HOW CLOSE TO AN AUCTION IS THE LABOR MARKET?
EMPLOYEE RISK AVERSION, INCOME UNCERTAINTY,
AND OPTIMAL LABOR CONTRACTS

James N. Brown

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ABSTRACT

Section I of this paper develops a model of income insurance in the

labor market. The model differs from those of previous analyses in its

focus on quantitative implications regarding the degree to which wages

diverge from marginal value products, both in time-series and in cross-

section data. Sections II and III present empirical evidence consistent

with these implications. The main empirical finding is that of short-

term divergence, but long-term equality between wages and marginal value

products. The labor market appears to differ from an auction market only

in the short run, but this short-run divergence considerably reduces the

potential variability of employees' realized wealth.

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I.   Employee Risk Aversion, Income Uncertainty, and Optimal Labor Contracts

Recent efforts to explain the existence of layoffs and the cyclical

stability of real wages have focused renewed interest on the voluntary

nature of involuntary unemployment and on the equilibrium characteristics

of what appear to be non-market-clearing situations.[1]   One result of

these efforts has been the development of a class of models focusing on

employee aversion to earnings variance as the root cause of these phenomena.

Analyses within this class typically assume that employees are averse to

variability in their consumption, that employee consumption is not

independent of realized employee income, and that employees are less able

than employers to diversify their sources of income, or that employees

are simply more risk-averse than employers. The implication of these

assumptions is that both parties can benefit from arrangements which

shift income variability from employees to employers, and the argument

developed is that these income-stabilizing arrangements entail the use of

layoffs as a means of adjusting employment.[2]

According to this argument, wages are allowed to diverge from marginal

value products in order to reduce earnings variance for employees. In periods

of high demand, firms pay employees less than the value of their marginal

product, while in periods of low demand, wages exceed marginal value products.

As a result, because wages do not equate employees' supply of labor with

firms' demand for labor in states of low demand, supplementary adjustment

of employment by way of layoffs becomes necessary in such states.

One particularly interesting implication of most such analyses

is the optimality of contracts which specify state-invariant earnings

for employed workers.[3]   At first glance this result is surprising, for

economists seldom find reason to argue that prices are better left
unresponsive to states of demand, even when there exist costs associated
with price variability. On closer inspection, however, the result becomes
transparent, for while introducing costs of wage variability through
employee risk aversion, these analyses introduce no counterbalancing
costs of wage rigidity.

A central assumption in these analyses is the absence of any allocative
function performed by wages once an initial sorting of workers across firms
has taken place. Specifically, this absence results from the assumption
that the costs of interfirm labor mobility are sufficiently high relative
to the value of moving between firms that no such interfirm movement ever
takes place. Clearly this assumption guarantees the optimality of state-
invariant earnings for employed workers, for it eliminates any reason for
wage variability after the initial sorting has taken place. By precluding
any effect of realized wages on the realized interfirm distribution of the
labor force, that assumption precludes as well any consideration of the
influence of that effect on the optimal wage policy. Performing no ex post
allocative function, wages are left free to be determined by other criteria
such as earnings variance.[4]

While the absence of ex post interfirm labor mobility might be an
acceptable assumption for analyzing the optimal degree of insurance against
shifts in aggregate product demand when relative product demands are certain,
relaxing this assumption is essential for any study of optimal income insur-
ance in the presence of relative demand uncertainty. Clearly, it is necessary
also for any study of voluntary labor mobility or of the effect of income
insurance on voluntary labor mobility.

This section develops a model of the optimal income-insuring charac-
teristics of labor contracts which extends previous analyses in one funda-

mental respect: the model considers relative changes in product demand among firms and relaxes the assumption that there is no wage-responsive interfirm labor mobility after an initial sorting of workers across firms has taken place. By allowing the ex post supply of labor realized by firms to depend on the ex post wages offered by firms, the model developed in this paper allows explicit consideration of the resource misallocation that is caused by attempts to reduce the dispersion of employee earnings over states of product demand. Consideration of this cost of wage rigidity leads to results which differ from those of earlier analyses. In this model the exact wage and employment policies offered by firms are determined by a tradeoff between the value of variable wages and employment in allowing efficient resource allocation and the cost of variable wages and employment in creating income uncertainty for employees. Variable wages become necessary for optimal resource allocation, and because realized state-contingent wages offered by firms may once again influence the ex post interfirm distribution of the labor force, optimal wages may no longer be determined simply by employee aversion to earnings variance. This extension is of more than theoretical interest, for it leads to explicit, quantitative expressions for the optimal response of wages and employment to variations in product demand that can be applied in something more than a loose, qualitative fashion and which can provide a basis for an empirical test of the theory.

The following analysis focuses on a single contracting period, during which firms experience random shocks to the demands for their products, and during which firms employ workers who dislike the prospect of uncertain earnings. It assumes that workers sort themselves among firms at the start of the period on the basis of the labor contracts, explicit or implicit, which firms offer. These contracts are assumed to specify wages

and layoff probabilities (and imply quit probabilities) contingent on the distribution of product demand among firms which is realized.

During the first part of the contracting period, each firm receives a certain price for its product and pays certain wages to its employees. After a given interval, however, all firms experience shocks to the demands for their products and may respond to this new situation with layoffs, additional hires, or wage revisions, leading to some level of quits among their employees. For simplicity the analysis focuses on a single firm, assumed to be insignificant in the market, and abstracts from general equilibrium considerations.

The firm is assumed to maximize the value of profits expected over all states of product demand by choosing the number of workers with whom contracts are made at the start of the period and by choosing values for wages, layoffs, non-wage payments to laid-off workers, and additional hires corresponding to each possible state of product demand. The firm is assumed to survive forever and to know the manner in which quits by its employees and applications for employment from workers initially at other firms respond to the wages which it offers in each state.

Constraining the firm's efforts to maximize expected profit are the profit-maximizing activities of other firms and the efforts of workers to maximize their utility. In order to attract workers at the start of the period, the firm must offer an expected value of earnings which, adjusted for income uncertainty, is at least as great as that available at other firms. And in order to achieve the desired level of employment once the new distribution of product demand is known, the firm must offer a new level of earnings which is consistent with the efforts of workers to arbitrage realized differences among firms in wages net of mobility costs.

It is assumed that after the new states of demand for firms' products become known, employees of the firm are given one drawing from the realized distribution of new wages paid elsewhere. If a firm is drawn which pays a wage exceeding the value to the employee of remaining at the initial firm by at least the cost of interfirm labor mobility, a quit occurs. If an employee chooses not to quit and if he is laid off, he is assumed to be given some severance payment by the firm making the layoff and to accept the offer of the firm previously drawn but rejected, or to be unemployed for the remainder of the period if the firm drawn is not offering a wage[6] which exceeds the employee's value of leisure.

More specifically, the firm's severance pay policy is assumed to guarantee a certain level of income for all employees laid off in a given state. This level may vary with the state of demand for the firm's product, but given any particular realized level of demand, the firm is assumed to pay all employees laid off the difference between the net earnings which they realize at their next best alternative and the guaranteed income[7] for the specific state of demand realized.

More precisely, the firm is assumed to maximize

(1) $PF(N)-WN$

$$+\Sigma_{s} \{P(s)F[N(s)(1-\ell(s))+h(s)]-N(s)(1-\ell(s))w(s)-N(s)\ell(s)[g(s)-w_\ell(s)]-h(s)\mu(s)\}\pi(s)$$

subject to the labor supply constraints

(2) $W+\Sigma_{s}\{[w(s)-L(w(s))]\frac{N(s)}{N}(1-\ell(s))+\frac{N(s)}{N}\ell(s)[g(s)-L(g(s))]+(1-\frac{N(s)}{N})[w(s)-L(s)]\}\pi(s)=\frac{\bar{w}}{q}\frac{\bar{w}}{q}$

(3) $\mu(s)=\mu(h(s))$, $\mu'>0$

by choosing N, $h(s)$, $w(s)$, $\ell(s)$ and $g(s) \geq 0$ for all s, where:

P denotes the initial certain product price

$F()$ denotes the firm's production function, $F' > 0$, $F'' < 0$

N denotes the firm's initial work force

W denotes the initial certain wage paid by the firm

s indexes the state of demand for the firm's product[8]

$P(s)$ denotes the product price obtaining in state s

$N(s)$ denotes the number of employees who do not quit the firm in state s.[9]

$\ell(s)$ denotes layoffs in state s, expressed as a fraction of workers who do not quit in state s, and assumed to be randomly distributed among workers who do not quit in state s

$h(s)$ denotes additional hires in state s

$w(s)$ denotes the wage paid by the firm in state s

$g(s)$ denotes the level of income guaranteed to employees laid off in state s

$w_\ell(s)$ denotes the expected net level of earnings available elsewhere to employees laid off in state s[10]

$\mu(s)$ denotes the wage paid to additional hires in state s

$\pi(\cdot)$ denotes the probability distribution function for future states of demand

$L(\cdot)$ denotes the monetary value of the utility loss per employee caused by deviations of realized income in state s from its ex ante mean level[11]

$w_q(s)$ denotes the expected net level of earnings available elsewhere to employees who quit in state s[12]

$L_q(s)$ denotes the expected value of the function $L(\cdot)$ for those workers who quit in state s[13]

Ω denotes the expected value of risk-adjusted earnings available elsewhere to initial employees.

Substituting labor supply constraints (2) and (3) into the firm's objective (1), the firm's problem can be written in a more revealing form as choosing N, h(s), w(s), g(s) and ℓ(s) to maximize

(4) $PF(N)-N\Omega+\Sigma\{P(s)F[N(s)(1-\ell(s))+h(s)]-N(s)(1-\ell(s))L(w(s))$
        s

$+N(s)\ell(s)[w_\ell(s)-L(g(s))]+(N-N(s))[w_q(s)-L_q(s)]-\mu(s)h(s)\}\pi(s)$.

Expression (4) shows that the firm's maximization problem involves a tradeoff between the effects of the firm's choice variables on the income uncertainty associated with the firm's contact and the effects of those variables on the expected net earnings of the firm and its initial employees considered jointly, where the expectation is taken over all possible future relocations of the firm's initial work force. Roughly stated, the firm can reduce income uncertainty for its employees by reducing the extent to which wages reflect marginal value products. But it can do so only at the cost of lower expected joint net earnings, because any gap between marginal value products and wages reduces the efficiency of voluntary labor mobility, and because layoffs or additional hires cannot eliminate this inefficiency without creating greater costs of their own. The implications of this tradeoff for the extent to which wages and employment respond to changes in the distribution of product demand can be seen from the first-order conditions for the firm's maximization problem. The optimal number of contracts offered by the firm at the start of the period and the firm's optimal hiring, wage, severance pay,and layoff policies applying in any state s must satisfy:

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(5) $0 \geq PF'(N) - \Omega + \Sigma \{ [P(s)F'(s) - L(w(s))][1 - \lambda(s)]\dfrac{N(s)}{N}$

$\quad + \lambda(s)\dfrac{N(s)}{N}[\underset{\lambda}{w}(s) - L(g(s))] + [1 - \dfrac{N(s)}{N}][\underset{q}{w}(s) - \underset{q}{L}(s)]\} \pi(s)$

(6) $0 \geq P(s)F'(s) - [\mu(s) + h(s)\dfrac{du(h(s))}{dh(s)}]$

(7) $0 \geq [\ [P(s)F'(s) - \lambda(s) + L(\lambda(s)) - L(w(s))][1 - \lambda(s)] + \lambda(s)[L(\lambda(s)) - L(g(s))]\ ]\dfrac{dN(s)}{dw(s)}$

$\quad - N(s)[1 - \lambda(s)]\dfrac{dL(w(s))}{dw(s)}$

(8) $0 \geq [\ [P(s)F'(s) - \lambda(s) + L(\lambda(s)) - L(w(s))][1 - \lambda(s)] + \lambda(s)[L(\lambda(s)) - L(g(s))]\ ]\dfrac{dN(s)}{dg(s)}$

$\quad - N(s)\lambda(s)\dfrac{dL(g(s))}{dg(s)}$

(9) $0 \geq [\underset{\lambda}{w}(s) - P(s)F'(s) + L(w(s)) - L(g(s))]N(s)$

$\quad + [\ [P(s)F'(s) - \lambda(s) + L(\lambda(s)) - L(w(s))][1 - \lambda(s)] + \lambda(s)[L(\lambda(s)) - L(g(s))]\ ]\dfrac{dN(s)}{d\lambda(s)},$

where strict equalities hold for all non-zero values of the relevant variables.

Condition (5) is equivalent to the restriction that the marginal expected profit from additions to the firm's initial work force be zero. More interestingly, this condition requires that the expected (over all possible future relocations of the firm's initial work force) net risk-adjusted income of the firm and its initial employees taken jointly be equal to that expected at other firms. Applied more generally, condition (5) guarantees that the initial sorting of workers across firms will be optimal in the sense that no

initial reallocation could increase the expected net risk-adjusted product of all firms taken together.[14]

Given that condition (5) is satisfied, conditions (6)-(9) determine the optimal response of income and employment to changes in the distribution of product demand. Consider first condition (6). Condition (6) requires that the marginal value product and marginal factor cost of additional hires in state s be equal if any hiring takes place in state s. Through this condition, the availability of additional hires to the firm influences the optimal characteristics of the firm's contract in two ways. First, the elasticity of the supply curve of additional hires to the firm influences the relation between the price of the firm's product and the marginal value product of the firm's employees. Second, variability in the position of that supply curve introduces an additional source of variation in the firm's demand for the services of its initial work force.

If the supply curve of additional hires to the firm were perfectly elastic and stable, then regardless of the volatility of demand for the firm's product, there could be no uncertainty about the marginal value product of the firm's employees. Alternatively, even if the price of the firm's product were perfectly certain, there still could be uncertainty about the marginal value product of employees if variability in the demand for other firms' products caused variability in the supply price of additional hires to the firm. In general, for any given variability in the price of the firm's product, the corresponding variability in the marginal value product of the firm's employees would be less, the more elastic the supply curve of additional hires to the firm and the more the position of that curve varied to offset the effect of changes in product price.

Condition (6) can be seen as a determinant of the state distribution

of the firm's demand for the services of its initial work force. Given this distribution, conditions (7)-(9) determine the corresponding state distribution of income and employment for initial employees.[15] The exact manner of this determination depends on the value taken by layoffs. Two cases are possible. For states of product demand in which layoffs are positive, conditions (6)-(9) jointly determine wages and employment. But for states of product demand in which layoffs are optimally zero, conditions (6) and (7) alone are determining.[16]

In states of product demand for which layoffs are zero, condition (7) reduces to[17]

$$(10) \quad 0 \geq [P(s)F'(s) - w(s)]\frac{dN(s)}{dw(s)} - N(s)\frac{dL(w(s))}{dw(s)} \quad .$$

The first term in condition (10) is the net effect of a marginal increase in the state-s wage on the expected joint earnings of the firm and its initial employees. This term represents the value of the marginal reduction (increase) in resource misallocation brought about by increasing the wage when it is below (above) that value which leads the firm's employees to allocate themselves across alternative employments such that, net of mobility costs, earnings available elsewhere to the marginal employee equal the marginal value product of employees remaining at the firm.

Any shortfall of wages below marginal value products will cause some workers to quit even though the value of their marginal product exceeds the net earnings which they realize by quitting. When such quits occur, the firm loses (PF'-w) while the employee gains (v-L(v)-c)-(w-L(w)). Similarly, any surplus of wages over marginal value products will cause some workers not to quit even though the value of their marginal product falls short of the

net earnings they could realize by quitting. When such quits fail to occur, the firm loses $(w-PF')$ while the employee gains $(w-L(w))-(v-L(v)-c)$. In either case, the difference—that part of the loss to the firm for which there is no corresponding employee gain—is given by $|(PF'-L(w))-(v-L(v)-c)|$. This loss is solely due to the divergence of wages and marginal value products resulting from efforts to stabilize employee income.

For the marginal employee, v is equal to $w+c$, and so the marginal value of this distortion is $(PF'-w)$. Given a positive (negative) distortion between marginal value products and wages, a marginal increase in the wage will discourage some quits which would have resulted in a net loss (gain) to the workers and the firm considered jointly. The contribution of this effect to joint earnings in state s is $(PF'-w)\dfrac{dN(w(s))}{dw(s)}$, the first term in condition (10).

The second term in condition (10) is the (negative of the) effect of a marginal increase in state-s wages on the risk premium which the firm must pay to its employees. Given that employees are averse to variance in their earnings, this term will be positive for values of w greater than the mean of w, negative for values less than the mean, and zero otherwise. Thus, an implication of condition (10) is that wages will be set at values which fall short of marginal value products in states of demand for which realized earnings exceed their mean level, and at values which exceed marginal value products in states of demand for which realized earnings fall short of their mean.

In order to reduce income uncertainty for employees, the firm allows wages to diverge from marginal value products. But this procedure leads to a level of quits which is unprofitable for the firm and its employees taken jointly. This fact limits the extent to which the firm can optimally reduce employee income uncertainty by reducing the extent to which wages reflect

marginal value products. Optimal wages are too sticky to be fully efficient
in allocating labor, but too flexible to eliminate income uncertainty for
employees.

To illustrate, consider the firm's response to an increase in product
price. An increase in the price of the firm's product will cause the first
term in condition (10) to increase without altering the second term. Condition
(10) indicates that the firm's optimal response will be to increase its
wage. When product demand increases, it becomes profitable for the firm to
raise wages in order to discourage quits among its employees. The resulting
increase in the firm's labor force allows the firm to take advantage of
the initial excess of marginal value product over wages paid. As wages
and employment are increased, however, this excess is reduced, and in addition
the firm must increase the risk-premium paid to its employees. The optimal
wage for state s is determined by marginal equality of the net gains from
additions to the firm's labor force induced by higher wages with the incre-
mental effect of higher state-s wages on the risk premium paid by the firm.

For states of demand in which layoffs are zero, condition (10) implies
a relation between wages and marginal value products of the basic form shown
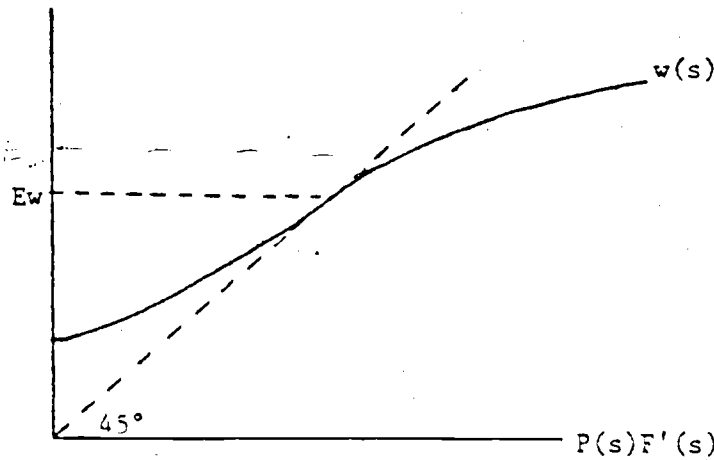below in Figure 1.

Figure 1
Approximate Relation Between Insured Wages and Marginal
Value Products When Layoffs are Zero

The exact form of this relation can be seen more clearly by re-expressing condition (10) as

$$(11) \quad w(s) = \frac{P(s)F'(s)}{1+\dfrac{dL(w(s))/dw(s)}{d\log N(s)/d\log w(s)}}.$$

It can be seen directly from condition (11) that if the marginal risk premium associated with a wage increase, $dL(w(s))/dw(s)$, increases in absolute value as wages diverge from their mean value, or if the elasticity of labor supply to the firm, $d\log N(s)/d\log w(s)$, diminishes as wages diverge from their mean value, then wages will be less than unit-elastic in response to marginal value products, as drawn in Figure 1.[18] Intuitively, if successive employment increases require increasing marginal wage increases, or if the marginal risk premium implied by a wage increase rises as wages are further increased, then firms will increase employment (and, by implication, wages) less readily in response to product price increases as wages diverge further from their mean value. Similarly, firms will reduce employment (and, by implication, wages) less readily in response to product price reductions if, as wages fall further below their mean value, either the marginal wage reduction required to induce a separation or the marginal risk premium implied by a further wage reduction increases.

Similar reasoning suggests that firms with relatively inelastic labor supply and relatively risk averse employees would have wage-response schedules more closely approximating a horizontal line, while firms with relatively elastic labor supply and relatively risk neutral employees would have wage-response schedules more closely approximating a 45° line through the origin in Figure 1. At one extreme, with zero risk aversion, the firm's wage-response schedule would be given by the 45° line, with

wages unit-elastic in relation to marginal value products. It is this
special case that auction models of the labor market are led to. At the
other extreme, with either infinite risk aversion or zero labor supply
elasticity, the firm's wage response function would be given by a horizontal
line, with wages zero-elastic in relation to marginal value products and
states of demand. It is this special case that previous analyses of
income-insuring labor contracts have been led to by the assumption of
zero ex-post labor mobility. It is an advantage of the present analysis
that it supplies a framework broad enough to incorporate both extreme cases--
pure auction and complete insurance--and yet specific enough to suggest the
form of the relation between wages and marginal value products in the
presence of income insurance.

To investigate the role of layoffs and severance pay in the firm's
optimal contract, consider first the implications of condition (8) for
the supplemental payments made by the firm to employees laid off in state s.
Condition (8) requires that the firm guarantee all employees laid off in
state s a level of income such that, at the margin, the benefits from such
payments in reducing income uncertainty equal the implied loss in joint
net income resulting from the deterrant effect of severance pay on quits.
If quits were unaffected by severance pay, the firm would choose a level
of layoff benefits such that employees' expected income was unaffected by
the prospect of layoffs. That is, the firm would guarantee all laid-off
employees a level of income equal to their ex ante mean level of income,
paying each employee the difference between the ex ante mean and that
employee's realized level of income at his next-best alternative.[19]

But to the extent that the prospect of severance pay discourages quits,
the firm's optimal severance pay policy will fail to eliminate the income

loss associated with layoff status. In states of low product demand, some employees whose net earnings elsewhere exceed that at their current job will choose not to quit because the value to them of remaining at the firm, $(1-\ell(s))w(s)+\ell(s)g(s)$, may exceed the wage offered at their next best alternative. As a consequence, the marginal effect of severance pay on quits will lead to a net loss in expected joint income which must be balanced against the marginal value of severance pay in reducing income uncertainty. Higher values for g(s) reduce income uncertainty for employees, but only at the cost of a lower mean level of income due to the negative effect of severance pay on the efficiency of voluntary labor mobility.

The preceding discussion of condition (8) may seem reminiscent of the discussion of condition (10) and the firm's optimal wage policy, for the same tradeoffs are involved in both conditions. In fact, conditions (7) and (8) together imply that the optimal value for the level of income that the firm guarantees all employees laid off in state s is simply w(s), the level of income which it offers to those not laid off in state s. [20] This characteristic of the optimal severance pay policy has important implications both for the firm's optimal layoff strategy and for the optimal response of wages to product price reductions. Setting g(s) equal to w(s), and noting that with g(s) equal to w(s), $dN(s)/d\ell(s)$ becomes zero, conditions (7) and (9) reduce to

(12) $0 \geq [P(s)F'(s)-w(s)]\dfrac{dN(s)}{dw(s)} - N(s)\dfrac{dL(w(s))}{dw(s)}$

(13) $0 \geq \underset{\ell}{w(s)}-P(s)F'(s),$

which reveal some interesting aspects of the optimal response of wages and

layoffs to variations in product demand in states of demand for which layoffs are non-zero.

Condition (13) shows that the firm's optimal layoff strategy is directly determined only by efficiency criteria.[21] Because severance pay allows the firm to compensate employees for the income loss associated with being laid off, it thereby allows the firm to choose its layoff strategy without being directly constrained by employees' aversion to income uncertainty. When the firm guarantees all employees who do not quit in state s a certain wage which is independent of layoff status, the direct relation between layoffs and income uncertainty is broken. Also, quits are no longer affected by the prospect of layoffs, since layoffs no longer affect realized earnings. As a result, the firm's layoff strategy involves only a comparison between the marginal value product of employees at the firm and the expected net value of what randomly laid off employees could earn elsewhere. The firm chooses a level of layoffs in state s so as to equate these two values.[22]

By substituting condition (13) into condition (12), condition (12) can be expressed as

$$(14) \qquad 0 \geq [w(s) - \frac{w(s)}{\lambda}] \frac{dN(s)}{dw(s)} - N(s) \frac{dL(w(s))}{dw(s)} \quad ,$$

which, although identical in form to condition (10), is a function only of the wage paid by the firm in state s. There is nothing in condition (14) to change when states of demand change. The implication of this fact is that once layoffs become positive, wages are made invariant to states of product demand at a level given by

$$(15) \qquad w(s) = \frac{\frac{w(s)}{\lambda}}{1 + \frac{dL(w(s))}{dw(s)} / \frac{d\log N(s)}{dw(s)}}$$

It is interesting to note the determinants of this minimum income which the firm guarantees to its employees. Condition (13) indicates that in response to a price decline, the firm will lay off enough workers to raise the marginal value product of its employees to its estimate of their net alternative earnings elsewhere. By construction, the firm has no knowledge of any particular employees' next-best alternative and so cannot be selective in whom it chooses to lay off. The best the firm can do is to satisfy condition (13), realizing that some employees not laid off will have net earnings elsewhere which exceed those of some laid-off employees.

In contrast, when the firm reduces its wage, it causes only those workers who have the highest alternative net earnings to leave the firm. However, all employees must suffer the wage reduction necessary to induce the marginal employees to leave the firm. Although adjustment of the firm's labor force by way of wage cuts may be more efficient in terms of the particular employees who are induced to leave the firm, it may be more costly in terms of the income variability which it entails. In choosing the optimal level for the minimum income which it guarantees its employees, the firm balances at the margin these efficiency costs and income stability benefits to satisfy condition (14).

Because the marginal risk premium implied by a wage-induced separation increases as wages fall below their mean value, and because the relative allocative inefficiency implied by a layoff diminishes as wages are further reduced, layoffs may ultimately dominate wage reductions as a means of employment adjustment, even though wage reductions are initially preferred.[23] Further, because the relative allocative inefficiency of layoffs depends only on the wage paid by the firm, once layoffs become the preferred means of employment reduction, they will remain preferred

for all further employment reductions. This point is illustrated below

in Figure 2.
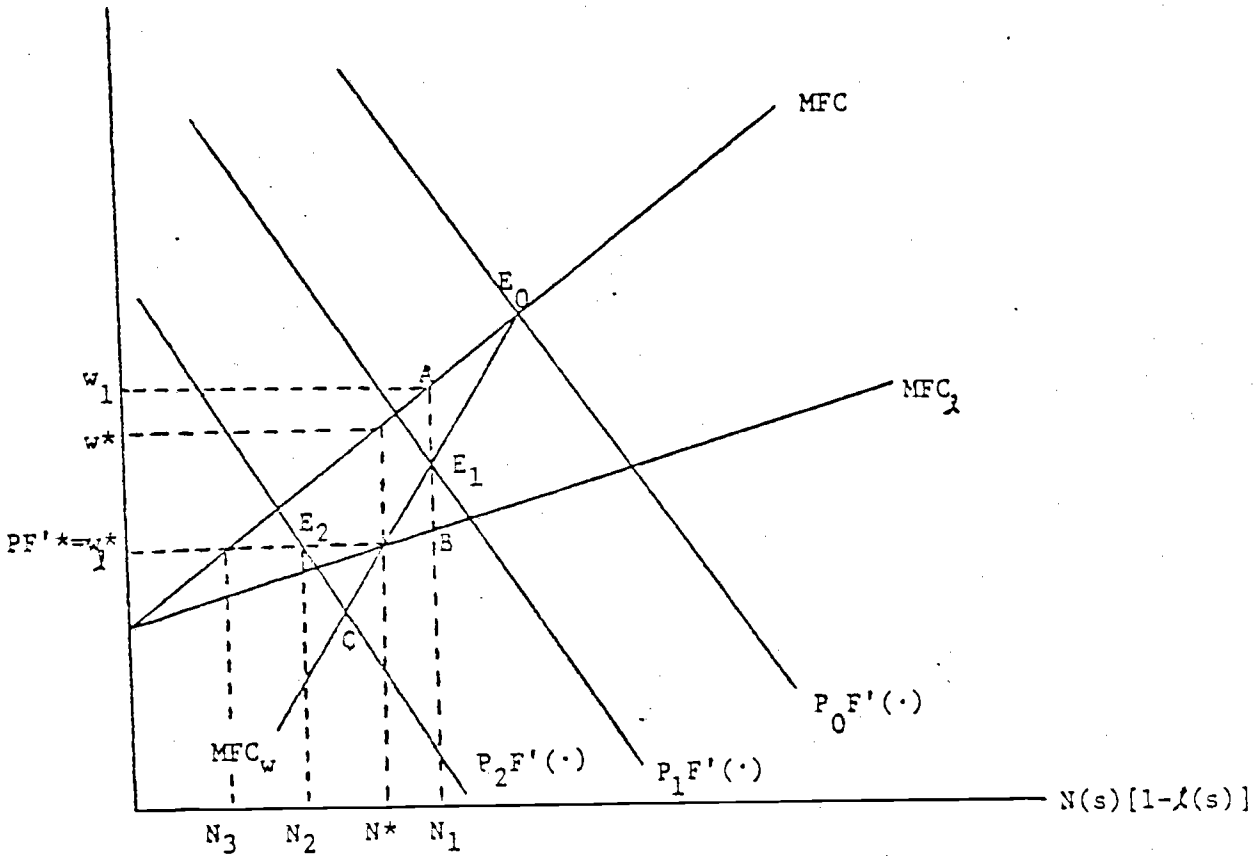
Figure 2
Optimal Income-Insuring Responses to Reductions
in Product Demand

Figure 2 illustrates the firm's choice of wages and layoffs in

responding to product price reductions. The downward-sloping curves are

marginal value product schedules corresponding to different values of

product price ($P_2 < P_1 < P_0$). The upward-sloping curves are marginal factor

cost schedules corresponding to different assumptions about employee risk

aversion and different means of separation.

The curve labeled MFC in Figure 2 is the ex post reservation wage

schedule for the firm's initial employees, derived directly from the ex post

alternative wage distribution in the firm's initial work force. This curve

would be the marginal factor cost schedule relevant to the firm in the

absence of employee aversion to income uncertainty. The curve labeled MFC_W

is derived from the MFC curve by subtracting from it the monetary value of

the utility loss suffered by all the firm's employees as a result of the

wage reduction implied by that point on the MFC curve. This curve can be

interpreted as the marginal factor cost schedule relevant to the firm when

employees are averse to income uncertainty and when separations are wage-

induced. The curve labeled MFC_λ plots the expected net wage available else-

where to employees having alternative wages lower than that given by the

corresponding point on the MFC curve. This curve generates the (horizontal)

marginal factor cost schedules that would be relevant to the firm's choice

of layoffs at different levels of wages.

Starting from an initial equilibrium at point E_0, consider first a

reduction in product price from P_0 to P_1. Figure 2 illustrates that the

firm's optimal response will be to reduce wages to w_1, adjusting employment

entirely by voluntary separations. At point E_1, the marginal adjustment

cost implied by wage-induced separation, $E_1 A$, remains less than the marginal

adjustment cost that would be implied by a layoff at that wage, AB. Even

though all employees must suffer the wage reduction to W_1, this reduction is

small enough to be preferred to layoffs, given that layoffs imply relatively

great allocative inefficiency when wages are high.

At lower values of product price, however, this need not be true.

Consider the firm's response to a price decline from P_0 to P_2. At point C

it is no longer true that the marginal adjustment cost associated with wage-

induced separation is less than the marginal adjustment cost associated with

involuntary separation at that wage. Indeed, for any level of employment

less than N*, the reverse will be true. As the firm's wage falls toward the minimum wage in the market, the difference between what the marginal voluntary separation could receive elsewhere and what a randomly laid-off employee could expect to receive elsewhere diminishes. As a result, because the marginal allocative inefficiency associated with a layoff depends positively on this difference, these adjustment costs also decline as the wage falls.

In Figure 2, at a product price of P_2, the firm's equilibrium response is given by point E_2. The firm reduces its wage to w*, at which the marginal adjustment cost implied by wage-induced separation comes to exceed that marginal adjustment cost associated with a layoff at that wage. Given w*, the marginal expected net alternative earnings of randomly laid-off employees is fixed at the value of w_λ^*, and so the firm lays off employees to the point at which the marginal value product of employees remaining at the firm is brought into equality with that value. In Figure 2, the optimal number of layoffs corresponding to product price P_2 is given by N^*-N_2.

It is interesting to note that for sufficiently large reductions in product price, the presence of income insurance may actually increase the employment response to product price reductions. Consider employment level N_3. At this level of employment, the firm's expectation of what an employee randomly laid off at a wage of w* could receive elsewhere is equal to what the marginal net alternative at that level of employment would have been in the absence of income insurance. For lower levels of employment, the marginal factor cost relevant to the firm in the presence of income insurance, w_λ^*, exceeds the marginal factor cost that would apply in the absence of income insurance. Thus, for product prices low enough to make employment less than N_3 optimal, employment in the presence of income insurance

will be less than the level that would have been optimal at the same price in the absence of income insurance. Correspondingly, marginal value products in the presence of income insurance can exceed marginal value products in the absence of income insurance for sufficiently low product prices.

Combining these results with those for states of demand in which layoffs are zero, the implications of conditions (6)-(9) for the optimal response of wages and employment to changes in product price can be summarized graphically as in Figure 3 below.

Figure 3 plots values of wages, marginal value products, quits, layoffs, new hires, and employment corresponding to alternative possible ex-post values of product price. The curves labeled "contract" refer to a firm which supplies income insurance to its employees, while for a point of reference, the curves labeled "auction" refer to a firm which supplies no income insurance to its employees, but which is assumed to have the same initial level of employment.

Panel (a) of Figure 3 shows that, for states of demand in which layoffs are zero, the presence of income insurance reduces the response of wages to variations in product demand, but correspondingly increases the response of marginal value products to variations in product demand. Because income insurance reduces wages in states of high demand and increases wages in states of low demand, the responsiveness of quits to variations in product demand is reduced, as shown in panel (b). To some extent, the firm can compensate by increased additional hires in states of high demand and by reduced additional hires in states of low demand (panel [d]). But so long as the marginal supply price of additional hires is an increasing function of additional hires, the effect of income insurance on voluntary separations will not be fully offset.[24] Thus, income insurance will reduce the responsiveness of employment to variations in product demand when layoffs are zero (panel [e]),
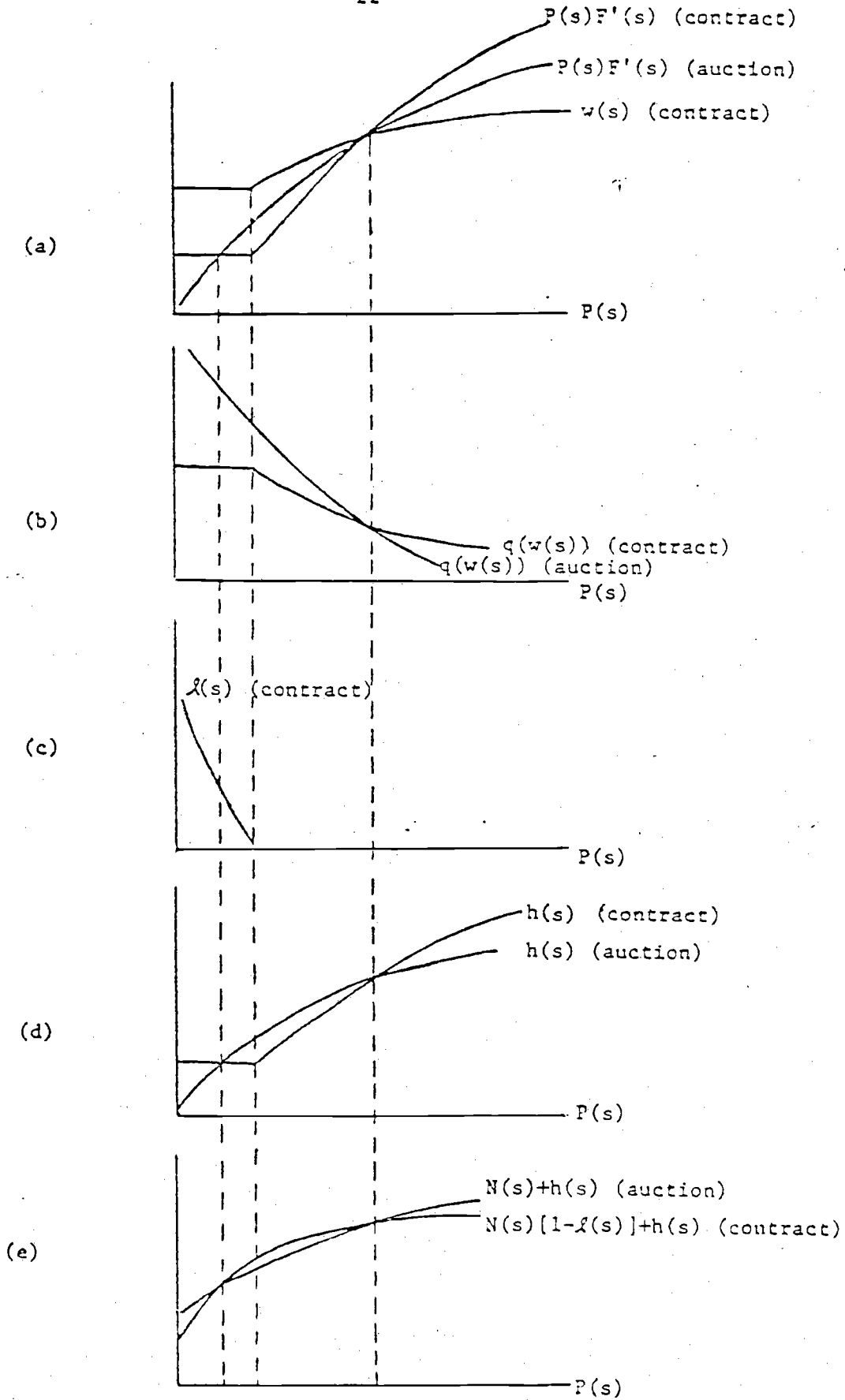
(a)

(b)

(c)

(d)

(e)

Figure 3

Characteristics and Implications of Income-Insuring Labor Contracts:
Alternative Values of Selected Variables Corresponding to
Alternative Possible Values of Product Price

which implies the effect on marginal value products shown in panel (a).

For states of demand in which layoffs are non-zero, panel (a) shows that income insurance leads to locally fixed levels of wages and marginal value products. Panel (b) translates this effect on wages into a locally fixed level of voluntary separations, and panel (d) translates the effect on marginal value products into a locally fixed level of additional hires.[25] The firm's marginal response to changes in product demand takes place solely by way of layoffs in such states, as shown in panel (c). Because layoffs are chosen so as to maintain the marginal value product of the firm's employees at a fixed level exceeding the minimum possible level in the absence of income insurance (Panel [a]), employment in the presence of income insurance ultimately falls below that in the absence of income insurance (panel [e]).

II. An Empirical Assessment of the Theory

The preceding analysis argues that if income-insuring labor contracts are present in the labor market, then wages should be less variable than marginal value products and firms should rely on layoffs as a means of employment adjustment in states of sufficiently low product demand. That this argument is at least broadly consistent with empirical observation can be seen from the data presented below in Table 1.

Table 1 is based on annual values of residual income, production worker earnings, value-added, and average monthly layoff rates for U.S. manufacturing industries, 1954 to 1976. The first three columns of Table 1 list values of real annual residual income per production worker, real annual earnings of production workers, and real value-added per production worker, all expressed relative to their time trends for the sample period. Column four lists similarly[26] constructed relative values for annual averages of monthly layoff rates.

TABLE 1

VALUES OF SELECTED VARIABLES EXPRESSED RELATIVE TO TREND:
U.S. MANUFACTURING, 1954-1976

Year	Residual Income Per Production Worker	Average Annual Earnings of Production Workers	Value-Added Per Production Worker	Average Monthly Layoff Rate
1954	.923	.991	.964	1.031
1955-57	1.096	1.012	1.014	.833
1958	.844	.981	.980	1.314
1959	1.009	.999	1.019	1.040
1960-62	.914	.983	.989	1.207
1963-69	1.006	1.009	1.011	.871
1970-71	.875	.979	.962	1.162
1972-74	1.031	1.013	1.044	.811
1975	.903	.977	.992	1.531
1976	1.068	1.008	1.030	.956

Definition of variables and source: see Appendix

The data presented in Table 1 display two characteristics consistent with the hypothesis that firms stabilize employee earnings. First, production worker earnings and residual income per production worker move together over the cycle, but the variability of production worker earnings is substantially less than the variability of residual income per production worker. The mean annual absolute deviation from unity for the series underlying column one is .082, while the corresponding value for column two is only .014. Also, the mean absolute year-to-year change for the relative values underlying column one is .098, compared to .017 for column two.

To put these numbers in context, if firms' production functions were Cobb-Douglas and

if firms offered no income insurance to their employees, then the percentage variability of annual earnings and annual residual income per employee would be equal, and equal also to the percentage variability or value-added per employee. But if firms offered contracts that stabilized the annual income of their employees, then the percentage variability of residual income per employee would exceed the percentage variability of value-added per employee.[27] For the data underlying Table 1, the standard deviations about trend for the logarithms of residual income per production worker, annual earnings of production workers, and value-added per production worker are .102, .013, and .024, respectively. The fact that the percentage variability of residual income per production worker exceeds the percentage variability of both value-added per production worker and production worker earnings suggests the presence of income insurance. The non-zero variability of annual earnings, however, suggests that this insurance is not complete.

The second feature of Table 1 consistent with the presence of income insurance is the existence and significant (counter-) cyclical variability of layoffs. Although not evident from Table 1, layoffs comprise a significant fraction of total separations. The mean share of layoffs in total separations—the mean probability of layoff conditional on separation—is .402 for the sample period, ranging from a value of .196 in 1973 to a value of .634 in 1958. Corresponding values of the average monthly layoff rate for those two years are .9 and 2.6, respectively.

As Table 1 shows, periods during which residual income per production worker lies below its trend value are characterized by small deviations of annual earnings below trend and high values of layoffs relative to trend. Periods of relatively high residual income on average display the reverse. The average year of relatively low residual income (.907 of trend value)

has production worker earnings equal to .984 of trend value and layoffs

equal to 1.199 of trend. In the average year of relatively high residual

income (1.065 of trend value), production worker earnings are 1.010 of

trend value, while layoffs are .855 of trend value.

These characteristics appear to be inconsistent with an auction model

of the labor market in which wages adjust to clear the market at all times.

The auction model could explain the relative cyclical stability of earnings

by appropriate choice of labor supply and demand elasticities and by appro-

priate assumptions about the joint distribution of shocks to labor supply

and labor demand. But such a model would leave unexplained firms' reliance

on layoffs in reducing employment. The data in Table 1 indicate a signi-

ficant departure, at least in form, from an auction market, a departure which
                                                                          28
can be rationalized by an appeal to risk-shifting considerations.

But while the data in Table 1 may be qualitatively consistent with the

risk-shifting explanation of wage rigidity and layoffs, they may at the same

time be quantitatively inconsistent with that explanation. Of particular

interest in Table 1 is the fact that the cyclical behavior of production

worker earnings differs only marginally from the cyclical behavior of value-

added per production worker. If firms' production functions were Cobb-Douglas,

the relative variability of value-added per production worker would equal the

relative variability of production workers' marginal value product. Therefore,

on the assumption of Cobb-Douglas production functions, Table 1 could

imply that wages do not differ much from marginal value products, and

so cast doubt on explanations of layoffs that rely on such a difference.

More generally, on the assumption that firms' production functions are

of the constant elasticity of substitution (CES) form, the interpretation of

the data in Table 1 would depend on the elasticity of substitution between

production workers and other factors of production. For the CES production

function, the percentage variability of residual income per production worker would equal the percentage variability of value-added per production worker if firms supplied no income insurance to their employees.[29] Thus, columns one and two of Table 1 would continue to suggest the presence of income insurance. However, internal consistency would require that the elasticity of substitution between production workers and other factors of production be less than unity. For values of the elasticity of substitution less than one, the relative variability of marginal value products would exceed the relative variability of average value products, while for elasticities of substitution greater than one the reverse would be true.[30] Thus, Table 1 would indicate a difference in the cyclical behavior of wages and marginal value products if the elasticity of substitution were less than one. It would indicate little or no difference otherwise. Depending on the value of the elasticity of substitution, then, the data in column three of Table 1 could either support or contradict the hypothesis that the data in columns one, two, and four reflect the presence of income insurance.

Many studies have estimated production functions for U.S. manufacturing industries using the CES framework. In general, studies using time-series data have found elasticities of substitution less than unity.[31] One might be tempted, therefore, to conclude that the data in Table 1 support the income insurance hypothesis in a consistent fashion. However, because previous estimates have been based on the equality of wages and marginal value products, and because wages may not equal marginal value products in the presence of income insurance, it is not clear that previous estimates of the elasticity of substitution are valid in the presence of income insurance. Accordingly, it seems advisable not to rely on previously estimated elasticities of substitution in interpreting the data in Table 1.

To develop an alternative method of estimation that can allow for the presence of income insurance, consider equation (11), repeated here for convenience

(11)
$$w(s) = \frac{P(s)F'(s)}{1 + \dfrac{dL(w(s))/d\log N(s)}{dw(s) \ / \ d\log w(s)}}$$

Interpreting the "contracting" period as being of one year's length, this equation would determine the relation between annual earnings and annual marginal value products in the presence of income insurance. It is analogous to the equilibrium condition w=PF' in the absence of income insurance (equation [11] reduces to this condition in the absence of aversion to income uncertainty or in the presence of infinitely elastic labor supply), and it can play the same role in estimation.

By taking logarithms, equation (11) can be re-expressed as

(16)
$$\log[w(s)] = \log[P(s)F'(s)] - \log[1 + \frac{dL(w(s))/d\log N(s)}{dw(s) \ / \ d\log w(s)}]$$

$$= \log[P(s)F'(s)] - \frac{dL(w(s))/d\log N(s)}{dw(s) \ / \ d\log w(s)}$$

for values of w(s) near the ex-ante mean of w. On the further assumptions that: (a) the supply of labor to the firm is of constant elasticity with respect to annual earnings at the firm; and (b) the marginal risk premium, $dL(w(s))/dw(s)$, is proportional to the logarithmic difference of w(s) from the ex-ante mean level of earnings (as might be the case if employees are averse to percentage uncertainty in their earnings), equation (16) can be rewritten as

(17) $\log[w(s)] = \left[\dfrac{\varepsilon}{\varepsilon+R}\right]\log[P(s)F'(s)] + \left[\dfrac{R}{\varepsilon+R}\right]\log[Ew],$

where ε again denotes the elasticity of labor supply to the firm, R is a measure of employees' aversion to income uncertainty, and Ew is the ex-ante mean level of earnings for the firm's employees.[32] Finally, on the assumption that firm's production functions are CES, equation (17) would take the particularly simple form of

(18) $\log[w(s)] = c + \left[\dfrac{\varepsilon}{\varepsilon+R}\right]\log[P(s)] + \left[\dfrac{\varepsilon}{\sigma(\varepsilon+R)}\right]\log\left[\dfrac{F(s)}{N(s)}\right] + \left[\dfrac{\varepsilon}{\varepsilon+R}\right]\left[\dfrac{1-\sigma}{\sigma}\right]\left[\dfrac{1-\nu}{\nu}\right]\log[F(s)] + \left[\dfrac{R}{\varepsilon+R}\right]\log[Ew]$

where F(s) denotes output in state s and c denotes a constant.[33]

Interpreted in a time-series context, equation (18) suggests the following estimating equation:

(19) $\log[w(t)] = c + \gamma\log[P(t)] + \dfrac{\gamma}{\sigma}\log\left[\dfrac{F(t)}{N(t)}\right] + \gamma\left[\dfrac{1-\sigma}{\sigma}\right]\left[\dfrac{1-\nu}{\nu}\right]\log F(t) + (1-\gamma)\log[Ew(t)] + u_t$,

where u_t is a regression disturbance term, and where γ can be interpreted as an elasticity of annual earnings with respect to annual marginal value products, holding expected earnings constant. If the labor market operated as an auction, with employees always paid the value of their marginal product, then estimates of equation (19) should result in estimated values of γ near unity. In this case, equation (19) could be interpreted as just a renormalized version of the Arrow-Chenery-Minhas-Solow equation, but without the assumption of constant returns to scale and without the imposed restriction

that γ equal unity.   Alternatively, if firms offered contracts which stabilized

employees' income in the manner assumed by equation (11), then estimates

of γ should be less than unity, with the difference from unity reflecting the

degree to which employees' income is stabilized by firms.   Thus, at the price

of some additional assumptions about the form of employees' aversion to income

uncertainty and about the labor supply curve facing the firm, CES production

functions can be estimated in a manner that allows for the presence of income

insurance.   More importantly for the purpose at hand, these assumptions allow

direct measurement of the extent to which firms stabilize employee income.

Presented below in Table 2 are estimates from the following version of
equation (19):

$$(20) \quad \log[w(t)] = \alpha_0 + \alpha_1 t + \alpha_2 t^2 + \gamma \log[P(t)] + \frac{\gamma}{\sigma} \log\left[\frac{F(t)}{N(t)}\right] + \gamma \left[\frac{1-\sigma}{\sigma}\right]\left[\frac{1-\nu}{\nu}\right] \log[F(t)] + u_t \quad ,$$

where t denotes time measured in years.

TABLE 2

ESTIMATES OF EQUATION (20) FOR U.S. MANUFACTURING, 1954-1976:

$$\log[w(t)] = \alpha_0 + \alpha_1 t + \alpha_2 t^2 + \gamma \log[P(t)] + \frac{\gamma}{\sigma} \log\left[\frac{F(t)}{N(t)}\right] + \gamma \left[\frac{1-\sigma}{\sigma}\right]\left[\frac{1-\nu}{\nu}\right] \log[F(t)] + u_t$$

Coefficient	α_0	α_1	α_2	γ	γ/σ	$\gamma\left[\frac{1-\sigma}{\sigma}\right]\left[\frac{1-\nu}{\nu}\right]$
Coefficient estimate	2.409	−.011	−.0003	.221	.787	.055
Standard error	(1.452)	(.008)	(.0001)	(.111)	(.151)	(.039)
R^2	.9923					
Durbin Watson	1.7792					
F(5,17)	438.158					

Definition of variables and source: see Appendix

The estimates presented in Table 2 are based on the same data as underlie Table 1--U.S. manufacturing industries, 1954 to 1976. In place of the variable $Ew(t)$, the regression reported in Table 2 includes a quadratic time trend. Given that $Ew(t)$ is intended to reflect conditions of labor supply, which may be expected to change only gradually over time, the use of a time trend in place of $Ew(t)$ seems reasonable. A quadratic function was chosen to allow for the changing industrial, demographic, and skill composition of the labor force over the sample period.

The estimates in Table 2 were derived by an instrumental variables estimation method in order to allow for possible endogeneity of the explanatory variables. Auxiliary regressions were first performed for the logarithms of product price, output, and output per production worker. Fitted values from these regressions were then used to estimate equation (20). In addition to a quadratic time trend, the auxiliary regressions included as explanatory variables the logarithms of the current and previous year's values of: (a) net new orders for manufacturing establishments; and (b) an index of help-wanted newspaper advertisements. All nominal values were deflated by the Consumer Price Index (all items). The maintained assumption, of course, is that these variables are uncorrelated with the error term in equation (20), although correlated with product price, output, and output per production worker. There is little question about the latter,[35] but the assumption of zero correlation with the error term in equation (20) is subject to some doubt. However, given that short run, cyclical deviations from trend are more likely to be demand-induced than labor-supply-induced, it seems reasonable to assume that these variables mainly reflect variation in product demand that is exogenous to the wage paid in manufacturing.

The diagnostic statistics reported in Table 2 are self-explanatory and require little comment. The only questionable statistic is the Durbin-Watson statistic, which lies toward the upper tail of the inconclusive region for a test of positive autocorrelation in the residuals. Equation (20) was also estimated by a Cochrane-Orcutt procedure to account for the possibility of autocorrelated errors, but the resulting estimate of the auto-correlation coefficient was only .149, with a standard error of .211. Further, the estimates of all coefficients were virtually unchanged and the standard errors were increased only slightly when the presence of autocorrelated disturbances was allowed for. If autocorrelation is present in true regression disturbances, it is not significant enough to alter any conclusions based on the estimates in Table 2. Therefore the following discussion will focus only on the estimates shown in Table 2.

Conditional on the maintained assumptions underlying equation (20), the estimates in Table 2 offer support for the income insurance hypothesis. Contrary to the predictions of an auction model of the labor market, percentage changes in product price do not translate into equal percentage changes in annual earnings when annual marginal products are held constant. Indeed, according to the estimates in Table 2, the elasticity of annual earnings with respect to annual marginal value products is only .221. Thus, for the data underlying Tables 1 and 2, annual earnings appear to be roughly only one-fifth as responsive to annual marginal value products as an auction model of the labor market would suggest.

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This estimated relation between annual earnings and annual marginal value products can be used to measure the relative variability of employees' annual marginal value products over the sample period. The fitted values from equation (20) provide yearly estimates of $\gamma \log PF' + (1-\gamma)\log Ew$, where Ew is a quadratic function

of time. Thus, if these fitted values are regressed on a quadratic function of time, the residuals from that regression will measure the percentage deviation of marginal value products from (quadratic) trend, multiplied by the factor γ. If these error terms are then divided by the estimated ŷ and exponentiated, the result will be an estimated series for employees' marginal value products, expressed relative to trend as in Table 1.

Table 3 below lists these estimated marginal value product relatives for production workers in U.S. manufacturing, 1954 to 1976. For purposes of comparison, the corresponding relative values of annual earnings of production workers are reprinted from Table 1. Table 3 also lists the ratios of the two series' yearly values, which can be interpreted as measuring the relative difference between annual earnings and annual marginal value products over the sample period.[37]

TABLE 3

VALUES OF ANNUAL EARNINGS AND ANNUAL MARGINAL VALUE PRODUCTS
EXPRESSED RELATIVE TO TREND: U.S. MANUFACTURING
PRODUCTION WORKERS, 1954-1976

Year	Annual Marginal Value Product	Annual Earnings	Annual Earnings ÷ Annual Marginal Value Product
1954	.963	.991	1.029
1955-57	1.038	1.012	.975
1958	.904	.981	1.085
1959	1.049	.999	.952
1960-62	.956	.983	1.028
1963-69	1.032	1.009	.978
1970-71	.913	.979	1.072
1972-74	1.053	1.013	.962
1975	.902	.977	1.083
1976	1.025	1.008	.983

Definition of variables and source: see Appendix.

Taken together, Tables 1 and 3 offer consistent support for the income insurance hypothesis. Annual earnings and annual marginal value products are related in the manner suggested by Figure 3. [38] Also, the relation between layoffs and the excess of annual earnings over annual marginal value products is as shown in that figure. At this aggregate level, the data are strongly consistent with the hypothesis that firms reduce the extent to which wages reflect marginal value products and, consequently, rely on layoffs to induce separations in periods of low product demand.

More detailed evidence related to this phenomenon is presented below in Table 4. Table 4 presents estimates of equation (20) for eighteen two-digit U.S. Manufacturing industries. The estimates again are based on annual data for the period 1954 to 1976. In basic form, the method of estimation used for Table 4 was the same as that used for Table 2. There are three differences, however. First, in addition to net new orders and an index of help wanted newspaper advertisements, the regressions reported in Table 4 included as first-stage instrumental variables the logarithms of value added and average annual production worker earnings for all manufacturing industries other than that for which estimates were being derived. Second, many of the regressions reported in Table 4 were estimated by a Cochrane-Orcutt procedure to allow for autocorrelated disturbances. The decision to correct for first- or second-order autocorrelation was based on an F-test with significance level of .05. Third, in order to conserve degrees of freedom, the equations underlying Table 4 imposed the restriction of constant returns to scale, except where estimated values of $\frac{(1-\sigma)}{\sigma}\frac{(1-\upsilon)}{\upsilon}$ were statistically non-zero at a significance level .05. [39]

The estimates of equation (20) presented in Table 4, like those in Table 2, support the hypothesis that firms insure employees' earnings. In fourteen of the eighteen industries studied, the estimated elasticity of

TABLE 4

ESTIMATES FROM EQUATION (20) FOR SELECTED TWO-DIGIT INDUSTRIES, 1954-1976[a]

$$\log[w(t)] = a_0 + a_k t + a_2 t^2 + \gamma \log\left[\frac{F(t)}{N(t)}\right] + \frac{\gamma}{\sigma}\log[P(t)] + \gamma\frac{[1-\alpha][1-\nu]}{\nu}\log[F(t)] + u_t$$

Industry	γ	γ/σ	R^2	Durbin-Watson	Industry	γ	γ/σ	R^2	Durbin-Watson
20**	-.019 (.1510)	.695 (.128)	.9940	2.2525	29*	-.051 (.045)	.595 (.133)	.9752	2.0087
21*	0.085 (.189)	.334 (.104)	.9929	1.8652	30	1.044 (.313)	1.155 (.265)	.8728	1.8682
22**	.458 (.079)	.135 (.089)	.9945	1.8393	31	1.084 (.245)	1.284 (.271)	.9315	1.7804
23	1.122 (.198)	1.102 (.336)	.9709	1.8253	32*	.298 (.100)	.310 (.172)	.9886	2.1663
24*	.417 (.043)	.575 (.084)	.9918	2.0562	33*	.103 (.058)	.744 (.107)	.9922	2.0776
25**	.499 (.063)	.607 (.083)	.9905	1.8089	34*	-.141 (.205)	-.399 (.474)	.8393	1.5112
26**	.126 (.039)	.535 (.087)	.9938	2.0217	35*	.661 (.104)	.707 (.098)	.9901	2.1038
27*	.785 (.253)	.536 (.151)	.9700	1.8078	36*	.622 (.068)	.823 (.088)	.9892	1.9710
28	.045 (.052)	.420 (.054)	.9959	2.2133	37	.577 (.123)	.565 (.069)	.9914	1.9946

[a]Estimates for all industries other than 22, 32, 33, 34, and 37 assume constant returns to scale (on the basis of an F-test with significance level .05).

*denotes Cochrane-Orcutt correction for first-order autocorrelation of residuals.

**denotes Cochrane-Orcutt correction for second-order autocorrelation of residuals.

Definition of variables and source: see Appendix

earnings with respect to marginal value products, γ, lies more than two standard errors below unity. For six of those fourteen, the estimated value of γ lies within two standard errors of zero. The remaining eight industries' estimates of γ are fairly uniformly distributed over the unit interval.

It is interesting to note the diversity in the estimated degrees of income insurance present in the industries listed in Table 4. In the absence of any recognition of labor mobility, one would have to explain this diversity by an appeal to inter-industry differences in risk aversion on the part of employees or employers. When labor mobility is recognized, however, these differences can, at least potentially, be related to observable variables.

According to equation (11), the response of wages to changes in marginal value products will be smaller as the elasticity of labor supply to the firm is smaller. In the presence of highly inelastic labor supply, the marginal benefit from a wage reduction will be low, since the marginal labor supply response to that wage reduction will be low. Therefore, the firm will be discouraged from varying wages in response to changes in product demand.

A special case of this general principle occurs when there exist fixed costs of interfirm labor mobility which are significant in relation to the potential benefits from such mobility. For reductions in product demand sufficiently limited or temporary in nature that the present value of the benefits from labor mobility remain less than the cost of interfirm mobility, the relevant elasticity of labor supply to the firm would be determined by the distribution of employees' values of leisure. If that distribution were very dense over some small range considerably below the firm's mean wage and were of small density in the region of the firm's mean wage, then: (a) the

relevant, local elasticity of labor supply to the firm would be near zero; and (b) the potential efficiency loss from laying off an employee would be small, since the difference between employees' values of leisure would be small. For temporary, limited reductions in product demand or extensive fixed costs of interfirm mobility, therefore, layoffs would dominate wage reductions as a means of employment adjustment. It follows that, for any given distribution determining the size and duration of shocks to product demand, the larger the fixed cost of interfirm labor mobility, the less likely would be a wage-induced employment response and the more likely would be a response by way of layoffs. Also, given any distribution of mobility costs among firms in an industry, the larger the average cost of mobility, the smaller would be the average response of wages to changes in marginal value products.

This argument can be extended to the presence of firm- or industry-specific human capital as well. Interpreting the mobility-induced depreciation of human capital as a fixed cost of labor mobility, the above reasoning suggests that industries with a greater degree of specificity in the human capital of their employees should have lower estimated values of γ. Further, given any positive relation between the specific and general components of human capital, this reasoning suggests also that industries with higher average annual earnings should have lower estimated values of γ.[40]

Although the evidence is not conclusive, it is interesting to note that the estimated values of γ in Table 4 are negatively related to the mean annual earnings (over the sample period) of production workers in those industries. A simple regression of the estimated values of γ in Table 4 on the average real annual earnings of production workers in the corresponding industries yields the results shown below in Table 5.

TABLE 5

ESTIMATES OF THE RELATION BETWEEN ESTIMATED VALUES OF γ FROM TABLE 4
AND MEAN ANNUAL EARNINGS OF PRODUCTION WORKERS IN THE
CORRESPONDING INDUSTRY

$$\hat{\gamma} = \alpha_0 + \alpha_1 \text{ Mean Earnings}$$

Coefficient	α_0	α_1
Coefficient Estimate	1.460	-1.812
Standard Error	(.396)	(.692)
R^2	.3133	
$F(1,15)$	6.845	

Definition of variables and source: see Appendix

More directly, for the seven industries having estimated values of γ
less than .15, the average real annual earnings of production workers is equal
to 6173, in comparison with an average of 4191 for the three industries
with estimated values of γ greater than .85, and an average of 5457 for the
remaining eight intermediate industries. Thus, on the hypothesis that general
and specific human capital are positively related, the estimates in Table 4
suggest that the extent of income insurance is greater in industries employing
more highly specific human capital.

This suggestion is made even more strongly when inter-industry variation
in employees' education is accounted for. Holding average annual earnings
constant, an increase in the median level of education in an industry can be
interpreted as reflecting an increase in the generally marketable component
of employees' human capital relative to the more specific, less easily
marketable component.[41] On this interpretation, therefore, industries with
higher median levels of education should have higher estimates of γ when

average earnings are held constant. Correspondingly, because inter-industry variation in mean earnings may reflect differences in either the general or specific component of employees' human capital, and because controlling for education would make inter-industry variation in mean earnings more reflective of inter-industry differences in specific human capital, any negative relation between mean earnings and estimated values of γ should be strengthened when education is controlled for.

As can be seen from the regression results in Table 6 below, the estimates in Table 4 are consistent also with this stronger set of hypotheses. The estimated coefficient on median education in the above regression is positive and, although statistically significant only at a level of .10, fairly large relative to the coefficient on mean earnings. Moreover, the inclusion of median education considerably strengthens the estimated negative relation between mean earnings and estimated values of γ. By focusing only on education and earnings, almost forty percent of the inter-industry variation in estimated values of γ can be accounted for.

TABLE 6

ESTIMATES OF THE RELATION BETWEEN ESTIMATED VALUES OF γ FROM TABLE 4
AND MEAN ANNUAL EARNINGS AND MEDIAN YEARS OF SCHOOLING
OF PRODUCTION WORKERS IN THE CORRESPONDING INDUSTRY

$$\hat{\gamma} = \alpha_0 + \alpha_1 \text{ Mean Earnings} + \alpha_2 \text{ Median Years of Schooling}$$

Coefficient	α_0	α_1	α_2
Coefficient Estimate	-.043	-2.527	1.608
Standard Error	(1.149)	(.847)	(1.158)
R^2	.3964		
F(2,14)	4.597		

Definition of variables and source: see Appendix

Evidence of the relation between income insurance and specific human capital also can be seen in the relation between the estimated values of γ in Table 4 and the median job tenure of male employees in the corresponding industries. On the assumption that inter-industry variation in median job tenure reflects inter-industry differences in human capital specificity, the previous discussion would suggest a negative relation between estimated values of γ and median job tenure. The estimates in Table 4 are clearly consistent with this hypothesis, as can be seen from the regression results shown below in Table 7. Over one-fourth of the inter-industry variation in estimated values of γ can be explained by inter-industry variation in median job tenure.[42]

TABLE 7

ESTIMATES OF THE RELATION BETWEEN ESTIMATED VALUES OF γ FROM TABLE 4
AND MEDIAN JOB TENURE OF MALE EMPLOYEES IN THE
CORRESPONDING INDUSTRY

$$\hat{\gamma} = \alpha_0 + \alpha_1 \text{Median Tenure}$$

Coefficient	α_0	α_1
Coefficient Estimate	.920	-.779
Standard Error	(.223)	(.339)
R^2	.2604	
$F(1,15)$	5.282	

Definition of variables and source: see Appendix

The estimated values of γ in Table 4 reflect also on the relevance of equation (II-8) in explaining inter-industry differences in layoff rates. As discussed in Section I the presence of income insurance implies the use of layoffs as a means of reducing employment in periods of sufficiently

low product demand. Further, the greater the degree of income insurance, the higher would be the critical state of demand below which layoffs become positive. Consequently, for any given interfirm distribution of product demand, industries with higher average degrees of income insurance also would have higher average layoff rates.

With reference to Table 4, the implication of these considerations is that estimated values of γ should be negatively related to average layoff rates, ceteris paribus. Marginal evidence of this relation can be seen below in Table 8. As the estimates below suggest, industries in which layoffs comprise a larger share of total separations tend to have higher degrees of income insurance (lower estimated values of γ). Equivalently, industries with high degrees of income insurance tend to rely more on layoffs to achieve a given level of separations.

TABLE 8

ESTIMATES OF THE RELATION BETWEEN ESTIMATED VALUES OF γ FROM TABLE 4
AND AVERAGE MONTHLY LAYOFF AND SEPARATION RATES IN THE
CORRESPONDING INDUSTRY

$$\hat{\gamma} = \alpha_0 + \alpha_1 \text{Mean layoff rate} + \alpha_2 \text{Mean Separation Rate}$$

Coefficient	α_0	α_1	α_2
Coefficient Estimate	.092	-2.217	1.606
Standard Error	(.321)	(1.704)	(.996)
R^2	.1506		
F(2,15)	1.330		

Definition of variables and source: see Appendix

Also, for a given average level of layoffs, industries with higher average levels of separations tend to have higher estimated values of γ.

In part, this may reflect the fact that industries with higher average levels of voluntary separations are those with relatively low degrees of specificity in employees' human capital. But it may also reflect the fact that industries with higher values of γ are more likely to respond to reductions in product demand by the use of wage reductions and so have higher average levels of voluntary separations.

The estimated values of γ presented in Table 4 are entirely consistent with the income insurance hypothesis. In absolute value, they are as the theory predicts, and perhaps more importantly, they vary across industries in a manner implied by the theory. Further, they appear to be related to inter-industry differences in layoff rates as the theory suggests they should be. In conjunction with Tables 1, 2, and 3, the evidence contained in Table 4 appears to warrant acceptance of the hypothesis that firms stabilize the income of their employees in a manner similar to that described by equation (11).[43]

The empirical analysis in this section suggests that firms supply income insurance to their employees by reducing the extent to which wages reflect marginal value products, and that firms consequently rely on layoffs to reduce employment in states of sufficiently low product demand. However, these results are based on a sequence of within-year comparisons of earnings and marginal value products. The analysis in this section has not considered either the dynamic or longer-term implications of the theory developed in Section I. The following section considers these implications and interprets the previous results within the broader context which these implications provide.

III. How Close to an Auction is the Labor Market?

Perhaps the most striking empirical finding of the previous section is the low estimated response of earnings to marginal value products. This low response seems to indicate that the labor market differs considerably from an auction, at least on a year-to-year basis. Whether the labor market differs from an auction on any longer-term basis remains to be seen, however.

In part, the low estimated values of Y in Tables 2 and 4 can be attributed to the inclusion of a time trend in equation (20). With a time trend included in the regression, the estimated value of Y reflects the movement of wages relative to trend that is induced by movements of marginal value products relative to trend. It does not reflect any longer term relation between wages and marginal value products that might be impounded in the time trend.[44] Thus, the low estimated values for Y in equation (20) are not necessarily inconsistent with a longer-term, trend equality of wages and marginal value products.

This distinction between short-run and long-run suggests that while estimates of equation (20) may reflect the presence of income insurance, they may not adequately describe the long-run characteristics of income insurance. Equation (20) assumes that employees' wage expectations are exogenous. However, with any sort of endogenous, lagged adjustment of wage expectations, such an assumption requires estimates of that equation to be interpreted only within an explicitly short-run context. Given enough time to adjust, or given enough forewarning, the utility loss suffered by employees as a result of initially unexpected changes in income might be expected to approach zero. This fact suggests that the response of wages to changes in marginal value products might be distributed over time, and that the long-run response might differ substantially from the short-term response.

Indeed, equation (19) assumes that the "long-run" elasticity of wages

with respect to (fully anticipated) changes in marginal value products is
unity. So long as expected wages change in proportion to marginal value
products, wages also will change in proportion to marginal value products.
Defining the long run as a period long enough for expectations to adjust fully,
the estimated "short-run" values of γ in Tables 2 and 4 are entirely consistent
with a long-run view of the labor market as an auction.

To elaborate with a specific example, assume that employees' wage
expectations evolve according to the adaptive scheme[45]

(21) $Ew(t) = \lambda w(t-1) + (1-\lambda)Ew(t-1)$.

In this case, by using equation (19) to express $Ew(t-1)$ as a function
of $PF'(t-1)$ and $w(t-1)$, and then substituting this expression into
equation (21) to express $Ew(t)$ as a function of those same variables,
equation (19) can be rewritten as

(22)
$$\log[w(t)] = \gamma\log[P(t)] + \frac{\gamma}{\sigma}\log\left[\frac{F(t)}{N(t)}\right] + \gamma\left[\frac{1-\sigma}{\sigma}\right]\left[\frac{1-\nu}{\nu}\right]\log[F(t)]$$

$$-\gamma(1-\lambda)\log[P(t-1)]-\frac{\gamma}{\sigma}(1-\lambda)\log\left[\frac{F(t-1)}{N(t-1)}\right]-\gamma\left[\frac{1-\sigma}{\sigma}\right]\left[\frac{1-\nu}{\nu}\right](1-\lambda)\log[F(t-1)]$$

$$+(1-\lambda\gamma)\log[w(t-1)]+u_t$$

It can be seen from equation (22) that, so long as neither γ nor λ
is equal to unity, the effect on wages of a change in marginal value products
will be distributed over time. For equation (22), the short-term elasticity
of wages with respect to marginal value products is equal to γ, while the
long-run elasticity (found by setting $w = Ew$ in equation [19]) is equal
to unity. Only in the case where γ or λ equals unity will short-run and
long-run elasticities coincide.

If the labor market operated as an auction for all time intervals, then estimates of γ from equation (22) should be near unity, while estimated coefficients on lagged variables should be near zero. Alternatively, if the labor market operated as equation (20) implies, with no endogeneity of wage expectations, then estimated values of γ from equation (22) should be less than unity, while estimated coefficients on lagged variables again should be near zero. Finally, if employees' wage expectations were endogenous, so that employee aversion to initially unexpected income changes diminished with the extent of forewarning, then estimates of γ from equation (22) should be less than unity, while estimated coefficients on lagged variables should be non-zero and indicative of the time-distributed pattern of wage adjustment in response to changes in marginal value products.

Presented below in Table 9 are estimates from equation (22) based on the same data as underlie Tables 1, 2, and 3.[46]

TABLE 9

ESTIMATES OF EQUATION (22) FOR U.S. MANUFACTURING, 1954-1976

$$\log[w(t)] = \alpha_0 + \gamma\log[P(t)] + \frac{\gamma}{\sigma}\log[\frac{F(t)}{N(t)}] - \gamma(1-\lambda)\log[P(t-1)]$$

$$-\frac{\gamma}{\sigma}(1-\lambda)\log[\frac{F(t-1)}{N(t-1)}] + (1-\lambda\gamma)\log[w(t-1)] + u_t$$

Coefficient	α_0	γ	γ/σ	$-\gamma(1-\lambda)$	$-\frac{\gamma}{\sigma}(1-\lambda)$	$(1-\lambda\gamma)$
Coefficient Estimate	−.634	.402	.766	−.116	−.588	.714
Standard Error	(.680)	(.265)	(.131)	(.252)	(.162)	(.170)
R^2	.9863					
Durbin-Watson	1.8451					
F(5,16)	239.224					

Definition of variables and source: see Appendix

It is interesting to note that, although there is no a priori justification for equation (21) as a description of employees' expectations, the estimated coefficients on current price, lagged price, and lagged wage in equation (22) come very close to satisfying the restrictions implied by equations (19) and (21). According to equation (22), the sum of the coefficients on current price, lagged price, and lagged wage should be equal to unity. The sum of the estimates of those coefficients from Table 9 is equal to 1.0005. However, the estimated coefficients on current and lagged output per production worker are less consistent with the restrictions implied by equation (22). According to that equation, the ratio of the coefficients on current price and current output per production worker should equal the ratio of the coefficients on lagged price and lagged output per production worker. For the estimates in Table 9, the former ratio is equal to .524, while the latter ratio is equal to .197. However, an increase in the estimated coefficient on lagged price of less than three-fourths of its standard error would equate the two ratios. Thus, although the estimated coefficients in Table 9 are not exactly consistent with the interpretation given them by equation (22), they are close enough to suggest that equation (21) might provide a reasonable approximation to the evolution of employees' wage expectations over time.[47]

This interpretation of the estimates in Table 9 is subject to two questions. First, it is possible that the estimated coefficients on lagged variables simply reflect the effects of autocorrelated disturbances. Second, the general form of equation (22) is consistent with interpretations other than that suggested by equations (19) and (21).

To address the first question, notice that if the proper specification of equation (19) were given by

$$(23) \log[w(t)] = \underset{0}{\text{c}} + \gamma\log[P(t)] + \underset{\sigma}{\underline{\gamma}}\log[\frac{F(t)}{N(t)}] + u(t)$$

where: $u(t) = \rho u(t-1) + v(t)$,

then, written in autoregressive form, equation (19) would become

$$(24) \quad \log w(t) = \gamma\log[P(t)] + \underset{\sigma}{\underline{\gamma}}\log[\frac{F(t)}{N(t)}] - \rho\gamma\log[P(t-1)]$$

$$-\underset{\sigma}{\underline{\rho\gamma}}\log[\frac{F(t-1)}{N(t-1)}] + \rho\log[w(t-1)] + v(t)$$

which is identical in form to equation (22), but which implies different restrictions on the estimated coefficients. In particular, if equation (23) is true, the product of the estimated coefficients on current price and lagged wage should equal the negative of the coefficient on lagged price, and the product of the coefficients on current output per production worker and lagged wage should equal the negative of the coefficient on lagged output per produduction worker. Thus, the estimated coefficients in Table 9 can provide a basis for distinguishing between equations (22) and (24).[48]

But on this subject, the evidence provided by Table 9 is mixed. In absolute value, the product of the coefficients on current price and lagged wage exceed the coefficient on lagged price by .171, a difference which is almost exactly consistent with equation (22). In contrast, the product of the coefficients on current output per production worker and lagged wage differ from the coefficient on lagged output per production worker by only .041, a difference more consistent with equation (24) than with equation (22). Further, any use of the estimates in Table 9 to distinguish

between equations (22) and (24) is hampered by the fact that the implications
of the two equations are too similar for the data underlying Table 9 to allow
a test with much power. However, a Durbin h-test for serial correlation
yields a value of .602, which is significant only at a level of .275. Thus,
although the estimates in Table 9 should be interpreted with caution, it
appears reasonable at this stage to interpret them as more than the result of
misspecification, and to interpret them as they stand.[49]

The second question mentioned above is less easily addressed. There
is no guarantee that estimated coefficients from equation (22) do not simply
reflect costs of wage adjustment that have nothing to do with employees'
aversion to income uncertainty. Thus, although the estimates from equation (22)
(and equation [20], for that matter) are consistent with the income insurance
hypothesis, they cannot be taken as conclusive proof that income insurance
exists.[50]

Nevertheless, regardless of the true underlying structure of wage
adjustment and employees' wage expectations, equation (22) can be justified
on the more general grounds that it is capable of approximating a wide
variety of distributed lag patterns for the effect of changes in marginal
value products on current and subsequent wages. Ex post, it can be justified
on the grounds that it fits the data as well as do models which allow for
more complicated lag structures.[51] Thus, one need not accept the interpre-
tation of equation (22) implied by equations (19) and (21) in order to
accept equation (22) as a reasonable basis for estimating the time-distributed
response of wages to changes in marginal value products, and for testing
whether the long-run response of wages to marginal value products differs
from the short-run response in a manner consistent with the income insurance
hypothesis.

Therefore, consider the implications of the estimates in Table 9 for the time-distributed response of wages to changes in marginal value products. The estimated coefficient of .402 on current product price indicates that, holding the previous year's wage and marginal value product constant, a ten percent increase in product price would lead to a four percent increase in wages. In the following year, assuming that product price remained at its current level and assuming for simplicity that marginal products remained constant, wages would rise by an additional .171 percent (equal to $\frac{\partial w(t+1)}{\partial P(t)} + \frac{\partial w(t+1)}{\partial w(t)} \frac{\partial w(t)}{\partial P(t)}$). On the same assumptions, wages would increase in the next period by a further .714 of .171 percent (equal to $\frac{\partial w(t+2)}{\partial w(t+1)} [\frac{\partial w(t+1)}{\partial P(t)} + \frac{\partial w(t+1)}{\partial w(t)}\frac{\partial w(t)}{\partial P(t)}])$, and so on. Ultimately, the complete long-run response of wages would be given by $[\frac{\partial w(t)}{\partial P(t)} + \frac{\partial w(t)}{\partial P(t-1)}]/[1-\frac{\partial w(t)}{\partial w(t-1)}]$, which for these data is equal to 1.0015. That is, the estimated coefficients from equation (22) imply that the long-run elasticity of wages with respect to marginal value products is unity, just as an auction model of the labor market would predict. The short-run elasticity of .402 is significantly lower, however, and is consistent with the income insurance hypothesis.[52]

The question "How close to an auction is the labor market?", then, is perhaps better posed as "How long does it take wages to respond to changes in marginal value products as they would respond in an auction market?" The estimated coefficients from equation (22) provide an answer to this question. Listed below in Table 10 are various measures (implied by the estimates in Table 9) of the effects of changes in annual marginal value products on current and subsequent annual earnings.

Column one of Table 10 lists the estimated effect on earnings at time t of a permanent, unit increase in marginal value products at time zero. Column

two lists the cumulative totals of these effects at time t, divided by the number t+1. Column three is derived from column one by multiplying the elements of column one by the factor $(1+r)^{-t}$, where r is assumed equal to .10. Column four lists the cumulative totals of column three, divided by the factors $\sum_{j=0}^{t} (1+r)^{-j}$, where r is again assumed equal to .10.

TABLE 10

ESTIMATED EFFECTS OF A PERMANENT, UNIT INCREASE IN ANNUAL MARGINAL
VALUE PRODUCTS ON SUBSEQUENT ANNUAL EARNINGS AND REALIZED
WEALTH: U.S. MANUFACTURING 1954-1976

Period	Direct Effect	Cumulated Effect as a Percentage of Auction Market Effect	Discounted Direct Effect	Cumulated Discounted Direct Effect as a Percentage of Auction Market Effect
0	.402	.402	.402	.402
1	.573	.488	.521	.483
2	.695	.557	.574	.547
3	.782	.613	.587	.598
4	.844	.659	.576	.638
5	.888	.697	.551	.670
10	.979	.814	.378	.762
15	.996	.869	.238	.801
20	.998	.900	.149	.819

Definition of variables and source: see Appendix

As column one of Table 10 shows, almost eighty-five percent of the unit-elastic response of wages to changes in marginal value products is achieved within five years of the initial shock. Almost ninety percent is achieved within six years. The mean lag for the effect of a change in marginal value products on wages is equal to 1.811 years, and, as column one clearly

shows, the distribution of lagged effects is heavily weighted toward short lags. Thus, although the labor market appears not to operate as an auction in a short-run sense, these data indicate that, at the margin, it may be reasonably modeled as an auction for time intervals on the order of five years' length.

But while the "marginal" deviation of wages from marginal value products diminishes fairly rapidly, the cumulative deviation remains. Thus, while a permanent ten percent increase in marginal value products would lead to an 8.8 percent increase in wages by the end of those six years (column one), the cumulative effect on wages over those six years would be only seventy percent of the cumulative increase in marginal value products (column two). Discounted at a rate of ten percent, the present value of the cumulated effect on wages would be only sixty-seven percent of the cumulated increase in marginal value products (column four). Cumulating over a twenty year period, the present value of the future wage changes induced by a permanent, time-zero increase in marginal value products would be equal to ninety percent of the auction result at a zero rate of interest (column two), and equal to only eighty-two percent of the auction result at a ten percent rate of interest (column four).

As the estimates in Table 10 show, the labor market returns fairly rapidly to the equality of wages and marginal value products. But the interim period of inequality between wages and marginal value products reduces the wealth effect corresponding to any given permanent change in marginal value products by ten to twenty percent. Although the effects of income insurance on employee income and the allocation of labor disappear in the long run, the stabilizing effect on employees' realized wealth remains. In answer to the

question posed by this section, the analysis indicates that the labor market does operate as an auction, but with an adjustment period of around six years. This period of partial adjustment reduces the potential variability of employees' realized wealth by approximately ten to twenty percent. In the short-run, the labor market appears to differ from an auction market both in terms of factor rewards and in terms of factor allocation. In the long-run, it appears to differ only in terms of realized wealth.

Appendix.   Sources and Definitions of Variables Used in the Empirical Analysis

Listed below by table are sources and definitions for the variables referred to in the text.

Table 1, page 24

Relative values for profit per production worker, annual earnings of production workers, and value-added per production worker were constructed by regressing the logarithm of the variable in question on a constant, time, and time squared, averaging the deviations within the given periods, and then exponentiating those averages. The relative values for layoff rates were constructed by regressing the layoff rate on a constant, time, and time squared, expressing the actual values relative to fitted values, and then taking a geometric average of those relative values within the given periods.

"Real" values were formed by deflating nominal values by the Consumer Price Index (all items).

Data for production workers (as opposed to all employees) were chosen to avoid possible biases due to cyclical changes in the composition of manufacturing employment.

Annual values of residual income (before taxes) were taken from various issues of U.S. Federal Trade Commission, Quarterly Financial Report for Manufacturing, Mining, and Trade Corporations, Table A1, "Income Statement for Corporations Included in:"

Annual values of production worker employment, production worker earnings, and value added were taken from the U.S. Department of Commerce, Bureau of the Census 1972 Census of Manufactures and from the 1974 and 1976 Annual Survey of Manufactures, General Statistics for Industry Groups and

Industries. Annual averages of monthly layoff rates were taken from U.S.

Department of Labor, Bureau of Labor Statistics Employment and Earnings,

1909-1975 and recent issues of Employment and Earnings.

These sources apply both for two-digit industries and for the aggregate

of all manufacturing industries.

Table 2, page 30

The variable w(t) was formed by taking the ratio of annual wage payments

to production workers and annual employment of production workers (sources

listed above for Table 1).

The variable P(t) was formed by taking the ratio of annual value-added

to an index of industrial production, (F(t)) (sources listed above for Table 1).

Annual indices of industrial production were taken from: Board of

Governors of the Federal Reserve System, Industrial Production: 1976 revision.

Annual values of net new orders for manufacturing corporations and an

index of help-wanted newspaper advertisements were taken from Business

Statistics: 1977 Supplement to the Survey of Current Business.

Table 3, page 33

Sources and definitions are listed above for Tables 1 and 2. The

derivation of column one is discussed in the text.

Table 4, page 35

Sources and definitions are listed above for Tables 1 and 2.

Table 5, page 38

Mean annual earnings for each industry (except 21) were computed by

averaging the variable w(t) for the years 1954 through 1976.

Table 6, page 39

Values of median years of schooling for each industry (except 21, for

which data were not available) were taken from U.S. Bureau of Labor Statistics
, Special Labor Force Report #103: Educational Attainment of Workers, March 1968.
Other sources and definitions are listed above for Tables 1, 2, and 5. Education
is measured in 10-year units.

Table 7, page 40

Values of median job tenure of male employees for each industry (except 21,
for which data were not available) were taken from U.S. Bureau of Labor
Statistics, Special Labor Force Report #112: Job Tenure of Workers, January
1968. Other sources and definitions are listed above for Tables 1, 2, 5, and 6.
Tenure is measured in 10-year units.

Table 8, page 41

Annual averages of monthly layoff and separation rates were taken from
U.S. Department of Labor, Bureau of Labor Statistics, Employment and Earnings,
1909-1975 and recent issues of Employment and Earnings. These annual averages
were then averaged over the period 1954 through 1976.

Table 9, page 45

Sources and definitions are listed above for Table 2.

Table 10, page 50

These estimates are implied by the estimated coefficients in Table 9.
For sources and definitions of the underlying variables, see the
listing for Table 2 above. For a description of the method by which these
estimates were formed, see the text.

FOOTNOTES

1

See, for example, the work of Azariadis (1975, 1976, 1978), Baily (1974), 1977, 1977), Feldstein (1974, 1975, 1976, 1978), Gordon, Grossman, Polemarchakis, and Polemarchakis and Weiss.

2

In this context, see the papers by Azariadis, Baily (1974), Grossman, Gordon, Polemarchakis, and Polemarchakis and Weiss, listed above.

3

See, for example, Azariadis (1975, 1976), Baily (1974), and Polemarchakis. Although these authors recognize that state-invariant wages might not be optimal where wages influence the ex post allocation of labor among firms, their analyses do not relax the separation of ex post interfirm wage differences and ex post interfirm labor mobility, and do not explore the determination of optimal wages and layoffs in situations where completely state invariant wages are not optimal. Some previous authors have allowed for ex post interfirm labor mobility and ex post wage variability (see, for example, Grossman, and Akerlof and Miyazaki), but as yet the optimal extent of ex post wage variability has not been analyzed.

4

Akerlof and Miyazaki also have made this point.

5

No credit can be claimed for the basic structure of the model that is developed in this section. In major respects it is identical to that developed by Baily (1974) and Azariadis (1975). However, the extension of this model to allow for ex post interfirm labor mobility is original to this author. For a first analysis along these lines, see Brown (1976).

6

Although identical in productivity at their current employment, employees of the firm may differ in productive characteristics of value elsewhere. Consequently, there may be a distribution of best alternative employments and alternative earnings among the firm's employees. If the firm's employees are assumed to be identical in all respects, this distribution should be interpreted as a short run phenomenon due to limited information.

The presence of severance pay in this model constitutes a second important departure from the assumptions standard in previous analyses of income-insuring labor contracts. Non-wage payments to laid-off workers are a widespread practice, but their inclusion in the model does more than simply add realism to the analysis. The existence of such state-contingent supplementary payments significantly alters the implications of the model with respect to both the extent and mix of wage reductions and layoffs which the firm makes in states of slack product demand. It can be shown, in fact, that such payments are necessary if layoffs are to be an element of the optimal contract. Further, the model provides a natural justification for such payments in their effect on the optimal degree of efficiency in production and resource allocation. The absence of such payments in previous analyses is somewhat puzzling, given that such payments may considerably reduce the degree of income uncertainty implied by any given degree of employment uncertainty.

7

An alternative assumption would be that the firm pays all employees laid off in a given state some fixed payment independent of the value of the next best alternative which is realized. This alternative assumption was rejected for two reasons. First, it would not allow the firm to stabilize employee income as effectively as does the separation pay policy assumed in the text. It therefore appears that this alternative policy would be dominated by a policy of the sort assumed in the text, at least within the context of the assumptions underlying the present analysis. Second, given the limitations imposed by the single-period framework of the model developed in the text, the separation pay policy assumed does a better job of approximating the manner in which payments made to laid off workers depend on those workers' realized alternatives (e.g., on how long workers remain unemployed before being reemployed).

8

For simplicity, the analysis assumes that a unique distribution of demand at other firms exists, and that the realized state of demand for the firm's product is simply a drawing from this distribution. This assumption makes the supply of labor to the firm deterministic within each state of demand for the firm's product, and it insures that maximizing over all states of own product demand is the same as maximizing over all distributions of demand.

9
Letting $f(v)$ denote the probability density function for alternative earnings within the firm's initial labor force, $N(s)$ would be given by

$$\int_0^{\lambda(s)+c} f(v)dv, \text{ where } \lambda(s) = (1-\ell(s))w(s)+\ell(s)g(s),$$ where c denotes a

fixed cost of interfirm mobility, and where $\ell(s)$, $w(s)$, and $g(s)$ are as defined below.

10

Again letting $f(v)$ denote the probability density function for alternative earnings within the firm's initial labor force, $w_\ell(s)$ would be given by

$$\int_0^{\lambda(s)+c} (v-c)f(v)dv \div \int_0^{\lambda(s)+c} f(v)dv, \text{ where } \lambda(s) \text{ is as defined above.}$$

11
Given the utility function $U(w)$, the level of utility corresponding to any given level of income can be approximated by

$$U(w) = U(Ew) + U'(Ew)(w-Ew) + \frac{1}{2}U''(Ew)(w-Ew)^2.$$

Dividing by $U'(Ew)$ yields

$$\frac{U(w)}{U'(Ew)} = \left[\frac{U(Ew)}{U'(Ew)} - Ew \right] + w + \frac{1}{2}\frac{U''(Ew)}{U'(Ew)}(w-Ew)^2.$$

Interpreting equation (2) as an expected-utility-constant constraint, it can be seen from this last expression that $L(w(s))$ is equivalent to $-\frac{1}{2}\frac{U''(Ew)}{U'(Ew)}(w(s)-Ew)^2$.

The expected value of this term can be interpreted as the risk premium which the firm must pay its employees in order to attract them at the start of the period, given the wage and employment schedule which it offers its employees. Employee aversion to income uncertainty implies that $L(w)$ will increase as w diverges from its ex ante mean level. Thus, the firm's risk premium will increase as the uncertainty of the income prospect which it offers its employees increases.

12

Defining $f(v)$ and $\lambda(s)$ as above, $w(s)$ is given by

$$\int_{\lambda(s)+c}^{\infty} (v-c)f(v)dv \div \int_{\lambda(s)+c}^{q} f(v)dv \ .$$

13

Again defining $f(v)$ and $\lambda(s)$ as above, $L(s)$ is given by

$$\int_{\lambda(s)+c}^{\infty} L(v-c)f(v)dv \div \int_{\lambda(s)+c}^{q} f(v)dv \ .$$

14

This implication follows from the fact that the expected marginal value product of employees is diminishing in N, while expected costs of future relocation are increasing in N. Because the expected net risk-adjusted joint income of firms and employees is diminishing in N, equality at the margin will maximize the expected value of current and future aggregate net risk-adjusted income.

15

More precisely, conditions (6)-(9) jointly determine state-s income and employment for initial employees, but condition (6) does so only indirectly through its effect on employees' marginal products. The following analysis abstracts from randomness in the supply curve of new hires and assumes that the supply curve of new hires is not infinitely elastic.

16

Condition (6) is, of course, only trivially operative for states of demand in which additional hires are zero. In such states, if layoffs also are zero, condition (7) alone determines the optimal wage and, implicitly, optimal employment. If layoffs are positive, conditions (7)-(9) are determining.

17

Condition (10) is derived from condition (7) by setting $\dot{\lambda}(s)$ equal to zero in condition (7) and by noting that $\lambda(s)$ is equal to $w(s)$ when $\dot{\lambda}(s)$ is equal to zero.

18 These conditions are not extreme. The elasticity of labor supply to the firm will diminish as the firm's wage diverges from its mean value if the density of the alternative wage distribution among the firm's employees is greatest at the mean wage and falls as the firm's wage approaches extreme values. The marginal risk premium, $dL(w(s))/dw(s)$, will increase in absolute value as the firm's wage diverges from its mean if employees are averse to income variability or uncertainty, since $dL(w(s))/dw(s)$ is equal to $-\dfrac{U''(Ew)}{U'(Ew)} (w(s)-Ew)$.

19

This result follows from the fact that, defining $L(\cdot)$ as above, $dL(g(s))/dg(s)$ is equal to zero only if $g(s)$ is equal to Ew.

20

It is easily seen that conditions (7) and (8) both reduce to condition (10) when g(s) is set equal to w(s).

To understand this result, notice that the firm's payments to its employees are made responsive to product price only because of the effect of those payments on the labor supply realized by the firm. Now, after all quits for the period have occurred, and given the assumption embodied in the model that supplemental payments made to laid off workers do not influence those workers' search behavior, supplemental payments to laid off workers induce no labor supply response. Consequently, there is no reason not to eliminate that income uncertainty which results from being laid off, given that state s has occurred and given that the employee has not quit in state s. The optimal policy therefore makes employees indifferent to being laid off in any particular state.

This result rests on the assumption that severance payments made to laid off workers do not influence those workers' search behavior. In the absence of this assumption, it would not generally be profitable for severance payments to eliminate the income loss associated with layoff status.

21

Because this result rests on the equality of g(s) with w(s), it rests also on the assumptions underlying that equality.

22

The optimal layoff policy in the presence of fully compensating severance payments provides an interesting contrast to the optimal layoff policies in models for which severance pay is not an element of the labor contract (see, for example, Baily (1974) and Azariadis (1975, 1976). If severance pay is assumed not to exist, then the firm's layoff strategy will be directly influenced by employees' aversion to income uncertainty. In the absence of severance payments, the firm will hoard labor in periods of slack product demand in order to make work at the firm more attractive to current and prospective employees. The firm's layoff strategy will therefore be less efficient from the standpoint of production and resource allocation, sacrificing some productive efficiency in order to reduce income undertainty for employees. It will not generally be profitable for the firm to eliminate the risk of layoff, however, and so the firm will have to pay some premium to its employees in the form of higher mean earnings in order to compensate for whatever risk remains. This premium would be reduced if the firm were to make severance payments to its employees. It could be eliminated if those severance payments were fully compensating, as assumed in the text.

23

The relative allocative inefficiency implied by a layoff diminishes as the firm's wage is reduced because the difference $w - E[v \mid v < w]$ diminishes as the firm's wage is reduced.

24

In the absence of income insurance, the following equality would hold in equilibrium

$$\mu(s) + h(s)\frac{du(h(s))}{dh(s)} = P(s)F'(s) = w(s) .$$

Now, suppose that w(s) were reduced (e.g., in order to reduce the extent of unexpected wage increases in states of high demand) and h(s) increased so as to keep employment constant. In this case the following would be true

$$\mu(s) + h(s)\frac{du(h(s))}{dh(s)} > P(s)F'(s) ,$$

and h(s) would be reduced to restore equilibrium. Alternatively, if w(s) were increased (e.g. in order to reduce the extent of unexpected wage reduction in states of low demand) and h(s) reduced so as to keep employment constant, the following inequality would result

$$\mu(s)+h(s)\frac{du(h(s))}{dh(s)} < P(s)F'(s) \ ,$$

and h(s) would be increased to restore equilibrium. In either case, it would not be optimal to fully offset the effect of a change in the wage paid to initial employees. Only if μ(s) were independent of h(s) would complete offsetting be optimal.

[25]
Panel (b) assumes a stable distribution of alternative wages among the firm's employees, while panel (d) assumes a stable supply curve of new hires to the firm.

[26]
A precise description of the manner in which the numbers presented in Table 1 were derived can be found in the appendix.

[27]For the Cobb-Douglas production function, $F(K,N) \equiv AK^{\alpha}N^{\beta}$, annual residual income per employee in the absence of income insurance would be given by $(1-\alpha-\beta)PF(\ )/N$, and annual earnings per employee would be given by $\beta PF(\ )/N$. Taking the coefficient of variation as a measure of percentage variability, it can be seen from these expressions that in the absence of income insurance, the percentage variability of annual earnings and annual residual income per employee would be equal, and equal also to the percentage variability of value-added per employee. At the opposite extreme, if firms completely stabilized the wage income of their employees, residual income per employee would be given by $(1-\beta)PF(\ )/N - \overline{W}$, where $\overline{W}$ denotes the stabilized level of wage payments per employee. It is easily seen from this expression that in the presence of such complete income insurance, the percentage variability of residual income per employee (again measured by the coefficient of variation) would exceed the percentage variability of value added per employee by a factor equal to one plus the ratio of labor earnings to residual income.

[28]
For an alternative explanation which focuses on the role of unemployment insurance and imperfect experience rating in encouraging layoffs, see Baily (1977a, 1977b),Brechling, and Feldstein (1974, 1975, 1976, 1978).

[29]
For the CES production function given by

$$F(K,N) = A[\delta K^{-\rho}+(1-\delta)N^{-\rho}]^{-\nu/\rho} \ ,$$

the marginal value products of labor and capital are given by

$$PF_N = (1-\delta)\nu A^{-\rho/\nu} \, PF()^{(\rho+\nu)/\nu} \, N^{-(1+\rho)}$$

$$PF_K = \delta\nu A^{-\rho/\nu} \, PF()^{(\rho+\nu)/\nu} \, K^{-(1+\rho)} .$$

Using these expressions in the definition of profits yields

$$PF(K,N) - PF_K \, K - PF_N \, N = (1-\nu)PF(K,N).$$

Residual income in the absence of income insurance would be proportional to value added. Thus, residual income per production worker would be proportional to value added per production worker in the absence of income insurance, and both would have the same percentage variability.

30
    This is not a general result, but it is true for the data underlying Table 1.

31
    For a discussion of this subject, see Nerlove and the works cited therein. Also see Griliches (1967), Lucas, and Mayor.

32
    Expression (17) is derived from (16) by substituting $Rlog[w(s)/Ew]$ in place of $dL(w(s))/dw(s)$, and ε in place of $dlogN(s)/dlogw(s)$. For an example in which the assumption of $dL(w(s))/dw(s) = Rlog[w(s)/Ew]$ would be appropriate, consider the logarithmic utility function U $Klog[w]$. Recall that $L(w(s))$ is equal to $-\frac{1}{2}\frac{U''(Ew)}{U'(Ew)}[w(s)-Ew]^2$. For the logarithmic utility function this term would be equal to $\frac{1}{2Ew}[w(s)-Ew]^2$, and so $dL(w(s))/dw(s)$ would equal $[w(s)-Ew]/Ew$, which is approximately equal to $log[w(s)/Ew]$. In this case, R is equal to one.

33
    Approximation (18) results from substituting into approximation (17) the logarithm of the expression for PF_N in footnote 29.

34
    The Arrow-Chenery-Minhas-Solow equation estimates the elasticity of substitution in the following fashion:

$$log[F(t)/N(t)] = constant + \sigma log[w(t)/P(t)] + u_t$$

This formulation follows from setting $w = PF_N$ and $\nu=1$ in the expression for PF_N in footnote 29. For a more detailed discussion of this subject, see Arrow, et al.

35
    This statement is based on an F-test with a significance level of .01.

36

    This limited degree of response applies to annual averages of hourly and weekly earnings as well. Empirical evidence of this fact is available from the author upon request.

37

    The ratio of the relative values of annual earnings and annual marginal value products will equal the ratio of their absolute values if annual earnings and annual marginal value products follow the same trend. Equation (20) implies that they do follow the same trend.

38

    This statement interprets the "contracting period" of Section I to be of one year's length.

39

    The estimated coefficients presented in Table 4 do not differ significantly from those that allow for non-constant returns to scale in all industries. Also, they do not differ significantly from estimates based on annual averages of hourly or weekly earnings. The complete set of estimates from which those presented in Table 4 are drawn is available from the author upon request.

40

    See Mincer for evidence that general and specific human capital are positively related.

41

    See Parsons for a development of this argument.

42

    It is interesting to note that the estimated values of γ in Table 4 bear no systematic relation to the percentage of workers unionized in the corresponding industries. In contrast, empirical work from Lewis to Medoff suggests a negative relation.

43

    These conclusions are not altered when different sets of estimated values of γ are chosen. Alternative versions of Tables 5-8 corresponding to different sets of estimated values of γ are available from the author upon request.

44

    For example, if the time-series behavior of marginal value products were given by

$$PF'(t) = \alpha_0 + \alpha_1 t + \alpha_2 t^2 + u_t , \quad Eu_t = 0 ,$$

and if employees' wages in the presence of income insurance were given by

$$w(t) = \alpha_0 + \alpha_1 t + \alpha_2 t^2 + \gamma u_t ,$$

then estimates of equation (20) would indicate non-equality of wages and marginal value products even though longer-term, trend equality existed. It is worth repeating that the following analysis interprets the "contracting" period as being of one year's length, and thus equates "wages" with annual earnings.

45

No claim of originality is made here. For a previous example of this framework, see Cagan. This expectations model is assumed only for the purpose of illustration. It will not generally be an unbiased predictor of future wages. For a discussion of this point, see Muth.

46

The estimates presented in Table 9 assume constant returns to scale in order to conserve degrees of freedom. An F-test for the significance of current and lagged output in equation (22) yielded a value of only .581.

47

At this stage, one could re-estimate equation (22) with the implied restrictions imposed on the coefficient estimates, and then perform an F-test for the consistency of the restrictions with the data. Because this analysis is not directly concerned with the exact structural description of employees' wage expectations, but rather is concerned only with the reduced-form distributed lag relation between wages and marginal value products, such an elaboration is bypassed.

48

See Griliches (1967a) for a discussion of this point. Notice that equations (22) and (24) assume constant returns to scale.

49

Strictly speaking, the h-test is a large sample test; therefore, the h-statistic should be interpreted with some caution in this context. It should also be noted that the coefficient estimates in Table 9 are not unbiased and will be inconsistent in the presence of autocorrelated disturbances.

50

For a discussion related to this point, see Mayers and Thaler.

51

Introducing additional lags into equation (22) does not significantly increase the explanatory power of the equation.

52

In comparison with the estimates presented in Table 2, those in Table 9 indicate a larger within-year response of wages to changes in marginal value products. However, the qualitative implications of the two equations are the same. Regardless of the specific assumptions maintained about the form of employees' expectations, wages appear to differ substantially from marginal value products in the short-run.

Notice that if equation (22) were the true model, and yet equation (20) were estimated, the coefficients on time and time squared would pick up the effects of the omitted lagged variables. If these omitted variables were well-described by a quadratic time trend (they are), then the estimated values of γ from such a misspecified equation would not differ too greatly from those of a correctly specified equation. Although the estimated values of γ from equations (20) and (22) differ, they are similar enough to suggest that their difference from unity is not the result of misspecification.

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