given increase in the cost of deploying an additional employee Φ, a more productive employee lowers the marginal product of other workers by more and this lowers other workers' wages by more. In effect, the setup cost Φ per unit of wage bill reduction is lower for more productive employees. The assumption that the cost of deployment does not rise when the employee is more productive is critical for this result. If this cost were proportional to the employee's productivity (as opposed to being the same for all employees), all employees would contribute the same to profits at the margin regardless of their productivity. It does, however, seems more plausible that the cost of deploying a particular employee rises less than proportionately with the employee's productivity.

Since all firms prefer to hire more productive employees, the question becomes which firms actually get to hire them. Since the payment to workers in units of factor K equals $\rho\omega$, every worker prefers to work for firms whose ω is higher. However, the size of ω depends, in turn, on the number and type of workers that a firm has hired. Unfortunately, the fact that the wages are determined *ex post* through bargaining makes this matching problem different from the labor matching problems considered in the literature (see the survey in ch. 6 of Roth and Sotomayor 1990). Nonetheless, I demonstrate that, quite generally, a firm whose ω is lower than another firm's cannot attract employees whose ρ is higher than that of the lowest-ρ employee at the higher ω firm.

If one abstracts from employee search costs, a reasonable requirement of an equilibrium is that it be stable in the sense that a firm cannot gain by spending an additional Φ, planning on having an additional employee and getting an employee from another firm to offer his services. Nor, should workers be able to gain by offering their services to a firm (with the knowledge that they would end up charging their *ex post* marginal product) in lieu of the services being offered by another.

Let ρ_i denote the productivity of the least productive employee working for a particular firm. Since (30) is increasing in ρ, it is strictly positive for employees whose ρ is larger than ρ_i. Thus, people whose ρ exceeds ρ_i cannot be working at firms where ω is lower. If they did, the firm would have gained by luring these workers away from their lower ω firm and the workers would gladly have attached themselves to the higher ω firm.

If there are two sectors as well as two types of workers, this means that it is impossible for the sector whose ω is lower to attract type 1 employees if the other sector also employs type 2 employees. Thus, it is impossible for both sectors to have both types of employees. One of the sectors must specialize in either type 1 or type 2 employees. To understand further the forces that lead to one or the other outcome, I now consider a situation where the two sectors are each populated by monopolistic firms. Their setup costs again satisfy $\Phi = P\tilde{\Phi}$ where P is the common price of goods produced by their sector and the sectors differ only in their initial values of η and $\frac{\tilde{\Phi}}{A}$. I denote the values of these parameters in sector j (where j takes on the values of 1 and 2) by η^j and $\frac{\tilde{\Phi}^j}{A^j}$ respectively. This example allows me to study another issue which also impinges on whether there is cyclical upgrading. This is whether firms that hire only type 1 workers are rationed in the number of them that they can obtain even when some type 1 workers are employed in the other sector.

For a firm to be at an interior solution with respect to the number of employees of type i that it hires, the derivative of (29) with respect to m_i must be zero. Thus

$$-F_{LL}L - \eta F_L\Big[\frac{F - F_L L}{F}\Big] = \frac{\tilde{\Phi}}{A\rho_i}. \tag{31}$$

This means that, if firms in sector j are able to hire employees of type i at the margin, they set their capital/labor ratio equal to $\kappa(\eta^j, \frac{\tilde{\Phi}^j}{A^j\rho_i})$. The ability to hire more productive employees at the margin thus lowers the capital/labor ratio. My simplifications ensure that the ability to hire more productive employees inframarginally has no effect on this desired capital/labor ratio even though it obviously affects total firm profits.

Since the dependence of profits on K in (29) is the same as in (22), the first order condition (24) remains valid. Thus (27) still describes the real wage ω earned by a worker who supplies one effective unit of labor. The wage of an individual with productivity ρ is simply $\rho\omega$.

I suppose, without loss of generality that sector 1 has either a higher η, a higher $\frac{\tilde{\Phi}}{A}$ or both. This means that, if ρ_i is the same in both sectors, sector 1 has a higher κ and a higher ω so that all workers prefer to work there. Thus, it is inconsistent with equilibrium to have all the type 1 workers work in sector 2 while sector 1 attracts only type 2 workers. The reason is that this would further exacerbate the extent to which K/L is bigger in sector 1 and thereby further increase wages in sector 1 relative to wages in sector 2.

This means that sector 1 attracts some workers of type 1. Whether it attracts them all depends on several additional factors. First, if $\bar{K}$ is sufficiently small relative to $\bar{M}_1$, all jobs are held by type 1 workers. Thus (31) holds in both sectors with ρ_i replaced by ρ_1. Second, if $\bar{K}$ is sufficiently large relative to $\bar{M}_1$, all workers of type 1 work in sector 1 but this sector also hires some workers of type 2. Thus (31) holds in both sectors with ρ_i replaced by ρ_2. Neither of these cases is of great interest because they do not provide a strong rationale for cyclical upgrading. Expansions in demand simply raise the demand for both high-paid and low-paid workers but there is no intrinsic reason why the new high paid jobs in sector 1 should go to people initially employed in sector 2. I am thus interested in the intermediate case where $\bar{K}$ is sufficiently large relative to $\bar{M}_1$ that some workers of type 2 are employed but $\bar{M}_1$ is sufficiently big that not all workers of type 1 work in sector 1.

In this case, (31) holds in sector 2 with ρ_i replaced by ρ_2. But, even though not all workers of type 1 work in industry 1, it is not necessarily true that (31) holds for industry 1 with ρ_i replaced by ρ_1. For this to hold, it must also be the case that

$$\omega\Big(\eta^1, \kappa\Big(\eta^1, \frac{\tilde{\Phi}^1}{A^1\rho_1}\Big)\Big) > \omega\Big(\eta^2, \kappa\Big(\eta^2, \frac{\tilde{\Phi}^2}{A^2\rho_2}\Big)\Big) \tag{32}$$

This says that the wage for a worker of type 1 in terms of factor K is higher in sector 1 than in sector 2 when firms in sector 1 can hire as many workers of type 1 as they want while firms in sector 2 can only hire workers of type 2. This is a much stronger condition than if ρ_2 appeared in the terms of both sides of the inequality. In that case, the fact that η and $\frac{\tilde{\Phi}}{A}$ are larger in sector 1 would be enough to imply the inequality in (32). But, its access to ρ_1-workers lowers the desired capital/labor ratio in sector 1 and this can mean that, if they hire as many workers of type 1 as they desire, they can end up paying less than firms in sector 2 to workers of type 1.

Condition (32) effectively requires that the difference in productivity not be too large relative to the differences in η and $\frac{\tilde{\Phi}}{A}$. It is automatically satisfied if the ratios of the larger $\frac{\tilde{\Phi}}{A}$ to the lower one is larger than the ratio of the larger ρ to the lower ρ.

If this condition is not satisfied because the gap in productivities is very large, then sector 1 must be rationed in the number of employees of type 1 that it can hire even though sector 2 also has access to some type 1 employees. Sector 1 can only hire type 1 employees until the point where ω is the same in both sectors. If ω were bigger in sector 1, the sector would have access to additional workers of type 1; if it were smaller, fewer type 1 workers would accept jobs in the sector. What makes this case less interesting for my purpose than the case where (32) holds, is that workers who move from sector 2 to sector 1 do not get wage increases when (32) is violated.

If the above conditions, including (32) hold, then sector 1 has only high productivity workers while sector 2 has a mix of high and low productivity workers. Only sector 2 is rationed in the amount of type 1 workers it can attract. Thus, the model captures - in a crude way - the fact that more able people tend to work in industries were wages are higher.

Now consider a situation where η falls in both sectors. This leads both sectors to seek new workers. Assuming that sector 1 incurs the same cost Φ whether it attracts unemployed workers (of type 2) or workers of type 1 employed in sector 2, it would prefer the latter. Since these would prefer working in sector 1, one can expect them to move. For a small change in η, the wages of these movers then gets multiplied by the ratio of the left hand side to the right hand side of (32). Thus, workers who move into high-wage industries experience wage gains.

In the literature on inter-industry wage differences, investigators have noted that the wage gains of job changers gain are only equal to a fraction of the inter-industry average wage difference. In my model this occurs as well. The ratio of the average wage in sector 1 over the average wage in sector 2 is

$$\frac{\rho_1}{\lambda\rho_1 + (1-\lambda)\rho_2} \; \frac{\omega(\eta^1, \kappa(\eta^1, \frac{\tilde{\Phi}^1}{A^1\rho_1}))}{\omega(\eta^2, \kappa(\eta^2, \frac{\tilde{\Phi}^2}{A^2\rho_2}))}$$

where λ is the fraction of workers in industry 2 that are of type 1. Since λ is smaller than one, the first of these ratios is greater than one so that the percentage wage gain by job movers (which is the second ratio) is smaller than the percentage gap between the average sectoral wages. Moreover, the lower is λ and the higher is the gap between ρ_1 and ρ_2, the smaller is the wage gain of movers in comparison to the average wage gap. These wage gaps plays a role not just in micro studies of individual wage gains but also in aggregate studies of whether real wages are procyclical or not. The larger is the wage gain of job changers, the more procyclical are the average wages of people who remain employed.

6 Conclusion

The main aim of this paper has been to construct a model where increases in the demand for labor cause smaller increases in average real wages than in models with competitive labor markets. A secondary aim has been to reproduce some of the individual wage changes that are observed during business cycles. Along these dimensions, the model of individual bargaining seems somewhat successful so that further exploration of the implications of this approach seems worthwhile.

The success of the model in explaining some aspects of wages raises the question of whether a model of this sort can also explain the dynamics of unemployment. The unemployment that arises in this model is of a very different sort than the one that is usually studied in theoretical models. The more common approach is to see unemployment as somewhat useful because it helps in matching workers to firms. Whether unemployment really is useful in this way does seem like an open empirical question at this point. As Clark and Summers (1979) and Akerlof, Rose and Yellen (1988) demonstrate, a large fraction of job changers do not experience any unemployment. Moreover, as shown by Murphy and Topel (1990) the unemployment spells that precede employment in high-wage jobs are, if anything, somewhat shorter than those that precede employment in low-wage jobs. Neither of these observations proves that unemployment is of no value in creating good matches in the labor market. Rather, they suggest that models where unemployment has no such benefits should not be ruled out and that there would be great value in sorting out whether one of these two classes of models has more realistic implications.

It seems at least possible that extensions of the model presented here would also explain some important aspects of labor market flows. One important feature of the U.S. labor market is that a very high fraction of total unemployment is accounted for by people who spend a great deal of time not working and whose jobs when they are working are quite short. A purely competitive explanation for this behavior could be that some people simply don't like working very much. My model suggests a possible alternative view. In this view, low skilled people find it difficult to get jobs even if their reservation wages are considerably lower than those of other people. The reason they have a hard time getting hired is that, once hired, they cannot help but press for high wages. The current version of the model only predicts that low-skilled individuals have trouble getting hired. It does not account for the ability of these individuals to get short term jobs on occasion. However a dynamic version of the model might account for these jobs in response to temporary variations in labor demand.

A dynamic version of the model might also explain why, as shown by Akerlof, Rose and Yellen (1988) and Blanchard and Diamond (1990) direct movements of employees from employer to employer are procyclical. While booms are periods where individuals quit their jobs for better jobs, people who separate from jobs in recessions tend to suffer bouts of unemployment. In the model I have presented, where the cost ΦL is incurred every period, such asymmetries are absent. Since relatively more productive workers are preferred by all employers, they should always be employed. Not only should these workers get to move from low-wage to high-wage jobs in booms, but they also ought to be picked up by low-wage sectors in recessions as less skilled workers lose their jobs.

Suppose that, instead, the cost Φ is incurred only when hiring workers and that workers tend to stay for multiple periods. Expansions in labor demand by all sectors would still tend to push more productive workers from low-wage to high-wage sectors as these sectors prefer more productive employees. In recessions, on the other hand, low-wage sectors might not want to replace immediately their relatively unskilled workers with the skilled workers who are losing their high-wage jobs. The reason is that this replacement increases hiring and training costs. This extension of the model might thus predict that, in recessions, the direct worker flow from employment to employment ought to be relatively meager.

7 References

Abraham, Katherine G. and John C. Haltiwanger, "Real Wages and the Business Cycle," *Journal of Economic Literature*, 33, September 1995, 1215-64.

Acemoglu, Daron, "Good Jobs versus Bad Jobs: Theory and Some Evidence," mimeo, MIT, May 1997.

Akerlof, George, Andrew Rose and Janet Yellen, "Job Switching and Job Satisfaction in the U.S. Labor market," *Brookings Papers on Economic Activity*, 1988:2, 495-582.

Bentolilla, Samuel and Guiseppe Bertola, "Firing Costs and Labour Demand: How Bad is Eurosclerosis?," *Review of Economic Studies*, 57, July 1990, 381-402.

Bertola, Guiseppe and Ricardo J. Caballero, "Cross-Sectional Efficiency and Labour Hoarding in a Matching Model of Unemployment," *Review of Economic Studies,* 61, 1994, 435-56.

Bils, Mark, "Real Wages over the Business Cycle: Evidence from Panel Data," *Journal of Political Economy,* 93, August 1985, 666-89

—— , "Pricing in a Customer Market," *Quarterly Journal of Economics*, November 1989.

—— and Kenneth J. McLaughlin, "Inter-Industry Mobility and Cyclical Upgrading of Labor," *Rochester Center for Economic Research Working Paper 367*, November 1993.

Blanchard, Olivier J. and Lawrence H. Summers, "Hysteresis and the European Unemployment Problem, *NBER Macroeconomics Annual*, 1986, 15-78.

Caballero, Ricardo and Mohammed Hammour, "The Macroeconomics of Specificity," *NBER Working paper 5757*, September 1996.

Carmichael, Lorne, "Can Unemployment Be Involuntary?: Comment," *American Economic Review*, 75, December 1985, 1213-4.

Clark, Kim B. and Lawrence H. Summers, "Labor Market Dynamics and Unemployment: A Reconsideration," *Brookings papers on Economic Activity*, 1979, 13-61.

Diamond, Peter, "Wage Determination and Efficiency in Search Equilibrium," *Review of Economic Studies*, 49, 1982, 227-247.

Dickens, William T. and Lawrence E. Katz, "Inter-industry Wage differences and Industry Characteristics," in Kevin Lang and Jonathan Leonard eds. *Unemployment and the Structure of Labor markets*, New York and Oxford: Blackwell, 1987, 48-89.

Feinstein, Jonathan and Jeremy Stein, "Employee Opportunism and Redundancy in Firms," *Journal of Economic Behavior and Organization*, December 1988, 10(4), pp. 401-14.

Gali, Jordi, "Monopolistic Competition, Business Cycles, and the Composition of Aggregate Demand," *Journal of Economic Theory,* 96, 1994, 63-73.

Gibbons, Robert and Lawrence F. Katz, "Does Unmeasured Ability Explain Inter-Industry Wage Differentials," *Review of Economic Studies*, 59, July 1992, 515-35.

Gibbons, Robert, Lawrence F. Katz and Thomas Lemieux, "Unmeasured Ability, Unobserved Ability and Inter-Industry Wage Differentials," mimeo, 1997.

Holden, Steinar, "Local and Central Wage Bargaining," *Scandinavian Journal of Economics*, 90, 1988, 93-99.

Katz, Lawrence F. and Lawrence H. Summers, "Industry rents: Evidence and Implications," *Brookings papers on Economic Activity - Microeconomics*, 1989, 209-275.

Kimball, Miles S., "Labor Market Dynamics when Unemployment is a Worker Discipline Device," *American Economic Review*, 84, September 1994, 1045-59.

Lindbeck, Assar and Dennis Snower, "Efficiency Wages versus Insiders and outsiders," *European Economic Review,* 31, February 1987, 407-16.

—— and ——, "Cooperation, Harassment and Involuntary Unemployment: An Insider-Outsider Approach," *American Economic Review,* 78(1), March 1988a, 167-88.

—— and ——, *The Insider-Outsider Theory of Employment and Unemployment,* Cambridge: MIT Press, 1988b.

McDonald, Ian M. and Robert M. Solow, "Wage Bargaining and Employment," *American Economic Review*, 71, December 1981, 896-908.

Moene, Karl O., "Unions' Threats and Wage Determination," *The Economic Journal*, 98, June 1988, 471-83.'

Mortensen, Dale T., "The Matching Process as a Noncooperative Bargaining Game," in J. J. McCall ed. *The Economics of Information and Uncertainty*, Chicago: Chicago University Press, 1982.

Moscarini, Guiseppe, "Self-Selection of Workers in Search Equilibrium," mimeo 1997.

Murphy, Kevin M. and Robert H. Topel, "Efficiency Wages Reconsidered: Theory and Evidence," in Yoram Weiss and Gideon Fishelson, eds *Advances in the Theory and Measurement of Unemployment*, New York: St. Martin's Press, 1990.

Roth, Alvin E. and Marilda A. Oliveira Sotomayor, *Two-sided Matching*, Cambridge: Cambridge University Press, 1990.

Rotemberg Julio J. and Garth Saloner, "A Theory of Inter-Industry Wage Differentials," *Sloan School of Management Working paper 1822-86*, September 1986.

Rotemberg, Julio J. and Michael Woodford, "The Cyclical Behavior of Prices and Costs," in Michael Woodford and John Taylor eds. *Handbook of Macroeconomics*, forthcoming, 1997.

Shapiro, Carl and Joseph E. Stiglitz, "Equilibrium Unemployment as a Worker Disciplining Device," *American Economic Review*, 74, June 1984, 433-44.

Shimer, Robert, "Wage Inequality and Unemployment over the Business Cycle," mimeo, 1996.

Shin, Dongyun, "Cyclicality of Real Wages among Young Men," *Economics Letters*, 46(2), October 1994, 137-42.

Solon, Gary, Warren Beatley and Ann Huff Stevens, "Wage Changes and Intrafirm Job Mobility over the Business Cycle: Two Case Studies," *Industrial and Labor Relations Review,* 50, April 1997, 402-15.

Stole, Lars A. and Jeffrey Zwiebel, "Organizational Design and Technology Choice under Intrafirm Bargaining," *American Economic Review*, 86, March 1996, 195-222.

Weitzman, Martin, "The Simple Macroeconomics of Profit Sharing," *American Economic Review*, 75, 1985, 937-53.

Wilson, Beth Ann, "Movements of Wages over the Business Cycle: An Intra-Firm View," *Federal Reserve Board Working Paper*, January 1997.