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ABSTRACT

This paper considers a model where individual workers bargain with firms over their wages and where their bargaining power is so strong that some workers are unemployed. The result is that an increase in the elasticity of demand facing individual firms raises employment (as in the case where the labor market clears) but that wages rise only modestly. In fact, consistent with the findings of Wilson (1997), some job-specific wages actually fall. Nonetheless, average wages may rise either because wages of non-rationed workers rise or because there is cyclical upgrading of jobs. Assuming that workers are also rationed in financial markets, the increase in employment that accompanies the increase in the demand elasticity for individual products also increases consumption substantially. Thus, the model rationalizes the finding that real wages rise less in booms than does consumption. At the same time, the model is consistent with a lack of secular movements in hours and unemployment as well as a secular proportionality of consumption and real wages.

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The joint behavior of hours worked, consumption and real wages poses a central challenge to macroeconomics. The problem is that business cycle booms are periods with high levels of both aggregate consumption and hours worked. As stressed by Barro and King (1984) and Mankiw, Rotemberg and Summers (1985), this implies both that the marginal utility of consumption is low in booms and that the marginal utility of leisure is high. If people were on unchanged labor supply curves, the real wage would have to equal the ratio of the marginal utility of leisure to that of consumption and would thus have to be very high in booms. 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.

The puzzle is not just that the intertemporal elasticity of labor supply has to be very high to explain the increase in hours worked that accompanies cyclical booms. Rather, it is that the preference parameters that could explain the cyclical movements in these variables are very different from the parameters that would explain their secular movements. In the period after World War II, secular movements in hours per capita are negligible while, at the same time, the average percent increase in consumption is matched by an essentially equal average percent increase in hourly compensation. For preferences to be consistent with these secular observations, one must follow King, Plosser and Rebelo (1988) and consider utility functions which require that real wages rise by the same amount as consumption to keep per capita labor supply constant. Such preferences imply that real wages have to rise more than consumption if hours are to increase. However, in business cycle expansions the increase in real wages is smaller than the corresponding increase in consumption even though hours rise as well.

In this paper I explain these observations with a model in which many workers are rationed in the amount of labor that they can sell. This rationing helps explain the puzzle by making it possible for increases in employment to occur without necessarily increasing wages while, at the same time, this increase in employment leads people to consume more. The reason some workers are rationed in my model is that, as in Caballero and Hammour (1996) their wages are not market determined but are determined instead through individualistic bargaining with the employer.

In the particular setting I consider, workers have all the bargaining power and demand that their wages be equal to their *ex post* marginal product, *i.e.*, their marginal product at the time of bargaining. Unemployment results because, first, this *ex post* marginal product is larger than the marginal product at the time the firm is considering an increase in employment and because, second, workers are unable to compensate their employer for this difference in marginal products. One key difference between my analysis and Caballero and Hammour (1996) is that I consider a setting where capital can be combined with varying amounts of the labor input so that it is possible to have cyclical booms in which capital changes little but output and hours worked change considerably. [1] In particular, reductions in markups of price over marginal cost that result from increases in the elasticity of demand facing firms lead these firms to hire more workers even though their wage is above their marginal product. Thus, as in models surveyed in Rotemberg and Woodford (1997), increases in the elasticity of demand lead to booms.

Interestingly, I show that this need not increase wages. [2] Indeed, increases in employ-

[1] Much of the search literature starting with Diamond (1982) and Mortensen (1982) and including, among recent references that are related to this paper, Caballero and Hammour (1994), Shimer (1996) and Moscarini (1997) also assumes that wages are set as a result of bargaining between workers and firms. One important difference between these models and the model developed here is that, in these papers, the wage that workers earn as a result of bargaining is not larger than their *ex ante* marginal product so that unemployment does not exist in the absence of search frictions.

For a search-theoretic paper with individualistic bargaining in a model where the number of employees per firm is not fixed, see Bertola and Caballero (1994). Their paper differs from mine in analyzing only steady states. Another difference is that, because their paper is search-theoretic, it has firms that differ in the number of workers they have been able to hire. This leads to the counterintuive result that larger (and older) firms pay lower wages.

[2] This result bears a resemblance to the results for union bargaining in McDonald and Solow (1981). They show that a firm whose demand increases may not increase its wage very much (and may even decrease it) if it bargains with a union. However, their result depends on assuming a disutility of labor that does not vary with consumption or employment. Because these preferences also imply that wages do not respond to industry demand in a model where the labor market clears, it is not clear what role bargaining plays in

ment lower the *ex post* marginal product of workers and this tends to reduce the wages that employees can demand without fear of being fired. This fits with Wilson (1997) who documents that, in her sample, job-specific wages are indeed countercyclical. However, I show that there are also two countervailing forces that can make average real wages procyclical. The first is that workers who are not initially rationed may see their wages rise with output. The second is that booms may lead people to move from low paying jobs to high paying jobs. Still, the net effect of expansions in activity on real wages is ambiguous in that it depends on the parameters of the model. This is important because the degree to which real wages are procyclical appears to depend on the country and the time period one is looking at (Geary and Kennan 1982).

To ensure that consumption rises substantially when employment rises, I suppose that the workers who are rationed in the labor market also fail to have access to financial markets on which they can borrow against their future earnings. As a result, the consumption expenditure of these workers is very sensitive to their current income and, in particular, it rises significantly when a worker becomes employed. While rationing in financial markets is key to this result, rationing in labor markets plays a role as well. If there were only rationing in financial markets, and not in labor markets, the workers whose consumption increases in booms would demand much higher wages so that the puzzle of insufficiently procyclical real wages remains. Thus, simultaneous rationing in labor and financial markets appears helpful in explaining the joint behavior of hours, consumption and the real wage.

Much of the paper is concerned with situations in which all firms are identical. The assumption of homogeneous firms considerably simplifies the analysis while keeping a tight focus on aggregate movements in employment and consumption. However, the case of homogeneous firms is probably not the most realistic one for understanding the dynamics of real wages over the business cycle. As Bils (1985) and Shin (1994) demonstrate, people who change employers have real wages that are significantly more procyclical than those whose employer does not change. Individuals tend to upgrade their employer in booms by mov-

changing the cyclical behavior of wages in their model.

ing to employers where their wages are higher and they tend to downgrade their employer in recessions by having to move to employers where their wages are lower. [3] These cyclical movements in jobs extend beyond the people who change employers. As demonstrated by Solon, Whatley and Stevens (1997) and Wilson (1997) people who experience procyclical changes in wages while staying with their current employer often change their job description as well.

Job upgrading in booms is also a feature of my bargaining model, once I consider the possibility that jobs are heterogeneous in the sense that they involve producing output with different production functions (and possibly different degrees of market power). The reason is that in this model where workers demand their marginal product, the force that usually leads marginal products to be the same in different jobs (namely that all firms face the same wages) is absent, so that equilibrium marginal products and wages tend to differ in different jobs. The result, naturally, is that many workers would prefer to switch jobs in order to increase their income. When markups fall, all firms increase their employment so higher paying jobs open up and employees get to upgrade their jobs. The result is that an employee's wage can be procyclical even if "job-specific" wages are actually countercyclical.

One final feature of the analysis of heterogeneous jobs deserves note. If one couples the assumption of heterogeneous jobs with the assumption of heterogeneous workers, so that some workers are more productive than others *at all jobs*, the model tends to predict that the better jobs go to the more productive workers. In other words, workers with higher productivity earn more not only because they are more productive but also because they tend to end up in jobs in which wages are higher for any given level of productivity.

The paper proceeds as follows. I first lay the stage by considering a simple version of the model in which all firms have the same production function and in which these firms are perfectly competitive. The point of this section is to show how bargaining by individual workers leads to unemployment even when the rest of the model is relatively standard. The

[3] This fits with the well known observation that quits are higher in booms (presumably as people find better jobs) while layoffs are higher in recessions (and presumably force people to accept jobs they find less desirable).

unemployment comes about because workers get paid their *ex post* marginal product which exceeds their *ex ante* marginal product. Thus, a key role of this section is to explain why firms hire workers nonetheless. In this section I also sketch the reasons for wages to differ in different jobs. In addition, I analyze the effects of technical progress and show that, in the long run, such progress leads to balanced growth.

In Section 2, I return to the assumption that firms are identical and extend the model to the case where firms are monopolistic competitors. I show how increases in the elasticity of demand facing these firms, which lower the markup of price over marginal cost, lead to increased hiring of workers. Thus, supposing some workers were initially unemployed, this reduction in markups increases employment. In this section I also discuss the extent to which consumption would rise with employment if workers were initially rationed in financial markets. Section 3 applies the analysis of Section 2 to the particular case of Cobb-Douglas production functions. This allows me to explore the dependence of the degree to which average wages are procyclical on the parameters of the model. Section 4 then considers cyclical upgrading and section 5 concludes.

1 Perfectly Competitive Firms

In this section, I introduce the basic mechanism that leads to unemployment by considering perfectly competitive firms which take their output price P as given. I also analyze the effects of technical progress, in part to provide a comparison to the effects of changes in the demand elasticity that I consider below. Finally, this section also lays the groundwork for the model of cyclical upgrading of labor by explaining why wages in different industries will often be different.

1.1 The Basic Model of Rationing

This subsection introduces the basic model of rationing in the labor market. Two inputs are used for production: the labor input that bargains with the firm L, and another input (which I will later decompose into another kind of labor and capital) which I call N. The production function for the typical firm is

$$Y = F(L, N) - \Phi L \tag{1}$$

where Φ is a constant while F is homogeneous of degree one in L and N. It is important to stress that the existence of the second term in this production function does not restrict the production function itself. I could simply have assumed that output is given by the constant returns to scale production function $\tilde{F}(L, N)$ and $F(L, N)$ would then be equal to $\tilde{F}(L, N) + \Phi L$ which is still homogeneous of degree one in L and N. The reason I have written the production function as in (1) is that it simplifies my description of L's equilibrium wage.

At the beginning of the period the firm sets its input N as well as hiring L units of the input that bargains with the firm. The act of hiring these L workers commits the firm to spend ΦL. After these costs are sunk, these workers make independent 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

$$W_L = PF_L(L, N) \tag{2}$$

the firm would keep them all. It is immediately apparent that this is indeed the wage demand that constitutes the unique Nash equilibrium in the game among workers. If workers expect other workers to make this demand, it becomes optimal for them to do so as well (demanding more leads to dismissal). [4]

There are several interpretations for the cost Φ which the firm must pay and which does not reduce the wage demanded by the employees. One interpretation is that it is a cost of training the employee that the firm must pay (and that the employee cannot be made to pay because moral hazard would then lead the firm to extract such payments from the employee without actually training them). Another possibility is that Φ is a cost to the firm

[4] 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.

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. Third, Φ may be the cost to the firm of finding the employee.

There is a final possibility, which requires a slight modification of the model without changing any of 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. The cost Φ can then represent the costs of reorganizing production to make up for the employee's departure. In other words, a firm that planned on 100 employees and found itself with 99 might have to incur additional organizational costs to obtain the output it would have gotten from just hiring 99 in the first place. The reason for this might be that the employees are assigned specific tasks when they are hired and that they must thus be reassigned if an employee leaves. In this alternate formulation, the output of the firm is $F(L, N)$, but the employee demands a wage equal to $P(F_L + \Phi)$ because this is the amount lost to the firm if the employee leaves. [5]

The profits of a perfectly competitive firm faced with an elastic supply of factor N at a cost per unit equal to W_N are then

$$\pi^c = P[F(L, N) - \Phi L - F_L L] - W_N N. \tag{3}$$

The first order conditions for an interior solution to this problem are

$$-\Phi - LF_{LL} = 0 \tag{4}$$

$$P[F_N - LF_{LN}] - W_N = 0. \tag{5}$$

The homogeneity of degree 1 of F implies that F_{LL} is homogeneous of degree -1 in L and N so that LF_{LL} depends only on the ratio L/N. I denote the optimal ratio of L/N by λ.

[5] While I have made the cost Φ take the form of a reduction in the firm's output, the results would be essentially unchanged if these costs took the form of an additional factor that the firm must hire.

Given that the wage W_L is above the marginal product of L, it is important to check the second order condition associated with varying L while keeping N constant. This is obtained by differentiating (4) and is given by

$$-F_{LL} - LF_{LLL} < 0. \tag{6}$$

As long as this second order condition (6) is satisfied, the ratio of L to N, λ, falls when Φ rises. The second partial derivative of F with respect to L is negative, so satisfying the second order condition requires that F_{LLL} be significantly positive. In both the Cobb-Douglas case where $F(L, N)$ is $L^{\nu}N^{1-\nu}$ and the CES case where $F(L, N)$ is $(L^{\gamma} + N^{\gamma})^{1/\gamma}$, this condition is satisfied.[6]

At this point it is worth giving some intuition for why a firm would ever hire more than a minuscule amount of a factor such as L which gets paid more than its marginal product. The key benefit from increasing the use of factor L beyond a small amount is that, by hiring additional units of the factor one reduces the factor's marginal product and thus the wage that this factor earns. That is why the reduction in the marginal product multiplied by the amount that is originally hired $-PLF_{LL}$ gives the benefit from increasing L in (4). Indeed, in the closely related model of Stole and Zwiebel (1996) in which Φ is effectively zero, this logic leads firms to "overhire" and to keep employing factor L until the wage W_L is equal to factor L's reservation wage. [7] Here, the firm may stop short of hiring this many workers because of the cost Φ which discourages additional hiring of L.

One interesting property of this model is that the homogeneity of F implies that profits equal zero at an interior optimum. To see this, note that the homogeneity of F implies that

[6]For the Cobb-Douglas case, the left hand side of (6) is $-\nu(1-\nu)^2 N^{1-\nu} L^{\eta-2}$ while for the CES case it is $-(1-\gamma)(L^{\gamma} + N^{\gamma})^{1/\gamma-3} N^{\gamma} L^{\gamma-2}[(1-\gamma)N^{\gamma} + \gamma L^{\gamma}]$. Both of these expressions are negative for all values of N and L and become infinite in the limit where L goes to zero.

[7]They also consider training costs in their analysis. Still, Φ is effectively zero in their model because they allow workers to offer to pay *ex ante* for a fraction of their training costs. The equilibrium offers of this sort then ensure that workers get paid their reservation wage. Another difference between their paper and mine is that, in their paper, workers do not make a single simultaneous offer to their employer. Rather, if the bargaining between one worker and his firm leads the worker to leave, the firm then bargains individualistically with the remaining workers. Nonetheless, the basic idea that workers must contend themselves with lower wages when the firm reduces their bargaining power by hiring additional workers is just as important in their analysis as it is in mine. For a different benefit to "overhiring", see Feinstein and Stein (1988).

$F = F_L L + F_N N$ which, substituted in (3) yields

$$\pi^c = P[F_N N - \Phi L] - W_N N = PL(F_{LL}L + F_{LN}N) = 0 \tag{7}$$

where the second equality obtains by using (4) to substitute for Φ and (5) to substitute for PF_N and the third equality follows from the fact that F_L is homogeneous of degree zero in L and N. Thus, just as in the case of competitive factor markets, the homogeneity of F ensures that the sum of factor payments exhausts all revenue so that profits are zero and firms are indifferent between producing and not producing. Even though factor L gets paid more than his marginal product, factor N gets sufficiently less than his own marginal product to leave profits equal to zero.

This still leaves the question of whether the firm isn't better off hiring zero units of factor L. What makes this issue relevant is that the derivative of profits with respect to L, which is given by the left hand side of (4), is discontinuous at L equal to zero. So, it is possible that the profit function is discontinuous here as well. If the firm sets L to zero, (5) implies that the wage to factor N equals PF_N. The issue is then whether

$$\left(\frac{W_N}{P}\right)_{L=0} = F_N(0,0) < F_N(\lambda, 1) - LF_{LN}(\lambda, 1) = \left(\frac{W_N}{P}\right)_{L/N=\lambda}. \tag{8}$$

If this condition is satisfied, as it is automatically in cases like the Cobb-Douglas production function in which F_N is zero when L/N is zero, the solution is interior. The reason is that, in this case, firms that hire a positive quantity of L can afford to pay higher wages to factor N than can firms that hire only N (because $F_{NN} < 0$, such firms can afford to pay at most $F_N(0,0)$. Or, put differently, firms that hire only N and pay this factor W_N must charge a higher price for the product in order to break even than do firms that also pay W_N but use both L and N. As a result, all production takes place in firms that use both factors. Obviously, if this inequality is reversed, this result is reversed as well and all production takes place in firms that use only N. In what follows, I'll be interested in situations where (8) holds so that the factor L is hired in positive quantities.

So far, I have considered a single firm in isolation. I now consider the general equilibrium outcome in a world populated by many such firms, all of which sell the same product. To carry out this analysis, I suppose that the factors N and L are in fixed supply and I denote the amounts supplied by $\hat{N}$ and $\hat{L}$ respectively. I return to the determination of $\hat{N}$ below. Assuming W_N clears the market for factor N, this wage must fall to the point where firms are willing to hire the entire supply $\hat{N}$. The issue is then whether λ is above or below $\hat{L}/\hat{N}$. In most of what I follows, I assume that

$$\lambda < \hat{L}/\hat{N}. \tag{9}$$

This implies that, when firms are at their interior optima and hire the entire supply of N, $\hat{N}$, they hire $\lambda\hat{N}$ units of L which is less than the total supply $\hat{L}$. Some of factor L is thus unemployed. The reason nothing can be done about this unemployment is that workers cannot commit themselves to accepting a wage lower that given in (2). As will become clear below, one advantage of focusing on this unemployment case is that it leaves room for employment to change in responses to changes in labor demand even though labor supply is, in some sense, fixed.

There does exist the possibility that the inequality (9) either holds as an equality or is reversed. When it is reversed, the firms can no longer satisfy the two first order conditions (4) and (5) because the market clearing W_N/P together with (5) leads to an L/N different from the one implied by (4). In the only symmetric equilibrium that arises in this case, (5) still holds because the market for N clears. [8] On the other hand, since (L/N) must be below λ,

$$-\Phi - LF_{LL} > 0 \tag{10}$$

so firms are rationed in the amount of L they can hire. Given the amount of L they are able to obtain, they hire N until (5) is satisfied. The equilibrium W_N ensures that this equation is satisfied when N/L is equal to $\hat{N}/\hat{L}$ so that all factors are employed. The result is that workers get the same wage in all firms.

When firms are rationed in this way, they make positive profits. Each worker that they obtain is a source of rents. This can be seen by noting that (10) implies that $-\Phi$ is greater

[8] Depending on the configuration of parameters, there may also be asymmetric equilibria where some firms do not hire factor L at all while others hire some of factor L. I neglect this possibility in my discussion.

than $-LF_{LL}$. Plugging this into the term after the first equality in (7) implies that profits are positive. What happens is that the equilibrium W_N falls so much that firms are better off even though they cannot get as many workers as they desire.[9]

1.2 Inter-Industry wage Differences

I now turn briefly to the analysis of a situation where there are several different types of firms (or jobs), each with a different production function. Firms that produce different outputs will naturally have different output prices P even though they will all have to pay the same price W_N for factor N which is freely traded in an economy wide market. What is more interesting is that factor L need not earn the same wage in all industries.[10]

Factor L once again sets its wage according to (2) though this now refers to the production function and factor mix of the particular firm employing factor L. Assuming once again that firms are not rationed in the amount of L they can buy because the ratio of factor supplies is such that this factor is rationed, each firm still satisfies the first order conditions (4) and (5). Thus, one can use (4) to obtain the ratio of L over N in the particular firm (or job) and (5) to obtain W_N/P given this factor mix. Since W_N is the same in all sectors, this determines the price P for each job.

Thus, letting a job correspond to a particular production function, the relative wage in a job is given by combining (2) and (5) which yields

$$\frac{W_L}{W_N} = \frac{F_L}{F_N - LF_{LN}}$$

where the right hand side is evaluated at the point where L/N equals the λ that solves (4) for the particular job.

[9]It might be thought that such an equilibrium with rationed firms may thus give place to an equilibrium where firms make up-front payments to workers. In the case of rationed firms that make positive profits, these up-front payments may be somewhat more plausible than in the case of workers because the latter may be resource constrained. However, up front payments lead to moral hazard problems if workers (or firms) can abscond with them as is clear in Ramey and Watson (1997), and so I neglect them.

[10]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).

To see that this does indeed lead to different wages, it is worth considering the special case in which the production functions are all in the Cobb-Douglas class. In this case, λ is given by

$$\Phi = (1-\nu)\nu\lambda^{-(1-\nu)} \qquad \lambda = \Big(\frac{\nu(1-\nu)}{\Phi}\Big)^{\frac{1}{1-\nu}} \tag{11}$$

and thus depends on Φ and ν.

The real product wage of factor N, W_N/P is

$$(1-\nu)^2\Big(\frac{1}{\lambda}\Big)^{-\nu}$$

while the real product wage of L is

$$\nu\Big(\frac{1}{\lambda}\Big)^{1-\nu}.$$

Thus, using the expression above for λ, the relative wage is

$$\frac{W_L}{W_N} = \frac{\nu}{(1-\nu)^2}\Big(\frac{\Phi}{\nu(1-\nu)}\Big)^{\frac{1}{1-\nu}}. \tag{12}$$

Figure 1 draws this relative wage for different values of ν assuming that Φ is equal to .04. The figure also draws the equilibrium values of λ which, not surprisingly, are increasing monotonically in the exponent of L, ν. What is interesting about the figure is that it shows a range of parameters for which higher values of ν are associated with reductions in the wage for factor L. Thus, the model can rationalize the finding of Katz and Summers (1989) that sectors in which the capital to labor ratio is higher (which here can be represented as a higher ratio of N to L), have higher wages. I should stress, however, that variations in ν do not necessarily cause capital intensity and wages to move together; this depends on the value of Φ and ν. On the other hand, (11) and (12) immediately imply that increases in Φ raise both the wage of L and the ratio of N to L. Whether this means that this model can actually explain the pattern of industry wage differences will have to await more research on production function parameters.

1.3 Technical Progress

In this subsection, I suppose that there is labor augmenting technical progress represented by the parameter z. In particular, I let the production function be

$$Y = F(zL, N) - z\Phi L \tag{13}$$

so that the factor L is being augmented by z. Moreover, I suppose that N is given by

$$N = G(zV, K) \tag{14}$$

where G is a function homogeneous of degree one, V is the number of hours worked by workers whose wage clears the market and K is the capital stock. While it also represents a labor input, the factor V differs from L in three ways. First, the wage of this factor is set at the market clearing level so that, if the supply curve for this factor is vertical, this factor is always fully employed. Second, the quantity of this factor is determined before L bargains with the firm. Third, and this is required for (8) to be satisfied, L and V cannot be perfect substitutes. One possible interpretation for V that may, once developed more fully, satisfy all these requirements is that it represents hours of work by managerial workers. Managerial workers may be under more pressure to behave "responsibly" to protect their reputations and thus a threat on their part to quit for no other reason than that the firm has not compensated them to the maximum possible extent may not be credible.

What is important in what follows are really the first and third requirements *i.e.*, that the wage ensure that all of the factor is always employed and that the factor be an imperfect substitute for L. Then, even if this factor also bargains with the firm, its wage will be close to its marginal product. This might be consistent with having V bargain like L as long as the supply of V is sufficiently small, or the training cost Φ associated with this factor is sufficiently small, that the condition equivalent to (9) is violated for V (this last interpretation suggests that some workers with very little skills ought to be modeled in the same way as V). I do not pursue this alternative because the assumption of market clearing for V is simpler.

If V is relatively scarce or if it represents managerial workers, this factor is relatively rich. This provides some basis for the extremely convenient assumption that factor V's savings are the only source of capital accumulation. To avoid writing an explicit intertemporal model, I draw a stylized distinction between the short and the long run reactions of the capital stock to a change in z. I suppose that, in the short run, the capital stock is fixed because investment is fixed in advance (with short periods, this could also be due to the fact that capital is a stock while investment is a flow). In the long run, I suppose that the savings behavior of these individuals is such that

$$K = \alpha \frac{W_V}{P} \tag{15}$$

where α is a parameter and W_V is the wage received by one unit of V. This equation can be derived in a very crude overlapping generations model without bequests where these individuals have logarithmic utility over consumption in two periods and where they supply one unit of V only in the first. They then consume a fixed fraction of their wages and save the rest. Supposing the produced good is also used as capital, the price of a unit of capital is P and the equation follows. In a more sophisticated multi-period model of savings and consumption, the capital stock would presumably evolve somewhat differently. However, the basic idea that, in the long run, the capital stock is proportional to the wages of people who are life-cycle savers is more general and this is the main ingredient of my analysis.

Given the production function (13), each unit of L now demands a wage equal to zF_1 where F_1 represents the derivative of F with respect to its first argument. Profits are then given by

$$\pi^c(z) = P[F(zL, N) - \Phi zL - zLF_1] - W_N N. \tag{16}$$

The first order conditions are then

$$-z\Phi - z^2 LF_{11}(zL, N) = 0 \tag{17}$$

$$P[F_2(zL, N) - zLF_{12}(zL, N)] - W_N = 0. \tag{18}$$

Thus, (17) determines the ratio zL/N which is the ratio of effective units of L to effective units of N. Since (18) makes W_N/P depend only on this ratio, this wage is independent of z.

Now consider the short run effects of a one percent increase in z. Since K and V are fixed, the factor N goes up by zVG_1/G percent which is less than one percent because of the homogeneity of G. Since the ratio of effective units of zL over N must remain unchanged, L must actually decline so that technological improvements lead to short term employment losses. The wage for factor L, however rises by z percent because the constancy of the ratio zL/N implies that F_1 is unchanged.

It is worth comparing this to the outcome when the market for factor L is competitive. The wage of L is then $z(F_1 - \Phi)$ and the level of L is the full employment level $\hat{L}$. A one percent increase in z now raises this wage by less than one percent precisely because the fixity of the capital stock now implies that zL/N rises somewhat so that F_1 falls. Thus, my model of bargaining leads to larger short term percentage increases in wages than does the corresponding model of competitive factor markets. This means that, for this model to explain relatively weak increases in wages when output rises, a different shock must lead to cyclical changes in output.

I now turn to the long term effects of a change in z. Given (14), the wage of a unit of V is given by

$$W_V = zG_1(zV, K).$$

Thus (15) implies that, in the long run

$$K = \alpha z G_1(zV, K).$$

Since G is homogeneous of degree 1, G_1 depends only on the ratio zV/K. With a fixed V, and assuming a unique solution, this equation then implies that K is proportional to z. This means that, in the long run, N is proportional to z. The constancy of the ratio zL/N then implies that L is independent of z in the long run. This means that changes in z have no permanent effect on the unemployment rate. As in the analysis of the short run, the wage of factor L remains proportional to z as well. Assuming as I do below that this factor consumes its entire income, aggregate consumption is then proportional to z as well so the model implies that growth is balanced.

2 Cyclical Movements in Wages with Imperfect Competition

I now turn to a very different source of changes in labor demand which, as suggested by Rotemberg and Woodford (1997), is plausibly more cyclical. In particular, I suppose that changes in labor demand are the result of changes in the markup of prices over marginal cost. In particular, I study 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.

I analyze the problem of a monopolist whose own price is P and whose product competes with those offered by other firms, all of which charge the price $\bar{P}$. This monopolist uses the production function

$$Y = F(L, N) - \Phi L - B. \tag{19}$$

This differs from (1) only in that it includes a fixed cost B that ensures that firms make zero profits even though their price is above marginal cost.

To keep the analysis simple, I suppose that the ultimate consumers derive utility from a CES aggregate of purchases of individual goods as in Dixit and Stiglitz (1977). Thus, the demand facing an individual firm is

$$Y^d = \bar{Y}\Big(\frac{P}{\bar{P}}\Big)^{-1/\eta} \tag{20}$$

where Y^d is the level of demand, $\bar{Y}$ is the CES aggregate of all purchases and η is a parameter representing the inverse elasticity of demand. This elasticity will vary over time and thus provide a source of variation for employment.

At the beginning of each period the firm sets its price P and, as before, hires N and L thereby committing itself to the expenditure of ΦL. The L units that are hired then make independent take-it-or-leave-it-offers to work for particular wages. The firms then decides how many units of labor to keep. [11]

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_L, though I show shortly that this is indeed what they will all do. Given that there is no reason to produce any more than Y^d at this point, the firm then maximizes

$$P[F(\tilde{L},N)-\Phi L]-W_L\tilde{L} \qquad \text{subject to} \qquad \tilde{L}\leq L \qquad \text{and} \qquad F(\tilde{L},N)\leq Y^d(P)$$

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_L is above PF_L, or until the number of employees it has already decided to keep is equal to either L or the level L^* such that $F(L^*,N)$ is equal to $Y^d(P)$. 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 PF_L. If L is lower than L^*, all employees are again retained if they offer to work for no more than PF_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^*. I also suppose that the employees expect the firm to initially set L so that L is equal to L^*. Finally, I assume that employees know their marginal product as well as the pre-set price of the output so they know PF_L. Given this knowledge and these beliefs, all L employees find it in their interest to set W_L equal to PF_L so that (2) is satisfied once again. [12]

[11] This timing is by no means the only interesting one. I have also considered the case where the firm sets its price after it has decided how many workers to keep. This leads to more ambiguous effects of changes in markups on wages. This alternative formulation has two disadvantages, First, the analysis is somewhat more complex. Second, and more importantly, this alternative analysis does not extend as readily to the case where prices are rigid.

[12] 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 of the employees would be let go. This would induce them to lower their wage so as to retain their position in the firm. But 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

Given that the firm knows employees will pick wages in this way, it chooses its levels of L and N to maximize

$$P[F(L, N) - \Phi L - F_L L - B] - W_N N.$$

This leads to the first order conditions

$$-F_{LL}L - \Phi - \eta(F_L - \Phi)\Big[\frac{Y - F_L L}{Y}\Big] = 0 \quad (21)$$

$$F_N - F_{LN}L - \eta F_N\Big[\frac{Y - F_L L}{Y}\Big] - \frac{W_N}{P} = 0. \quad (22)$$

For the determination of changes in employment and wages as η changes, I'll assume that B and N are fixed. Thus, the first of these equations determines the changes in L while the second determines the changes in W_N/P. Assuming the second order conditions are satisfied, the expression on the left hand side of (21) decreases as L increases. Since, the left hand side of (21) also falls when η increases (because η is multiplied by terms that must be positive) it follows that 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.

This result is analogous to the ones surveyed in Rotemberg and Woodford (1997) in which a reduction in the elasticity of demand raises the markup of price over marginal cost and thus reduces 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 price falls by less when the firm produces more by hiring more people.

The effect of an increase of η on the real wage of factor L can be obtained by differentiating (2). Since F_L is decreasing in L, it follows immediately from this equation that an increase in employment leads to a reduction in the real product wage of L. This stands in sharp contrast to what occurs when the elasticity of demand goes up in a model where there is a market clearing wage for labor. In this more standard case, the increased demand elasticity raises labor demand and the wage is determined by moving along the supply curve for labor

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 set. Thus, the ignorance of employees about the connection between L and L^* eliminates the incentive of the firm to hire beyond L^*.

which, in the usual case, is quite steep. Thus real wages rise sharply. Here, they fall because each worker can only get paid his *ex post* marginal product and this falls when employment increases.

Very similar results are likely to obtain if output prices are fixed and there is an increase in the quantity demanded. If there is no fall in price, the firm's gain from hiring an additional worker is $(-F_{LL}L - \Phi)$ and this is positive at a point where the first order condition (21) 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 for factor L ought to fall once again. I do not pursue the effect of sticky prices on this model any further but it is important to keep in mind that my analysis of the effects of an increased demand elasticity is motivated by a more general desire to understand the effect of cyclical changes in labor demand.

The reduction in the wage of L does not mean that average wages fall. In particular, average wages can rise if there are workers, such as those whose hours are captured by V, whose wages clear the market and whose services are complementary to those of L. As will be clear from the simulation I report below, reductions in η can raise the wage of this factor while increasing L at the same time. [13] This is true both because a reduction in η directly raises the demand for factor N (thus pushing up its wage) and because, if the inputs are complementary, the increase in L raises the marginal product of N.

To compute the effects of W_N on average wages, I suppose that N is given by (14) with z normalized to one and that both V and K are fixed over time. As a result of the homogeneity of G and the fixity of both V and K, the percentage change in the wage of V, W_V is equal to the percentage change in W_N. To see this, note that the cost of an additional unit of N

[13] Letting V represent managerial workers thus fits with Chang's (1996) findings that their wages are more procyclical than others. Similarly, the idea that V represents the labor of rich individuals fits with Blank's (1993) finding that the earnings of rich individuals are more procyclical than those of poor individuals. This does not mean that industries that pay higher wages have more procyclical wages. As discussed in Bils and MacLaughlin (1993) and the references cited therein, the opposite appears more nearly to be true. These facts can be consistent with one another because the people who occupy high rungs on the income distribution do not necessarily include the bulk of the people working in high-wage industries.

must be the same whether N is increased through V or through K. Thus

$$W_N = \frac{W_V}{G_V} = \frac{W_K}{G_K}.$$

Given the fixity of V and K, G_V and G_K are constant so that both W_V and the cost per unit of capital W_K are proportional to W_N.

As my measure of the change in the average real wage, I compute a weighted average of wages that keeps the weights constant. In particular, I consider the average wage given by

$$W = \frac{\bar{V}W_V + \bar{L}W_L}{\bar{V} + \bar{L}} \tag{23}$$

where $\bar{V}$ and $\bar{L}$ are the typical levels of V and L respectively. If, instead of using the typical values, I used the actual values of V and L in defining the wage so that the average wage is defined as total wage payments divided by employment, cyclical increases in L accompanied by an acyclical V would impart a countercyclical bias into average wages if W_V exceeded W_L. The empirical relevance of this type of composition effect has been demonstrated by Bils (1985), and Solon, Barsky and Parker (1994). In any even, my focus on (23) leads me to abstract from this compositional change.

Given (23), and using the notation $\dot{X} = dX/X$, $\dot{W}$, is given by

$$\dot{W} = v\dot{W}_V + (1-v)\dot{W}_L \qquad \text{where} \qquad v \equiv \frac{\bar{V}W_V}{\bar{V}W_V + \bar{L}W_L}. \tag{24}$$

I suppose that the percent changes in the wage are relatively small so that I can treat v as constant in my calculations. This constant v then represents the typical share of total wage payments that accrues to workers who receive market clearing wages.

Given that the driving force behind increases in output and employment is an increase in the elasticity of demand that tends to lower markups, it is of some interest to analyze the response of accounting profits to this change. This is particularly true because Christiano, Eichenbaum and Evans (1996) suggest that models where output varies because of countercyclical markups generate countercyclical profits. As Rotemberg and Woodford (1997) show, this result is not very robust. It obtains in part because Christiano, Eichenbaum and Evans

(1996) consider a model where wages rise a great deal when markups fall. This increase in costs then tends to make profits fall. Since real wages do not exhibit such pronounced movements in this model, it is of interest to understand the response of accounting profits here. I will take these accounting profits to be revenues minus the cost of labor only. Thus, real accounting profits equal

$$\pi^A = F(L, N) - \Phi L - F_L L - B - \frac{W_V}{P} V$$

and the change in profits when L changes because of changes in η is

$$d\pi^A = [-F_{LL}L - \Phi]dL - Vd(W_V/P) = L\Big\{[-F_{LL}L - \Phi]\dot{L} - \frac{W_V}{P}\frac{V}{L}\frac{\dot{W}_V}{P}\Big\}. \tag{25}$$

Equation (21) implies that the term in square brackets equals $\eta(F_L - \Phi)(Y - F_L L)/Y$, which is positive. This means that the first term makes profits rise when L rises (as a result of a decline in η). The decline in η raises W_V/P, however, so the net result is ambiguous. However, if V/L is small, so that most of labor is subject to rationing, accounting profits are procyclical.

I now turn to the response of consumption. My aim is only to show that strong procyclical responses of consumption are compatible with the model even though real wages are only mildly procyclical. For this purpose, I use the simplest model that achieves this result. In particular, I assume that only the V workers face a nontrivial consumption-savings decision. As I did above, I further simplify the analysis by supposing that the response of the consumption of the V agents can be neglected altogether because the change in η is temporary and these agents have a very long horizon.

By contrast, I suppose that the L workers have no assets, are unable to borrow and are so impatient that they consume their entire labor income. This fits with the Campbell and Mankiw (1989) model where a fraction of consumers simply consumes their income except that the fraction is fairly large in my model. This tends to overstate the response of consumption in my model. It would be more desirable to have a richer model of worker rationing in financial markets along the lines of Deaton (1991) and Carroll (1997) in which workers sometimes lend for buffer stock reasons even though they would be net borrowers if markets were complete. That is left for further research.

The result of these assumptions is that the change in consumption is simply equal to the change in $W_L L$. Thus the percent change in consumption, $\dot{C}$ is equal to

$$\frac{W_L L}{C}\left[\dot{W}_L + \dot{L}\right].$$

The ratio of the percent change in consumption to the percent change in Y, $\dot{C}/\dot{Y}$ is then

$$\frac{W_L L/Y}{c}\,\frac{\dot{W}_L + \dot{L}}{\dot{Y}}$$

where c is the average ratio of consumption to income. As we shall see in the next section, this elasticity tends to be high because L tends to rise more in percentage terms than Y.

3 The Cobb-Douglas Case

In this section, I compute numerical values of the responses of output, employment, consumption to changes in η. I am particularly interested in computing the ratios of the percent changes in consumption and wages to the percentage changes in income. Before doing so, I analyze the level of steady state (or typical) wages. As is clear from (21) and (22), factor rewards depend on $(Y - F_L L)/Y$ which depends on the fixed costs B relative to Y. This relative size of fixed costs, in turn, depends on how many firms enter and the extent of this entry is determined by the profitability of firms.

I thus start my analysis by computing the relative importance of fixed costs under the assumption that there is free entry which ensures that economic profits are zero in equilibrium. In real terms, these profits are given by

$$F(L,N) - F_L L - \Phi L - B - \frac{W_N}{P}N.$$

The zero profit condition thus requires that

$$\frac{B}{N} = \frac{F(L,N) - F_L L - \Phi L}{N} - \frac{W_N}{P} \tag{26}$$

which, using (19) implies that

$$\frac{Y - F_L L}{Y} = \frac{W_N/P}{F_L(L/N) + W_N/P}. \tag{27}$$

Plugging this expression into (21) and (22), one obtains

$$-F_{LL}L - \Phi - \eta(F_L - \Phi)\Big[\frac{W_N/P}{F_L(L/N) + W_N/P}\Big] \;=\; 0 \tag{28}$$

$$F_N - F_{LN}L - \eta F_N\Big[\frac{W_N/P}{F_L(L/N) + W_N/P}\Big] - \frac{W_N}{P} \;=\; 0. \tag{29}$$

Since F is homogeneous of degree one in L and N, F_L and F_N depend only on L/N so that these equations can be solved for L/N and W_N/P. In the case where $F(L, N)$ is given by $L^\nu N^{1-\nu}$, these equations become

$$\nu(1-\nu)\Big(\frac{N}{L}\Big)^{1-\nu} - \eta\Big[\nu\Big(\frac{N}{L}\Big)^{1-\nu} - \Phi\Big]\frac{W_N/P}{W_N/P + \nu(N/L)^{-\nu}} - \Phi \;=\; 0 \tag{30}$$

$$(1-\nu)\Big(\frac{N}{L}\Big)^{-\nu}\Big[1 - \nu - \frac{\eta W_N/P}{W_N/P + \nu(N/L)^{-\nu}}\Big] - \frac{W_N}{P} = \; 0 \tag{31}$$

and these equations have a unique solution for L/N and W_N/P. Having obtained these values, one can use (26) (whose right hand side depends only on L/N and W_N/P) to obtain B/N. For any given value of the fixed cost B, this gives the relative value that ensures that profits are zero and which thus prevents further entry and exit.

One thus obtains the equilibrium allocation for given parameters ν, η and Φ. While this is not crucial for the results, I do not allow entry or exit in response to cyclical variations in η. I thus keep both B and N fixed for each firm which means, of course, that B/N is constant as I vary η. In the Cobb-Douglas case, $(Y - F_L L)/Y$ is then

$$\frac{Y - F_L L}{Y} = \frac{(1-\nu)\big(\frac{N}{L}\big)^{-\nu} - \frac{\Phi L}{N} - \frac{B}{N}}{\big(\frac{N}{L}\big)^{-\nu} - \frac{\Phi L}{N} - \frac{B}{N}}. \tag{32}$$

Substituting this expression in (21) and (22) and using the properties of the Cobb-Douglas production function one obtains equations analogous to (30) and (31) which can be solved for N/L and W_N/P for a fixed value of B/N. These equations also satisfy the second order conditions for profit maximization in that the derivative of the first equation with respect to L is negative and so on.

In my numerical analysis, I assume that the initial value of η is equal to .15 so the markup of price over marginal cost in a model with conventional factor markets would be fairly small. I set c, the share of consumption in income, equal .65 as in U.S. data. I continue to let Φ equal .04 and set ν equal to .38. There is little to recommend these two parameter values over others, so I consider some variations below. With these parameters the share of L compensation in total output, $W_L L/PY$, which is given by $\nu(N/L)^{(1-\nu)}/[(N/L)^{(1-\nu)} - \Phi - B/L]$, is equal to .53. Supposing that total employee compensation accounts for .75 of income, this means that the parameter v is equal to .53/.75 or .71 so that more than two thirds of labor compensation goes to the L workers. Given the parameter c, it also means that these types of workers carry out 82 percent of total consumption. This figure is almost surely larger than the actual fraction of the population which is forced to consume its income due to lack of access to financial markets.

The result of assuming these parameter values is that an increase in η by .01 lowers the input of L by .64 of one percent while output Y falls by .14 of one percent. [14] The wage of factor L, W_L actually rises by .4 percent so that consumption only falls by .20 percent (because the relatively large drop in L is offset to some extent by the increase in W_L). The result is that the percentage drop in consumption is 1.43 times greater than the percentage drop in income. This is much larger than is empirically plausible. However, as I stated earlier, the point of this exercise is to show that it is possible to construct a plausible model where consumption reacts a great deal. My hope is that a weakening the financial constraints on the households who supply L will reduce this effect.

The factor payment for N, W_N falls by 1.10 percent for a .01 increase in η which means that this wage is extremely procyclical. The result is that, using (24), the average wage falls. The elasticity of this average wage with respect to income, *i.e.*, the ratio of the percent fall

[14]Thus labor productivity is countercyclical for these parameters. For higher values of η, however, labor productivity is procyclical.

in the wage to the percent fall in output is .35. This elasticity is similar to that estimated by Solon, Barsky and Parker (1994). While not all sensitive with respect to changes in Φ, this elasticity is extremely sensitive to ν. Even a small increase of ν from .38 to .39 lowers this elasticity to .11 as a result of increasing L's income share and thus increasing the weight of W_L in the computation of the change in the average wage. What is robust for all the parameters I have explored is that W_L is countercyclical while W_N is procyclical.

For my baseline parameters, the change in accounting profits computed as in (25) is positive so the level of profits is countercyclical because of the large weight that attaches to the wage of V employees. If ν is made larger, this weight falls, and accounting profits become procyclical. Given the other parameters, this starts to occur when ν is just above .54 though, at this point, overall wages are countercyclical. This provides an additional motivation for exploring an alternative mechanism that makes wages procyclical, namely the cyclical upgrading of jobs. I do this next.

4 Cyclical Upgrading

To focus on this alternative mechanism, I now neglect the factor V that led to procyclical wages in Sections 2 and 3. I suppose that there are several different types of jobs, each of which produces output with a different production function. I treat these jobs as taking place in different firms, each of which faces a downwards sloping demand curve as in (20). This simplifies the analysis but ought to give the same qualitative conclusions as if the outputs of some activities were consumed by downstream activities within the same firm. If the firm overall faces an increase in its demand elasticity, it will choose to produce more and hire more labor in each of its jobs. Here this is modeled by letting the demand elasticity for each "product" rise.

Before considering the issue of cyclical upgrading, it is worth discussing how wages vary cross-sectionally with the elasticity of demand. This is not quite the same question as asking how they vary cyclically because, in my cyclical analysis, I have treated the ratio B/N as fixed. By contrast, a proper cross-sectional analysis would take into account that sectors with different η's would have different levels of profitability if their B/N were the same so that B/N would adjust trough entry and exit.

To learn the effect of varying η on wages, it is enough to compute the solution to (30) and (31) for different values of η. This is done in figure 2, which plots W_L/W_N for different values of η relative to the value this ratio takes when η is equal to zero. It is apparent from this figure that the qualitative conclusions from the previous section extend to this case. A higher η, which corresponds to a lower elasticity of demand, raises real wages by reducing the demand for factor L and thereby raising its marginal product. What the figure shows is that this effect is quantitatively important, at least for the parameters I have considered. These parameters are the same as those I used in the previous section: Φ is .04 while ν is .38. The result is that moving from a sector which is perfectly competitive (*i.e.*, has a η of zero) to one whose elasticity of demand is 2.5 (so that η equals .4) raises the wage by more than 50 percent.

I now turn to the analysis of cyclical movements in employment and wages in the presence of heterogeneous employers. Since (21) is still applicable for each of these employers, an increase in the elasticity of demand simply raises employment in all jobs whether they have low or high wages. The wage in each job falls but, insofar as people succeed in moving from low paid jobs to highly paid ones, their wages are procyclical. The question then becomes why such moves should actually take place. It might be regarded as simpler to assume that all new positions are filled by unemployed workers. This would follow if people who were originally unemployed found searching for jobs easier, as seems consistent with the perspective of much of the search literature. In this case, there would be no cyclical upgrading although some highly paid jobs would certainly be created in booms.

The question of why there is cyclical upgrading boils down to the question of why booms lead so many workers to move, escalator style, from one job to one that pays a bit more. One possible answer is that this upgrading economizes on search costs because it takes place inside firms as people are simply promoted. This answer is incomplete for two reasons. First, when someone is promoted, he leaves a vacancy behind so the firm still has to fill a position and this requires search too. Second, much of the upgrading occurs between firms as workers quit their jobs to take up new highly paying jobs and this definitely requires search.

In this section, I provide a different answer for why booms lead workers to change jobs upwards. The idea is that workers differ in their intrinsic productivity. I then show that, under some plausible assumptions, firms which pay high wages tend to have employees who are relatively more productive. In other words, these workers get high wages not only because their productivity is high but also because they work for firms where workers earn more per unit of effective labor. When the elasticity of demand rises, all firms including those that pay higher wages want to hire more workers. The ones that pay high wages have an advantage however: workers prefer to work for them. They thus get the pick of all the workers who are not working for high wage firms already. They would thus hire unemployed workers only if there were no more productive workers employed. Workers employed by slightly lower-paying firms would generally be preferable and the high-paying firms can easily lure them away thereby upgrading their jobs. The firms with slightly lower wages must then dip further down into the pool of worker ability and so on. At the bottom of this pyramid, the unemployed (who are the least productive) move into relatively low wage jobs.

To see this formally, suppose that there exist a total of M workers indexed by i, each of which offers an effective amount of L that is equal to ρ_i. To simplify the analysis, I suppose that there are many workers with each possible level of productivity ρ. The total effective supply of factor L is thus

$$\sum_{i=1}^{M} \rho_i.$$

Suppose further that a particular firm has a subset I of the M workers and that this subset contains m workers. Assuming it also employs N units of the other factor, I let the output of this firm equal

$$Y = F(L, N) - \Phi m - B \qquad \text{where} \qquad L \equiv \sum_{i \in I} \rho_i. \tag{33}$$

What is special about writing the production function in this way is that the cost of determining what each employee must do, Φm, depends only on the number of employees hired while the other contribution of the employees to output depends on the productivity parameters ρ. This is an assumption that is central for the results that follow. It has a certain degree of plausibility in that the cost of 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).

The employees all still demand their *ex post* marginal product, which, for an employee with productivity parameter ρ equals approximately $\rho P F_L$. Thus, profits from this collection of inputs are

$$P[F(L,N) - \Phi m - B - F_L L] - W_N N$$

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

$$-\rho_m\big[F_{LL}L + \eta F_L \frac{Y - F_L L}{Y}\big] - \big\{\Phi\big(1 - \eta\frac{Y - F_L L}{Y}\big)\big\}. \tag{34}$$

If the firm is maximizing profits, the expression in (34) is nonnegative for all its employees and is nonpositive for any worker who is available to the firm and who is outside of the subset I of employees. One interesting feature of (34) is that it is lower for employees with lower values of ρ. This can be seen by noting that both η and $(Y - F_L L)/Y$ are smaller than one so the expression in curly brackets is positive. Thus, since the entire expression in (34) is nonnegative for all employees in I, it must be that the expression in square brackets is positive. This implies that higher values of ρ_m raise the overall value of the expression in (34). Thus, the firm strictly prefers hiring more productive employees to hiring less productive employees. [15]

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

[15]Similar results can be found in the search-theoretic models of Moscarini (1996) and Shimer (1997) but their origin is quite different. In those papers, the workers do not have all the bargaining power so that their wage ends up being an average of their productivity and of what they can expect to earn if the firm fails to hire them. As long as this alternative wage is low even for very productive workers then the difference between a person's wage and that person's productivity is higher for more productive workers. This is what leads these people to be preferred as employees in these papers.

it is true that the fact that an employee with a higher marginal product generates more sales has no direct effect on the desirability of hiring him because his wage is higher as well, there are two other effects. The first, which is less important, is that adding a more productive individual to the employment roster lowers the price the firm receives by more (because he raises output more). This makes hiring a more productive employee less desirable. The more important effect, however, 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. This is what makes hiring high-ρ employees desirable. For this result, the assumption that the cost of deployment does not rise when the employee is more productive is critical. 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. Because it seems more plausible to suppose that the cost of deploying a particular employee rises less than proportionately with the employee's productivity - and inspection of (34) makes it clear that this is all that is needed for the result - the result that firms prefer more productive employees seems of some interest.

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 N equals $\rho F_L P/W_N$, every worker prefers to work for firms whose PF_L is higher. However, the size of PF_L 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 am able to show that, broadly speaking, firms with higher equilibrium values of PF_L hire more productive workers. In particular, the stability of the equilibrium implies that a firm whose PF_L is lower than another firm's has no employees whose ρ is higher than that of the lowest-ρ employee at the higher PF_L firm.

I now demonstrate this. A basic 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 (and charging their *ex post* marginal product) in lieu of the services currently provided by another person. Thus, at an equilibrium (34) must be nonnegative for all the employees employed at any particular firm (so the firm prefers keeping them to letting them go).

Let ρ_a denote the productivity of the least productive employee working for the firm. Since (34) is increasing in ρ, it is strictly positive for employees whose ρ is larger than ρ_a. Thus, people whose ρ exceeds ρ_a cannot be working at firms where PF_L is lower. If they did, the firm would gain by luring these workers away from their lower-PF_L firm and the workers would gladly leave that firm. This demonstrates that the employees of a firm whose PF_L is lower must have ρ's no larger than those of the lowest-ρ employee at the higher-PF_L firm.

This description of the properties of the equilibrium is not complete because it does not determine the PF_L's of different firms. I do this only for a simpler case with two types of employees and two types of firms. I suppose that, out of $\hat{L}$ available individuals, $\hat{L}_1$ have a productivity parameter ρ_1 while the remaining ones have a productivity parameter ρ_2. Without loss of generality, $\rho_1 > \rho_2$. There is free entry into two sectors, both of which have production functions given by (33). For both sectors, $F(L, N)$ is given by $L^{\nu}N^{1-\nu}$. I let ν and B be the same for both types of firms (though the equality of B does not matter since, with free entry, this determines only the size of firms). The parameters η and Φ differ across sectors with $\eta_1 > \eta_2$ and $\Phi_1 > \Phi_2$.

To simplify the analysis, I neglect integer constraints and treat employment as a continuous variable. With free entry, a condition analogous to (26) holds (except with Φm replacing ΦL). Using (33) in this modified condition, we once again obtain (27). Letting ρ_a be the lowest ρ of all the employees hired by the firm and supposing the firm is not constrained in the number of these that it hires, (34) must equal zero when ρ_m is equal to ρ_a. Using the Cobb-Douglas production function and supposing the firm is not constrained in the amount of N it hires, its first order conditions are

$$\rho_a \nu(1-\nu)\Big(\frac{N}{L}\Big)^{1-\nu} - \eta\Big[\rho_a \nu\Big(\frac{N}{L}\Big)^{1-\nu} - \Phi\Big]\frac{W_N/P}{W_N/P + \nu(N/L)^{-\nu}} - \Phi \;=\; 0 \tag{35}$$

$$(1-\nu)\Big(\frac{N}{L}\Big)^{-\nu}\Big[1 - \nu - \eta\frac{W_N/P}{W_N/P + \nu(N/L)^{-\nu}}\Big] - \frac{W_N}{P} = \;0\;. \tag{36}$$

As before, these two equations can be solved for N/L and W_N/P as a function of the parameters ν, η, Φ and ρ_a. I denote by $\lambda(\nu, \eta, \Phi, \rho_a)$ the solution for L/N and by $\omega(\nu, \eta, \Phi, \rho_a)$ the solution for W_N/P. Interestingly, these solutions depends only on the "marginal" ρ, *i.e.*, the ρ of the employees that the firm is indifferent to hiring at the margin. Having the ability to hire some inframarginal employees with higher values of ρ does not affect the equilibrium ratio N/L, though it does affect profitability and thus affects the size of the firm (as represented by B/N) that ensures that profits are zero.

Consistent with the findings I reported earlier, increases in η and in Φ starting at the baseline parameters I have been using, raise the equilibrium value of N/L. The reason is that increases in η make the benefit of raising L smaller while increases in Φ raise the effective cost of hiring additional units of L. This means that, if sectors 1 and 2 had the same "marginal" ρ_a and neither was constrained, sector 1 would have a higher value of N/L. As a result, it would have a higher value for W_L/P. In addition, (36) implies that the firm with a higher value of N/L has a higher value of P/W_N. Thus, its PF_L is surely higher and all workers prefer to work there.

This means that sector 1 attracts some workers of type 1. Whether it attracts them all depends on several additional factors. First, if $\hat{N}$ is sufficiently small only workers of type 1 will work at any firm whatsoever and all workers of type 2 will be unemployed. Thus ρ_1 plays the role of ρ_a in both sectors. Second, if $\hat{N}$ is sufficiently large and $\hat{L}_1$ is sufficiently small, all workers of type 1 work in sector 1 but this sector also hires some workers of type 2. Thus, ρ_2 plays the role of ρ_a in both sectors. Neither of these cases is of great interest because they do not exhibit any 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 case where $\hat{N}$ is sufficiently large that some workers of type 2 are employed and also require that $\hat{L}_1$ be sufficiently big that not all workers of type 1 work in sector 1.

In this case, ρ_2 plays the role of ρ_a in sector 2. But, even though not all workers of type 1 work in industry 1, it is not necessarily true that (35) holds for industry 1 with ρ_a replaced by ρ_1. For this too hold, it must also be the case that

$$\frac{\nu\Big(\lambda(\nu,\eta_1,\Phi_1,\rho_1)\Big)^{1-\nu}}{\omega(\nu,\eta_1,\Phi_1,\rho_1)} > \frac{\nu\Big(\lambda(\nu,\eta_2,\Phi_2,\rho_2)\Big)^{1-\nu}}{\omega(\nu,\eta_2,\Phi_2,\rho_2)}. \tag{37}$$

This says that the wage for a worker of type 1 in terms of factor N is higher in sector 1 than in sector 2 even though firms in sector 1 treat workers of type 1 as marginal in their decision. 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 Φ are bigger in sector 1 would be enough to imply the inequality in (37). But, given its access to ρ_1-workers, firms in sector 1 have higher values of λ and this can mean that, if they treat workers with productivity parameter ρ_1 as marginal, they can end up paying less than firms in sector 2 to workers of type 1.

If the above conditions, including (37) hold, then sector 1 has only high productivity workers while sector 2 has a mix of high and low productivity workers. The equilibrium is stable even though workers with productivity parameter ρ_1 earn less when they work in sector 2 because sector 1 has as many workers as it wishes to employ. This general pattern, where sector 1 both pays more to workers of a given productivity and also tends to hire more productive workers fits with the evidence of Dickens and Katz (1987). They show that sectors that pay high wages after controlling for worker characteristics also tend to hire workers whose overall productivity is higher and, in particular, tend to have a more educated work force. [16]

If inequality (37) is violated, firms in sector 1 must be rationed in the amount of labor they can hire. They obtain workers of type 1 but only until the point where the wages that they pay them (in terms of a common good) are the same as the wages these workers

[16] See also Gibbons, Katz and Lemieux (1997) who show that the wage premia for measured and unmeasured ability are higher in high wage sectors. This too is consistent with this model as is their finding that these difference in skill premia are not the only source of intersectoral wage differences.

earn in sector 2. When (37) is violated, the ratio N/L in sector 1 must be greater than would be necessary to satisfy (35). What makes this case less interesting for my purpose than the case where (37) holds, is that workers who move from sector 2 to sector 1 do not get wage increases when (37) is violated. The reason is that, with (37) violated, any stable equilibrium must have identical wages. If the wages in sector 1 were bigger, the sector would hire additional workers of type 1; if they were smaller workers would leave the sector.

I thus return to the case where (37) holds in what follows. In my numerical analysis, I suppose that ν is .38 as before, that $\eta_1 = .15$ and $\eta_2 = .1$ while Φ_1 is given by the earlier baseline value of .04. I let ρ_1 be 1.05 while ρ_2 is 1.00. If I let Φ_2 be equal to Φ_1, (37) is violated. I thus consider two values for Φ_2. In the first set of experiments, Φ_2 is .038 so that wage differences between sectors are relatively modest. In particular, measuring all wages in terms of how much factor N they can purchase, workers with productivity parameter ρ_1 in sector 1 earn 7.5 percent more than workers with productivity parameter ρ_2 in sector 2. Thus, since workers with productivity parameter ρ_1 who work in sector 2 earn 5 percent more than their co-workers whose productivity parameter is ρ_2, they gain about 2.5 percent by moving from sector 2 to sector 1. Assuming that 3/4 of the workers in sector 2 have a productivity parameter equal to ρ_2, the average difference in wages between the two sectors is 6.1 percent. Thus a worker with productivity parameter ρ_1 who moves from sector 2 to sector 1 gains less than half the average "interindustry wage difference."

At the other extreme, I also consider the case where Φ_2 is equal to .015. The intersectoral wage differences are then huge. In particular, workers with productivity parameter ρ_1 who work in sector 1 now earn 4.58 times as much as workers with productivity parameter ρ_2 who are employed in sector 2. Thus, in this case, the gains to movers with productivity parameter ρ_1 are almost equal to the difference in average wages between the two sectors. The relation between the wage gains to industry movers and the average inter-industry wage differences have been the subject of some debate in the empirical literature (see Gibbons and Katz (1992) for a discussion of this evidence) so it may be attractive to have a model where this connection depends on technological parameters.

The discussion above assumes that workers with productivity parameter ρ_1 do sometimes move. Such moves can be triggered by reductions in η_1 because, as in the earlier sections, such reductions lead firms in sector 1 to hire more workers. Because these firms both prefer and are able to attract additional workers with productivity parameter ρ_1, they do so. Since all these additional workers in sector 1 were initially employed in sector 2, the model implies that workers upgrade their jobs cyclically in response to changes in the elasticity of the demand for goods.

The overall cyclical behavior of wages then becomes more complicated. For those workers with productivity parameter equal to ρ_1 that are able to move, the reduction in η_1 leads to an increase in wages. On the other hand, workers who remain at their jobs in sector 1 experience wage declines. The effect on the average wage depends on such variables as the size of the wage premium in sector 1, the number of workers of each type and so on.

For illustrative purposes only, I have also solved for the quantitative response of average wages and aggregate income in a more completely specified version of this model. In particular, I suppose that the initial equilibrium is one where 40 employees work in each sector.[17] All the employees in sector 1 and a quarter of the employees in sector 2 have a productivity given by ρ_1 while the rest of the employees in sector 2 have a productivity equal to ρ_2.

To obtain the endowment of N, $\hat{N}$, that is consistent with this pattern of employment all one needs to do is to add the values of N that are needed in each sector given that sector's L and its λ. The total spent as fixed costs for each sector can be obtained from the modified form of (26). The value of total output in each sector can then be computed with (33). To analyze the effects of changes in the elasticities of demand, I first compute the derivative of λ and ω with respect to η in each sector. I am thus analyzing the effects of changing η by the same amount in both sectors. To do this, I treat as fixed N and the total expenditure on B in each sector as before. This allows me to calculate the changes in employment and output in each sector as well as the changes in W_L/P and W_N/P.

[17] It is easier to describe the analysis by specifying the number of employees that work in each sector. However, the results are independent of the overall scale of the economy so all that matters is the fraction of employees of different types that work in each sector.

To compute the change in aggregate output, I sum the changes in individual output weighted by the initial value of P/W_N for the sector. This corresponds to the change in real GDP since outputs are being evaluated at base period prices. To compute the change in average real wages, I deflate the W_L's by an analogue of the CPI index. Thus, I first obtain the average wage in terms of N by giving each individual his $\frac{W_L/P}{W_N/P}$ and computing the proper weighted average. I then deflate this by the purchasing power of factor N which I measure by adding together the values of W_N/P weighted by the expenditure share of each good (for good i, the expenditure share is equal to Y_iP_i/W_N divided by the sum over j of Y_jP_j/W_N). Since I can compute these average real wages numerically for any value of η I choose, I can compute the derivative of real wages with respect to η and thus the percent change in average real wages. An alternative picture of what is happening to real wages can be obtained by calculating the average change in the logarithm of individual real wages. This gives an estimate of the average percent change in real wages for the people who are employed both before and after the change.

Whether Φ_2 equals .038 or .015, a .01 reduction in η increases real GDP by about .11 of one percent. However, the behavior of real wages is quite different in the two cases. When Φ_2 equals .039, average real wages decline by .33 of a percent and this is essentially equal to the average percent change in individual wages. When Φ_2 equals .015, average real wages increase by .02 of one percent (so they are mildly procyclical) while the average of the percent changes in individual wages is .09 of one percent. This latter number is significantly larger because the wage increases of job switchers are a much larger fraction of their original wages than they are of average wages (which consist partly of highly paid workers in sector 1). Thus, if wage differences across sectors are sufficiently large, it is possible to generate somewhat procyclical real wages in this model even if all wages are determined by bargaining.

5 Conclusion

This paper has shown how the existence of the unemployment that results from aggressive bargaining by workers can lead real wages to be only slightly procyclical (or even countercyclical) in response to changes in labor demand. This makes intuitive sense. The fact that workers are unemployed should surely dampen wage increases in booms. Having said this, it turns out that the extent to which unemployment exerts this moderating pressure appears to depend on what is causing unemployment in the first place. For example, if unemployment comes about because firms pay above-market wages to deter shirking (as in Shapiro and Stiglitz 1984), it is not at all clear that it significantly reduces the degree to which wages are procyclical. The reason, as Kimball (1994) shows, is that the reduction in unemployment that occurs in booms promotes shirking. To prevent shirking from actually rising, wages must be increased substantially. Similarly, it is not at all clear that the unemployment that results from search leads wages to be less procyclical than they would be if the labor market worked without frictions.

By contrast, the individualistic bargaining considered here does reduce the extent to which wages are procyclical because it implies that workers get paid their *ex post* marginal product. As long as booms do not involve an unusual amount of technical progress, this marginal product is low in booms and this keeps wages low. Whether this mechanism for wage moderation is empirically important in booms deserves to be investigated further. The essence of this mechanism is that individual wages are constrained by the availability of other workers carrying out similar activities in the same firm. The bigger the number of these partial substitutes, the lower the individual's wage. This is quite different from the usual view, where individual wages are constrained by the firm's ability to bring in substitutes from the outside. Under this more standard view, tightness in labor markets in the form of low unemployment ought to translate into higher wages because these substitutes are less easily available. Under the view explored here, tightness in the external labor market is not important. What matters instead is a kind of tightness in the internal labor market which takes the form of having relatively few workers that are qualified to do particular tasks.

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Figure 1

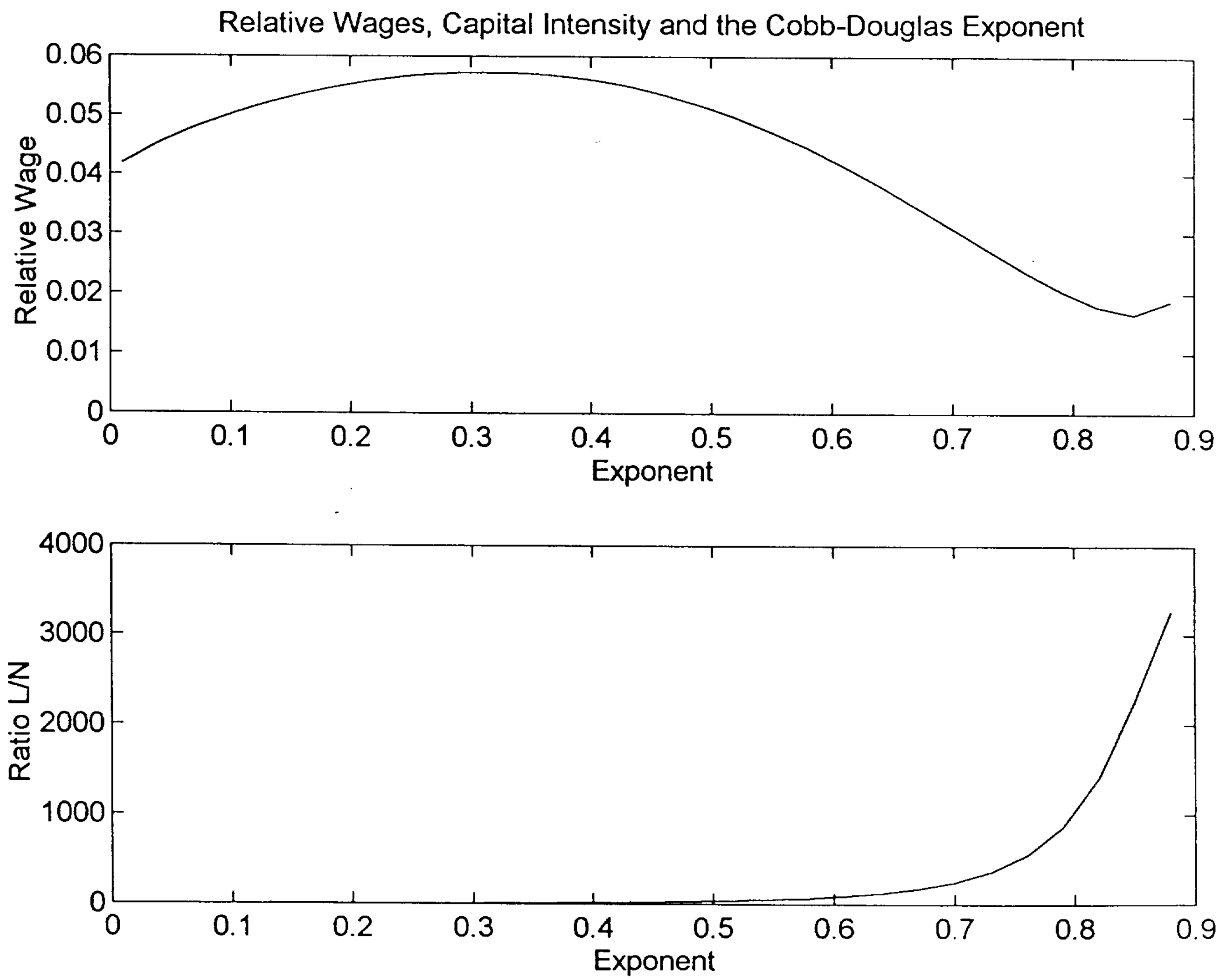
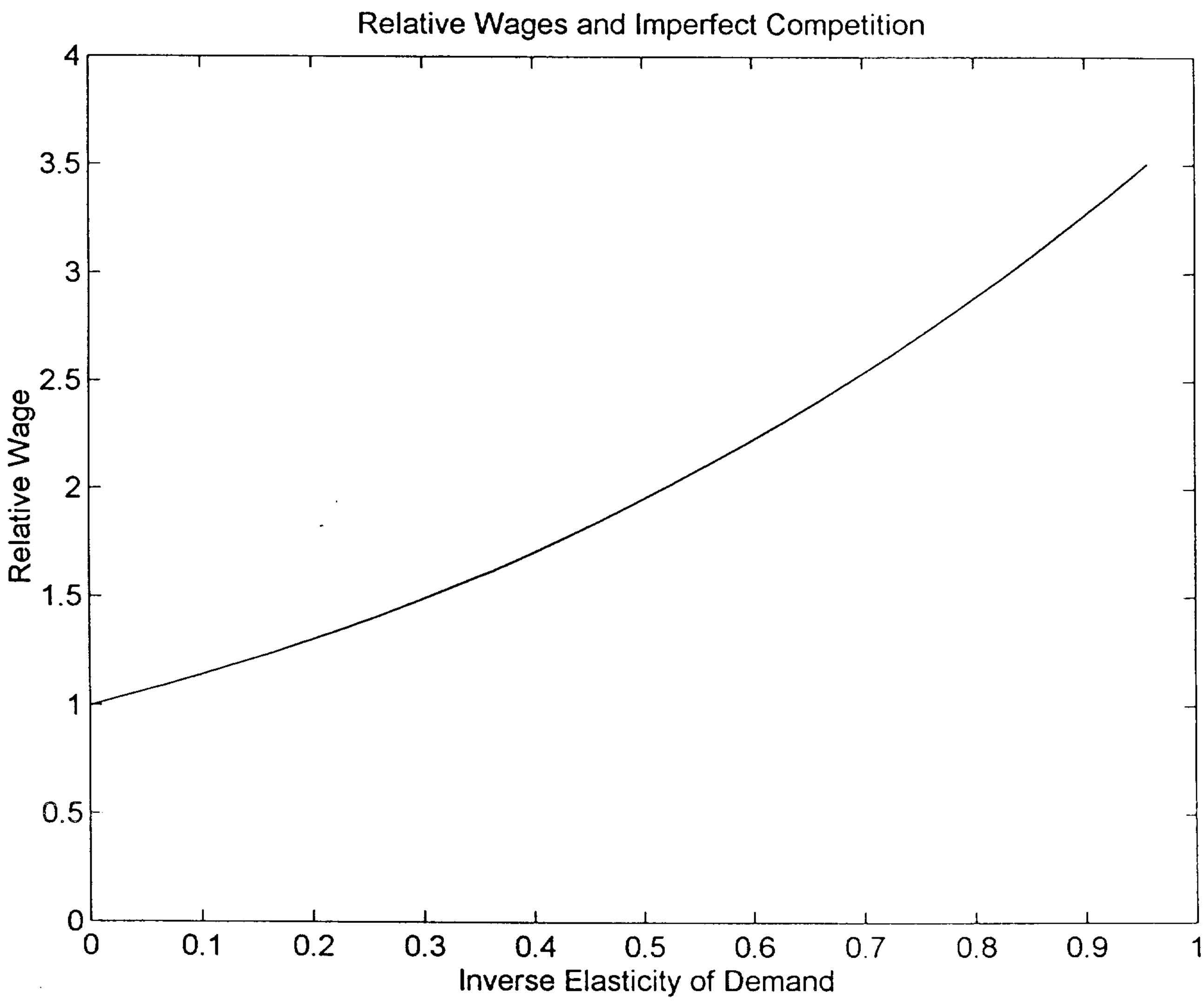

Relative Wages, Capital Intensity and the Cobb-Douglas Exponent
Relative Wage
0.06
0.05
0.04
0.03
0.02
0.01
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Exponent
Ratio L/N
4000
3000
2000
1000
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Exponent

Figure 2



Relative Wages and Imperfect Competition
Relative Wage
Inverse Elasticity of Demand
0
0.5
1
1.5
2
2.5
3
3.5
4
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1