Volume Title: Studies in Labor Markets

Volume Author/Editor: Sherwin Rosen, ed.

Volume Publisher: University of Chicago Press

Volume ISBN: 0-226-72628-2

Volume URL: http://www.nber.org/books/rose81-1

Publication Date: 1981

Chapter Title: Risk Shifting, Statistical Discrimination, and the Stability of Earnings

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Chapter URL: http://www.nber.org/chapters/c8914

Chapter pages in book: (p. 295 - 318)

9 Risk Shifting, Statistical Discrimination, and the Stability of Earnings

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9.1 Introduction

This paper develops possible theoretical explanations for the observed racial differential in stability of earnings. Most research on racial factors in the labor market has focused on observed differences in the average earnings of whites and blacks in the United States. However, some authors have also recognized the existence of a racial differential in earnings stability over business cycles. For example, Wohlstetter and Coleman (1972) observe that year-to-year percentage changes in median family income and median income of persons were roughly parallel to business cycles and greater in absolute values for nonwhites than for whites from 1947 through 1967. Deviations from trend of percentage changes in median family income and median income of persons were much greater for nonwhites than for whites over that period.

In order to address these observations, this paper draws together two recent theoretical developments in labor economics: the theory of the risk-shifting function of labor contracts (see, for example, Azariadis 1975; Baily 1974; Grossman 1977; and Stiglitz 1974), and the theory of statistical discrimination (see, for example, Arrow 1972, 1973; and Phelps 1972). A central idea developed in the paper is that statistical discrimination can generate distortions in market behavior—for example, different competitive equilibria for intrinsically identical groups, as

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The National Science Foundation, a W. Randolph Burgess Fellowship, and the Brookings Institution have supported this research. Dennis Carlton and James Brown have given helpful comments.

suggested by Arrow (1973) and Starrett (1976). The theoretical analysis focuses specifically on the distortions in worker behavior that can result from statistical discrimination in the market for risk-shifting arrangements, and shows how the nature of these distortions depends on interactions between the price of risk shifting and the average reliability of workers and on the presence or absence of intrinsic differences in the attitudes of different groups of workers toward reliability.

The theory of the risk-shifting function of labor contracts develops what can be denoted as a Knightian view of the entrepreneur and the firm. In this view, certain individuals, either because they are intrinsically less timid or because they have substantial wealth which facilitates asset diversification, exhibit less risk-averse behavior than the average person. The equilibrium structure of a market economy finds these individuals specializing in the entrepreneurial role, forming firms, and employing labor services. According to the theory, this systematic difference between firms and their workers with regard to risk aversion leads to long-term contractual commitments in which firms absorb risk that would otherwise be borne by workers.

Several recent papers noted above apply this view to an analysis of risk associated with variations in the value of worker output. Specifically, these papers suggest that labor contracts explicitly or implicitly involve two transactions: (1) firms pay workers for the productivity of labor services; (2) risk-averse workers purchase from less risk-averse firms insurance against fluctuations in earnings that would result, in the absence of such insurance, from variations in the value of worker output. The insurance arrangement involves (1) a premium payment by the worker, which takes the form of an excess of the value of the worker's product over his earnings when the value of his product is high; and (2) an indemnity to the worker, which takes the form of an excess of the worker's earnings over the value of his product when it is low. This arrangement shifts risk to the firm and facilitates the stabilization of worker consumption, making it unnecessary for the worker to accumulate a large store of assets for that purpose.

The point of departure for the present analysis is the observation that once the value of worker output is known, either the employer or the worker has an incentive to default on a risk-shifting agreement. If the value of worker output is low, employers can obtain short-run gains by temporarily lowering wages to take advantage of cheaper substitute labor. If the value of worker output is high, workers can make themselves better off in the short run by demanding a temporary wage increase or by quitting their jobs to take advantage of more lucrative opportunities available elsewhere. The term "reliability" refers here to an individual's propensity to forego short-run gains to comply with an existing risk-shifting agreement. The analysis below focuses on default behavior—that is, "unreliability"—on the part of workers.

In choosing between default and reliable behavior, a worker considers the short-run increase in consumption that he can obtain by defaulting and weighs it against a variety of incentives for reliability. These incentives include such factors as moral aversion to default, the value of a good reputation for reliability in facilitating future risk-shifting arrangements, and the preservation of claims to deferred compensation, such as nonvested pensions. The present paper abstracts, for simplicity, from considerations other than the moral factor. The analysis assumes, critically, that this moral aversion to default varies among workers, but that it is typically finite. Specifically, for a given high value of his product, whether a particular worker will evince reliable behavior depends on both the strength of his moral aversion to default and the terms of his existing risk-shifting arrangement, particularly the excess of the value of his product over his contractual earnings. Further research will deal with such related considerations as the effect on worker behavior of a relation between individual work history and the terms of risk-shifting arrangements, and the interplay between cyclical risk shifting, on which the present discussion focuses, and changes in productivity over the life cycle. A general point worth noting is that, mainly because of the subjective motivation aspect of labor services, these examples of incentives for reliable behavior all involve extralegal considerations.

As essential assumption for the analysis is that employers do not know the moral characteristics of individual workers and, consequently, are unable to identify and avoid hiring unreliable workers. This informational imperfection means that, in order to avoid expected losses in risk-shifting arrangements, employers can offer to absorb risk only on terms that reflect their beliefs about the proportion of workers who will behave reliably.[1]

Employers adjust these beliefs, and, thus, the terms of risk-shifting arrangements, on the basis of their actual observations of average worker reliability. However, as noted above, the terms of risk-shifting arrangements affect individual choice between reliable behavior and default. This interaction between employer beliefs and worker behavior creates a possibility for multiple competitive equilibria—that is, there may be more than one employer estimate of average reliability such that worker behavior will be induced that will confirm employer beliefs and be invulnerable to competitive attempts to increase expected profits by marginal adjustments in the terms of risk shifting.

The employers' inability to determine an individual's reliability before hiring also makes it likely that employers engage in statistical discrimination. Specifically, if workers are distinguished by characteristics that employers can observe easily, such as race and sex, and if employers believe that such identifiable groups of workers differ with respect to average reliability, competition will cause employers to take an individual's observable characteristics into account when making risk-shifting arrangements. Consequently, different identifiable groups will make risk-shifting arrangements on different terms.

Whether or not employer beliefs about the average reliability of identifiable groups are correct, describing this employer behavior as discriminatory seems appropriate because individuals who may be equally reliable receive different treatment. The use of the term "statistical" to describe discrimination in this context reflects the fact that employer behavior is based on belief in the existence of empirical correlations between reliability and the observable characteristics of workers, rather than, for example, on taste or distaste for those characteristics.

Given the interaction between employer beliefs about reliability and worker behavior, statistical discrimination generates two important implications regarding differences in the stability of earnings of different groups. First, if the market for risk-shifting arrangements possesses multiple equilibria, then even if two identifiable groups are identical with respect to the distribution of aversion to default among their members, they can exhibit persistent differences with respect to reliability, the terms on which they shift risk to employers, and stability of earnings. Second, if two identifiable groups differ with respect to the distribution of aversion to default among their members, then in equilibrium they can differ more or less with respect to actual reliability than they would if employers pooled them and absorbed risk from both groups on terms that reflected the average reliability of the two groups combined.

In what follows, section 9.2 describes a specific analytical framework. Within this framework, section 9.3 analyzes the terms of risk-shifting arrangements and the worker's choice between reliable and unreliable behavior. Section 9.4 discusses the characteristics of equilibrium in the market for risk-shifting arrangements and derives sufficient conditions for the existence of a unique equilibrium. Section 9.5 analyzes the stability properties of equilibria when multiple equilibria exist. Section 9.6 analyzes the impact of statistical discrimination on risk-shifting arrangements. Section 9.7 analyzes the implications of more sophisticated employer behavior that takes account of the influence of the terms of risk shifting on worker reliability. Section 9.8 contains a summary of the main results and briefly discusses the implications of the theoretical analysis for a program of empirical research.

9.2 Analytical Framework

Consider a labor market in which, as discussed above, employers and workers differ in their attitudes toward risk. Specifically, employers compose a large class of identical individuals who behave as if they were risk neutral. In other words, their utility is a linear function of consumption, and, thus, they are indifferent between a constant consumption stream and a fluctuating consumption stream that has the same average value. In addition, these employers have a deserved reputation for complete reliability, which means that they never fail to comply with the risk-shifting agreements that they have made.

Workers, in contrast, compose a large class of individuals whose degree of risk aversion is identical and positive. In other words, their utility is a concave function of consumption, and, thus, they prefer a constant consumption stream to a fluctuating consumption stream that has the same average value. In addition, worker utility functions reflect an exogenous moral aversion to default, which is finite, differs among individuals, and is distributed such that, given the terms on which risk shifting takes place, some workers behave reliably and some do not.

The class of workers is divisible into large groups according to observable characteristics such as race and sex. Each such group has a reputation for average reliability. The analysis in the next three sections focuses on transactions between the employers and one such group of workers. The reputation for reliability of this group is such that employers believe that a proportion $\hat{R}$ of the group will comply with the risk-shifting agreements that they make, where $0 \leq \hat{R} \leq 1$.

In order to focus on the importance of risk shifting, the analysis ignores the technological aspects of the organization of production. Such factors as the advantages of team production, firm-specific human capital, costs of adjusting employment, and mobility costs surely influence both the organization of production and the form of optimal long-term agreements between firms and workers. However, the present analysis considers only the role played by firms in absorbing risk that their employees otherwise would bear. Specifically, the analysis assumes that each individual in the economy would be equally productive whether he chose to be an independent producer, an employer, or an employee. In other words, the assumed technology makes production solely an independent activity. In addition, the analysis abstracts from interpersonal differences in productivity. Thus, the value of output is perfectly correlated across individuals.

The value of per capital output, denoted by X, is the product of the number of units of output per capita and, if this output is not directly consumed, the exchange ratio between consumption goods and produced output. Either or both of the factors in this product can be subject to variation. Specifically, assume that the actual value of X is determined at periodic intervals by serially independent drawings from an exogenously determined population. The interval between these drawings defines a unit of time. The population of X is such that

$$X = \begin{cases} X_1 \text{ with probability } \alpha_1 \\ X_2 \text{ with probability } \alpha_2 \end{cases}$$

where $X_2 > X_1 \geq 0$, $\alpha_1 + \alpha_2 = 1$, and $0 < \alpha_1 < 1$. Thus, X_2 characterizes a good state of nature and X_1 characterizes a bad state of nature. The expected value of per capita output, denoted as $\bar{X}_{av}$, is $\alpha_1 X_1 + \alpha_2 X_2$.[2]

Another convenient simplification is that individuals have no alternative uses, such as direct production of consumption goods or leisure activities, to which to devote their time. This assumption enables the analysis to avoid analyzing employment schedules, which would involve variations in the amount of time devoted to the production of marketable output, and to focus on the earnings schedules stipulated in labor contracts. Grossman (1978) analyzes the determination of employment schedules in labor contracts involving risk shifting.

9.3 The Decisions of Workers and Firms

9.3.1 The Worker Consumption Schedule

A worker consumption schedule under a risk-shifting arrangement is a vector (w_1, w_2), where $w_1(w_2)$ is the worker's earnings if X turns out to equal $X_1(X_2)$. Given (w_1, w_2), the worker receives an insurance indemnity equal to $(w_1 - X_1)$ if the bad state of nature occurs, and $\alpha_1(w_1 - X_1)$ is the worker's expected indemnity per period. Alternatively, the worker is obliged to pay an insurance premium equal to $(X_2 - w_2)$ if the good state occurs, and $\alpha_2(X_2 - w_2)$ is the worker's expected premium payment per period if he complies with the insurance arrangement. The worker's expected premium per period is zero if he is unreliable. Thus, if a worker complies with an insurance agreement, he is effectively charged, on average, a price of $\alpha_2(X_2 - w_2)/\alpha_1(w_1 - X_1)$ units of consumption in the good state per unit of indemnity consumption received in the bad state. Let Q denote this price.

A reliable worker, when entering into an employment agreement, takes Q and the distribution of X as given, and selects (w_1, w_2) to maximize expected utility $\alpha_1 u(w_1) + \alpha_2 u(w_2)$, subject to the budget constraint $Q = \alpha_2(X_2 - w_2)/\alpha_1(w_1 - X_1)$ and the nonnegativity constraints $w_1 \geq X_1$ and $w_2 \geq 0$, where $u(w)$ is the worker's concave utility function. The constraint $w_1 \geq X_1$ rules out the possibility that these individuals might try to play the entrepreneurial role, in which they have no reputation for reliability. This maximization involves the first-order condition $u'(w_1) = Qu'(w_2)$, which in turn implies worker demand schedules for consumption in the good and bad states.

For consumption in the bad state, we have $w_1 = \max\,[f(Q), X_1]$ and $f[u'(X_1)/u'(X_2)] = X_1, f(1) = \bar{X}$, and $f'(Q) < 0$. According to this demand schedule, as long as Q is less than the ratio of the marginal utilities of X_1 and X_2, each worker desires to reduce his risk by contracting for w_1 to exceed X_1. As Q decreases, his desired level of w_1 increases. If Q is equal to unity, he wants w_1 to equal the average value of per capital output, which, according to his budget constraint, is equivalent to making w_1 equal to w_2 and thereby avoiding all risk. As noted above, we assume that unreliable workers demand consumption in state 1 according to the same schedule.

For consumption in the good state, we have

$$w_2 = \min\,[g(Q), X_2] \text{ and } g[u'(X_1)/u'(X_2)] = X_2$$
$$g(1) = \bar{X}, \text{ and}$$
$$g'(Q) \gtreqless 0 \text{ as } RRA(w_1) \equiv \frac{-w_1 u''(w_1)}{u'(w_1)} \lessgtr \frac{w_1}{w_1 - X_1}$$

The variable $RRA(w_1)$ denotes the coefficient of relative risk aversion that characterizes a worker's utility function at consumption level $w_1 = f(Q)$. Note that for a decrease in Q the income and substitution effects on w_1 are both positive, whereas the income effect on w_2 is positive and the substitution effect on w_2 is negative. Consequently, the net effect of a change in Q on w_2 depends on the size of $RRA(w_1)$ relative to $w_1/(w_1 - X_1)$. This result reflects the familiar proposition that the strength of an income effect depends on the shape of the utility function and on the quantity currently demanded of the item whose price is changing. Note further that, given $x_1 > 0$, $g'(Q)$ can be negative only if $RRA(w_1)$ exceeds one.

9.3.2 The Determination of Q

Let $\hat{P}$ denote the number of units of consumption that employers expect to receive from workers in the good state of nature per unit of indemnity consumption paid out to workers in the bad state of nature. Assume, for simplicity, that $\hat{P}$ is equal to unity in competitive equilibrium. This assumption implies that aggregate worker demand for consumption in the bad state does not exceed the value of aggregate output in the bad state. See Grossman (1977) for a fuller discussion of the determination of the equilibrium price for risk shifting.

If employers expect some workers to default on a risk-shifting agreement—that is, if $\hat{R}$ is less than unity—this anticipated unreliability drives a wedge between $\hat{P}$ and Q. Specifically, given $\hat{R}$ and w_2, employers expect to receive a premium equal to $\hat{R}(X_2 - w_2)$ from a representative worker in the good state, and $\hat{R}\alpha_2(X_2 - w_2)$ is the expected premium per worker per period. Employers expect to pay indemnity equal to $(w_1 - X_1)$ per worker in the bad state, and $\alpha_1(w_1 - X_1)$ is the expected indemnity payment per worker per period. Thus,

$$Q = \frac{\alpha_2(X_2 - w_2)}{\alpha_1(w_1 - X_1)} = \frac{\hat{P}}{\hat{R}}$$

where $0 \leq \hat{R} \leq 1$. This relation indicates that, to expect a given $\hat{P}$, employers must charge workers a higher price for indemnity consumption as their estimate of worker reliability decreases. Finally, this section assumes that employers form their belief about the proportion of workers who are reliable by observing the proportion of workers who actually behave reliably, denoted by R, and that this learning process involves gradual adjustment of $\hat{R}$ in the direction of R. Section 9.7 below considers the possibility that employers take account of the fact that the terms of risk-shifting arrangements affect worker reliability.

9.3.3 The Choice between Reliability and Unreliability

As discussed above, a worker who has entered a risk-shifting arrangement has an incentive to default on the arrangement when the good state of nature occurs. Specifically, if the worker threatens to leave his employer or actually quits to work elsewhere in the good state of nature, he can obtain X_2, the full value of his product, rather than w_2, the lower consumption which he has agreed to accept under the risk-shifting arrangement. Thus, a worker who chooses default over reliable behavior obtains an increase in utility from consumption equal to $u(X_2)$ minus $u(w_2)$. However, given his moral aversion to default, if the ith worker behaves unreliably, he suffers a loss of utility, denoted by A_i with $A_i \geq 0$. Thus, assuming, for simplicity, that A_i is independent of the terms of the risk-shifting arrangement, unreliable behavior produces a net change in utility equal to $u(X_2) - u(w_2) - A_i$. A worker chooses to behave unreliably (reliably) if this net change is positive (negative or zero).

Aversion to default varies among individuals. Assuming A_i to be distributed in the worker population with cumulative distribution function $H(A_i;Z)$ where Z is a vector of parameters of the distribution function, then the aggregation of individual choices between reliability and unreliability yields the following functional relation for the proportion of workers who behave reliably:

$$R = 1 - H[u(X_2) - u(w_2);Z] \equiv R(w_2;Z)$$

For the moment, we can suppress the vector Z, which plays no role in the analysis until section 9.7. The assumption that A_i is nonnegative implies that $R(X_2) = 1$, and the nature of the cumulative distribution function and the utility function implies that $R'(w_2) \geq 0$. Finally, fairly weak restrictions on the form of $H(A_i)$—for example, uniformity or approximate normality—imply that $R''(w_2) \leq 0$, either everywhere or at least for sufficiently high values of w_2.

9.4 Equilibrium in the Risk-Shifting Market

Informational equilibrium involves a value of $\hat{P}$ equal to unity, and an employer estimate of worker reliability and a corresponding vector of worker consumption that induces worker default behavior that confirms employers' beliefs concerning reliability. Thus, an informational-equilibrium vector of worker consumption has the property that (w_1, w_2) maximizes worker utility, given Q, where $Q = 1/\hat{R}$, and $\hat{R} = R(w_2)$. An informational equilibrium is also a competitive equilibrium if it is invulnerable to attempts by employers to increase expected profits by experimenting with marginal adjustments in Q.

Figure 9.1 depicts one example in which the market for risk-shifting arrangements possesses a unique informational equilibrium, which is also a competitive equilibrium. The locus labeled $R = R(w_2)$ depicts the relevant segment of the functional relation between actual worker reliability and consumption in the good state. As indicated above, the depiction of

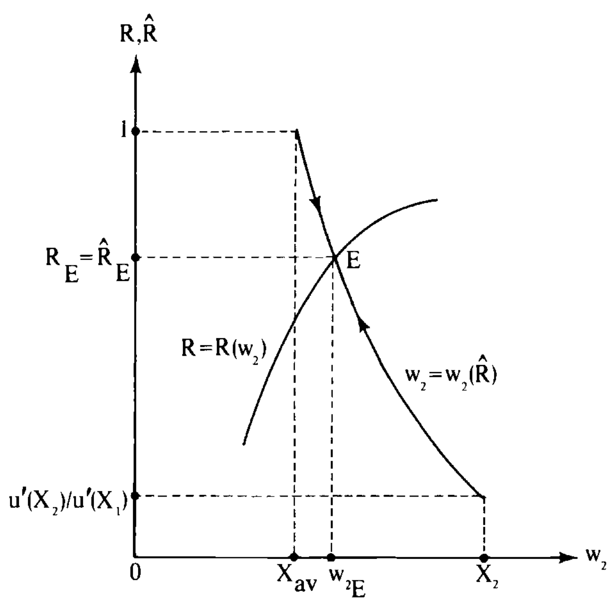

Figure 9.1 Unique Equilibrium. $w_2'(\hat{R}) < 0$ for all $R \varepsilon [u'(X_2)/u'(X_1), 1]$

this segment as concave seems reasonable. The locus labeled $w_2 = w_2(\hat{R})$ represents the relation between worker demand for consumption in the good state and the estimate of worker reliability held by employers, for all $\hat{R} \varepsilon [u'(X_2)/u'(X_1), 1]$—that is, for all $Q \varepsilon [1, u'(X_1)/u'(X_2)]$. As depicted in this example, the negative slope of this locus implies that the negative substitution effect on w_2 of an increase in $\hat{R}$ (decreases in Q) outweighs the positive income effect.

Point E in figure 9.1 represents competitive equilibrium. At point E, $\hat{R}$ equals $\hat{R}_E$ and workers choose to receive consumption w_{2E} in the good state. Note that consumption in the bad state, w_{1E}, can be calculated by substituting the coordinates of point E into the worker's budget constraint. At point E, the locus $w_2 = w_2(\hat{R})$ intersects the locus $R = R(w_2)$ indicating that w_{2E} induces a proportion of workers R_E to behave reliably, such that $R_E - \hat{R}_E$, thereby confirming employer beliefs concerning reliability.

If, either as an initial condition or as a result of employer experimentation, $\hat{R} \neq \hat{R}_E$, workers choose $w_2 \neq w_{2E}$. These values of w_2 induce values of R, according to the schedule $R = R(w_2)$, such that $R \neq \hat{R}$. Consequently, employers revise R, in accordance with the assumed learning process. This learning process moves the system toward point E along the locus $w_2 = w_2(\hat{R})$, as indicated by arrows attached to that locus.

An essential question is whether informational equilibrium and competitive equilibrium in this market generally are unique. Given that R is nondecreasing with respect to w_2, a sufficient, but unnecessarily strong, condition for uniqueness of both informational equilibrium and competitive equilibrium is that worker demand for w_2 is strictly decreasing with respect to R, as depicted in figure 9.1. However, the above analysis of the worker consumption schedule revealed that the income effect associated with Q can make w_2 a decreasing function of Q, and, thus, an increasing function of $\hat{R}$ in the relevant range. Specifically, noting that $Q = 1/\hat{R}$, the analysis of worker consumption implies the following lemma about the relation between w_2 and $\hat{R}$:

(L1) For all $\hat{R} \varepsilon [u'(X_2)/u'(X_1), 1]$

$$w_2'(\hat{R}) \gtreqless 0 \text{ as } RRA(w_1) \gtreqless \frac{w_1}{w_1 - X_1}$$

where $w_1 = f(1/\hat{R})$.

The following useful lemmas follow from (L1).

(L2) If relative risk aversion is nondecreasing with respect to consumption, then either (a) there exists a value of $\hat{R}$, denoted as $\hat{R}^*$, $\hat{R}^* \varepsilon [u'(X_2)/u'(X_1), 1]$, such that

$$w_2'(\hat{R}) \begin{cases} > 0 \text{ for } \hat{R} \varepsilon (\hat{R}^*, 1] \\ = 0 \text{ for } \hat{R} = \hat{R}^* \\ < 0 \text{ for } \hat{R} \varepsilon [u'(X_2)/u'(X_1), \hat{R}^*) \end{cases}$$

or (b) $w_2'(\hat{R})<0$ for all $\hat{R}\,\varepsilon\,[u'(X_2)/u'(X_1),\ 1]$.

(L3) If relative risk aversion is nondecreasing with respect to consumption, then

$$w_2'(\hat{R})<0 \text{ for all } \hat{R} \text{ for which } w_2(\hat{R})\,\varepsilon\,(\bar{X},\ X_2)$$

To understand L2 and L3, recall that $w_2[u'(X_2)/u'(X_1)]$ equals X_2, whereas $w_2(1)$ equals $\bar{X}$, which is less than X_2. Therefore, for some values of $\hat{R}\,\varepsilon\,[u'(X_2)/u'(X_1),\ 1]$, the substitution effect of an increase in $\hat{R}$ on w_2 must dominate the income effect, implying that $w_2'(\hat{R})$ is negative. Furthermore, if relative risk aversion is constant or increasing, the income effect is always increasing in size relative to the substitution effect. Thus, there can exist at most one value of $\hat{R}$, denoted by $\hat{R}^*$, for which the two effects are exactly offsetting and for which $w_2'(\hat{R})$ equals zero. Moreover, the substitution effect dominates and $w_2'(\hat{R})$ is negative for all $\hat{R}\,\varepsilon\,[u'(X_2)/u'(X_1),\ \hat{R}^*)$, whereas the income effect dominates and $w_2'(\hat{R})$ is positive for all values of $\hat{R}$ above $\hat{R}^*$. Furthermore, since $w_2(1)$ equals $\bar{X}$, $w_2'(\hat{R})\geq 0$ implies $w_2(\hat{R})\leq \bar{X}$.

Taken together, L1, L2, and L3 imply proposition P1 about equilibrium in the market for risk-shifting arrangements.

(P1) Nondecreasing relative risk aversion is a sufficient condition for uniqueness of informational and competitive equilibrium in conjunction with either of the following conditions:

(a) $RRA(\bar{X})\leq \bar{X}/(\bar{X}-X_1)$ or

(b) $R(\bar{X})\leq u'(X_2)/u'(X_1)$

To understand the first part of P1, recall that when $\hat{R}$ equals one, workers select the consumption schedule $(w_1,\ w_2)=(\bar{X},\ \bar{X})$. Thus, according to L1, the sign of $w_2'(\hat{R})$ at $\hat{R}=1$ depends on the value of $RRA(\bar{X})$. Specifically, if $RRA(\bar{X})$ is less than (equal to) $\bar{X}/(\bar{X}-X_1)$, then $w_2'(\hat{R})$ is negative (zero) when $\hat{R}$ equals one. If, in addition, relative risk aversion is nondecreasing, then, by L2, $w_2'(\hat{R})$ is negative for $\hat{R}\,\varepsilon\,[u'(X_2)/u'(X_1),\ 1)$.

To understand the second part of P1, refer to figure 9.2. The locus labeled $w_2=w_2(\hat{R})$ again depicts the demand for w_2. The shape of this locus reflects two assumptions: (1) Relative risk aversion is nondecreasing, implying, by L3, that the demand locus is negatively sloped for $w_2\,\varepsilon\,(\bar{X},\ X_2)$; (2) $RRA(\bar{X})>\bar{X}/(\bar{X}-X_1)$, implying, by L2, that the demand locus has a positive slope for $\hat{R}\,\varepsilon\,(\hat{R}^*,\ 1]$. The locus labeled $R=R(w_2)$ again depicts the relevant segment of the reliability function. If, as shown, $R(\bar{X})\leq u'(X_2)/u'(X_1)$, then the reliability function necessarily lies below the locus $w_2=w_2(\hat{R})$ for $w_2\leq \bar{X}$. Furthermore, since the reliability function is nondecreasing on the interval $(\bar{X},\ X_2)$, whereas the demand locus is negatively sloped on this interval, the two loci intersect once and only once at point E.

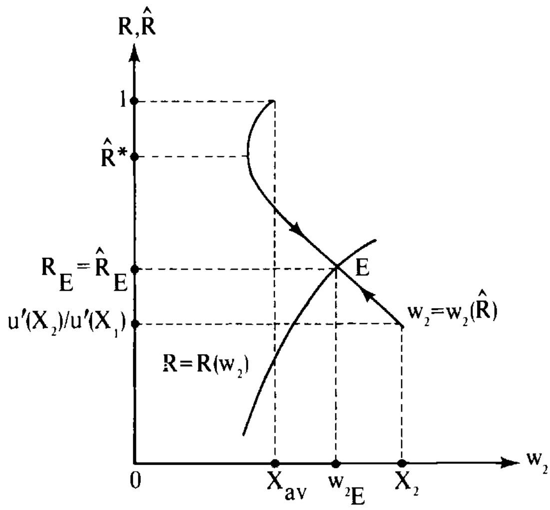

Figure 9.2 Unique Equilibrium, $R(\overline{X}) < u'(X_2)/u'(X_1)$

The analysis of worker consumption also implies proposition P2 about equilibrium.

(P2) The following condition is sufficient for uniqueness of informational and competitive equilibrium:

$$R'(w_2) \leq \frac{R}{X_2 - w_2} \text{for all } w_2 \varepsilon [0, X_2]$$

This condition says that worker reliability decreases slowly as w_2 falls from X_2 to zero. To understand P2, note that, given this restriction on the reliability function, the existence of more than one equilibrium would imply that worker demand for w_1 remains constant or increases with respect to its relative price Q, for some range of Q less than $u'(X_1)/u'(X_2)$. However, the income and substitution effects of an increase in Q both serve to reduce worker demand for w_1.

9.5 Dynamics of the Market for Risk Shifting in the Presence of Multiple Equilibria

The results of the previous section imply that if the market for risk-shifting arrangements exhibits multiple informational and competitive equilibria, then all of the following conditions hold:

(a) The demand for w_2 is not strictly decreasing for $\hat{R} \varepsilon [u'(X_2)/u'(X_1), 1]$,

(b) $R'(w_2) > R/(X_2 - w_2)$ for some $w_2 \varepsilon [0, X_2]$, and

(c) $R(\bar{X}) > u'(X_2)/u'(X_1)$, if relative risk aversion is nondecreasing with respect to consumption.

The analysis in this section assumes that these conditions hold and focuses on the stability properties of informational equilibria and the relation between informational equilibrium and competitive equilibrium.

Figure 9.3 depicts a situation in which the market for risk-shifting arrangements possesses three informational equilibria. If $\hat{R}$ initially equals $\hat{R}_E$, $\hat{R}_F$, or $\hat{R}_G$, then worker behavior confirms employer beliefs concerning reliability, and the market remains in informational equilibrium at point E, F, or G, respectively. As in earlier figures, arrows attached to the locus labeled $w_2 = w_2(\hat{R})$ indicate the direction in which learning moves the market along this locus.

The informational equilibrium at point F is locally unstable. Specifically, if $\hat{R}$ is marginally greater than $\hat{R}_F$ initially, then $R > \hat{R}$, and learning moves the market away from point F toward point E. Alternatively, if $\hat{R}$ is marginally less than $\hat{R}_F$ initially, then $R < \hat{R}$, and learning moves the market away from point F toward point G.

Because informational equilibrium at point F is locally unstable, it is not a competitive equilibrium. Specifically, it is vulnerable to individual firms' experimentation with a value of $\hat{R}$ that is marginally greater than

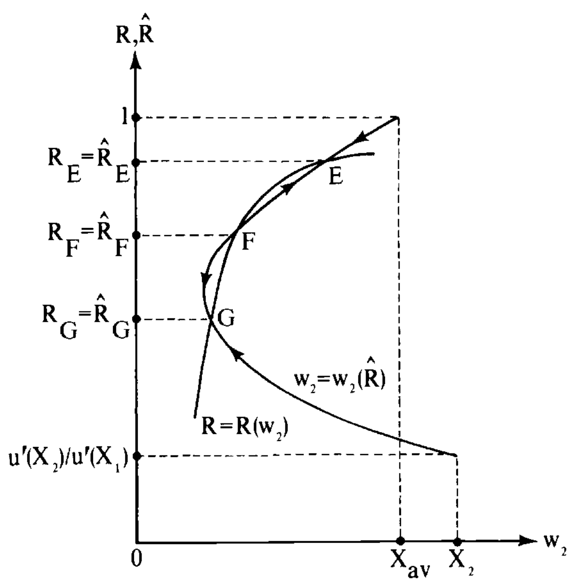

Figure 9.3 Multiple Equilibria

$\hat{R}_F$. Suppose that $\hat{R}$ were to equal $\hat{R}_F$ initially, yielding informational equilibrium at point F. If a firm were then to experiment with a slightly higher $\hat{R}$ and a correspondingly lower price of indemnity consumption, it would (1) find $R>\hat{R}$; (2) earn positive profits; and (3) attract workers away from other firms. All firms would have an incentive to raise $\hat{R}$ and lower Q. Thus, experimentation of the sort described would move the market toward point E.

The informational equilibria at points E and G are locally stable, and thus are competitive equilibria. Specifically, they are vulnerable to neither learning on the part of employers nor to marginal experimentation by individual employers.

Points E and G, however, are not globally stable. Moreover, the competitive equilibrium at point G is vulnerable to experimentation with much different beliefs by firms. Specifically, if the market were initially in competitive equilibrium at point G, and if firms were to experiment with values of $\hat{R}$ other than $\hat{R}_G$ but less than $\hat{R}_F$, worker behavior would disconfirm beliefs and learning would return the market to competitive equilibrium at G. However, if firms were to experiment with values of $\hat{R}$ greater than $\hat{R}_F$, they would attract workers away from other firms and learning would move the market toward competitive equilibrium at point E.

9.6 Statistical Discrimination

This section considers transactions between employers and two large groups of workers, denoted by W and B, which, as noted above, are distinguished by an easily observable characteristic, such as race. Statistical discrimination means that employers form separate estimates of average reliability, $\hat{R}_W$ and $\hat{R}_B$, for the groups. The analysis assumes, for simplicity, that employers revise these estimates according to the same learning process. Moreover, employers equate $\hat{P}$ across groups by charging a group a price for indemnity consumption that is inversely related to the employers' estimate of the group's reliability—that is,

$$Q_W=\frac{\hat{P}}{\hat{R}_W}=\frac{1}{\hat{R}_W} \text{ and}$$

$$Q_B=\frac{P}{\hat{R}_B}=\frac{1}{\hat{R}_B}$$

Statistical discrimination can have the effect of distorting the market behavior of these two groups, but the nature of the possible distortion depends on whether or not the groups are intrinsically different. One possibility is that the two groups are identical with respect to the distribution of aversion to default among their members. In this case, given the assumption that all workers have the same degree of risk aversion, if employers do not engage in statistical discrimination, but instead charge all workers the same Q based on the average reliability of the total labor force, or if the market for risk shifting has a unique competitive equilibrium, the observed behavior of the two groups in this market in competitive equilibrium will be indistinguishable. However, if multiple competitive equilibria are possible and if employers practice statistical discrimination, then, depending on initial conditions, the two groups in competitive equilibrium can exhibit different average reliability, shift risk to employers on different terms, and experience different stability of earnings, even though they possess the same propensity to default for a given w_2. For example, referring to figure 9.3, if $\hat{R}_W > \hat{R}_F$ and $\hat{R}_B < \hat{R}_F$ initially, then group W attains the superior competitive equilibrium at point E while group B attains the inferior competitive equilibrium at point G. Furthermore, group B can move to E only if firms undertake major experiments with $\hat{R}_B > \hat{R}_F$.

An alternative possibility is that groups W and B actually differ with respect to the distribution of aversion to default among their members. Specifically, let K be a positive constant, and assume that,

$$R_B(w_2) = R_W(w_2) - K$$

In this case, if employers do not engage in statistical discrimination, both W and B workers select the same w_2, and the difference between R_W and R_B equals K. However, if employers practice statistical discrimination, the behavior of the two groups in competitive equilibrium can differ by more or less than K. Figures 9.4 and 9.5 illustrate these possibilities. Both diagrams assume that competitive equilibrium is unique.

In figure 9.4, competitive equilibrium for both groups occurs where w_2 is increasing with respect to $\hat{R}$. In this case, the difference between R_W and R_B is R_{EW} minus R_{EB}, which is clearly greater than K. Statistical discrimination magnifies the exogenous behavioral differences between groups.

In figure 9.5, competitive equilibrium for both groups occurs where w_2 is decreasing with respect to $\hat{R}$. In this case, the difference between R_W and R_B is clearly smaller than K. Statistical discrimination narrows the differences between groups. Furthermore, in both this case and the previous case, given K, the absolute magnitude of the difference between K and R_{EW} minus R_{EB} is greater as reliability is more responsive to changes in w_2, and as worker demand for w_2 is more sensitive to changes in $\hat{R}$.

9.7 More Sophisticated Employer Strategy

The preceding analysis assumes that employers do not take account of the dependence of worker reliability on the terms of risk-shifting arrangements. In other words, employers behave as if R were an exogenous

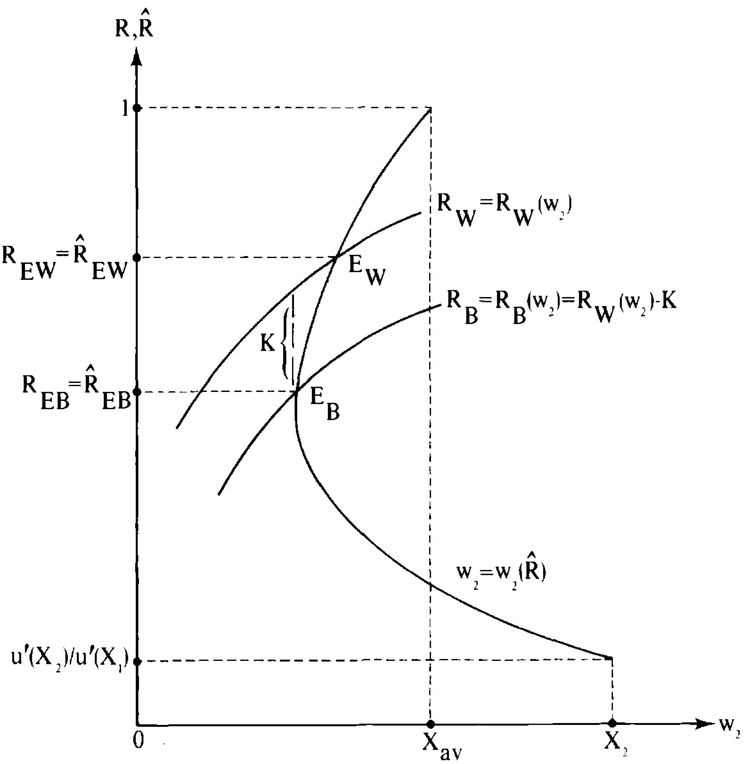

Figure 9.4 Statistical Discrimination Magnifies Differences between Groups

variable, rather than determined by the function $R(w_2;Z)$. However, such simplistic behavior may not be realistic. After witnessing changes in worker reliability that are positively correlated with changes in w_2, employers would tend to realize that R is endogenous and to adopt a more sophisticated strategy for setting Q that takes account of the functional dependence of R on w_2.

This section analyzes the implications of such a strategy. However, in order to retain an element of informational imperfection, the analysis allows the employers to be less than fully informed about the relation between R and w_2. This possible ignorance is embodied in an implicit belief, denoted by $\hat{Z}$, about the vector of parameters Z that describe the distribution of aversion to default. Thus, the employers' estimate of average reliability is given by

$$\hat{R} = R(w_2;\hat{Z})$$

In addition, the analysis assumes that employers revise their beliefs about the distribution of aversion to default in response to any observed error in their estimate of average reliability, and that this learning process involves adjustment of $\hat{Z}$ toward Z in response to any discrepancy between R and $\hat{R}$. Note that this learning process need not produce full information concerning the relation between R and w_2. Because $R(w_2;\hat{Z})$ is not a one-for-one function of $\hat{Z}$, for any given value of w_2, equality between $R(w_2;\hat{Z})$ and $R(w_2;Z)$ does not imply that $\hat{Z}$ is equal to Z. (See Trepeta 1981 for a fuller discussion of this problem as well as the other issues raised in this section.)

The main behavioral consequence of employers' taking account of the dependence of R on w_2 is that they do not allow workers to choose any amount of indemnity for the bad state at a fixed level of Q. Instead, employers offer workers a schedule of quantity and price given by the functional relation

$$Q = 1/R(w_2;\hat{Z}) \equiv Q(w_2;\hat{Z}) \text{ with } Q'(w_2;\hat{Z}) \leq 0$$

The worker, when entering into an employment agreement, takes this relation between Q and w_2 as given. Thus, the worker's problem now is to

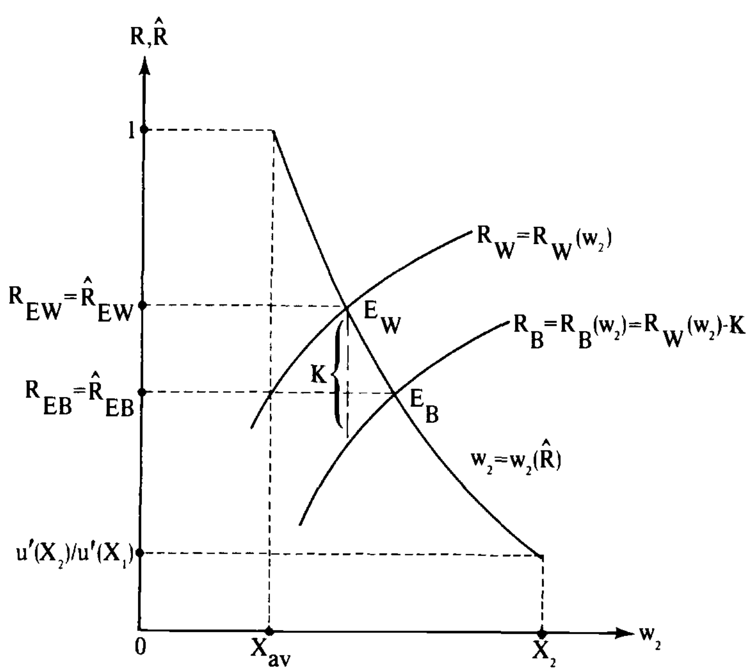

Figure 9.5 Statistical Discrimination Narrows Differences between Groups

choose (w_1, w_2) to maximize $\alpha_1 u(w_1) + \alpha_2 u(w_2)$, subject to the budget constraint $Q(w_2;\hat{Z}) = \alpha_2(X_2 - w_2)/\alpha_1(w_1 - X_1)$, and the nonnegativity constraints $w_1 \geq X_1$ and $w_2 \geq 0$.

This maximization involves the first-order condition

$$u'(w_1) = \frac{Q(w_2;\hat{Z})\ u'(w_2)}{1 + (X_2 - w_2)Q'(w_2;\hat{Z})/Q(w_2;\hat{Z})}$$

If, as in the analysis of the preceding sections, employers were to set Q independently of w_2, the worker would treat Q' as being equal to zero, and this first-order condition would reduce to the first-order condition of section 9.3, $u'(w_1) = Qu'(w_2)$. However, in the present context, when employers adjust Q to allow for the effect of w_2 on R, the worker takes $Q'(w_2;\hat{Z})$ to be negative. In that case, the worker chooses (w_1, w_2) such that $u'(w_1)$ is larger than $Q(w_2;\hat{Z})\ u'(w_2)$. In other words, if the purchase of an additional unit of indemnity raises the price of all intramarginal units, the marginal cost of indemnity for the individual worker exceeds its price. Consequently, the worker would associate with a chosen value of Q a lower value of w_1, and a higher value of w_2, than he would choose for that value of Q if Q were independent of w_2.[3] Referring to earlier diagrams, worker choices in the present context can occur anywhere on or to the right of the locus $w_2 = w_2(\hat{R})$.

Informational equilibrium in the present context involves a value of $\hat{P}$ equal to unity, an employer estimate of the vector Z and a corresponding vector of worker consumption, and a correct employer estimate of worker reliability at the contracted level of w_2. Thus, an equilibrium vector of worker consumption has the property that (w_1, w_2) maximizes worker utility given the function $Q(w_2;\hat{Z})$, and given that $R(w_2;\hat{Z}) = R(w_2;Z)$. Because informational equilibrium does not require that $\hat{Z}$ be equal to Z, the set of potential informational equilibria is large. Referring again to earlier diagrams, this set consists of all points that lie (1) either on or to the right of the locus $w_2 = w_2(\hat{R})$—that is, constitute potential worker contract choices and (2) on the locus $R = R(w_2)$—that is, involve suspension of learning.

Only one informational equilibrium can survive competitive experimentation by employers in the present context. Specifically, starting from any other informational equilibrium, experimentation with marginally different values for $\hat{Z}$ by employers seeking higher profits induces workers to choose new values for w_2 and generates additional information about the function $R(w_2;Z)$. This new information generates new contract forms that are more attractive to workers than the initial equilibrium. Given continued experimentation, $\hat{Z}$ approaches Z, and the market converges to the unique competitive equilibrium, which involves the vector of worker consumption that maximizes worker utility subject to the full information price schedule $Q(w_2;Z)$. When the market reaches competitive equilibrium, employers may not have full knowledge about the vector Z; they may, therefore, undertake some further experimentation. However, additional information about Z would not generate new contract forms more attractive to workers than the contract at competitive equilibrium.

9.8 Summary and Implications for Empirical Research

This paper has analyzed the stability of workers' earnings in a context where employers, who are less risk averse than workers, absorb from workers risk that is associated with fluctuations in the value of worker product. The terms on which employers stabilize workers' earnings depend on employers' estimates of worker reliability, which is defined as the propensity of workers to comply with risk-shifting agreements that they make. The analysis has assumed that employers adjust their estimates of worker reliability if new observations on reliability disconfirm prior beliefs. In addition, the analysis has assumed that worker reliability depends on the terms of risk-shifting arrangements, as well as on workers' exogenous attitudes toward default on contractual commitments. A basic result is that the two-way interaction between employer beliefs and worker reliability can generate multiple informational equilibria—that is, more than one employer estimate of worker reliability can be self-confirming. However, in order for more than one equilibrium to be competitive—that is, invulnerable to individual firms' competitive experimentation with marginally different beliefs—employers must behave as if worker reliability is exogenous, and the degree of worker risk aversion and the distribution of aversion to default must obey specific restrictions.

An important implication of this result is that, if employers engage in statistical discrimination, identifiable worker groups that are identical with respect to risk aversion and the distribution of attitudes toward default among their members can exhibit different reliability and experience different stability of earnings in competitive equilibrium, simply because employers initially believe that the groups differ with respect to reliability. However, the nature of the necessary conditions suggests that such an outcome is unlikely. Nevertheless, even if intrinsically identical groups approach the same competitive equilibrium, a historical legacy of discrimination could persist for many years. Specifically, the speed with which groups approach competitive equilibrium depends on such factors as the frequency with which new data on reliability become available to employers, which depends in turn on the frequencies of industry-specific and general business cycles. Discrimination in the market for risk-shifting arrangements could take decades to disappear because cycles in demand have a duration of many months.

The analysis has also shown that statistical discrimination can either magnify or narrow intrinsic behavioral differences between groups. Specifically, if identifiable groups of workers differ with respect to the distribution of aversion to default among their members, then they will exhibit different average reliability when allowed to enter risk-shifting arrangements on the same terms. However, if employers absorb risk from the groups on different terms, on the basis of a belief that the groups differ with respect to reliability, the reliability differentials between groups in competitive equilibrium may be greater than, equal to, or less than those that would exist in the absence of statistical discrimination.

The foregoing analysis suggests that if statistical discrimination by employers in the market for risk-shifting arrangements contributes to the racial differential in stability of earnings, and if employers' beliefs about worker reliability are correct, then whites behave more reliably on average than blacks. A basic test of the theory would be to determine whether such a difference in reliability actually exists, in the form of a racial differential in the quit rate in periods of high aggregate demand. Unfortunately, accessible data do not readily provide evidence on this issue. However, work on this question continues and some tentative inferences from the data may be possible.

The preceding analysis shows that average reliability differences between worker groups could result either from intrinsic differences in the distribution of attitudes toward default or from initial differences in employer beliefs about reliability. If reliability differences do exist, another important and difficult empirical problem would be to determine the source of these differences.

Notes

1. If unreliable workers were naive, they might reveal their intention to pay nothing for indemnity income by seeking agreements that provide very large earnings when the value of worker product is low. In contrast, the present discussion implicitly assumes that unreliable workers demand indemnity income as if they plan to act reliably, dissembling their true intentions in order to avoid exclusion from risk-shifting arrangements. For a further discussion of dissembling behavior, see Grossman (1979).

2. The analysis also assumes that consumption goods and produced output are the only commodities in the economy. Specifically, there are no investment goods, and neither consumption goods nor produced output is storable. These assumptions imply that, in aggregate, current consumption is equal to the value of current output, and that, in aggregate, the economy cannot smooth out its consumption stream by varying either its accumulation of investment goods or its commodity inventories. Allowing for either invest-

ment goods or commodity inventories would make the analysis both more realistic and more complex, but would probably not change the main conclusions regarding the market for risk-shifting arrangements.

3. Jaffee and Russell (1976) use a similar framework to analyze the terms of loan agreements in a competitive credit market. In their model, lenders expect the default rate among borrowers to be positively related to the amount owed, and they make the interest rate an increasing function of the amount owed. Consequently, the actual loan size associated with any interest rate is smaller than borrowers would demand if they could obtain loans of any size at that interest rate. Jaffee and Russell denote this outcome as "credit rationing." Moreover, Jaffee and Russell assume that lenders know precisely the relation between the default rate and the terms of loan agreements. The present discussion extends their analysis to allow for the possibility that imperfect lender (employer) understanding of borrower (worker) default behavior can generate multiple informational equilibria.

Comment Dennis W. Carlton

This is an interesting and instructive paper. It combines ideas from the literature on statistical discrimination with those from the literature on contracts. It also makes some headway in analyzing the important issue of default behavior. A major finding of the paper is that the existence of multiple equilibria could help explain the lower earnings of blacks relative to whites.

The paper makes very simple assumptions. Such an approach has both virtues and costs. One virtue is that the essential ideas can be presented clearly and quickly. One cost is the possibility that relaxation of some of the assumptions could fundamentally alter some of the model's conclusions.

Some of the assumptions could probably be relaxed without changing the main results of the model, though the model would become more complicated. For example, firms could be allowed to "cheat" workers through layoffs when the value of the marginal product of a worker fell below price. Firms and workers could acquire reputations for reliability. I suspect that the better the information the less likely multiple equilibria become. Firms could require advance payments (or investment in job-specific skills) to be returned only to nonquitting workers. If the worker's loss from quitting always equals or exceeds the wage gain from quitting, no contracts will be broken. I believe that these relaxations can be made in such a way as to make the model more realistic but still allow for (though reduce) the possibility of multiple equilibria.

My main criticism is that the paper emphasizes the case where firms take quit rates as independent of the wage. Even in the simple model in the first part of the paper this assumption cannot hold exactly; otherwise unreliable workers would choose as high a payoff as possible in the

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favorable state and as low a payoff as possible in the state in which they quit. The authors rule out this case by assumption—but it is clearly awkward to maintain on the one hand that firms do not realize that wages are correlated with quit rates but on the other hand that unreliable workers do not choose high payoffs in the good state and low payoffs in the bad state because firms will use wage choices to infer quit probabilities (i.e., reliability).

Assuming that firms do not realize that wage rates affect the behavior of labor supply strikes me as unrealistic. If firms realize that the supply of labor depends on wages they offer, then the problem of characterizing equilibrium reduces to the problem of choosing wages w_1 and w_2 so as to maximize expected utility subject to the budget constraint

$$\alpha_1(w_1 - X_1) + \alpha_2\, R(w_2)(w_2 - X_2) = 0$$

where α_i = probability of state i, w_i = wage paid in state i, X_i = amount produced in state i, and $R(w_2)$ = probability that a worker quits in unfavorable state given a wage w_2. In this formulation, firms recognize that the quit rate R will change as wage w_2 changes. The budget constraint guarantees zero expected profits for firms. The equilibrium (w_1, w_2) will be a tangency—in (w_1, w_2) space—between the indifference curves and the budget constraint. It is a simple exercise to show under the assumptions of the model that along an indifference surface $d^2w_2/dw_1^2 > 0$, while along the budget constraint $d^2w_2/dw_1^2 < 0$. This means that there can be at most one tangency between the indifference curves and the budget constraint—hence we obtain a unique equilibrium. The possibility of explaining black-white earning differentials as arising from multiple equilibria vanishes. I find it disturbing that relaxing what appears to be an overly restrictive assumption fundamentally changes one of the model's results.

I therefore doubt that much of the black-white earnings inequality can be attributed to the multiple equilibria story. Nevertheless the model is a rich one with many empirical applications. For example, the model makes predictions about the relation of wage rates and reliability, and about quit rates in booms. I would encourage the authors to analyze these issues with their insightful model.

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