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If the legal rate . . . was fixed so high . . . , the greater part of the money which was to be lent, would be lent to prodigals and profectors, who alone would be willing to give this higher interest. Sober people, who will give for the use of money no more than a part of what they are likely to make by the use of it, would not venture into the competition. . . . Adam Smith, Wealth of Nations, *1776.*

A plentiful subsistence increases the bodily strength of the laborer and the comfortable hope of bettering his condition and ending his days perhaps in ease and plenty animates him to exert that strength to the utmost. Adam Smith, Wealth of Nations, *1776.*

Low wages are by no means identical with cheap labour. From a purely quantitative point of view the efficiency of labour decreases with a wage which is physiologically insufficient . . . the present-day average Silesian mows, when he exerts himself to the full, little more than two-thirds as much land as the better paid and nourished Pomeranian or Mecklenburger, and the Pole, the further East he comes from, accomplishes progressively less than the German. Low wages fail even from a purely business point of view wherever it is a question of producing goods which require any sort of skilled labour, or the use of expensive machinery which is easily damaged, or in general wherever any greater amount

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The opening quotations were supplied by Michael Perelman, Gavin Wright (second and fourth quotation), Graciela Chichilnisky, and Franklin Allen.

Gavin Wright has drawn my attention to the fact that there was a large literature in the eighteenth and nineteenth centuries arguing for a link between wages and productivity. For instance, he cites the former U.S. Secretary of State Thomas F. Bayard's "Introductory Letter" to Jacob Schoenhof (in *The Economy of High Wages* New York, 1893) as saying, "The facts you have adduced and your deductions irresistibly establish the proposition that low wages do not mean cheap production, and that the best instructed and best paid labor proves itself to be the most productive. . . ." Similarly, Thomas Brassey, Jr., is quoted by John H. Habbakuk (*American and British Technology in the Nineteenth Century,* 1962) as saying, "The cheap labour at the command of our competitors seems to exercise the same enervating influence as the delights of Caphua on the soldiers of Hannibal" (*Work and Wages,* 1872, p. 142).

Some of this earlier literature is reviewed by Gregory Clark, in "Productivity Growth without Technical Change: European Agriculture before 1850" (1986), and by A. W. Coats, in "Changing Attitudes to Labour in the Mid-eighteenth Century," *Economic History Review* (August 1958, 2(11), pp. 35–51). Coats traces the idea that high wages lead to high productivity back to Jacob Vanderlint, in *Money Answers All Things* (London, 1734).

Financial support from the Hoover Institution and the National Science Foundation is gratefully acknowledged.

> *of sharp attention of of initiative is required. Here low wages do not pay, and their effect is the opposite of what was intended. Max Weber,* The Protestant Ethic and the Spirit of Capitalism *(Scribner, New York, 1925, p. 61).*
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> *. . . highly paid labour is generally efficient and therefore not dear labour; a fact which though it is more full of hope for the future of the human race than any other that is known us, will be found to exercise a very complicating influence on the theory of distribution. Alfred Marshall,* Principles of Economics, *1920.*
>
> *. . . the landlord who attempted to exact more than his neighbour . . . would render himself so odious, he would be so sure of not obtaining a metayer who was an honest man, that the contract of all the metayers may be considered as identical, at least in each province, and never gives rise to any competition among peasants in search of employment, or any offer to cultivate the soil on cheaper terms than one another. J. C. L. Simonde de Sismondi,* Political Economy, *1814, cited in John Stuart Mill,* Principles of Political Economy, *1848.*

CONVENTIONAL competitive economic theory begins with the hypothesis of price-taking firms and consumers, buying and selling homogeneous commodities at well-defined marketplaces. In many situations, these assumptions are implausible: in insurance markets, firms know that some risks are greater than others (some individuals' life expectancy is greater than others'; some individuals are more likely to have an automobile accident than others), but cannot tell precisely who is the greater risk, even within fairly narrowly defined risk categories. In labor markets, firms know that some workers are better than others, but at the time they hire and train the worker, they cannot tell precisely who will turn out to be the more productive. In product markets, consumers know that some commodities are more durable than others, but at the time of purchase, they cannot ascertain precisely which are more durable. In capital markets, banks know that the probability of bankruptcy differs across loans, but cannot tell precisely which loans are better.

This heterogeneity has important consequences, some of which have long been recognized. There are strong incentives to sort, to distinguish the high risk from the low risk, the more able from the less able. This sorting can be done on the basis of observable characteristics (say, sex or age) or the (inferences made from) actions undertaken by individuals, e.g., the job for which the individual applies (George Akerlof 1976), the wage structure chosen by the individual (Joanne Salop and Steven Salop 1976), or the quantity of insurance purchased (Michael Rothschild and Joseph Stiglitz 1976). In these models, the choices made convey information; individuals know this, and this affects their actions.

Willingness to trade may itself serve as a sorting device. In insurance markets, firms have recognized that as the price of insurance increases, the mix of applicants changes *adversely*. Akerlof (1970) has shown how such adverse selection effects may also arise in other markets, including the market for used cars (see Charles Wilson 1979, 1980). His analysis has subsequently been applied to the labor market (Bruce Greenwald 1986) and to capital markets (Greenwald, Stiglitz, and Andrew Weiss 1984; Stewart Myers and Nicholas S. Majluf 1984). In each of these instances, the uninformed party (the seller of insurance, the used car buyer, etc.) forms rational expectations concerning the quality mix of what is being offered on the market; the price serves as a signal or as a screening device. The fact that an employee is willing to

work for $1 an hour suggests that she knows of no better offers; others who have looked at her have evidently decided that she is worth no more than $1 an hour.

Insurance firms have also long recognized that the terms at which they write insurance contracts may affect the actions undertaken by individuals; that is, the likelihood of the insured against an event occurring is an *endogenous* variable, which the insurance firm can hope to affect. The fact that individuals can undertake unobservable actions that affect the likelihood of an accident is referred to as the *moral hazard* problem. The term has come to be used to describe a wide range of incentive problems. In particular, employers know that the incentives workers have to work hard may be affected by the wage paid; and the incentives borrowers have to undertake risky projects may be affected by the interest rate charged on the bank's loan. Thus, the characteristics of what is being traded again depend on the price at which the trade is consummated, though now because of *incentive* effects rather than *selection* effects.

These are instances in which price serves a function in addition to that usually ascribed to it in economic theory: It conveys information and affects behavior. Quality depends on price. Of course, in standard economic theory, higher-quality items will sell at higher prices: Prices depend on quality. But here, beliefs about quality, about what it is that is being traded, depend (rationally) on price.[1]

This dependence of beliefs about quality on price has some fundamental implications. Firstly, demand curves, may under quite plausible conditions, not be downward sloping. When the price of some security is higher, uninformed buyers may infer that the expected return is higher, and their demand may increase (Jerry Green 1973; Sanford Grossman and Stiglitz 1976, 1980). An increase in the wage may so increase the productivity of the workers that the demand for labor may actually increase. A decrease in the price of used cars results in a decrease in the average quality of those being offered and this may decrease demand (Akerlof 1970). In each of these instances, one can think of the change in the price as having two effects: a movement along a fixed-information demand curve, and a shift in the demand curve from the change in information (beliefs).

Secondly, one may not be able to separate out neatly the analysis of demand and supply. Individuals' demands are based on inferences they are making from prices, and these inferences are critically dependent on the nature of the supply responses. Thus, any alteration, say, in the probability distribution of supply characteristics will, in general, lead to an alteration in the demand functions.

Thirdly, markets may be thin. At the equilibrium price of insurance, some risk averse individuals choose not to purchase insurance, even though with perfect information, they would have. The marginal person buying insurance is, in effect, subsidizing other purchasers; he is not obtaining actuarially fair insurance, as he would in a (risk neutral) competitive market with full information.[2]

[1] Some 40 years ago, Tibor Scitovsky (1945) wrote a brief but important paper discussing the consequences of the habit of judging quality by price. Another antecedent of the recent literature is Alvin Klevorick and Roger Alcaly (1970), who explore the implications for the traditional theory of consumers' behavior.

[2] Akerlof (1970) investigated a case where equilibrium entailed no trade. As the price of cars decreased, supply decreased and demand decreased (the deterioration in car quality was so great that the quality-adjusted price actually increased): Intersection occurred only at zero trade. But this is a special case which arises primarily because of the limited incentives to trade in his model. The effect he noted in the used car market is the same as had

These models, while departing from the traditional paradigm in denying the validity of the hypothesis of homogeneous markets, retain the assumption of price-taking firms and consumers. In many situations, firms are not price or wage takers. Banks do not simply take the interest rate that they charge on loans as given.

This paper is concerned with situations where firms not only recognize the dependence of quality on price (of productivity on wages, of default probability on the interest rate charged), but also attempt to use what control they have over price (wages, interest rates) to increase their profits. The recognition of this possibility has important implications for economic theory, which have recently been explored in a large number of papers in several disparate fields. The objective of this paper is to survey these papers and to draw out the central themes of this literature.

This paper is divided into four parts. In Part I, we discuss the most important implications of the dependence of quality on price for competitive equilibrium theory—the repeal of the law of supply and demand (Part I.1), the repeal of the law of the single price (Part I.2), the existence of discriminatory equilibria (Part I.3), the comparative static consequences (Part I.4), and the inefficiency of market equilibria (Part I.5). Part II discusses alternative explanations for the dependence of quality on price in labor, capital, and product markets. Part III explains more precisely how these models differ from standard competitive models and from other models with imperfect information. Finally, Part IV discusses some of the more important applications of the theory, including those in macroeconomics (Part IV.1) and in development economics (Part IV.2).

I. *The Fundamental Implications of the Dependence of Quality on Price*

1. *Repeal of the Law of Supply and Demand*

No law in economics has such standing as the "Law of Supply and Demand." There is an old joke about being able to teach a parrot to be an economist—and a good economist at that—simply by teaching it to repeat the words "demand and supply." The law holds that competitive market equilibrium is characterized by demand equaling supply. It asserts that the way to analyze changes in market equilibrium is to isolate the changes in the demand function and in the supply function.

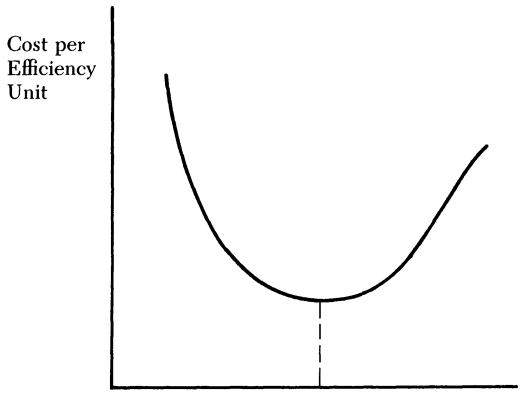
When quality depends on price, market equilibrium *may* be characterized by demand not equaling supply.[3]

Consider the labor market. Assume there is an excess supply of labor. The conventional story is that in the face of excess supply, unemployed workers go to potential employers and offer their services at lower wages. The wage is bid down. As the wage decreases, the demand for labor increases and the supply decreases. This process continues until the wage is bid down to the level where supply equals demand.

If, however, the firm believes that the workers who offer their services at a lower wage are less productive, then—if they are sufficiently less productive—

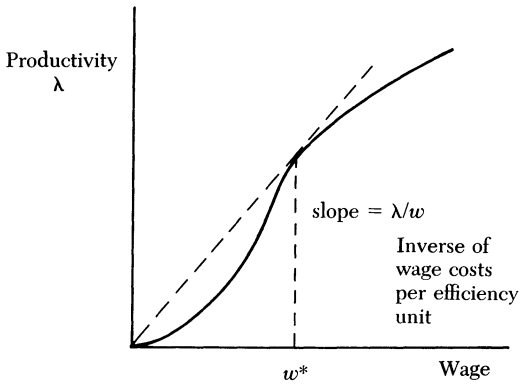
long been recognized in insurance markets. As the price of insurance increases, the adverse selection effect implies that the mix of applicants changes adversely; thus the premium required for the insurance firms to break even must increase. Nonetheless, there may exist insurance markets in which trade occurs.

[3] And as we have already noted (p. 2), because the inferences that can be drawn from observing a given price—and hence the demand at a given price—depend on the nature of supply, it may not be possible in some cases to isolate demand and supply disturbances.



Cost per efficiency unit is minimized at wage w^*

Figure 1



$\frac{\lambda}{w}$ increases as w increases to w^*, and then decreases.

Figure 2. Wage Productivity Curve

it will not hire the lower-wage workers, for the cost per effective unit of labor service will actually be higher with the lower-wage worker.

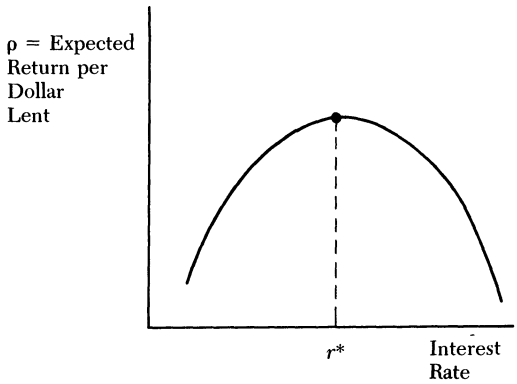
Thus, in Figure 1 we have depicted the cost per effective unit of labor service as initially falling as the wage is increased. There is a wage, w^*, at which wage costs per effective unit of labor service are minimized. This is referred to as the *efficiency wage*. For this section, we assume the same costs per efficiency unit schedule faces all firms and characterizes all workers. (In the following sections we shall consider the consequences of differing costs per efficiency unit schedules.)

If, at the efficiency wage, there is an excess supply of laborers, no firm has an incentive to lower its wage, or to hire a worker who offers his services at a lower wage, for to do so simply increases labor costs. Thus, when at w^*, the supply of labor equals or exceeds the demand, w^* is the equilibrium wage.

This curve, giving the relationship between the cost per effective unit of labor and the wage rate, is derived from the more fundamental *wage productivity curve*, giving the productivity of the representative worker hired at a particular wage. The curve depicted in Figure 2 shows λ, the productivity of the worker, increasing with the wage; the essential feature of this productivity curve is that there is initially a region of increasing returns, where an increase in the wage leads to a more than proportionate increase in the productivity. Many of our results depend critically on the existence of some region for which this is true; in the models that we investigate in detail, we establish that this is in fact the case.

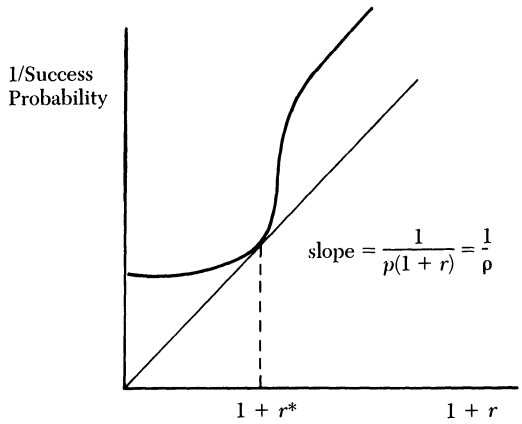
In Figure 2, the cost per efficiency unit (cost per effective unit of labor) is given by the (inverse of the) slope of a line through the origin to a point on the wage productivity curve. Because the slope is increasing as we increase the wage from 0 to w^*, the cost per effective unit of labor is decreasing. Beyond w^* the slope decreases and hence the cost per effective unit of labor increases. It is clear, then, that the wage-productivity curve generates a cost per effective unit of labor curve of the form depicted in Figure 1.

The existence of wage-productivity relationship has long been recognized, as the quotations at the beginning of this article indicate. The more recent revival of interest may be attributed to Harvey



Expected return per dollar lent is maximized at r^*.

Figure 3



$p(1 + r)$ increases as r increases to r^*, and then decreases.

Figure 4. Default Curve

Leibenstein (1957) who discussed it in the context of less developed countries and the subsequent developments by James Mirrlees (1975) and Stiglitz (1976b). There, however, the relationship is based on nutritional considerations.[4] Near subsistence, workers are not very productive; increases in wages may lead to marked increases in efficiency. Though our analysis focuses on alternative explanations of the relationship, the consequences are very similar.

Exactly the same analysis applies to the capital market (Stiglitz and Weiss 1981). Assume that as the bank increases the interest rate, the "quality" of those who apply decreases; that is, those who apply have, on average, a higher probability of defaulting, of not repaying their loans. The safest borrowers are unwilling to borrow at high interest rates. Then, the expected return on a loan, ρ, may actually decrease as the interest rate, r, increases, as depicted in Figure 3; r^* is the efficiency interest rate. If, at r^*, there is an excess demand for loans (credit is rationed), r^* is still an equilibrium. The bank will refuse to lend to anyone offering to borrow at a higher interest rate; its expected return would be lower than what it obtains by lending at r^*.

The curve in Figure 3 may be derived from the default curve. The probability of a default is postulated to increase with the rate of interest charged. Let p = probability that the loan is repaid; we assume, for simplicity, that when the loan is not repaid the lender receives nothing. Thus, the expected return to a lender is

$$\rho = p(1 + r).$$

In Figure 4, we have plotted $1/p$ as a function of $1 + r$. Thus, the slope of any line from the origin to the default curve is $1/(1 + r)p$. The bank wishes to maximize $p(1 + r)$, i.e., find the point on the default curve with the lowest slope; this is clearly just the point of tangency of a line through the origin with the default curve. Note that the slope decreases as r increases up to $1 + r^*$ (i.e., ρ increases) and decreases thereafter (i.e., ρ decreases), just as depicted in Figure 3. (We postpone until later a justification for the shape of the default curve.)

Again, the conventional story for why

[4] For discussions of the validity of this relationship, see Christopher Bliss and Nicholas Stern (1978, 1981). See also P. H. Prasad (1970), G. B. Rodgers (1975), and Dasgupta and Ray (1986b).

there cannot be credit rationing in equilibrium is that those who are willing to borrow at the given interest but denied credit go to the bank and offer it a higher interest rate; this bids up the interest rate. As the interest rate is bid up, the supply of credit is increased and demand decreases. The process continues until equilibrium is reached at the point where the demand for loans equals the supply; there is no credit rationing. But now, the bank realizes that if it charges a higher interest rate, the probability of default increases; and it may increase so much that the expected return to the bank actually decreases. Thus, no bank will ever charge an interest rate above r^*.[5,6]

In each of these cases, the story is the same: Because quality (labor efficiency, bankruptcy probability) changes as the price (wage, interest rate) changes, excess supply or demand may persist without any tendency for price (wages, interest rates) to move to correct the market imbalance.

General Formulation. In each of the instances described above, an individual (firm) sets the terms of the contract with another individual or firm to maximize its utility (profits), subject to offering terms that make the contract acceptable; under the circumstances described, the optimal contract will be such that the constraint on acceptability is not binding. That is, if $U[p, x, q(p, x)]$ is the utility of the buyer, paying a price p, and offering nonprice terms[7] of the contract x, where $q(p, x)$ represents a description of the (expected value of the) quality of the object (service) being purchased, a function of p and x, then the individual chooses p and x to

$$\underset{(p,\ x)}{\text{Max}}\ U \tag{1}$$

subject to the constraint of being able to obtain the item, i.e., if $V[p, x, q(p, x)]$ is the (expected) utility of an individual (firm) selling an item of quality q and V^* represents the reservation utility level,[8] then

$$V[p, x, q(p, x)] \geq V^*. \tag{2}$$

In a variety of circumstances, the solution to this problem may entail the constraint (2) not being binding, at least for some potential sellers.[9] When that happens, market equilibrium will be characterized by demand not equaling supply.[10]

2. *Repeal of the Law of the Single Price*

The law of supply and demand is of course, only one of the fundamental "laws" of conventional economics. Another central aspect of the traditional par-

[5] A cartoon appeared in several newspapers in the early eighties, when interest rates were soaring, in which a banker is seen leaning over his desk, asking the loan applicant, "What kind of person would be willing to borrow at the interest rates we charge?"

[6] Note too that in the circumstances with which we have just been concerned, where quality depends on price, the quantity demanded at any price depends on the quality supplied: Thus, for instance, a change in the mix of loan applicants will affect the supply of loans available at any interest rate; a change in the mix of job applicants will affect the demand for labor at any wage.

[7] Nonprice terms in credit markets include collateral requirements, specifications of circumstances under which credit is terminated, etc.

[8] The reservation utility level also may vary across sellers.

[9] In the incentive (moral hazard) versions, q is a result of an action taken by the individual; the action taken is a function of the terms of the contract. In the selection version, q is the average quality of those offering goods (services) at the price p and x; the constraint (2) is to be read as saying that at least one item is offered for sale at the given terms. In general, in adverse selection models, the constraint (2) is binding for only some individuals offering to sell the commodity.

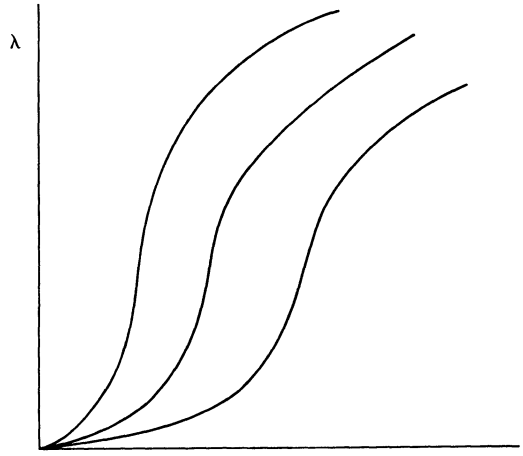
[10] It is worth noting that while (2) may be viewed, from the perspective of the buyer, as what has come to be called the "individual rationality constraint," V^* is in general itself endogenously determined (it represents the individual's best alternative opportunity); and in the adverse selection models, (2) also can be viewed as a self-selection constraint, differentiating between those for whom the job (loan) is acceptable and those for whom it is not.

adigm is codified in the "Law of the Single Price." This law holds that all objects with the same observable characteristics should sell at the same price. When there is a relationship between quality and price, the price itself becomes a relevant characteristic; market equilibrium may be characterized by a price distribution (or a wage distribution, or a distribution of interest rates) for objects that cannot be distinguished (before purchase) other than by price.

It has been widely observed that some firms have a high-wage policy; others pursue a low-wage policy. It is important to bear in mind that the differences we are concerned with here are not differences in whether the firm hires those with more education or less education, those with more work experience or those with less work experience. Rather, we are comparing the wages paid by firms for workers with a *given* set of observable qualifications.

There are several reasons that economies in which productivity depends on wages (or more generally quality on prices) may be characterized by a wage (price) distribution.

Differences in Firms. If the wage-productivity relationship differs across firms, as in Figure 5, the efficiency wage may differ. More generally, firms where net productivity is more sensitive to wages (with higher turnover costs, higher monitoring costs, or where shirking workers can do more damage) will find it desirable to pay higher wages for workers of identical characteristics (Steven Salop 1973). This is consistent with the observation that more capital intensive firms tend to pay higher wages, because the "damage" a worker can do in such jobs may be higher. If monitoring costs are higher in firms employing large numbers of workers, one might expect to see such firms paying higher wages (other things being constant).



The wage-productivity relationship may differ across firms. Different firms may find it optimal to pay different wages.

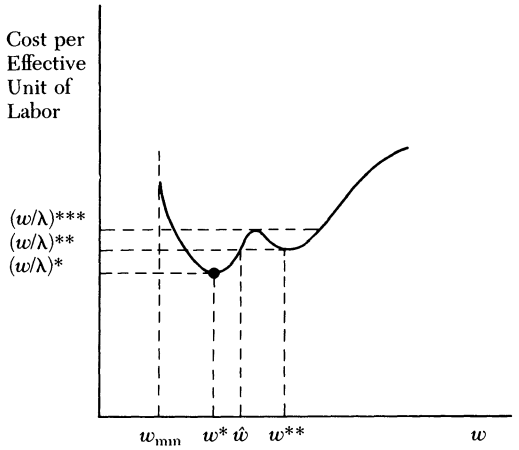
Figure 5

Wage Distributions When Costs per Effective Unit Are Not Monotonic. Wage (price, or interest rate) distributions also arise when costs per effective unit are not monotone, as we suggested that they might not be.

Assume, in particular, that the reason that productivity increases with wage is nutritional;[11] though productivity always increases with wage, it may increase more or less than proportionately. When it increases more than proportionately, labor costs per efficiency unit decline with wage increases. Thus, if over some ranges, say, for very low wages and for an intermediate range of wages, productivity increases more than proportionately with wages, one would obtain a curve describing wage per efficiency unit as in Figure 6.

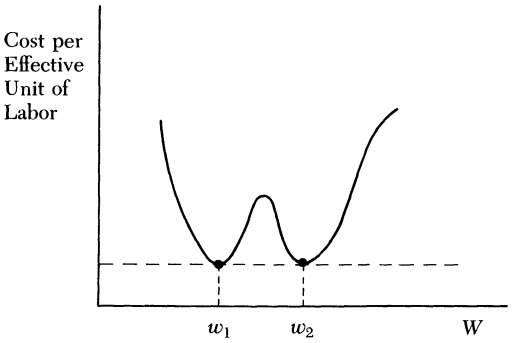
We define the Walrasian wage, $\tilde{w}$, as that wage at which demand for labor

[11] We choose this example because in more general models, with adverse selection or incentive effects, the productivity of a worker at one firm depends on the wages paid at other firms and on the unemployment rate. We wish to avoid these complications in this simple exposition.



Market equilibrium is characterized by excess supply of labor whenever Walrasian wage is lower than w^*. When Walrasian wage is between $\hat{w}$ and w^{**}, some workers are hired at w^{**}, and other workers are hired at $\hat{w}$.

Figure 6. Wage Distribution



Wage distribution where cost per effective unit of labor is the same at w_1 and w_2.

Figure 7

equals the supply. However, the Walrasian wage is not the equilibrium wage whenever there exists a wage higher than the Walrasian wage with a lower cost per efficiency unit. For it would pay any firm to increase its wage. Assume, in Figure 6, that the Walrasian equilibrium occurred at some wage between $\hat{w}$ and w^{**}. One might be tempted to suggest that w^{**}, the wage greater than the Walrasian wage at which costs per efficiency unit are minimized, is the market equilibrium; but at w^{**}, there is unemployment; and by lowering their wage enough (to any wage between $\hat{w}$ and w^*), workers can be hired with a cost per efficiency unit that is lower than at w^{**}. The equilibrium now entails full employment with a wage distribution; some workers are hired at w^{**} and others at $\hat{w}$. Costs per efficiency unit are exactly the same. If all workers were paid a wage of $\hat{w}$, there would be (by assumption) an excess demand for labor; that is why $\hat{w}$ is not an equilibrium. If all workers were paid w^{**}, there would be an excess supply of laborers. There is a particular proportion of workers hired at $\hat{w}$ and w^{**} at which demand is equal to supply for the low-wage jobs, though there is excess supply of labor at the high-wage firms.

Similar arguments apply to other markets.

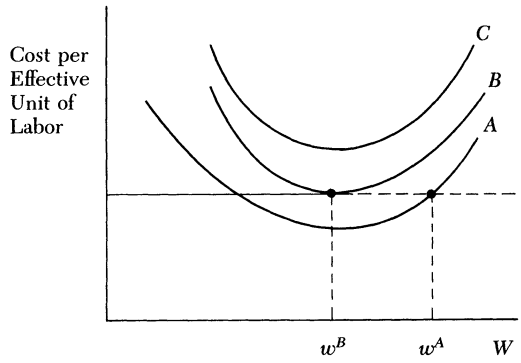
Wage Distributions When Costs per Effective Unit Are Minimized at Several Different Wages. The previous subsection considered a situation where the cost per effective unit was not monotonic. Equilibrium wage distributions also arise when the curve describing the cost per effective unit of labor, depicted earlier, has several peaks, and all of the peaks generate exactly the same level of costs per effective unit of labor, as illustrated in Figure 7. Such a configuration would seem to be an anomaly. Even if there is no reason that the productivity curve has a single peak, why should the peaks occur at the same level? One can show that this may, in fact, occur quite easily. The curve that we have depicted is the curve facing a particular firm, *given* the wages paid by all other firms. Stiglitz (1974b, 1985) shows, in the context of the labor-turnover model, that there is a wages distribution (and in fact many such distributions) with the property that the productivity curve has many peaks, each of which yields exactly the same cost per effective unit of labor. The reason for this

is that the turnover costs facing any firm are a function of the fraction of firms paying a higher wage, which itself is an endogenous variable. The low-wage firm faces a higher turnover. The fraction of high-wage firms is such that the total labor costs—wages plus turnover costs—are the same at low-wage firms and high-wage firms (see also Phillip Dybvig and Gerald Jaynes 1980).

Similar results can be obtained in the context of selection models. If different individuals have different costs associated with queuing, or with not selling their commodity (their labor), then high-wage firms may find that they face a longer queue and a higher quality of applicants. In these models, high-wage labor looks (in terms of observable characteristics) the same as low-wage labor, but in fact it is more productive with differences in productivity corresponding (in equilibrium) precisely to differences in wages. Wages together with queues are acting as self-selection devices.[12] (See Barry Nalebuff and Stiglitz 1982 and Stiglitz 1976a.)

3. *Discrimination*

It has long been noted that, in the absence of perfect information, there may be statistical discrimination: Members of a group will be paid the mean marginal product of the group, or will be charged an interest rate corresponding to the mean default probability of their group or charged an insurance premium corresponding to the mean probability of accident, illness, or death of their group. But the traditional theory of statistical discrimination (see, e.g., Dennis Aigner and Glen Cain 1977 or Rothschild and Stiglitz 1982) has not provided an explanation of job discrimination or red lining—the differential access to certain jobs or credit of certain groups. The theories we are concerned with here do this.



Group C is excluded from labor market.

Figure 8

Assume that in the labor market there are a number of different identifiable groups, each with its own "cost per effective unit of labor" curve, as depicted in Figure 8. Then, equilibrium will be characterized by all groups hired having the same cost per effective labor unit; those with lower costs per effective labor service at any wage are paid a higher wage. (There is, thus, wage discrimination.) But there are some groups, such as Group C in Figure 8, for whom the cost per labor service, at the optimum wage, and hence at any wage, exceeds that of the market equilibrium; such workers will not be hired. "Discrimination" takes the form not of paying the workers in group C a lower wage, but of refusing to hire them.

While all of those in category A will be hired, and none of those in category C, in general only some of those in category B will be hired. *Other apparently identical workers will not be employed.*

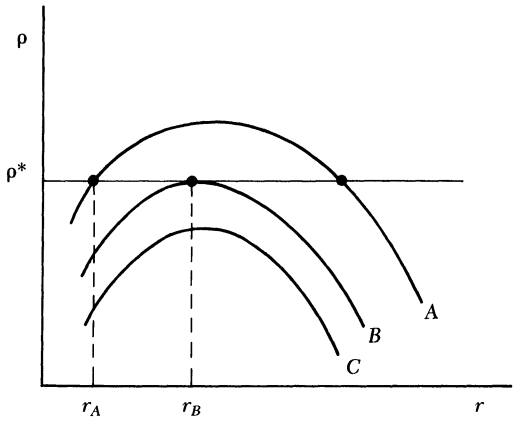
When productivity depends on the unemployment rate, there may be large differences in equilibrium in group specific

[12] Note, however, that the length of queue is not chosen by the firm, but is an endogenous property of the equilibrium. In this respect, these models differ in an important way from those in which the terms of the contract are determined either by the uninformed agent or the informed agent.

unemployment rates as well as wage rates.[13]

The theory not only predicts that some groups may be rationed out of the market, but also suggests that the brunt of changes in the demand for labor (aggregate demand) will be felt by some groups in increased job rationing. Moreover, some versions of the theory predict which groups will be rationed out of the market. In particular, in the incentive version of the model (Carl Shapiro and Stiglitz 1984), the wage that must be paid to a worker to induce him not to shirk depends on the cost of being fired. This cost is likely to be lower for part-time workers, for those close to retirement, and for secondary participants in the labor force (e.g., low-wage workers with high-income spouses).

Exactly the same phenomenon can occur in credit markets. Assume that the function relating the expected return to the interest rate differs across individuals who differ in certain observable characteristics, as depicted in Figure 9. There will be an equilibrium rate of return on a loan; loans to all categories that are offered yield the same expected return.[14] The interest rate charged for categories of loans, such as A, whose maximal expected return exceeds ρ^*, are charged lower interest rates ($r_A < r_B$). On the other hand, loan category C is such that at no interest rate does it yield a return equal to ρ^*; all those in this category are simply denied loans. The practice of denying credit to certain categories of potential borrowers is called red-lining. (Some of those in category B, where the maximal expected return is equal to ρ^*, receive loans, while others do not.)



Group C is excluded from capital market.

Figure 9

4. *Comparative Statics*

With "normally" shaped demand and supply curves, an increase in supply (that is, a shift in the supply curve such that at every price a greater quantity of the good is supplied) leads to an equilibrium with a lower price and a greater quantity traded. Similarly, a decrease in demand (that is, a shift in the demand curve such that at every price a smaller quantity of the good is demanded) leads to an equilibrium with a lower price and a lower quantity traded. Now, in the class of models being examined in this paper, the major effect of such a shift may be a change in the magnitude of rationing, with little effect on prices. Thus, in the labor market, when there is an equilibrium with excess supply of labor, a small increase in the demand for labor has no effect on the wage rate, but increases employment. An increase in the supply of credit available may have no effect on interest rates, but may simply lead to more loans (less credit rationing) at the old interest rates (Figure 10).

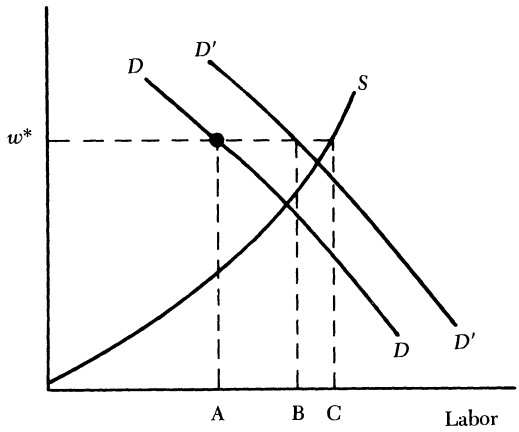
[13] If the productivity of group λ_i is a function of its wage w_i and its unemployment rate, U_i then in equilibrium, for all groups hired (for which $U_i < 1$)

$$\lambda_i(w_i, U_i)/w_i$$

is the same, and

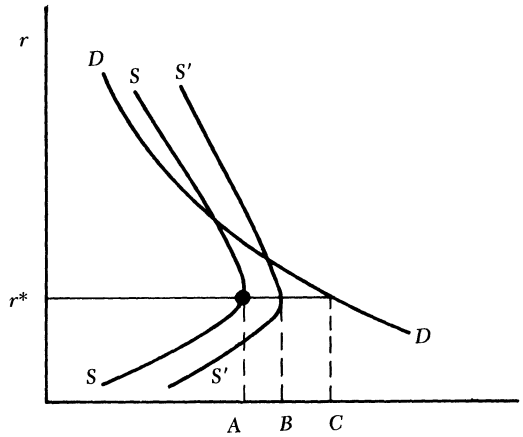
$$\lambda_i(w_i, U_i)/w_i = \lambda_i(w_i, U_i)/w_i.$$

[14] Assuming that bankers are risk neutral, and thus care only about the expected return of the loan.



An increase in the demand for labor may leave wage rate unchanged, but simply increase employment.

Figure 10a

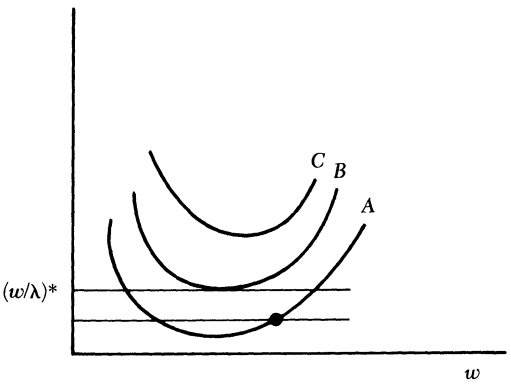


An increase in the supply of credit may leave interest rate unchanged, but simply decrease extent of credit rationing.

Figure 10b

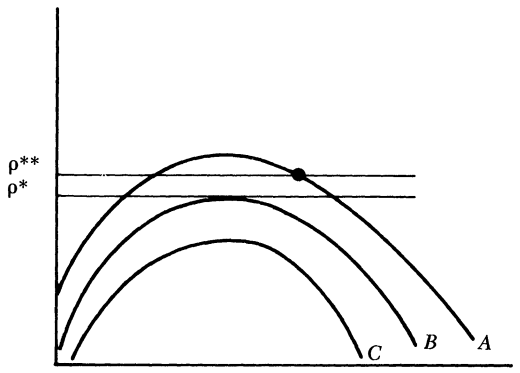
In markets where there are many groups in the population, a decrease in the demand for labor may result in some groups being completely excluded from the market, with only a slight lowering of the wage of those remaining. This is distinctly different from the conventional models, in which the wage for all workers would be reduced, and no group of workers would be excluded (though some groups of workers may decide to drop out of the labor market) (Figure 11*a*).

Similarly, in markets with credit rationing, a decrease in the supply of available credit may result in some groups being excluded from the credit market,



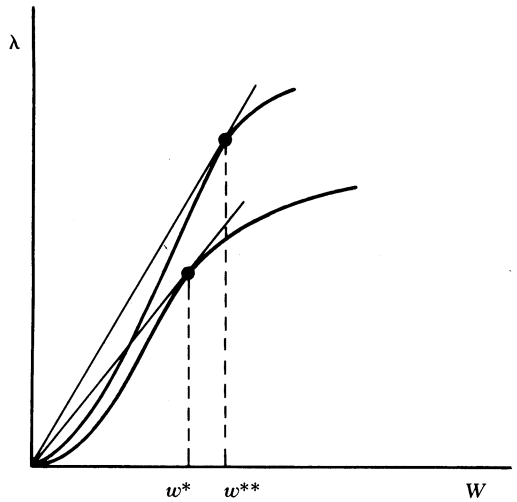
A decrease in the demand for labor may lead to a decrease in the equilibrium cost per effective unit of labor, resulting in exclusion of some groups from the labor market. (When wage per efficiency unit falls from just above $(w/\lambda)^*$ to just below it, group *B* is excluded.)

Figure 11a



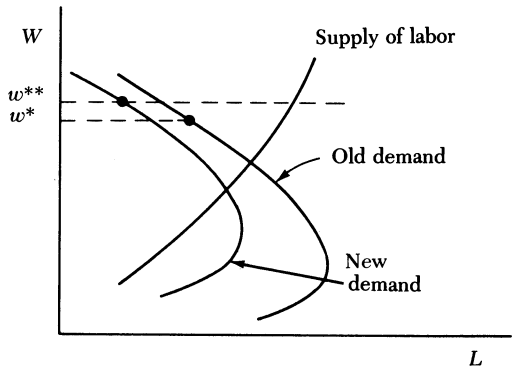
A decrease in supply of credit may lead to an increase in the equilibrium return, resulting in the exclusion of some groups from the credit market.

Figure 11b



A change in technology may result in a large change in wages, but a relatively small change in the cost per efficiency unit of labor.

Figure 12a



A technological change may lead to a higher wage and less employment.

Figure 12b

with relatively small increases in the interest rates charged to those who are not excluded (Figure 11b).[15]

Shifts in the Productivity Curves. The other important source of changes in the equilibrium comes from changes in the productivity (or return) curves. In the labor market, a change in technology may result in a change in the efficiency wage, as depicted in Figure 12*a*. If the efficiency wage increases markedly, but the cost per effective unit of labor decreases only slightly, as in Figure 12*b*, then the new equilibrium may be characterized by a lower level of employment and a higher wage.

Similarly, if banks' expectations of defaults increase, then the expected return, at any interest rate, will decrease. This will normally result in a decrease in the supply of credit; the effect on the extent of credit rationing will depend on how the changed expectations affect the demand for credit. But there are no clear implications for the interest rate charged by the bank; it may either increase or decrease (Figure 13).[16]

5. *Implications for Welfare Economics*

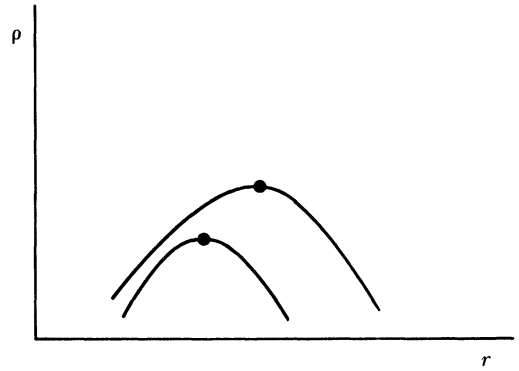
One of the crowning achievements of competitive equilibrium theory during the past half century has been the proof of the fundamental theorem of welfare economics—providing a precise statement of the meaning of Adam Smith's invisible hand conjecture.

An implicit assumption in the standard proofs of the Fundamental Theorem of Welfare Economics is that there is perfect information.[17] Obviously, economies

[15] Indeed, in some circumstances a decrease in supply may actually lead to a decrease in the weighted mean interest rate charged. See Stiglitz and Weiss (1986a, 1986b).

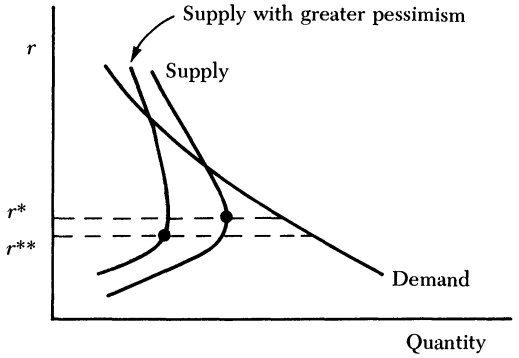
[16] In the simple models presented here, only one group in the population is rationed; those above the critical cutoff level receive all the credit they wish, or can sell all the labor they wish, while others are completely excluded from the market. But it is easy to construct models in which rationing is extended to many groups. See Barry Nalebuff and Stiglitz (1982) and Stiglitz and Weiss (1986a, 1986b, 1987).

[17] The analyses can be extended to situations where there is uncertainty, provided there is a complete set of risk markets, and provided that the nature of the commodity being traded (the quality of labor, the probability of bankruptcy, etc.) does not change as prices (wages, interest rates) change. It is the latter which concerns us here.



More pessimistic expectations may lower expected return and lower interest rate charged.

Figure 13a



More pessimistic expectations may result in more credit rationing and lower interest rates.

Figure 13b

with perfect information are likely to function better than economies with imperfect information:[18] That is an irrelevant comparison. The relevant question is, in a market characterized by incomplete information, are there interventions that can attain a Pareto improvement? Is the market, in other words, constrained Pareto efficient, taking into account the imperfections of information and costs of obtaining more information?

Greenwald and Stiglitz (1986a) have shown that competitive economies with incomplete markets and/or imperfect information are essentially never constrained Pareto efficient. These authors develop a general framework within which a variety of informational imperfections can be analyzed. They limit themselves to tax and subsidy interventions. They apply their analysis to one of the models that are the subject of discussion in this paper, namely, the Akerlof adverse selection model, where the quality offered is a function of the price but markets clear. In the context of the labor market, they show that a welfare improvement can be attained by subsidizing commodities whose consumption increases the mean quality of labor sold on the market and by taxing commodities whose consumption decreases the mean quality. The mean quality of labor offered on the market resembles the mean quality of air: There is an important externality in each individual's decision.

Their earlier paper was limited to economies with market clearing. In a sequel (Greenwald and Stiglitz 1986b), they identify the inefficiencies that arise in economies in which quality is dependent on prices and markets do not clear. There are inefficiencies both in setting wages (interest rates) and determining the level of employment (the number of loans of different types).

A direct consequence of the Fundamental Theorem of Welfare Economics is the decentralizability of efficient resource allocations; and a direct consequence of the failure of the Fundamental Theorem—of the externalities we have noted—is that the scope for decentralization may be limited.[19]

[18] This section focuses on the welfare economics of the imperfect information models. For a discussion of the welfare economics of the nutrition-based efficiency wage models, see Partha Dasgupta and Debraj Ray (1986a).

[19] One should perhaps distinguish between two situations: that where the decentralized allocation *without* government intervention is inefficient, but government intervention, in the form of taxes and subsidies, can induce a decentralized efficient alloca-

Some rationing may be consistent with Pareto efficiency. Assume the government has no more information about the quality of workers or potential borrowers than do firms (or banks). It has to allocate workers to different jobs. It has to allocate capital among different firms. The wage at which workers are willing to work or the interest rate at which firms are willing to borrow conveys information to the government, just as it does to the employer or the bank, and it will, in general, wish to use this information, even though to use it necessitates rationing—unemployment or credit rationing. But the objectives of the government, what it wishes to glean from the information, are different from those of firms and banks in the private market equilibrium. The latter are simply concerned with maximizing their own profits. Thus, in choosing a wage, the government would be concerned with ascertaining that those with a comparative advantage in a job get assigned to that job; the firm is simply concerned with cost per efficiency unit. (Similarly, the bank is not concerned with how its actions affect the profitability of investors, only with how it affects the profitability of the bank.)

Private firms will not only set the wage incorrectly; they will also hire an incorrect number of workers. Because all workers whose opportunity cost is less than the wage offer themselves for work, the mean opportunity cost of an individual randomly hired by a firm is less than the wage. Thus firms will not hire workers up to the point where the wage equals the mean opportunity costs, as a government concerned with maximizing national income would.

The inefficiencies we noted above are not the only inefficiencies associated with private market allocations and there may be other grounds for government intervention. Taxes and subsidies may affect the consumption vector of individuals, and thus indirectly the effort exerted by the worker (or the wage required to induce the worker not to shirk). Such taxes and subsidies may thus be welfare enhancing (Arnott and Stiglitz 1985).

Shapiro and Stiglitz (1984) point out a variety of other inefficiencies that arise in their model where high wages are used to reduce shirking. These relate to the intensity of monitoring and policies that affect quits and shirking. For instance, if workers are very risk averse, unemployment insurance may be desirable even though in their model private firms will never supply unemployment insurance; if there is an excess supply of labor, firms can obtain the desired labor force at the going wage; any increases in unemployment compensation simply increase the wage that a firm must pay to induce workers not to shirk.[20]

These models also have some more basic implications for how we think about the welfare properties of market economies. One of the important consequences of the Fundamental Theorem of Welfare Economics was that it enabled a neat separation of efficiency and equity issues. In particular, whether the economy is or is not Pareto efficient did not depend on the distribution of wealth. In the models under examination, this is not true, for two reasons. First, the inefficiencies with which we have been concerned arise because of the asymmetric information between two parties to a transaction—between landlord and worker, or between worker and capitalist. But whether these transactions arise

tion; and those where even with this form of intervention, a decentralized allocation, cannot attain certain Pareto efficient allocations. Both problems may arise here.

[20] This assumes that the firm cannot treat quits and fires differentially. There are good reasons for this: If quits are treated preferentially, a worker who knows he is about to be fired will quit. For a more extended discussion, see Shapiro and Stiglitz (1985a).

is, at least partly, determined by the distribution of wealth. For instance, sharecropping arises largely because of the concentration of wealth. Secondly, the distribution of ownership of factors determines whether it is, in fact, feasible to design Pareto improvements. In the Shapiro-Stiglitz model, for instance, national income can be increased by taxing capital and subsidizing wages; if wealth were equally distributed, the losses individuals would suffer qua capitalists would be more than offset by the gains that would be received qua workers. But if there are two distinct groups in the population, capitalists and workers, there may be no way of improving the welfare of the workers without simultaneously hurting the capitalists—the market equilibrium, while not maximizing net national product, is Pareto efficient (see Shapiro and Stiglitz 1984; Dasgupta and Ray 1986).

II. *Explanations for the Dependence of Quality on Price*

In the introduction, we described two broad classes of models giving rise to a dependence of quality on price based on incentive and selection effects. In the preceding sections, we showed that if the dependence of quality on price took on particular forms (e.g., the cost per effective unit had an interior minimum) then there might exist an equilibrium in which demand did not equal supply, or in which there might be, in equilibrium, a price (wage, interest rate) distribution. We now consider in more detail not only why quality may depend on price in certain situations, but why the dependence should take on a form that may give rise to nonmarket-clearing equilibria and/or wage/price/interest rate distributions.

The analysis is divided into three sections, describing selection models, incentive models, and nutritional models.

1. *Selection Models*

Labor Market. The reasons for the presence of adverse selection in the labor market are clear (Stiglitz 1976b; Weiss 1976, 1980; Greenwald 1979, 1986). One of the inferences I can make from the fact that a worker is willing to work for me for 50 cents an hour is that he does not have (know of) a better offer elsewhere.[21] If other firms are screening workers, keeping high-productivity workers and letting go of low-productivity workers, or adjusting their wages to reflect their lower productivity, the fact that no other firm has offered the worker a wage in excess of 50 cents an hour conveys a considerable amount of information. (Obviously, the inferences I make depend on a number of details of the surrounding circumstances; if the worker is a newly arrived worker to the United States, the fact that he is willing to accept a job at 50 cents an hour is more likely to reflect his limited opportunities for search and his lack of knowledge of the job market; if a job has a number of extremely attractive nonpecuniary advantages, the inferences I make should take that into account.)

More productive workers are likely to have better wage offers from other firms, but even if they are self-employed, they are likely to be more productive (that is, if those who are more able in one production task are more able, on average, in other production tasks as well).

In the simplest formulation of the adverse selection-labor model, a worker whose reservation wage is v has a productivity of $a(v)$; if all workers whose reservation wage v is less than or equal to w apply for a job with wage w,[22] then

[21] Unless a worker's productivity is completely firm-specific, then no information is conveyed to one firm by another firm's refusal to hire him.

[22] More generally, the reservation wage of an individual will depend on his fallback (self-employment)

the mean productivity of the applicants is

$$\Sigma\, a(v)f(v)/F(v)$$

where $F(v)$ is the distribution function of the population by reservation wages, and $f(v)$ the density function. It is clear that if $a' > 0$, then mean productivity will increase with w. To see that it may have the shape depicted in Figure 1, consider a two group model; low-productivity individuals with productivity a_1 have a reservation wage of v_1 while high-productivity individuals with productivity a_2, have a reservation wage of v_2. $\bar{a}$ is the mean productivity; obviously, at high wages, when everyone is willing to work, $a = \bar{a}$. The resulting productivity curve is depicted in Figure 14*a*.

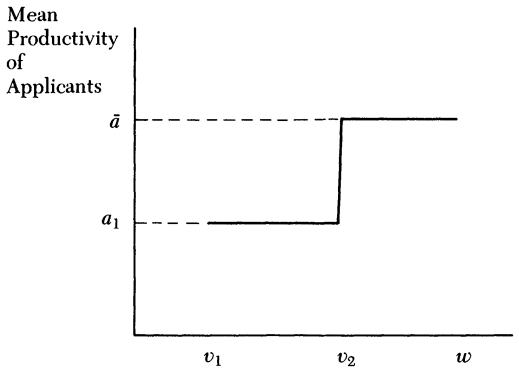


Figure 14a. Wage Productivity Curve in Two Group Model

A variant of this model arises when there are job-specific skills and positive search costs; the larger the applicant pool, the higher the expected productivity, simply because the firm can find a larger number of individuals that fit in well with the needs of the firm.

Capital Market. The intuitive reasons for the presence of adverse selection in the capital market follow along parallel lines to those in the labor market (Stiglitz and Weiss 1981). The fact that an individual is willing to borrow from a bank at a 25 percent interest rate implies that he has found no one else willing to lend to him at lower interest rate, and this fact conveys considerable information. Moreover, even if the individual had not been turned down by other banks, those who are undertaking very risky projects, with little prospect of repaying the loan, are likely to be less concerned about the interest rate they have promised to pay (when they do not default) than those who are undertaking safe projects and will always repay.

More formally, Stiglitz and Weiss (1981) consider a set of projects that the bank has identified as "similar." They all yield the same mean return, and require the same amount of bank finance. They show (*a*) the riskier projects[23] yield a lower return to the bank; (*b*) at any interest rate charged by the bank, firms with riskier projects apply, those with safer projects do not; and (*c*) as the bank increases the interest rate charged there is an adverse selection effect, with firms with the best projects (the least risky, i.e., those yielding the bank the highest expected return) no longer applying.[24] They show that the adverse selection effect may outweigh the direct gain from an increase in the interest rate. This may

income and the probability that he will obtain a higher wage, and this depends on the probability distribution of abilities and wage offers in the population, on the nature of the search technology, and on the costs of quitting a job once it has been accepted. See Nalebuff and Stiglitz (1982). Schlicht (1986) argues for a link between reservation wage and productivity based on the shorter expected duration of holding a job by less competent individuals.

[23] A project is said to be riskier than another if its return is a mean preserving spread of that of the other.

[24] The first result is a direct consequence of the concavity of the payoff function of the bank (in the absence of collateral, this is max $[R, (1 + r)B]$, where R is the return to the project, $(1 + r)B$ the amount the firm has promised to repay); the second result is a direct consequence of the convexity of the payoff function of the borrower (min $[R - (1 + r)B, 0]$ in the absence of collateral); the third result is an immediate consequence of the second.

be seen most easily in the case where there are only two kinds of firms; each project costs B dollars, and is entirely bank financed. The firm is required to put up c dollars worth of collateral per dollar loaned, which it forfeits in the event of a default. The projects of type i firm yield a return of R^i if successful, and nothing otherwise; the probability of success is p^i. The expected return to the bank per dollar loaned from a loan to a firm of type i is just $p^i(1 + r) + (1 - p^i)c$, where r is the interest rate charged. Thus, if $p^1 > p^2$, *one* is the safe project and yields a higher return to the bank, provided $c < (1 + r)$, which it always would be (otherwise, the bank faces no risk).

The expected return to a firm of type i is $p^i[R^i - B(1 + r)B] - cB(1 - p^i)$. It follows then that if the two projects have the same mean return, the riskier project yields the higher return to the firm. The safe firms no longer apply when

$$p^1[R^1 - (1 + r)B] - cB(1 - p^1) = 0.$$

Thus, for interest rates below $[p^1R^1 - cB(1 - p^1)]/p^1B - 1 = r^*$, both types of firm apply; for higher interest rates, only the risky firms apply. Even if at r^* there is an excess demand for funds, banks may not raise the interest rate (see Figure 14*b*).

2. *Incentive Effects*

We are concerned here with the variety of circumstances under which the quality of the product (the likelihood of bankruptcy, the productivity of a worker) is affected by actions of the seller (borrower, worker), and those actions are affected by the price (interest rate, wage). Two broad categories of models will be discussed, depending on whether there is or is not a long-term relationship. The latter are of particular interest; bad performance is (in these models) often punished by a termination of the relationship. For the threat of termination to be an effective incentive, the terms of the contract (relationship) must be such as to make that contract strictly better than that of the next best opportunity; e.g., price must be in excess of marginal cost or the wage paid must be higher than the minimum wage required to recruit the worker.

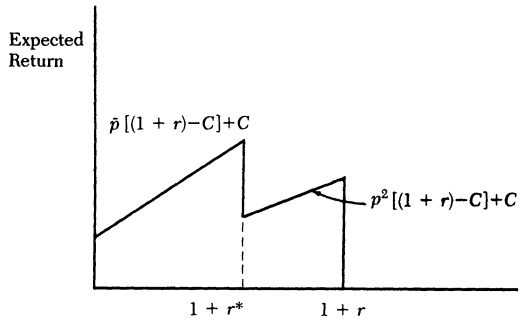


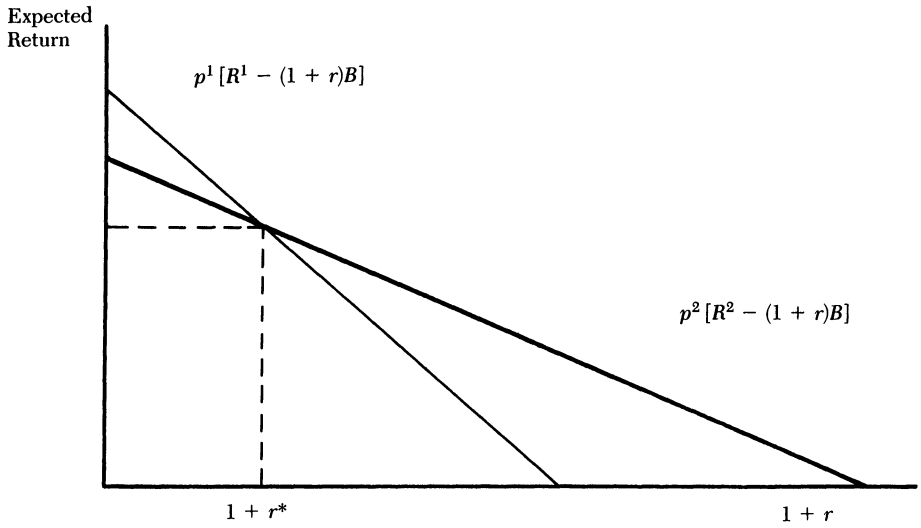
Figure 14b. Expected Return as Function of Interest Rate Change: Two Group Model

We now describe in greater detail the effects of wages, prices, or interest rates on economic incentives.

Capital Markets. An increase in the interest rate charged on a loan may induce the borrower to undertake greater risks, lowering the expected return to the lender (William R. Keeton 1980; Stiglitz and Weiss 1981). This may be seen most simply in the case where the firm has two projects that it can undertake, each of which costs B. As before, project i has a return, if successful, of R^i, and the probability of success is p^i; if unsuccessful, the project yields no return. For simplicity, we ignore collateral. Then, the expected return to the firm of undertaking project i when the interest rate is r is

$$p^i[R^i - (1 + r)B].$$

As Figure 15 illustrates, the safe project 1 has a higher expected return to the firm for $r \leq r^*$, where



Firm chooses safe project if and only if $r \leq r^*$.

Figure 15a

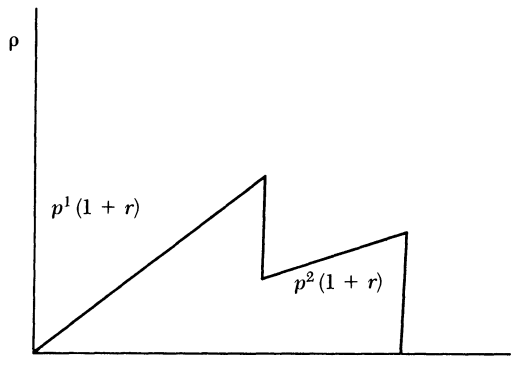
$$(1 + r^*)B = (p^1R^1 - p^2R^2)/(p^1 - p^2).$$

Thus, the bank will not raise the interest rate above r^*, even if there is an excess demand for funds at r^*, because to do so would induce firms to undertake the risky project, lowering the bank's return.

This is an example of what has come to be called a *principal agent* problem.[25] The principal (here the bank) can exert only indirect control over the actions of the agent (the firm) and, he does so through the design of the payoff schedule. Changing the nominal price (here the interest rate) may have adverse (in terms of the interests of the principal) effects on the actions undertaken by the agent.

The discussion so far has focused on a single period model. Stiglitz and Weiss (1983) have extended the analysis to a multi (two) period model. They establish that the threat of *terminating* the credit relationship may have beneficial incentive effects and that terminations are a better incentive device than threats to charge higher interest rates (pay lower wages).

Their analysis is similar to the explanation of why the expected return may decrease with the rate of interest charged provided by the models of Jonathan Eaton and Mark Gersovitz (1980, 1981a, 1981b), Eaton (1985), and Franklin Allen



Expected returns are maximized at r^*.

Figure 15b

[25] A vast literature has developed on the principal agent problem since the early papers by Steve Ross (1973), Mirrlees (1974), and Stiglitz (1974d). We make note of only those papers that are directly relevant to the subject of this review, the dependence of quality on price.

(1980, 1981, 1983). They are concerned with situations where contracts are not enforceable. We might say that there are implicit contracts, which have to be designed to be self-enforcing. The terms of the contract determine whether, and under what circumstances, it will pay a borrower to refuse to repay a loan (for a sovereign to repudiate his debt).[26]

In these models, it is again the threat of termination of the relationship that induces the borrower to repay the loan. (In the Eaton-Gersovitz model, access to international capital markets enables the country to smooth out income variability.) For any given amount loaned, the higher the rate of interest charged, the more likely it is that the loan will be repudiated.[27]

Labor Markets. There are several different explanations for why the wage might affect the productivity of workers and the profitability of the firm.

(*a*) *Shirking.* (Walter J. Wessels 1979, 1985; Guillermo Calvo 1979; Calvo and Phelps 1977; Calvo and Stanislaw Wellisz 1979; Shapiro and Stiglitz 1984; Samuel Bowles 1985;[28] Stiglitz and Weiss 1983; Steve Stoft 1982.) If there were no unemployment and if all firms paid the market-clearing wage, then the threat of being fired would not lead individuals to reduce their shirking: they would know that they could costlessly obtain another job. But if the firm pays wages in excess of that of other firms, or if there is unemployment (so that a fired worker must spend a period in the unemployment pool before he again obtains a job) then workers have an incentive not to shirk; there is a real cost to being fired.[29] One of the immediate consequences, then, of costly monitoring is that equilibrium must be characterized by unemployment and/or wage dispersion.

It also implies that the productivity of the worker hired by the *ith* firm, λ_i, is a function of the wage it pays, the wage paid by all other firms, w_{-i}, and the unemployment rate, U:

$$\lambda_i = \lambda_i(w_i, w_{-i}, U).$$

In the simplest version of the shirking model, workers either work or shirk; there is a critical wage below which the worker shirks. This critical wage is an increasing function of the employment level or of the wage differential between this firm and other firms. In the case where all firms pay the same wages, the so-called no-shirking constraint, giving the minimum wage below which shirking occurs, is depicted in Figure 16*a*. The demand for labor, given that workers do

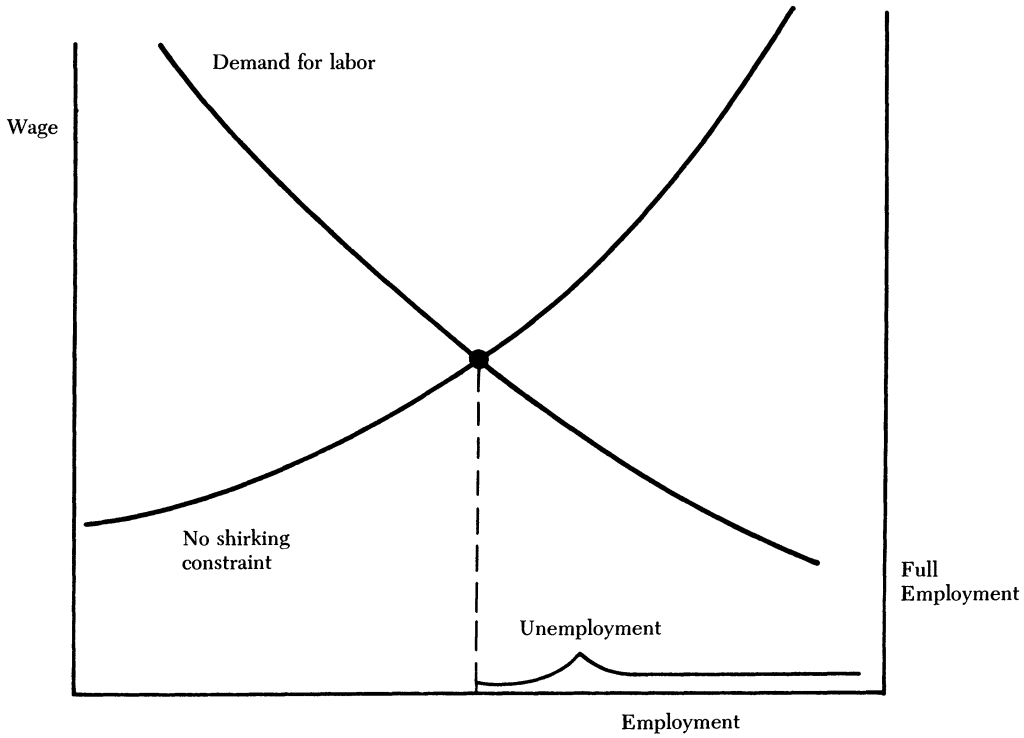
[26] In the Stiglitz and Weiss (1983) analysis, contracts are explicit, but enforceable only if it is in the interests of at least one party to the contract to do so. In the papers discussed in this paragraph, there is no legal enforcement mechanism. "Moral hazard" issues arise both in the compliance with the contract, and in the actions borrowers take which affect the likelihood they will wish to comply.

[27] Repudiation could always be avoided if the repayments could be made state dependent, and if all states were perfectly observable and verifiable by both parties. For a more general discussion, see Eaton, Gersovitz, and Stiglitz (1986).

[28] There is a large "radical" literature emphasizing the effect of the employment relationship on worker productivity. Other contributions to this literature include Herbert Gintis and Tsuneo Ishikawa (1985), Tom Weisskopf, Bowles, and David Gordon (1983), Gerry Oster (1980), and Geoff Hodgson (1982). The distinction between this literature and the nonradical literature is not always readily apparent. For instance, the Bowles (1985) and Shapiro and Stiglitz (1984) models appear to be essentially identical; some of the interpretations given to the model, and the lessons drawn, differ.

[29] These models are thus long-term models. The "punishment" is provided "publicly" by the period of unemployment (rather than privately, through reduced wages or other means). Stiglitz and Weiss (1983) provide conditions showing that termination is in fact the optimal punishment.

These models are constructed with identical individuals so there is no reputation effect associated with being fired. In any case, it is often hard to distinguish among voluntary and involuntary termination, in which case, the reputation effect of separations may be minimal (Shapiro and Stiglitz 1985a).



High wages and unemployment are necessary to induce workers not to shirk.

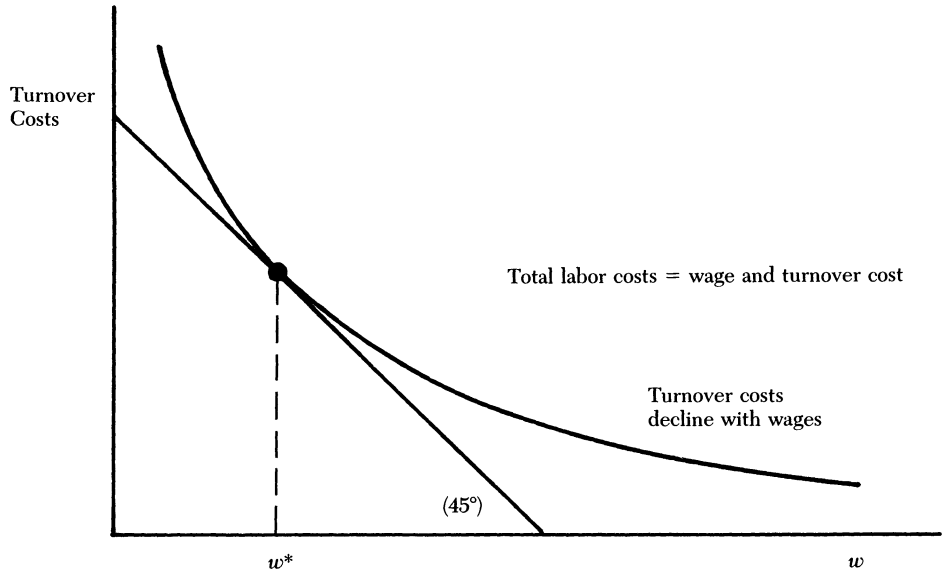
Figure 16a. Shirking Model

not shirk, is a decreasing function of the wage. Equilibrium, at the intersection of the demand curve and the no-shirking constraint, always entails unemployment.

(*b*) *Labor turnover.* (John Pencavel 1972; Wessels 1979; Stiglitz 1974b, 1974c, 1985; Robert Hall 1975; Salop 1973, 1979; Dybvig and Jaynes 1980; Ekkehart Schlicht 1978.) A second important way that workers' behavior affects the productivity of firms is through labor turnover.[30] In most jobs, there are costs to hiring and training that are specific to the firm. So long as individuals do not pay their full costs at the moment they are hired (recouping them later in the form of higher wages)[31] then the greater the quit rate, the greater the firm's expenditures on training and hiring costs. Increasing the wage rate (relative to wages paid by other firms) will, in general, lead to a reduction in the quit rate; there is a wage that minimizes total labor costs of the firm (Figure 16*b*). Moreover, the greater the unemployment rate, the less likely it is that the worker will find a better job. Because the effect of higher quit rates is to decrease the "net" productivity (net of turnover costs), we obtain a productivity wage relationship of the above form.

[30] The importance of this had, of course, long been recognized by labor economists. See Sumner Slichter (1919).

[31] Richard Arnott and Stiglitz (1985) and Shapiro and Stiglitz (1985a) provide explanations for why individuals do not bear the full costs of training; these have to do with worker risk aversion, incomplete insurance, and imperfect capital markets (though these market imperfections in turn, can be related to information imperfections).



Total labor costs are minimized at w*.

Figure 16b. Labor Turnover Model

(*c*) *Morale effects.* (James E. Annable 1977, 1980, 1985; Stiglitz 1973, 1974a; Pencavel 1977; Akerlof 1984; Whiteside 1974.) Employers often allege that paying higher wage results in higher productivity, and not simply because of the greater penalty associated with being fired. A worker who believes he is being treated more than fairly may not only get more job satisfaction from his job, but also may put out more for his employer. And notions of fairness are closely related to how one *perceives* others of similar ability being treated. Thus, we can postulate that an individual's efforts depend not only on his own wage, but on the wage of others in his reference group, $\hat{w}$, the monitoring intensity, m, and the cost of being fired (the unemployment rate):[32]

$$e_i = e(w_i, \hat{w}, m, U).$$

The formal analysis of this model follows closely along the lines of that of the shirking model.[33] (It may, in fact, be possible to derive at least some variants of this morale model from a standard utility maximizing model, in which utility depends not only on effort and wages, but on relative wages.[34] Obviously, quit rates

[32] These effects have, of course, long been discussed by labor economists. For an early formalization of the notion of interdependence, see Dan Hamermesh (1975).

[33] The observation that it is individuals' perceptions of whether they are being treated fairly that affects behavior has one important consequence. The productivity curve of a group that believes it is being treated unfairly will (if our argument is correct) lie below that of groups of identical abilities that do not believe they are being treated unfairly. Such individuals either will not be hired, or will be hired at lower wages than someone of the *same* ability (let alone someone of the ability that they believe that they have). The fact that they are hired at lower wages reconfirms their belief they are not being treated fairly. The employer who pays the lower wage does not believe he is discriminating, only that he is paying wages that are in accord with productivity, which depends both on (statistical projections of) ability and effort.

[34] Akerlof (1980, 1982) and Schlicht (1981a, 1981b) develop alternative theories of the employer-employee relationship in which psychological and sociological considerations lead to a dependence of productivity on wages. Akerlof (1984) describes some

too will depend on morale effects: Individuals may spend more resources searching for a better job if they believe that they are being unfairly treated on their present job.)

Sharecropping. (Stiglitz 1974d; David Newbery and Stiglitz 1979; Avishay Braverman and T. N. Srinivasan 1981; Braverman and Stiglitz 1982, 1986; Allen 1985a). It has long been recognized that increasing the share provided to the tenant worker could have beneficial effects on his work incentives, and thus could actually increase the receipts of the landlord.[35,36] It is possible that at the share at which the landlord's expected income is maximized, there is an excess supply of tenants.[37,38]

Product Markets. (Joseph Farrell 1979, 1980; Shapiro 1983; Dybvig and Chester Spatt 1983; Allen 1984; Ben Klein and Keith B. Leffler 1981).

In the product market, incentive effects similar to those described earlier arise: Buyers often cannot ascertain the quality of a commodity before they purchase it. Earlier, we noted that the penalty associated with a worker caught shirking and who is thereupon fired depended on the wage relative to the wage paid by other firms and the cost of getting another job (which depends, in part, on the unemployment rate). Similarly, the penalty a customer levies on a firm that has cheated him is to terminate the relationship; and the penalty associated with this depends on how high the price is relative to the production costs (the profit the firm attains from the relationship) and how hard it is to recruit another, similar customer.

The essential insights are provided by the following simple model. Assume that the cost of production for a high-quality commodity is c^h, for a low-quality commodity is c^l, and the price is p. Assume that when a customer observes a bad-quality commodity, he infers that the seller will always continue to sell a bad quality. The bad quality commodity is worth nothing to the customer, so if he believes that the commodity is bad, he will terminate the relationship. Then, the value to the firm of continuing to produce good-quality commodities is

$$(1 + r)\,(p - c^h)Q/r$$

where Q is the quantity sold, r the rate of interest. The value of cheating and producing a bad quality commodity is

$$(p - c^l)Q.$$

Thus, for it to be worthwhile for the firm to produce good-quality commodities,

$$(1 + r)\,(p - c^h)/r > p - c^l$$

or

$$p > (1 + r)c^h - rc^l = p^*.$$

Accordingly, any individual who saw a firm attempting to sell a commodity for less than p^* would infer that that commodity was a low-quality commodity.[39]

experiments in which different workers are assigned identical jobs and paid identical wages, but believe that they are either being under-or overpaid. These perceptions affect productivity.

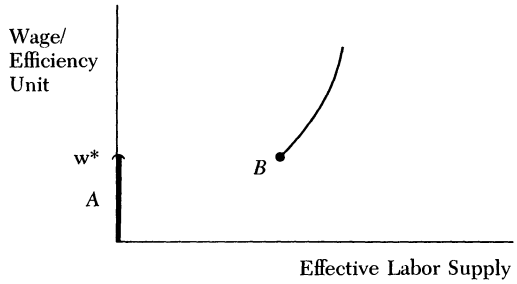
[35] Obviously, if the landlord could monitor the actions of the tenant, the share contract would specify the level of work required, and these incentive effects would not arise. See Steve Cheung (1969).

[36] Braverman and Srinivasan (1981) have identified circumstances in which in equilibrium there *cannot* exist an excess supply of labor.

[37] If part of the fixed payment is paid after the crop, then it is as if the landlord lent the funds to the worker; an increase in the amount to be paid has precisely the same effects as an increase in the rate of interest detailed earlier. An increase in the fixed fee can, accordingly, adversely affect the expected return of the landlord (-cum-lender) (D. Gale Johnson 1950). Allen (1985a) has shown that at low shares, tenants may have an incentive to "cheat" on the contract, absconding with the entire produce of the land.

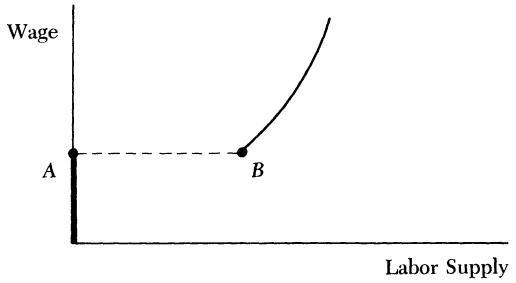
[38] The quotation from Sismondi in the introduction to this paper makes it clear that selection effects may also arise in the context of sharecropping.

[39] These beliefs are "rational"; given the beliefs of the individual, it would not pay the firm to produce a high-quality commodity, if it ever produced a low-



At wages below w^*, the effective labor supply is zero; at w^* it increases discontinuously.

Figure 17a



With nonconvexities in preferences, labor supply may be discontinuous, but with continuum of individuals equilibrium exists.

Figure 17b

3. *Nutritional Models.*

This paper focuses on the dependence of quality on price arising from imperfect information (adverse selection, moral hazard). But, as we noted, in one of the earliest sets of efficiency-wage models the quality of labor depended on the wage for nutritional reasons. How are these nutritional models related to the information models?

If the output of workers were perfectly observable, then presumably all workers would be paid on a piece rate basis. In equilibrium, some workers would be employed (at the efficiency wage), and other identical workers would be unemployed. Assume that workers get zero disutility from work, up to 40 hours per week, and infinite disutility thereafter (there is no disutility associated with effort up to a critical level λ, and infinite disutility thereafter) and that the output per unit time with the maximum effort level e is a function of nutrition. Then the number of labor units supplied will be a function of the wage rate. There is no way of obtaining any labor at a cost per efficiency unit of less than w^*/λ (w^*). At wages in excess of w^* effective labor supply increases, as depicted in Figure 17. Although, by assumption at w^*, each worker supplies either zero effective labor units or $\lambda(w^*)$, all workers strictly prefer to supply the latter; at w^* there is an excess supply of labor.

Although nutritional models can give rise to unemployment even if workers are paid on a piece rate basis, they obviously can also give rise to unemployment when piece rates are not feasible; thus, in the example given above, there are no incentive problems, whether workers are paid on a piece rate basis or not.[40]

Thus, the nutritional efficiency-wage models, while differing in fundamental ways from the informational efficiency-wage models in their microfoundations, yield similar conclusions: They generate similar reduced form relationships between productivity and the wage paid by

quality commodity; and given that the firm indeed produces a low-quality commodity, the beliefs of individuals are consistent with firm behavior. More formally, the equilibrium can be shown to be a perfect equilibrium. See Dybvig and Spatt (1983).

This is a "reputation" model based solely on incentive considerations. Other reputation models entail a mixture of incentive and adverse selection effects. There are good producers and bad producers. When a buyer purchases a commodity that turns out to be a low-quality commodity, then he infers that the seller must be a low-quality seller. It is their concern about being so labeled that induces good producers to produce high-quality commodities. One does not necessarily need many "bad" firms to induce good behavior on the part of the good firms, as David Kreps and Robert Wilson (1982) show in a rather different context.

[40] It is straightforward to construct models that incorporate both incentive and nutritional effects.

the firm, wages paid by other firms, and the unemployment rate. It is worth noting, however, that in one polar form of the efficiency-wage model, where individuals do not share any of their income with others, productivity depends only on the absolute value of the wage paid by the firm; accordingly the equilibrium wage will be independent of the unemployment rate. (This stands in contrast with several versions of the informational efficiency-wage model, where relative wages and the unemployment rate are the primary determinants of productivity.)

III. *The Implications of the Dependence of Quality on Price for Economic Theory*

1. *Differences Between Economies in Which the Law of Supply and Demand Is Repealed and Those Where It Still Holds*

It is useful to clarify the differences between the assumptions in our analysis and those that are (often implicit) in the traditional competitive paradigm, e.g., of the model of Arrow and Debreu. Arrow and Debreu assume that each employer has perfect information concerning the quality of his labor, that each buyer of a commodity has perfect information concerning the quality of the commodities which he purchases, and that each lender has perfect information concerning the characteristics of those to whom he lends. Thus, when they speak of a market for a commodity, they have in mind a market for a collection of objects, all of which are identical, at least in all relevant aspects. The person buying a commodity or hiring on the market is completely indifferent about which commodity he obtains; the firm hiring a worker is indifferent about which worker he obtains, and no additional information would change his indifference.

This assumption of a competitive market for homogeneous commodities is neither plausible nor innocuous. Markets in which commodities are completely homogeneous—with respect to location and the date as well as other characteristics—are almost inherently sufficiently thin so that the postulate of perfect competition is inapplicable. Markets that are sufficiently "thick" to be competitive are almost always nonhomogeneous. Consider the market for labor. If we define a submarket, say, J. E. Stiglitz's labor, then it may be homogeneous, but hardly competitive; if we take a broader definition of the market, say, those with PhDs in economics, it may be fairly competitive, but it is hardly homogeneous.

The problems with which we are concerned are central in capital markets and insurance markets. Both markets are essentially intertemporal: In the capital market, the lender lends the borrower money today, in return for a promise to repay $\$(1 + r)$ next period, provided the borrower can; in the insurance market, the insurer agrees today to pay the insured a given amount next period if a particular event occurs. The lender cares about the likelihood that the borrower will default; the insurer cares about the likelihood that the insured against event will occur. Borrowers (the insured) differ, but lenders (insurers) cannot tell who is more likely to default (to have an accident).

Moreover, the probability of default (of an accident) can be affected by the actions of the borrower (insured).

The Arrow-Debreu model does not actually require perfect information. What it does require is that the nature of the "commodity" be fixed (i.e., that the average quality of labor be unaffected by prices or wages and that average default (accident) probability be unaffected by the terms of the loan (insurance policy)). There can be neither adverse selection

or moral hazard effects; that is, if all individuals (commodities) are not identical, at least the mix of types is fixed *and* any actions which they might take that affect their productivity (or default, or accident, probabilities) are observable.

Many economic relationships involve an element of insurance and/or loan. This is the case, for instance, with most employment and rental arrangements.

There is one set of circumstances under which a firm does not care about the characteristics of those it hires. If the firm can perfectly and costlessly monitor the *actions*[41] of its employees, and pay the employee for the services performed, and there are no fixed costs associated with hiring a worker, then the firm is unconcerned whether the worker is a low-ability worker pulling out three medium sized weeds a day, or a high-productivity worker pulling out three hundred a day. It pays a fixed price per medium sized weed pulled out.

In fact, relatively few workers are paid even partially on a piece rate basis (which is not to say that performance goes unrewarded, either in terms of promotions or salary). The literature on compensation schemes details a number of reasons for this, all of which attest to the importance of the informational concerns that are the center of our analysis (Stiglitz 1975) but are completely ignored in the traditional competitive paradigm.[42]

Because most workers are not paid a piece rate equal to the value of their marginal product, and because there are costs associated with hiring workers, some of which are borne by the firm, firms are concerned both about the quality of the workers they hire, their productivity on the job, and their turnover rate.[43] The wage affects all of these variables. And so long as that is the case, the possibilities with which we have been concerned here—that equilibrium will be characterized by an excess supply of labor, and/or by a wage distribution—are real possibilities.[44]

[41] Where "actions" are sufficiently precisely specified to imply a particular outcome in a particular situation, regardless of who performed the action.

[42] The monitoring required by piece rate systems is costly; for it to be effective, there can be little variation in the quality of what is produced, or it needs to be easy to write a contract that specifies the relationship between quality and price, and then to observe and verify the quality of what is produced.

Moreover, as technology changes, the piece rate needs to change; but this is often a contentious process. If, of course, there were no costs of labor mobility (no costs of hiring workers and no costs to the worker of moving to another firm) then if the firm offered too low a piece rate, resulting in an income below the worker's opportunity cost, then the worker would simply quit; exit would replace voice, to use Albert Hirschman's insightful terminology. But labor mobility is costly, and thus workers and firms are concerned about how the piece rate is set; it determines the division of the "*ex post* surplus"—given that the workers are working for the firm, the difference between the worker's income and his opportunity cost; and the difference between the profits of the firm from the current employees and what the profits would be if the employer had to replace them.

[43] To the extent that firms bear these turnover costs or pay workers not solely on the basis of their actions, firms can be thought of as providing insurance.

[44] There is one other situation where moral hazard problems do not arise in labor markets: When workers are risk neutral (so there is no need for an insurance component in the relationship), then they can rent the machines on which they work (rent the land); because they receive all the residual, they will have "correct incentives"; and because what the capitalist (landlord) receives is independent of the action of the worker, he is indifferent to the actions they undertake. But even this is not correct if the worker cannot pay the rent ahead of time; then there is some probability that he will fail to pay the promised rent, and the likelihood of this is, in general, a function of the actions he undertakes: There is still a moral hazard problem. When rents are paid *ex post*, then it is as if the owner lent the money to the renter (see Johnson 1950; Stiglitz and Weiss 1981). Moreover, if how the worker uses the machine affects its future productivity and if it is difficult to verify whether the deterioration in the machine is due to misuse, there is a further moral hazard problem limiting the extent of rental markets. The contractual arrangements between the parties will try to limit these moral hazard problems, by stipulating restrictions on the use of the rented property. Thus, a landowner may stipulate what crops are to be planted, and he may impose restrictions on grazing. These moral hazard problems can be avoided by selling the machine; but this increases the risk of the worker; and it is even less likely that he will have the resources to pay for the purchase than to rent.

It should be noted that most of the issues with which we have been concerned here would arise so long as individuals are not paid on a piece rate, regardless of the reason. Similarly, if the firm must pay a uniform wage to all workers, even though it knows which workers are more productive, it will worry about the adverse selection effects of lowering wages.

The conventional models assume not only that there is not imperfect information concerning what is being bought, but also, in trades which occur over time, that there are no *enforcement* problems. In fact, of course, there are important enforcement problems, arising both from the incompleteness of contracts and from the costs of enforcing the contract terms that are explicit.[45]

The nutritional efficiency wage models can give rise to unemployment even without informational problems, as we have already noted. These models differ from the conventional Arrow-Debreu model in two technical respects, which turn out to be important: There is a nonconvexity associated with the productivity wage relationship, and in equilibrium individuals are on the boundary of their feasible set.[46]

2. *Alternative Equilibrium Concepts*

In Section I we argued that when quality depends on price, equilibrium may be characterized by markets not clearing. In traditional economic theory, equilibrium is defined as market clearing. Clearly, different notions of equilibrium are being employed. Indeed, even within the literature recognizing the dependence of quality on price, more than one equilibrium notion has been employed, with contrasting results. In this section, we review and contrast several of the more important equilibrium concepts that have been used.

Walrasian Versus Rationing Equilibria. In models where quality depends on price, there may exist a market-clearing price, for instance, a wage at which demand equals supply. We referred to this as the Walrasian equilibrium, but this may *not* be a market equilibrium. Whenever in the labor market there is a region where cost per effective labor unit decreases with an increase in the wage, or in the capital market there is a region where the expected return decreases with an increase in the interest rate, there *may* exist an equilibrium with excess supply of labor or excess demand for capital. Indeed, there always exists some level of demand for labor or supply of funds for which this is true.[47]

[45] These enforcement problems are, of course, central both in international lending, in implicit contract theory, in sharecropping markets, and in product markets.

[46] Thus what appears to be a technical assumption in Gerard Debreu's *Theory of Value* becomes of central importance in this analysis. Loosely speaking, to prove the existence of a market-clearing equilibrium, one must show that the supply correspondences are continuous, and to do this one must show that the budget sets are continuous functions of prices. To recast the nutritional efficiency-wage model in standard terms, we let $w\#$ denote the wage per efficiency unit. While at $w\# = w^*/\lambda^*$, the individual supplies λ^* efficiency units of labor, and at higher wages, the individual can supply, say, up to $\lambda(w)$ units of labor, at lower values of $w\#$ the feasible set shrinks to zero.

Note that while with nonconvex preferences, say, for leisure, the supply of labor correspondence might look as in Figure 17*b*, with the individual being indifferent between points A and B; with the efficiency wage model, the labor supply correspondence appears as in Figure 17*a;* the individual strictly prefers B to A. This explains why, with nonconvex preferences, an equilibrium exists with a continuum of individuals, but a market-clearing equilibrium does not exist in the efficiency-wage model. Moreover, while with standard nonconvexities those who supply labor and those who do not have the same level of utility, this is not true in our model. For a more extended discussion, see Dasgupta and Ray (1986a).

[47] The demand curve is derived as follows. Assume the firm's production function is $Q = F[\lambda(w)L]$. It chooses w and L to maximize $Q - wL$ where we have chosen output as the numeraire. From the first-order conditions, $\lambda/\lambda' = w$ meaning that the wage is chosen to minimize labor costs per unit of effective labor (the efficiency wage). Employment is chosen so that, at the efficiency wage, the real wage equals the value of the marginal product of labor: $w = F'(w)\lambda$.

It is important to emphasize that we are not arguing here that equilibrium is *never* characterized by the equality of demand and supply, only that it may not be.[48]

The Walrasian wage (interest rate) is the market equilibrium if and only if there exists no higher wage (*lower interest rate*) at which costs per efficiency unit (*expected returns*) are lower (*higher*)[49]

The Choice of Appropriate Equilibrium Concepts. Our analysis thus differs from the standard Arrow-Debreu model not only in its informational assumptions, but also in its definition of equilibrium. Traditional theory has taken the equality of supply and demand to be part of the definition of equilibrium. This, I think, is wrong.

Equilibrium is defined, loosely, as a state where no economic agents have an incentive to change their behavior. Whether a particular configuration of the economy is an equilibrium depends, then, on agents' perceptions of the consequences of changes in their behavior. If employers believed that at a lower wage they would obtain exactly the same quality of laborers as they obtained at a higher wage, then clearly, if a worker offered to work for a wage lower than that of existing workers, the firm would hire him (assuming there were no further repercussions of what might be viewed by other workers as antisocial behavior).[50] Under these circumstances, equilibrium would be characterized by demand equaling supply.

The fact that under these circumstances equilibrium is characterized by demand equaling supply is thus a theorem (admittedly trivial) to be proven; the equality of demand and supply should not be taken as a definition of equilibrium, but rather as a consequence following from more primitive behavioral postulates. What we have established in this paper is that, under plausible behavioral postulates, equilibrium may not be characterized by demand equaling supply. At the same time, it should be emphasized that our economy is competitive in the conventional sense in which that word is used: We are concerned with atomistic equilibria, in which all agents are small relative to the market though in spite of this they are not price takers.[51]

Passive Versus Active Sellers and Buyers. While the models presented here differ from the conventional competitive paradigm both in informational assumptions and in the equilibrium concept, these models differ from Akerlof's analysis of adverse selection only with respect to the equilibrium concept. In Akerlof's model, as in the traditional perfect information model, however, both buyers and sellers act completely passively. For instance, although firms know the statistical relationship between the wage paid

[48] In paticular, if the Walrasian wage exceeds the efficiency wage, the market equilibrium is the Walrasian wage, and the law of supply and demand holds. Any firm that attempted to lower the wage to the efficiency wage would not be able to obtain any labor.

[49] In this example, the cost per effective unit of labor curve has taken on a simple shape: At wages below w^*, cost per effective labor unit is decreasing, and at wages greater than w^*, it is increasing. There is no intrinsic reason why the cost per effective unit of labor curve should take on such a simple shape as we have already noted (see Figure 6). Then, there will be an excess supply of labor if the Walrasian wage is below w^* or between $\hat{w}$ and w^{**}. It always pays the firms to pay the wage in excess of the Walrasian wage, which minimizes cost per effective unit of labor. Thus, for Walrasian wages in the interval between $\tilde{w}$ and w^{**} it pays the firm to increase the wage to w^{**}. (In these circumstances, equilibrium may be characterized by a wage distribution, as we noted earlier.)

[50] These repercussions have been at the center of recent literature focusing on the distinction between insiders and outsiders. See Assar Lindbeck and Dennis Snower (1984a).

[51] The concept of equilibrium employed by Dasgupta and Ray (1986a) in their analysis of the nutritional efficiency wage model corresponds to a quasi-equilibrium in Debreu (1959) and to the concept of a compensated equilibrium in Kenneth Arrow and Frank Hahn (1971).

and the productivity of the workers they hire, they do not try to use this knowledge to increase their profits, e.g., by setting wages at other than a market-clearing level. We would argue that there is, in most situations, no persuasive reason to limit out uninformed agents to the passive role that conventional theory has assigned to them.

Nonprice Rationing. A number of writers have argued that when, in the capital market, interest rates cannot fall, there are other methods by which markets can be made to clear; similarly, in labor markets, when wages cannot fall, there are other methods by which markets can be made to clear. In markets with imperfect information, contractual arrangements involve more than a single term; and it must be shown that none of these can adjust in a way as to restore market clearing. There may be adverse selection and incentive effects from changes in each of the contract terms.

In the capital market, emphasis has been placed on the role of collateral. Increasing collateral does induce firms to undertake less risky projects, but may have adverse selection effects (Stiglitz and Weiss 1981; Hildegard Wette 1983; Gerhard E. Clemenz 1984, 1985; Chang-Ho Yoon 1984, 1985). Several authors (e.g., Helmut Bester 1985) have constructed models in which, if banks can design contracts with varying interest rates and collateral, there will be no credit rationing.

It is important to recall that our contention has been not that equilibrium would always be characterized by credit rationing, but that it may be, under plausible conditions. Indeed, it is easy to construct examples in which equilibrium is not characterized by credit rationing. Bester (1985) and David Besanko and Anjan Thakor (1984) provide examples with the peculiar property in that bankers can obtain, through offering a set of contracts, perfect information concerning their borrowers. By contrast, Stiglitz and Weiss (1986a, 1986b) argue that as long as there is a residual of imperfect information there may be scope for credit rationing.[52]

In the Stiglitz-Weiss models, each borrower borrows the same amount. Another term of the contract that can adjust is the amount lent. Under certain circumstances, reducing the amount lent reduces the risk faced by the bank. Thus, adjustments in the loan size can eliminate credit rationing (H. Milde and John Riley 1984). Again, the issue is not whether one can construct examples in which rationing does not occur, but rather, are there alternative, plausible structures under which it does. In a multiperiod context, Stiglitz and Weiss (1981) have shown that reducing the size of the loan may have an adverse effect on the risks undertaken by the borrower; they undertake projects that in effect, "force" the lender to ante up more money in subsequent periods, if they are to recover their initial loans (see also Martin Hellwig 1977).

In the labor market, discussions have focused on the role of bonding and "job" purchases. That is, a worker could put down a sum of money that he surrenders in the event of being caught shirking. Bonding, it is argued, can alleviate the incentive problems. B. Curtis Eaton and William White (1982), Shapiro and Stiglitz (1984, 1985a), Edward Lazear (1982), and Stoft (1985) have argued against this

[52] They constructed a simple model in which they combine incentive and selection effects; there are two groups in the population, and each group has two activities (a safe and a risky project). Even though the bank is able to sort individuals perfectly, it cannot raise interest rates, because to do so would induce greater risk taking. Hence, they show that there may be credit rationing at one or both credit contracts. Credit rationing may also arise if individuals differ in more than one dimension, e.g., with respect to risk aversion and wealth.

on several grounds: Firstly, they note that with young individuals having limited capital there is, at least for these workers, incomplete bonding, so that firms are, in fact, concerned with the relationship between wages and productivity. (Though they could borrow to put up the bond, this simply shifts who bears the risk that the worker fails to perform, from the firm to the lender. Though nonvested pensions can be viewed as a form of bonding, it takes individuals a number of years to accumulate enough within their pension fund to serve as a sufficiently effective bond to eliminate the need for firms to be concerned with whether their workers shirk.) Secondly, they note the "double moral hazard" problem, the incentive of the firm to declare that the worker has shirked when he has not. This may be alleviated by making the bond forfeiture go to a third party: again, the empirical relevance may be questioned; moreover such arrangements are sensitive to complicity by two of the parties against the third.[53] Thirdly, they note that many individuals may not have funds to post a bond; to borrow the funds would entail all the adverse effects noted earlier in our discussion of capital markets; and to restrict applicants to those who could finance the bond themselves would have the adverse selection effects noted earlier in connection with collateral.

Similar problems arise with job purchases (or, what is equivalent, in the context of labor turnover, with requiring individuals to pay for their full costs of training).[54]

Advocates of the efficiency wage models claim, in the end, that the central point is that firms do care about quit rates, they do care about the incentives of their workers, and they do use wage policies to affect the net profitability of their employees.

3. *Other Imperfect Information Models*

The last two decades have seen a burgeoning in imperfect information models. It is worth noting the relationships between the models that are the center of discussion here and some of these other models.

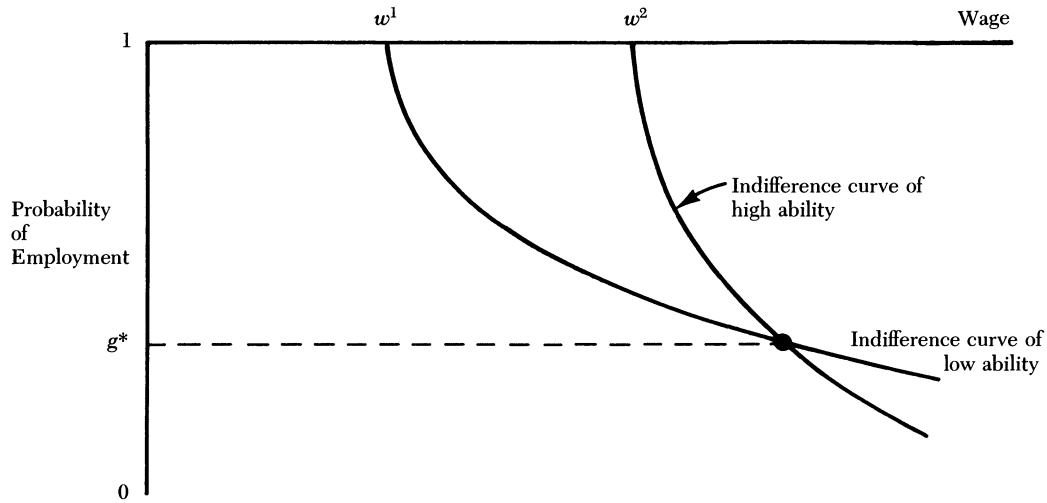
Prices Versus Quantities Earlier literature (Rothschild and Stiglitz 1976; Akerlof 1976; Michael Spence 1974) stressed the role of *quantities* in conveying information; the literature this paper is concerned with stresses the role of prices in conveying information.

The quantity of education obtained by an individual conveys information because it is more costly for a less able individual to acquire education than for a more able individual. But it is no more costly for a less able individual to announce that he is willing to work only at a higher wage than a more able individual. How then can workers (informed sellers) use prices to convey information about themselves? There must be some cost to announcing a higher reservation price: The price is the lower probability of being employed (or selling one's commodity). Stiglitz (1976a) and Nalebuff and Stiglitz (1982) have constructed models in which higher-quality workers are willing to face a higher probability of not obtaining a job because their fallback

[53] These problems would also be ameliorated if firms could establish a reputation.

Another mechanism for providing incentives for workers that does not suffer from the "double moral hazard" problem are contests (Lazear and Sherwin Rosen 1981; Green and Nancy Stokey 1983; Halebuff and Stiglitz 1983b; Sudipto Bhattacharya 1983). They do impose some risk for workers, and workers have to believe that the contests are fairly administered, and that they are evenly matched with their competitors. Intrafirm contests may also have deleterious morale effects.

[54] Some of the "problems" with job purchases explain why the price for jobs would be low (e.g., workers' risk aversion, limitations on workers' access to the capital market), but not why the market for jobs does not clear.



Wage and probability of employment acting as self-selection device.

Figure 18

wage is higher. (Wilson [1979, 1980] has constructed a similar model for the product market.)[55] Thus, if there are two types of workers, whose reduced form utility function can be represented by $U_i = U_i(w,g)$, where g is the probability of obtaining a job, then equilibrium may be characterized by both groups obtaining wages commensurate with their abilities (though employers cannot observe them directly), but with the low-ability individuals having a probability g^* just large enough to induce the low-ability not to apply, i.e., letting superscript 1 denote the low-ability workers

$$U^1(w^1, 1) = U^1(w^2, g^*)$$

(See Figure 18).[56,57]

In the simple models analyzing the dependence of quality on price, quantity variables are not observable. (There is no variable, like education, to reveal the

[55] Similarly the probability of consummating a deal may serve as a self-selection device within a bargaining model.

[56] Technically this analysis should be contrasted with that of Rothschild and Stiglitz (1976), where each firm (uninformed agent) sets the price and quantity; here firms set only the price; the unemployment rate is determined as part of the equilibrium. This is also true of the Stiglitz-Weiss (1986a) model of the capital market.

Some questions have been raised about the relevance of this particular model for the description of labor markets; it may have more to do with the number of hours worked by a Harley Street doctor than it does with unemployment among the low skilled. It is important to note, however, that in this model "unemployment" does not have the same interpretation that it does in the national income statistics: It means that the individual is not employed by others. For the low skilled, this may indeed correspond to unemployment; for the high skilled, it may correspond to self-employment.

[57] This model has been extended by Nalebuff and Stiglitz (1982) to the case where individuals can apply for several jobs. In that case, the nature of the equilibrium depends critically on whether contracts are binding—whether once a job has been accepted, the worker can quit when he is offered a better job. If contracts are binding, the opportunity cost of accepting a low-wage job is the foregone possibility of a high-wage job, the likelihood of which depends on both the job offers of different firms and the behavior of other individuals (how high they set their reservation wages). They show that there exists a particular wage distribution, such that when all workers rationally set their reservation wages, the cost-per-efficiency unit of the firm is the same for all firms. (In their equilibrium, while the quality of those who apply at each wage are, in fact, different, it is only the wage-cum-unemployment rate that distinguishes them: in all other respects the workers look the same. Moreover, at each wage, except the lowest, there is an excess supply of applicants.)

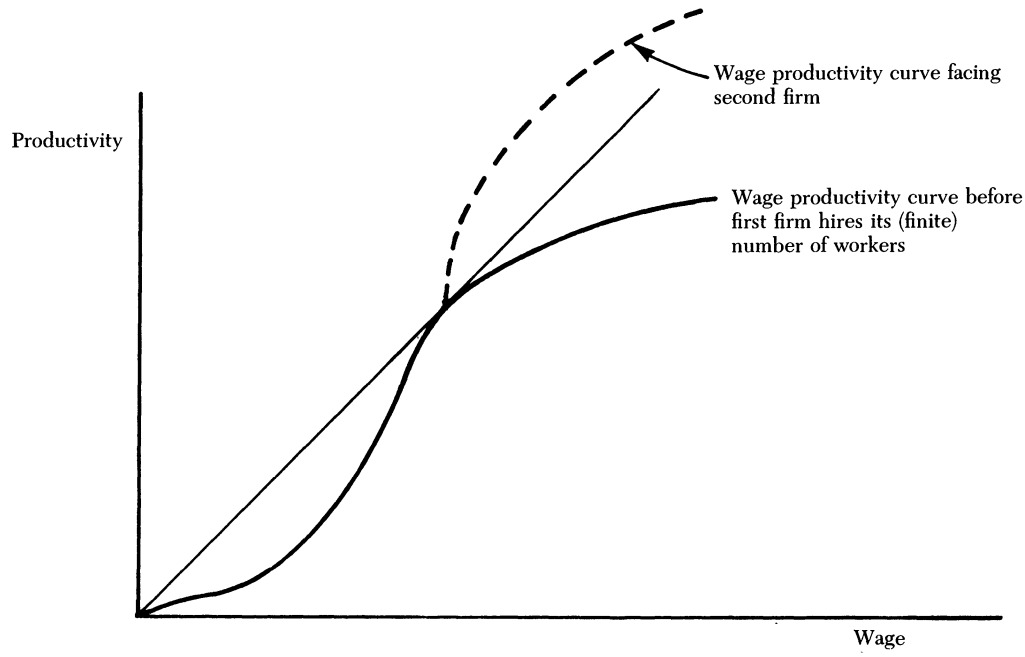


Figure 19. The Advantages of Being Late

individual's true ability.) But all that is required for wages/prices/interest rates to play a role in conveying quality information given whatever variables that are observable is that there remains some residual uncertainty of either the adverse selection or moral hazard sort.[58]

Information Revealing Prices in the Capital Market. There is a closely related literature to that discussed here, where prices also convey information. In capital markets, the price at which a security sells may convey information concerning the expected return of the security (or the likelihood of the occurrence of various states). (See Green 1973; Grossman and Stiglitz 1976, 1980; Margaret Bray 1981; Roy Radner 1979.) In structure, these models are most like the Akerlof "Lemons" (1970) model, in which both sellers and buyers act nonstrategically: They take prices, and the information conveyed by the price, as given. They differ in that, while there is only one seller (and usually only one buyer) of any particular automobile, or any particular person's labor services, there are many potential buyers and sellers of any

By contrast, if the first firm to enter the market had simply hired at what it thought was the efficiency wage, because it would have hired only lower-ability workers, those with reservation wages below the efficiency wage, the "new" efficiency-wage schedule facing the later entrant would lie above the old one, for $w > w^*$, and hence there would be an advantage to being late. See Lewis Guasch and Weiss (1980).

[58] Thus, models in which there are only limited sources of imperfect information may be very misleading. For instance, if individuals differ only in one dimension, then education may serve to sort individuals perfectly: There will be no residual imperfect information, and hence no need to lower wages to improve the mix of laborers. But if individuals differ in several dimensions, then education alone will not suffice to provide complete information. Similarly, in the capital market, if borrowers differ only in one dimension, and there is no moral hazard problem, there may exist a fully revealing self-selection equilibrium, and there will be, as a consequence, no role for credit rationing. But if borrowers differ in several dimensions and/or there are moral hazard problems, there may exist credit rationing. Though self-selection devices may reveal some information, they will not be perfectly revealing.

particular security. (Indeed, in the absence of transactions costs, with risk aversion and imperfectly correlated securities, virtually everyone is a buyer or seller.) Thus, while the price of a car sold at an auction reflects the valuation placed on it by those who value it most highly, in a security market, those who believe that a security is overpriced will sell it short, and their beliefs are, accordingly, reflected in the market equilibrium price.

IV. *Applications*

1. *Implications for Macroeconomics*

These models have direct and important implications for macroeconomics.[59]

This section is divided into four subsections, dealing respectively with labor markets, capital markets, product markets, and the relationship of these theories to other recently advanced theories.

Labor Markets. The fact that these theories have yielded competitive market equilibrium in which wages do not fall in the face of unemployment, in which there is an equilibrium level unemployment, immediately suggests the possibility that these theories may provide an important part of the explanation of involuntary unemployment. This is an area of active ongoing research and controversy. What I wish to do here is to explain why some economists find these models more persuasive than at least several of the competing theories, and to present what appear to be at the present time the major issues, both the criticism and the defenses, pointing to certain unsettled controversies.

(*a*) *The Pattern and Form of Unemployment.* A theory purporting to explain cyclical fluctuations in unemployment should not only show that it can generate unemployment, but also explain the pattern and form of unemployment. This efficiency-wage theories do.[60] Less productive workers—those for whom the minimum wage per efficiency unit is below some critical level—cannot get jobs, though they might at higher levels of effective demand. (These may include young workers, part-time workers, or others for whom the total surplus from work is small, so that the no-shirking wage, at any unemployment level, is high.)

Moreover, there is no work sharing, with the associated income reductions, for this would simply reduce the quality (productivity) of the labor force. In the incentive efficiency-wage model, it is the total surplus (the amount by which the value of wage payments exceeds the foregone leisure) that determines whether workers shirk; in the turnover model, it is the total surplus (relative to that offered by other firms) that determines whether a worker quits; in the selection models, it is again the total surplus that determines the individual's choice of one job over another. Work sharing reduces the surplus available to any individual, and thus adversely affects the effort (quality, labor turnover). See, for example, Arnott, Hosios, and Stiglitz (1983) or Michael Hoel and Bent Vole (1986).

(*b*) Criticisms. Critics have raised several objections, concerning both the quantitative significance of the efficiency-

[59] It is important to emphasize that although we believe that these models provide an important part of the microfoundations for macroeconomics, they do not provide the whole story: Other models (many of them also based on considerations of imperfect information) are required.

This section owes much to the comments of Bruce Greenwald and Larry Summers.

[60] This should be contrasted with the standard implicit contract theories (e.g., Costas Azariadis 1983; Grossman and Oliver Hart 1981; for recent surveys, see Azariadis and Stiglitz 1983; and Hart 1983) which, at best, provide an explanation of work sharing (see Stiglitz 1986). Arnott, Arthur Hosios, and Stiglitz (1983) incorporate some aspects of efficiency-wage theory in their analysis of labor contracts with costly labor mobility.

wage effects and the consistency of the theory with certain observed macroeconomic phenomena.

1. Can efficiency wage theory explain involuntary unemployment? Perhaps the most widely cited criticism is that, unless efficiency wage considerations are important in all sectors, the theory cannot explain unemployment; that is, if there is some sector (such as agriculture) where workers can be paid on a piece rate basis, and the piece rate is flexible, then that sector should absorb all workers laid off from those sectors where efficiency-wage considerations are important. Thus, efficiency-wage theory might be able to explain wage differentials (the secondary labor market), but not unemployment. (Note that this objection can be raised against implicit contract theory explanations of unemployment as well.)[61]

Several of the efficiency-wage models have attempted to incorporate a flexible wage sector. In Stiglitz (1974c), for instance, the agricultural sector has flexible wages, while efficiency-wage considerations are important in the industrial sector. Individuals must choose in which sector to locate (mobility between the sectors is not costless and instantaneous). Unemployment in the urban sector is such as to equilibrate expected income (of the marginal migrant) in that sector to that in the rural sector.[62]

Jeremy Bulow and Larry Summers (1985) assume that individuals can search for a (high-wage) job only while unemployed, and thus even if individuals could have obtained a low-wage job, they choose not to do so.[63]

Greenwald has provided several alternative explanations for why individuals may not accept a low-wage job, based on information theoretic considerations: Accepting a low-wage job may convey information about the individual's ability; with high-ability individual's expecting to get a "good" job sooner than a low-ability individual, an individual who readily accepts a low-wage job signals that he thinks of himself as low-ability, and this signal will lower his future wages.[64] Moreover, accepting a job creates an information asymmetry—the firm's new employer will know more about the individual's ability than other prospective employers. Just as Akerlof showed that these information asymmetries lead to thin markets for used cars, Greenwald has shown that they result in thin markets for "used labor."[65] Finally, he has attempted to relate unemployment to capital market imperfections, which

[61] Including theories of staggered contracts (Taylor 1980), which need to explain why labor is not absorbed into those sectors whose contracts are up for negotiation.

[62] John Harris and Michael Todaro (1970) have developed a similar analysis to explain urban unemployment in LDCs. The major difference between the Harris-Todaro model and the Stiglitz model is that in the former, the wage is exogenous and in the latter—as in all the work under examination here—it is endogenous. Robert Hall (1975) has used a similar model to explain differences in unemployment rates in different urban areas.

[63] Similarly, Arnott, Hosios and Stiglitz (1985) assume that the costs of search for the unemployed and the employed may be different and show that optimal contracts may then entail some individuals being layed off even if it means a finite probability of being unemployed for a period.

[64] As is often the case, there may be another equilibrium in which accepting a low-wage job does not signal one's ability: When there are significant transactions costs, it is more plausible that the acceptance of a low-wage job will serve as a signal. Alternatively, the argument to be given next serves to explain why accepting a job would lower one's lifetime wage prospects quite apart from signaling considerations: Signaling considerations would then serve to strengthen the magnitude of the effect of the acceptance of a low-wage job on lifetime income.

[65] This result depends, in part, on the firm's not being able to commit itself to paying higher wages in the future. Those commitments themselves are, at best conditional on the firm's surviving. Thus, a worker who accepts a low wage now from a firm in bad financial straits with the promise of a high wage in the future takes, in effect, an equity position in the firm. The reasons why workers may not be willing to do so have been set forth in Greenwald, Stiglitz and Weiss (1984).

themselves can be explained by information theoretic concerns. There are, in general, some training costs that firms must bear when they hire a worker; moreover, hiring a worker represents a risky investment. With imperfect capital markets, firms cannot divest themselves of this risk; as a result, the implicit cost of capital may be very high in a recession, and hence it is possible that in a recession, firms are willing to hire workers only if the lifetime wages are lower than they would be if the worker were hired in a later period, when the risks faced by the firm are less.

Critics might say at this juncture, "Aha, so unemployment is really voluntary." We think little is gained from a semantic debate over whether unemployment is, in this sense, voluntary or involuntary. What is critical is (*a*) in the market equilibrium, some individuals, with a given set of characteristics, have a distinctly higher level of (expected) utility than other similar individuals; (*b*) the equilibrium has, for one reason or another, some individuals in the unemployment pool who, under other circumstances, would be working; and (*c*) the market equilibrium is not (constrained) Pareto efficient.

2. Are there alternative mechanisms for ensuring quality? A second criticism is that if these efficiency-wage considerations were really important, alternative mechanisms would be found that would not be anywhere near as socially costly as the unemployment to which it gives rise. There are several answers to this objection: Firstly, the fact of the matter is that firms are concerned about the quality of their labor force and their rates of turnover. Secondly, we have already detailed some reasons why at least some of the proposed alternatives that would eliminate unemployment (credit rationing) may be ineffective. Some of these arguments may hold with more force for some groups of workers or for some industries than for others. Thus, consider the argument that bonding is not employed because workers have insufficient capital. This argument seems more applicable to young workers and to low-wage (unskilled) workers than to older workers, and therefore might suggest that the effort-efficiency wage model is more relevant for these workers than for other groups of laborers.[66]

Finally, we note that because of the presence of the important externalities discussed in Part I.5., the private costs of pursuing, say, high-wage policies (leading to unemployment) and of not employing alternative strategies of sorting and providing incentives may be much less than the social costs. This has been stressed by Akerlof and Janet Yellen (1985).[67] In particular, if firms are risk averse[68] then they may not revise their wages or may not change other policies even in the presence of some disturbance to the economy which leads to an excess supply of labor, even if were they to do so would be welfare enhancing.

3. Can efficiency wage theory explain nominal as well as real wage rigidities? Although the criticism that these models provide an explanation of real-wage rigidities, not of nominal-wage rigidities, is valid against most versions of the efficiency-wage models—as it is against most

[66] This argument was put forward by Robert Hall in his discussion of Yellen's survey of efficiency-wage models at the San Francisco meetings of the American Economic Association, December 1984.

[67] This is in fact a general property of economies that are not (constrained) Pareto efficient. There then exist large classes of perturbations to the economy that effect pareto improvements. If the firm sets its wage in a privately optimal way, there exist some pertubations of this wage that have a second order effect on the profits of the firm but have a first order effect on the welfare of other agents in the economy. See Greenwald and Stiglitz (1986a).

[68] Again, the fact that firms behave in a risk averse manner can be explained in terms of certain capital market imperfections which, in turn, can be related to imperfect information.

versions of implicit contract theory (where, in principle, contracts should be indexed)—it is worth noting that the labor-turnover efficiency-wage model is also consistent with money-wage rigidities: The turnover rate facing any firm depends on the wages set by other firms; if each firm believes that other firms will leave the wages unchanged in nominal terms, it pays it to leave its wage unchanged in nominal terms. The Akerlof (1984) morale model is also consistent with nominal-wage rigidities.

4. Can efficiency wage theory explain rationing among several groups? Simpler versions of the efficiency-wage theory yielded rationing for only one group in the population. For all other groups, either no one was hired or there was full employment. But with more general specifications, with productivity depending on (each group's) unemployment rate then in equilibrium, there may be unemployment among several groups. And even if there were a continuum of groups, with only one group rationed, the discontinuity in utility (between similar groups) would remain. It is this discontinuity—with similar individuals being treated discretely differently—which is so much at odds with standard competitive theory.

5. Can efficiency wage theory explain wage and employment dynamics? The final criticism[69] is that while the efficiency-wage theory may provide an explanation of the "natural unemployment rate," it does not provide an explanation of cyclical movements in real wages. This criticism takes on two forms. First, it is observed, that in a recession, increases in unemployment (reductions in relevant opportunities, including self-employment income) should result in lower wages in the effort-efficiency wage models. Whether this is in fact the case is debatable; if the quality of workers laid off in a recession is, on average, lower than those retained (a pattern that itself is consistent with efficiency-wage theory), then even if the average product wage does not fall much, the quality adjusted product wage may. Moreover, what is relevant for the incentive-based efficiency-wage theory is the lifetime return from holding a job; with low discount rates and long lifetimes, disturbances to the economy may leave this relatively unaffected. Though the value of alternative opportunities may decrease in a recession, thus enabling a myopic firm to lower its wage without inducing shirking, nonmyopic firms will realize that the value of the job is enhanced by the implicit insurance provided through income smoothing.[70,71] (On the other hand, because unemployment benefits are typically lengthened during recessions, and the stigma associated with being laid off is decreased, it may actually be worthwhile for firms to raise wages in recessions.)

[69] This list of criticisms is not meant to be exhaustive. Another objection is that these models require not only that productivity increase with wages, but also that there be a range of wages over which increases in wages lead to more than proportionate increases in productivity. This objection has been dealt with where we showed how several simple models exhibiting these properties can be constructed. It then becomes an empirical question whether in practice the wage-productivity relationship has the required shape. Unfortunately, there is insufficient empirical evidence to date to provide a convincing answer.

[70] This formulation entails, in effect, a synthesis of implicit contract theory with efficiency-wage theory. A firm that cheats on the implicit contract will find that their workers leave later, when job opportunities become better. In this view, the appropriate time unit for the analysis of the worker-employer relationship is longer than just a month or even a year.

Moreover, selection (quality-efficiency wage) considerations may strengthen these concerns, because it is likely to be the better workers who will have the easiest time finding alternative opportunities and will have the highest propensity to quit.

[71] Moreover, wages are affected not only by demand disturbances but also by any shock that affects the no-shirking constraint. Thus, the expectation of an upturn in the economy would shift the no-shirking constraint upward, necessitating an increase in today's wage and a decrease in current employment.

Still, the criticism that the efficiency-wage theories have yet to provide a dynamic theory is, for the most part, valid: The models constructed to date have been static. At a heuristic level, these models do provide an explanation for why when there is a sudden shift in, say, the demand for labor, it is not quickly reflected in a change in the wage, but rather is reflected in a decrease in employment; the new equilibrium may entail unemployment, but even if in the long run equilibrium entails full employment of labor, the adjustment process may entail unemployment as part of the transition.

The intuitive reason for this is easy to see. Under a variety of conditions, the quality of the workers obtained (or their productivity on the job) depends on the wage paid by the given firm relative to that of other firms. Thus, if the different firms in the economy do not simultaneously adjust their wages, given the high wages of other firms, it will not pay any single firm to lower its wage very much.[72]

Our analysis of dynamics stands in marked contrast to the standard kind of dynamics, which simply assumes slowness in the adjustment of wages and prices, and thus derives the transitional unemployment as a consequence of the ad hoc dynamic adjustment assumptions.

Consider, for instance, the staggered wage contract model (Taylor 1980). The *assumption* of nonsynchronous long-term contracts explains why wages at any particular firm do not fall instantaneously in the face of a decrease in the demand for labor, and why average wages fall only gradually. But in the absence of some kind of efficiency-wage story, staggered contracts cannot explain the persistence, even for a short while, of unemployment: At the first instance at which a contract comes up for renewal, the wage should fall to the market-clearing level.

Moreover, the explanation of the process by which wages change is markedly different from the conventional story. We have argued that in general the quality of the labor force (its productivity) depends on the unemployment rate as well as the wage. At higher unemployment levels, the efficiency wage may be lower. For a variety of reasons, firms may be slow to fire workers, and thus the unemployment rate increases only slowly in response to a decrease in the "long-run" demand for workers. In such circumstances, the fall in the wage rate can be viewed both as a consequence of the increased unemployment and as mitigating the extent to which unemployment increases. But in this theory the wage does not fall because of the "pressure" of excess supply directly on the labor market, but only because of the indirect effect, through the effect on the efficiency wage.

Capital Markets. We have already noted how the theory we have presented provides a theory of credit rationing. Credit rationing, in turn, may provide both an explanation of why, and the mechanism by which, government policy affects the macroeconomic equilibrium (Alan Blinder and Stiglitz 1983), and a part of the explanation of why the effective cost of capital actually rises in the recession (Greenwald and Stiglitz 1986c, 1986d).[73]

[72] The analysis is somewhat more subtle than this suggests: Each firm's wage is dependent not only on other firms' wages, but also on the unemployment rate; nevertheless, in at least some versions of the efficiency-wage model, the unemployment effect is dominated by the wage effect, and wages do not fall, or fall only slowly in the face of a downward shift in the demand curve for labor.

[73] This analysis can also be related to the recent studies (Robert Barro 1974; Stiglitz 1982c, 1983; Neil Wallace 1981) arguing for the irrelevance of public financial policies. A critical assumption in these analyses is that public and private borrowing are perfect substitutes for each other; in particular, individuals are assumed to have unlimited access to the capital market. If they do not (and the theories presented here explain why they do not), then public financial policies are not irrelevant.

Information concerning the nature of borrowers is firm-specific and not easily transferable. Accordingly, when the monetary authorities reduce the supply of high-power money, banks reduce the credit that they make available. Monetary policy, in this view, has effects not through the rate of interest (variations in real rates of interest until recently have been too small to account for much of the variability in investment or savings), but through its effects on the supply of credit. This theory agrees with the monetarists that the quantity of money may, as a result, play a more important role than the interest rate, but unlike the monetarists, provides a plausible mechanism by which these effects are realized.[74,75]

The increased uncertainty, for example, associated with recessionary periods, results in some groups being rationed out of the market who previously had not been. Moreover, other groups anticipate that the likelihood that they may be rationed out of the market sometime in the future has increased. Firms face, or anticipate facing, a liquidity crisis, one that may result in their bankruptcy: For them the effective cost of capital has increased. Thus, recessionary periods may be characterized by high effective interest rates (in contrast to low nominal interest rates, emphasized in the traditional literature); high effective interest rates can partly explain many of the anomolous features of the business cycle, including patterns of inventory accumulation (with a low shadow price on labor and low interest rates, there should be much more production smoothing than does in fact occur) and some aspects of pricing policies.[76]

Product Markets. Allen (1985b) has emphasized an alternative explanation for why firms may not lower prices in the face of a downward shift in the demand for their products: To do so could be interpreted as a signal of a deterioration of quality.

Relationship to Other Macrotheories. We have already discussed briefly some of the contrasting implications of efficiency-wage theory and implicit contract theory.

(*a*) *Insider-Outsider Theory.* Another important recent development is commonly called insider-outsider theory (Lindbeck and Snower 1984a, 1984b, 1986, 1987; Robert Solow 1985). This theory stresses the asymmetries between insiders (the firm's current employees) and outsiders (potential employees). These theories provide alternative explanations for why net profits of the firm might be reduced if a firm hired new workers at much lower wages; for example, the current workers, recogniz-

[74] For this to be a cogent explanation of the cyclical variability in investment, one must explain why firms do not turn to other sources of funds. The explanation for this is provided in Greenwald, Stiglitz, and Weiss (1984), where they argue that asymmetries of information make the cost of raising capital on the equity market very high, prohibitively high for many firms. (Their model is essentially a direct application of the Akerlof-Lemons model to the equity market; their result on the thinness of equity markets corresponds to Akerlof's results on the thinness of used car markets.)

Equity rationing can give rise to investment fluctuations, even without credit rationing; for the absence of futures markets combined with limitations on the ability to sell equity imply that a decision to produce forces managers/owners to absorb risk. A reduction in their working capital will thus lead to a reduction in their equilibrium production levels. If, as is in fact the case, debt is not indexed, monetary shocks can have real effects through their effects on working capital

[75] For other studies of monetary policy in the presence of credit rationing, see Jackman and John Sutton (1982), Smith (1983), Vale (1986), and Lindbeck (1963).

[76] As Edmund Phelps and Sidney Winter (1970) emphasized, there may be a trade-off involved in recruiting customers today by lowering prices, with higher future profits, but lower current profits. An increase in the effective cost of capital tilts the trade-off toward higher current profits, i.e., higher prices today.

ing the threat that these workers pose to them, may refuse to provide them training. These theories are thus perfectly consistent with efficiency-wage theories.[77]

(*b*) Fixed Price Models and Efficiency Wage Theories. One of the reasons for interest in the efficiency-wage theories is that they provide an explanation of wage and price rigidities, which play such a central role in the fixed wage-price models that have enjoyed such popularity during the past decade. Though the two approaches are, to that extent complementary,[78] the efficiency-wage models can also be seen as providing a critique of the fixed-wage models, or at least of the relevance of those models for policy purposes. Though wages do not fall to a market-clearing level, government policies can affect the level of wages and thus the equilibrium level of employment. (In contrast, the fixed-wage price models simply assume that wages and prices will remain unchanged.)

(*c*) *Multipliers.* Multipliers have had a long and noble history in macroeconomic analysis. It has not been widely recognized how difficult it is to obtain multipliers in conventional models: Usually price responses in stable systems dampen the effect of any initial disturbance. It is precisely because of price rigidities that traditional macroeconomic models yield multipliers. Our analysis provides the microfoundations of these price rigidities.[79]

2. *Implications for Development Economics*

We noted earlier that much of the recent interest in the unemployment consequences of the dependence of productivity on wages originated in the development literature, where the relationship was attributed to nutritional considerations. Since than a large literature has explored a variety of other causes and consequences of the wage-productivity nexus within LDCs.[80]

Mirrlees (1975) and Stiglitz (1976b) showed that wage-productivity relations of the form depicted in Figure 2 would give rise, even within utilitarian families (maximizing the sum of the utility of the members of the family) to inequality in consumption; some members would receive a low consumption level, others a high consumption level; those with a low consumption level would have a low productivity. What they consumed would exceed their marginal product, but be less than their marginal product plus a pro rata share of the rents. Conversely for the high consumers. Indeed, even if the family is Rawlsian (maximizes the welfare of the worst off individual) there may be consumption inequality.

Because productivity depends on consumption, individuals with landholdings will be more productive than landless

[77] They emphasize, however, at least one important aspect to which efficiency-wage theory has paid insufficient attention: The worker may not be able to commit himself to receiving low wages in the future; after he is trained he may be in a position to extract a high wage. What is relevant, of course, for the firm's decision is the relationship between lifetime wages and productivity. (Notice that while Greenwald has emphasized the consequences of the inability of firms to commit themselves to pay high wages in the future, insider-outsider theory has emphasized the consquences of the inability of workers to commit themselves to accepting low wages in the future.)

[78] For an explicit attempt to integrate the two approaches, see Karl Moene (1985).

[79] The externalities associated with incomplete markets and imperfect information also give rise to multipliers. These multipliers should not be confused with the welfare multipliers that arise whenever the economy is not (constrained) Pareto efficient. Then there always exist some perturbations to some individual or firm that have a second order effect on the welfare of the individual or firm but a first order effect on social welfare (see Greenwald and Stiglitz 1986b).

[80] In this section, we focus our discussion on the consequences of the nutritional-wage productivity nexus for LDCs. For a discussion of alternative explanations, see Stiglitz (1982b, 1974c).

workers, and will, accordingly, receive higher wages. Dasgupta and Ray (1986a, 1987) have explored the implications of inequality in land ownership for wages and output. In particular, they note that the very poor, those with very small landholdings, may be completely excluded from the market because their minimum wage costs per efficiency unit is too high. In their model, whether the economy is in an unemployment regime or a full employment regime will depend on the aggregate land supply (relative to the labor supply), in effect, on whether the Walrasian wage is below or above the efficiency wage; it may also depend on the distribution of land. A land reform may thus have a significant effect on national output.

The dependence of productivity on wages in the urban sector results in urban wages being set at levels in excess of the rural wage. This, by the familiar Harris-Todaro migration mechanism (Todaro 1968, 1969; Harris and Todaro 1970) and its generalizations (Stiglitz 1974c; Gary Fields 1975; Raaj Sah and Stiglitz 1984, 1985), results in urban unemployment. As noted earlier (Part I.5 above) the wage and employment levels set by private firms do not maximize national income (and are not Pareto efficient). On the other hand, even if the government could directly control the urban wage, it would not set it at the rural wage: Some level of unemployment is optimal. Moreover, policy prescriptions to reduce the real wage indirectly, through increasing the prices of commodities, are, at best, misguided. For private firms would respond, say, to an increase in the price of food by increasing the wage. Indeed, if productivity is more sensitive to the consumption of food than to the consumption of other commodities, government should subsidize the consumption of food.[81] In this context, specific and ad valorem wage subsidies have distinctly different effects on wage setting and employment policies. Because there are two objectives that the government wishes to achieve (the correct wage level and the correct urban employment level), it requires two instruments; the two forms of wage subsidies/taxes provide the requisite instruments.

The wage-productivity nexus also has important implications for the determination of the shadow wage of labor (particularly in the context of models with Harris-Todaro and related migration mechanisms). The opportunity cost of labor is not zero (in spite of the presence of unemployment) or even the rural wage. In some central cases, the shadow wage is the urban wage, independent of attitudes toward future generations; in other cases, it lies between the urban wage and the rural wage (see Stiglitz 1982a).

3. *Further Applications*

The dependence of quality on price has a large number of other implications, two of which we briefly note here.

Technological Change and Competitive Entry. The fact that a lower price is associated with lower quality has important implications for technological change. Normally, we argue that if a firm develops a cheaper way of making a mousetrap it will be able to undercut its rivals, and thus to capture the whole market for itself. When prices convey information, the firm may not be able to undercut its rivals; lowering the price may simply lead potential customers to believe that it is selling a lower-quality mousetrap. (Farrell 1984, 1985, has dis-

[81] Firms would, in such circumstances, find it in their interests to subsidize the consumption of food; but unless the subsidy is provided for on-premise consumption, workers could resell the subsidized food, and the firm would thus not directly gain from the food subsidy.

For an analysis of optimal taxation and subsidies in the presence of productivity effects, see Sah and Stiglitz (1984).

cussed the entry barriers that arise in these models.)

The Consequences of the Wage-Quality Relationship in Noncompetitive Markets. The analysis so far has been confined to competitive markets. But similar results apply to noncompetitive markets as well.

The standard theory maintains that a monopsonist would never ration. For at the given price, if there is an excess demand he can increase his profits simply by increasing his price. Similarly, a monopsonist in the labor market would never pay a wage in excess of the minimum wage required to hire the number of workers he wishes; there would never be an excess supply of workers (though the number of workers hired may be less than in a competitive market-clearing equilibrium). But if the firm recognizes that by raising the wage it increases the quality of its labor force, it may minimize its wage costs by paying a wage that is above the minimum required to obtain the amount of labor that it wishes to obtain. Similarly, in the capital market, a monopoly bank may charge an interest rate below the market-clearing level, recognizing that in doing so it increases its expected returns.

Earlier, we showed how, in a competitive market, wages cum queues would screen individuals; more able individuals might be willing to take the risk of applying for a high-wage job, with a low probability of getting the job, when an (observationally identical) individual of lesser ability would not. The monopsonist would similarly attempt to use wages cum queues to differentiate among workers.

Still, it should be emphasized that the motives for differentiating among individuals (customers or workers) are markedly different under monopoly than under competition: Under competition, the motive is simply to identify workers who differ in productivity, while under monopoly, the motive is to discriminate, to capture as much of the consumer surplus from each worker/customer as possible.

Concluding Remarks

There is little doubt that the observation that quality may depend on price (productivity on wages; default probability on interest rates) has provided a rich mine for economic theorists: A simple modification of the basic assumptions results in a profound alteration of many of the basic conclusions of the standard paradigm. The Law of Supply and Demand has been repealed. The Law of the Single Price has been repealed. The Fundamental Theorem of Welfare Economics has been shown not to be valid.

More than that, the theories that we describe here provide the basis of progress toward a unification of macroeconomics and microeconomics. They provide an explanation of unemployment and credit rationing, derived from basic microeconomic principles. It is a theory in which the extensive idleness that periodically confronts society's resources, human and capital, is seen as but the most obvious example of market failures that prevasively and persistently distort the allocation of resources.

Several caveats should, however, be borne in mind. Firstly, the repeal of the Law of Supply and Demand (and the Law of the Single Price) is a selective repeal: We have not contended that equilibrium is never described by the equality of demand and supply, only that it need not be, and will not be in some important circumstances.

Secondly, though the basic outlines of the general theory appear now to be well established, there remain several important extensions and developments. We have referred to several of these within the text. The models presented here were, for the most part, static; it is imperative to develop an explicitly dynamic model if these theories are to provide

part of the foundations of a theory explaining cyclical fluctuations in employment. Moreover, on several occasions we contrasted efficiency-wage theory with implicit contract theory, arguing that efficiency-wage theory provides a far better explanation of unemployment than does implicit contract theory. In fact, individuals do have long-term implicit contract relationships with their employers; these relationships are affected in fundamental ways by efficiency-wage considerations. The integration of implicit contract theory and efficiency-wage theory thus is a second important topic for a research agenda.

We have also noted that the problems with which we have been concerned are mitigated, but not eliminated, by monitoring and bonding (among other instruments that may be available to the firm). The limitations on monitoring and bonding have, however, received only limited theoretical scrutiny. Finally, we have, for the most part, analyzed incentive models and selection models in isolation from each other.[82] We have noted, however, that there may be important interactions between the two, and these require further study.

Thirdly, we have focused our attention on the burgeoning theoretical literature (but have made no pretense of being even complete within the scope of the topics covered). This is partly a consequence of the author's comparative advantage, but partly a consequence of the fact that the models presented here have not been the subject of extensive empirical testing.[83] We hope, in fact, that this survey will spur continuation of efforts in that direction.

This paper has, however, attempted to show how similar ideas have found application in the analysis of labor, capital, and product markets. These models provide an explanation of several phenomena within these markets that cannot be easily explained within the more conventional paradigm.

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[82] An exception is the Stiglitz and Weiss (1986a, 1986b) studies.

[83] There have, however, been numerous studies addressing particular aspects of the theories described in this paper. For an early investigation of the price-quality relationship, see Gabor and Granger (1966). For a recent examination of the empirical evidence on whether the labor market clears, see Thomas Kniesner and Arthur Goldsmith (1986). For a recent discussion of the relationship between productivity and wages, see, for example, James Medoff and Katharine Abraham (1981). Macroeconomic analyses of the relationship between unemployment and productivity include James Rebitzeer (1985), and Weisskopf, Bowles, and Gordon (1983).

There is a growing literature attempting to test the credit-rationing models. See, for instance, Charles Calomiris and R. Glenn Hubbard (1985), Leonard Nakamura (1985), and P. Kugler (1985).

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