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INDIVIDUAL PREFERENCES AND UNION WAGE DETERMINATION: THE CASE OF THE UNITED MINE WORKERS*

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I. INTRODUCTION

While analysis of the formation of bargaining goals by labor unions has been the subject of numerous theoretical investigations, no empirical work seems to have been performed in this area. As a result, investigators and policy makers lack a consistent framework within which to quantitatively analyze the effect of unions on costs and prices, and they often must make extremely naive assumptions about the path of union policy in order to arrive at cost and price projections.[1] In this study an economic model of union behavior applicable to the United Mine Workers (UMW) is developed based on the preferences of the individual members of the union.

The relationship between the UMW and the coal industry is an interesting collective bargaining situation for the purposes of this study. The recent Arab Oil Embargo and the increasing concern with future sources of energy have focused attention on coal as a potential source of energy in the medium to long run. When making projection of the cost of extracting coal, two facts make the determination of labor costs in the coal industry worthy of further consideration. First, wages are a large proportion of total costs in the coal industry which implies that any errors in predicting labor costs are likely to result in substantial errors in the prediction of the supply price of coal.[2] Second, the bituminous coal industry is dominated by a large and powerful union (the UMW) which has a substantial amount of power to set the level of compensation of labor. The lack of any explicit consideration of the behavior of the UMW is, therefore, a potential source of error in the projections of the cost of extraction of coal.

An important example of earlier theoretical work on union bargaining goals is Dunlop (1944).[3] Dunlop develops a model which implies that the union maximizes some objective function of wages and employment in union firms subject to a constraint imposed by a "membership function" or the amount of labor that will be supplied to the union at any wage rate. Dunlop, in fact, claims that the relevant objective function is the wage bill, i.e., the product of the wage rate and employment. Although this particular formulation leads to rather unrealistic predictions about union behavior, Dunlop's contribution lies in his recognition that "An economic theory of a trade union requires that the organization be assumed to maximize (or minimize) something."[4] Another important aspect of his study is the hypothesis, implicit in his choice of the wage bill as the union's maximand, that unions are concerned about the elasticity of demand for labor. On the other hand, Simons (1944, pp. 8-9) claimed that unions tend to maximize wages per member while Ross (1948, p. 80) claimed that labor demand schedules are too complex to be considered in formulating union wage policy. The clear implication of both of these studies is that unions, in fact, do not consider the employment effects of their wage policy in a systematic fashion. The analysis presented here is in the spirit of Dunlop's in that it is assumed that the union maximizes an objective function subject to a well defined labor demand schedule. However, in contrast to Dunlop, the objective function is not constrained to be the wage bill.[5]

A major problem with most of the earlier models, including Dunlop's, is that the union objective function is not based on a consistent

aggregation of the preferences of the individual members of the union. In contrast, Ross (1948) investigates the internal political processes of unions and the aggregation of individual preferences. However, he does not build a model of union behavior based on the maximization of individual objectives. Atherton (1973) develops an abstract model of union bargaining goals that begins with a relatively simple economic model and gradually relaxes key assumptions in order to analyze the effects on union objectives of such phenomena as the divergence of preferences within the union and uncertainty. However, Atherton does not test his framework empirically, and, given the level of abstraction, it is not clear what its testable implications are or how the model could be estimated.

In the next section, an operational model of union behavior is developed based on the individual preferences of the union members. Each individual is assumed to have a utility function which depends on the level of compensation he receives. A function defining the probability of each member being employed in a union mine is also constructed, and this is used to define the expected utility of each member of the union. A simple political process is defined in order to aggregate the preferences of the individual members into a coherent overall policy determining the level of compensation of union labor in the coal industry.

In Section III the model is estimated using Full Information Maximum Likelihood (FIML) techniques, and Section IV contains a discussion of

the results with particular interest in the implications of the estimates for (1) the preferences of the union members and (2) the sensitivity of union policy to changes in its economic environment. Finally, Section V contains a summary of the results and conclusions.

II. AN ECONOMIC MODEL OF UNION BEHAVIOR IN THE COAL INDUSTRY

In this section a model of the formation of union policy goals in the bituminous coal industry is developed. The model is based on the assumption that individual coal miners act as if they were maximizers of some utility function and the hypothesis that the leaders of the union act as if they attempted to maximize the expected utility of the median aged member of the union. The section concludes with a short discussion of some interesting and unique empirical hypotheses that will be tested in Section III using the model.

In order to focus on the formation of union bargaining goals, the problem of the actual mechanics of reaching agreement is abstracted from by assuming that UMW can impose whatever settlement it wishes upon the employers in the bituminous coal industry. The relatively fragmented market structure in the coal industry and the considerable bargaining power of the UMW suggest that this is a reasonable assumption.[6] The implication is not that the UMW can choose any wage-employment mix, but only that it can set the level of compensation per unit. Decisions left to others that are conditional directly or indirectly on union policy include: (1) the amount of labor that employers wish to use, (2) the price that firms wish to charge for coal, (3) the amount of coal that consumers will demand, and (4) the entry of non-union mines into the coal industry. The relationship of all of these decisions with union policy will be discussed below.

The bargaining goals of the union are derived from the utility functions of the individual members of the union and from the assumption that, by satisfying the desires of the members, the leaders of the UMW minimize the risk that they will lose their offices.[7]

It is assumed that the i^{th} member of the union has a utility index of the form

$$U_i = \frac{-1}{\delta} Y_i^{-\delta} \qquad (2\text{-}1)$$

where Y_i is the present value of income per hour received by individual i discounted from the date received to the present. δ is interpreted here as a "risk aversion" parameter where relative risk aversion is defined as

$$RRA = - \frac{U_i''}{U_i'} Y_i = 1 + \delta \qquad (2\text{-}2)$$

This particular parameterization of the utility function has the convenient properties of $U_i' > 0$ for all δ, $U_i'' < 0$ for all $\delta > -1$, and constant relative risk aversion.

Since 1946 the UMW has negotiated two basic types of compensation for its members in contracts with the Bituminous Coal Operator's Association. The first is an hourly wage paid to working members. The second is pension benefits paid to retired members and health and welfare benefits paid to both working and retired members. The nonwage benefits are financed by employer contributions to a number of trust funds paid at the rate of T dollars per ton of coal produced.

The Pension and Health and Welfare Funds have operated approximately as if they were to spend exactly what they took in each year. In other words, an individual's pensions and other future benefits are paid from receipts from coal mined in the future rather than from a previously accumulated fund.[8] For the purposes of this analysis, which covers the period from 1946 through 1973, it is assumed that fund benefits paid in each year equal fund receipts in each year and that individuals currently working expect the levels of fund related benefits to remain fixed through an implicit social contract with future miners.

The discounted lifetime income per hour of the i^{th} member of the union is

$$Y_i = \int_{o}^{A_R-A_i} \left[W_o + \frac{FR\ TQ_o}{L_o}\right] e^{-rt}dt + \int_{A_R-A_i}^{A_D-A_i} \left[\frac{(1-FR)}{FRET}\frac{TQ_o}{L_o}\right] e^{-rt}dt \qquad (2\text{-}3)$$

where W_o = the union wage rate,

W_A = the expected alternative wage available with certainty,

T = the ton tax,

A_R = the retirement age,

A_i = the age of the i^{th} member,

A_D = the expected age at death of the i^{th} member,

Q_o = total union coal input,

L_o = total union labor input,

FR = the fraction of ton tax receipts which go to working miners,

FRET = the ratio of the number of retired union members to the number of working union members and,

r = the rate of discount of a coal miner.

$\frac{FR\ TQ_o}{L_o}$ represents the benefit per manhour derived by working members from the ton tax. $\frac{(1-FR)\ TQ_o}{(FRET)\ L_o}$ represents the benefit per retired manhour derived by retired members from the ton tax.

It is assumed that member i acts as if he expects all of the variables in equation (2-3) to remain constant over time. This implies that

$$Y_i = M_{1i}\left[W_o + BK_i \frac{TQ_o}{L_o}\right] \tag{2-4}$$

where

$$BK_i = FR + \frac{(1-FR)}{FRET} M_i\ , \tag{2-5}$$

$$M_{1i} = \int_o^{A_R-A_i} e^{-rt}dt = \frac{1}{r}\left[1-\exp(-r(A_R-A_i))\right],$$

$$M_{2i} = \int_{A_R-A_i}^{A_D-A_i} e^{-rt}dt = \frac{1}{r}\left[\exp(-r(A_R-A_i)) - \exp(-r(A_D-A_i))\right],$$

and

$$M_i = \frac{-M_{2i}}{M_{1i}} = \frac{\left[1-\exp(-r(A_D-A_R))\right]}{\left[\exp(-r(A_i-A_R))-1\right]} > 0$$

for

$$A_i > A_R$$

Intuitively, M_i represents the value to individual i of a dollar of income received in retirement relative to the value of a dollar of income received while working. BK_i represents the value of individual i of a dollar of ton tax income relative to the value of a dollar of income derived from wage payments.

Y_i is the discounted income of member i conditional on his having a job in a union mine. It is assumed that if he does not find a job in a union mine he can, with certainty, find work at one of a variety of jobs with differing wage levels. This distribution of alternative wage possibilities is summarized by the certainty equivalent alternative wage rate, W_A. It is further assumed that there are no nonwage benefits associated with the alternative jobs and that W_A is the same for all individuals. The discounted income at the certainty equivalent alternative wage is

$$Y_A = M_{li} W_A.^{9} \tag{2-6}$$

A linear transformation of the utility index in equation (2-1) will preserve the individual's preference ordering over incomes (i.e., he will still prefer more income to less).[10] Accordingly, the utility index is transformed by adding $-U(Y_A)$ and dividing by $aM_{li}^{-\delta}$ where a is a constant defined later. This yields, substituting from equation (2-1), the transformed utility function

$$S(Y_i) = \frac{1}{aM_{li}^{-\delta}} [U(Y_i) - U(Y_A)] = - \frac{1}{a\delta M_{li}^{-\delta}} [Y_i^{-\delta} - Y_A^{-\delta}]. \tag{2-7}$$

Substituting further from equations (2-4) and (2-6) yields

$$S(Y_i) = -\frac{1}{a\delta}\left[\left(W_o + BK_i \frac{TQ_o}{L_o}\right)^{-\delta} - W_A^{-\delta}\right] \tag{2-8}$$

for the case of employment in a union mine and

$$S(Y_A) = -\frac{1}{a\delta}\left[W_A^{-\delta} - W_A^{-\delta}\right] = 0 \tag{2-9}$$

for the complementary case. $S(Y_i)$ is a valid ordering of the preferences of individual i over W_o and T, and it will provide the basis for the work that follows.

The utility index, S_i, varies across individuals only as their age varies. It is assumed that all workers employed in union mines receive the same wage rate, retirement benefits, alternative wage rate, etc. Older workers have a higher value for BK, or, in other words, they put a higher value on ton tax benefits relative to the wage income than younger workers. This is demonstrated by partially differentiating BK_i in equation (2-5) with respect to A_i. The result is that

$$\frac{\partial BK_i}{\partial A_i} = \frac{(1-FR)M_i\ r\ \exp(-r(A_i-A_R))}{FRET\ [\exp(-r(A_i-A_R))-1]} > 0$$

as long as the individual is below retirement age ($A_i < A_R$). If the individual is over the retirement age, he prefers only ton tax benefits since he receives no wage payments.

Each individual faces an uncertain situation where he receives discounted income Y_i if he is employed in a union mine and Y_A if he is not. Assume that the probability of employment in a union mine, ϕ,

for any individual i is proportional to total employment in union mines.[11] This can be expressed as

$$\phi = aL_o \tag{2-10}$$

where $0 \leq aL_o \leq 1$. The implicit assumption is that there is a once and for all drawing of individuals for union jobs and every individual has probability ϕ of being chosen for a union job. All union jobs are assumed to be identical in all respects, both pecuniary and nonpecuniary.

The expected utility of individual i, $E(S_i)$, is expressed as

$$E(S_i) = \phi S(Y_i) + (1-\phi)S(Y_A). \tag{2-11}$$

Substituting from equations (2-8), (2-9), and (2-10) and recognizing that $S(Y_A) = 0$ yields

$$E(S_i) = -\frac{L_o}{\delta}\left[\left(W_o+BK_i\frac{TQ_o}{L_o}\right)^{-\delta} - W_A^{-\delta}\right]. \tag{2-12}$$

Under certain basic consistency assumptions it can be shown that the utility to individual i of this uncertain situation is the expected value of the utilities of the two outcomes as expressed in equation (2-12).[12] Thus, individuals prefer the union policy which yields them the highest expected utility, $E(S_i)$.

It is assumed that the only policy variables that the union can use are the wage rate and the ton tax. However, in reality the union can directly set the retirement age (A_R) and the fraction of ton tax benefits that go to the working miners (FR). Union policy also has indirect effects on such variables as the age distribution of the membership and the ratio

of retired to working miners (FRET). All of these effects are neglected and these variables are assumed to be exogenous in this study.

On the other hand, the union (and implicitly its members) does recognize the effect of shifts in the wage rate and ton tax on the price of coal, the demand for coal, the demand for union labor, and the incentives for entry of nonunion firms into the coal industry. In other words, in choosing a policy the union does feel constrained by (1) a coal demand equation,

$$Q_o = Q_o(P_o) = Q_o(P_o(W_o,T)); \tag{2-13}$$

(2) a labor demand equation,

$$L_o = L_o(W_o,T) \tag{2-14}$$

derived from the coal production function and demand function; and (3) an extent of organization function

$$X = \frac{Q_o}{Q} = X(W_o,T). \tag{2-15}$$

X represents the ratio of union coal output to total coal output, Q represents total coal output, and P_o represents the price of union coal. The precise specification of these constraint equations are not presented here, but they are an integral part of the system of equations that is estimated in the next section.[13] Very briefly, separate log-linear coal demand equations are specified for the underground and surface sectors. Labor demand and price equations for the two sectors are derived from constant proportions production functions with neutral technical progress. Finally, the extent of organization function in the

coal industry is defined as a log-linear function of relative costs in the union and nonunion sectors.

In order to determine exactly what the policy objective of the union is, it is necessary to recall that the individual union members differ only by their age and the relative value of ton tax benefits to wage benefits. The preferences of the invididual members are arrayed along a single axis (age) and are also single peaked in $\frac{T}{W_o}$ along this axis for the set of $\frac{T}{W_o}$ that are pareto optimal in the sense that the constraints implied by equations (2-13), (2-14), and (2-15) are satisfied and neither T nor W_o can be changed without lowering expected utility, $E(S_i)$.[14] These conditions are sufficient to conclude that the pareto optimal $\frac{T}{W_o}$ combination which satisfies the median aged (A_m) member of the union will defeat any other feasible $\frac{T}{W_o}$ combination in a pairwise election.[15] Thus, the leadership of the UMW, in order to minimize the risk of their losing an election, will provide that W_o and T which maximizes the expected utility of the median aged member of the union.[16]

In Figure 1 is an arbitrary cumulative distribution function of the age of the union membership and a graphical presentation of the $\frac{T}{W_o}$ ratio that a union member will choose as a function of his age. This ratio approaches infinity as age goes to retirement age, A_R, because retired miners receive no wage income. By determining the median age of the union membership from the cumulative distribution function, the $\frac{T}{W_o}$ ratio that the leadership will choose is computed.

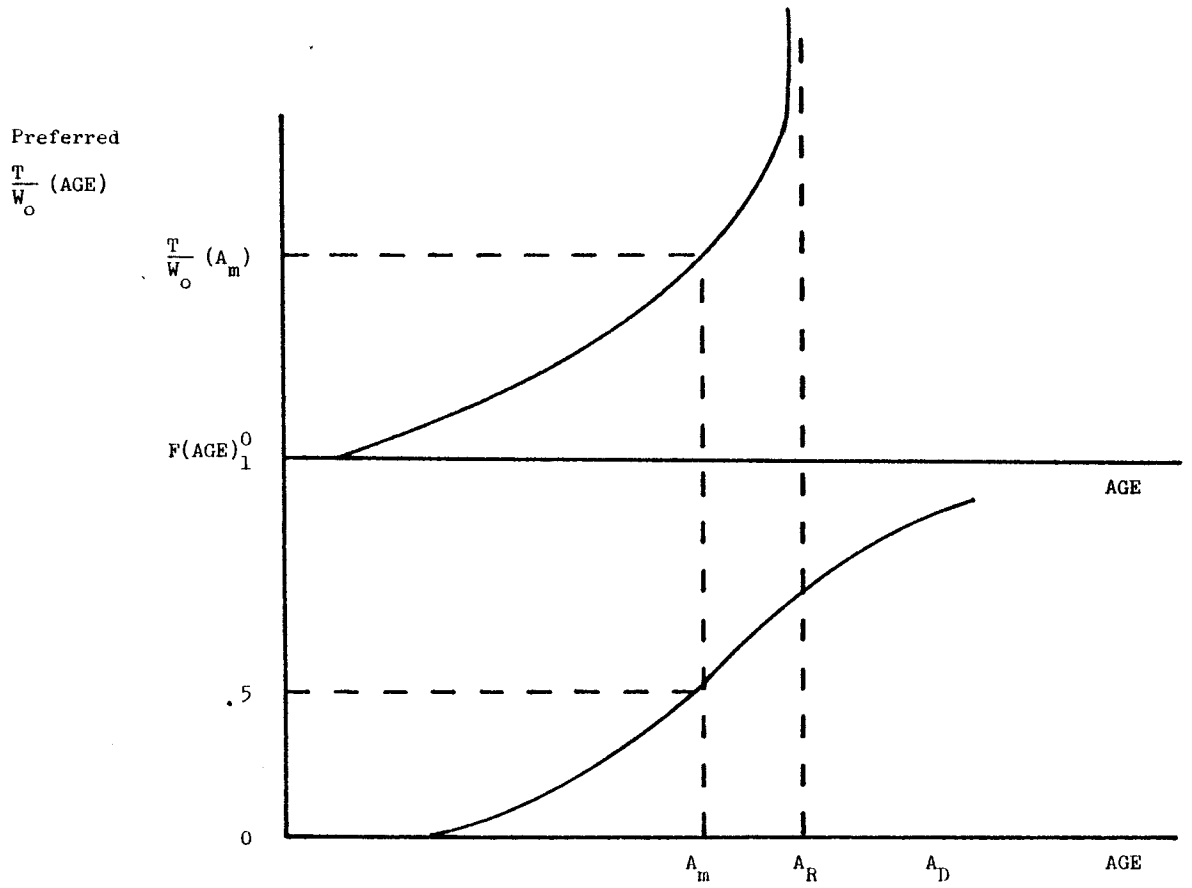


Figure 1: Optimal T/W_o As a Function of Age

Maximization of

$$E(S_m) = \frac{-L_o}{\delta}\left[\left(W_o+BK_m\frac{TQ_o}{L_o}\right)^{-\delta} - W_A^{-\delta}\right] \tag{2-16}$$

implies two first order conditions in W_o and T. In elasticity terms these are

$$0 = e_{L_oW_o} + I_m[W_oL_o+BK_mTQ_o(e_{Q_oW_o}-e_{L_oW_o})] \tag{2-17}$$

and

$$0 = e_{L_oT} + I_mBK_mTQ_o\,[1+e_{Q_oT}-e_{L_oT}] \tag{2-18}$$

where

$$I_m = \frac{\left[W_o+BK_m\frac{TQ_o}{L_o}\right]^{-\delta-1}}{E(S_m)} \tag{2-19}$$

and e_{ij} is the elasticity of i with respect to a change in j.[17] Equations (2-17) and (2-18) are the equilibrium relationships determining the wage rate and ton tax which result from collective bargaining. They also indirectly determine the quantity and price of coal consumed and the extent of unionization in the coal industry. When combined with specifications for the constraint equations (2-13), (2-14), and (2-15) and their implied elasticities, the entire system will be estimated and the sensitivity of union policy to various changes in its environment will be analyzed.

Of interest in their own right are the values of the parameters that are unique to the union members' utility function. The relative risk aversion implied by the estimated value of δ can be compared with the estimates of relative risk aversion derived in studies of portfolio

composition[18], and the rate of time discount estimated from the equilibrium equations can be compared to that estimated from human capital models.[19]

It is also possible to estimate from equations (2-17) and (2-18) the value to an individual of a discounted dollar of discretionary income relative to the value of a discounted dollar of fixed benefits. The latter may include medical insurance, tools, free meals, etc. In the case of the UMW, discretionary income takes the form of wage payments and pension benefits. Fixed benefits are the health and welfare benefits received both while working and retired.[20] Rewrite BK_m in equation (2-5) as

$$BK_m = \alpha FR + \frac{(\alpha HWR + PEN)}{FRET} M_m \qquad (2\text{-}20)$$

where HWR represents the fraction of ton tax benefits that go to health and welfare benefits for retired miners and PEN represents the fraction of ton tax benefits that go to pensions. FR, which was previously defined as the fraction of ton tax benefits that go to working miners, also represents the fraction of ton tax benefits that go to health and welfare benefits for working miners. In other words, all ton tax benefits paid to working miners are fixed benefits of this type. It is assumed that .

$$HWR + PEN = (1-FR) \qquad (2\text{-}21)$$

The parameter α represents the value of a discounted dollar of fixed benefits relative to the value of a discounted dollar of wage or pension income. Equation (2-5) is a special case of equation (2-20) where

$\alpha = 1$ or, in other words, where the two types of benefits are valued equally.

There are at least three reasons why α might differ from one. First, the individual might decide to provide himself with a smaller amount of the fixed benefits than the union provides if he had the equivalent income to dispose of himself. If he wanted less health benefits, for instance, than the union were providing then he would value the marginal dollar received as health benefits less than the marginal dollar received as discretionary income. This implies $\alpha < 1$.

The second reason why α would not equal one is that there may be economies of scale in the provision of fringe benefits. Group health and medical insurance and services may be less expensive than individual procurement. This would imply that $\alpha > 1$. Analogously, if there were diseconomies of scale $\alpha < 1$.

The third and perhaps most important reason why α would not equal one is that fringe benefits are not subject to an income tax while discretionary income is. If a dollar of expenditures of fixed fringe benefits has a value equal to the value of a dollar of after tax discretionary income, then

$$\alpha = \frac{1}{(1-t)} \qquad (2\text{-}22)$$

where t is the marginal tax rate and satisfies the relationship $0 \leq t \leq 1$.

On the basis of the above discussion it can be concluded that no rational union leader would provide a package with more of a particular

fringe benefit than the median member wants or with a fringe benefit whose provision is characterized by diseconomies of scale. However, in the context of the bituminous coal industry provision of these fringes may be rational. This is because, as discussed in the next section the coal industry in the United States consists of two sectors: an underground mining sector and a surface mining sector. These sectors have different production technologies with the underground sector much more labor intensive than the surface sector. Historically, while output in the surface sector has been increasing, the large majority of miners work in the underground sector.[21] The ton tax is a means of redistributing income from surface mine operations to the union membership which is largely in the underground sector. This, combined with the fact that, for a variety of reasons, the union does not make direct cash payments to working miners, may make it optimal for the union leaders to provide inefficient or excess fringe benefits to the members.[22]

In sum, the estimate of α to be obtained from the model is the result of conflicting influences which make it impossible to determine, a priori, whether $\alpha > 1$ or $\alpha < 1$.

III. MAXIMUM LIKELIHOOD ESTIMATION OF THE PARAMETERS OF THE UTILITY FUNCTION

In this section the two first order conditions for a maximum of the expected utility of the median aged member of the UMW [equations (2-17) and (2-18)], which determine the union wage and ton tax policy, are combined with the seven equations specified in Farber (1978) that determine prices, output, unit labor input, and the extent of unionization in the surface and underground coal mining sectors. The resulting nine equation system is then estimated by full information maximum likelihood (FIML) in order to derive estimates of the parameters of the union members' utility functions.[23]

The model was estimated using annual data from 1947 through 1973 for the relevant variables. The data used for most of the variables are straightforward. However, it was necessary to construct a series, for W_o, on union average hourly earnings. This was rather complicated and it is discussed in Farber (1977).

The only variable in the system which does not have an exact empirical counterpart and has not been discussed previously is the certainty equivalent alternative wage (W_A) that is available to union members if they do not find employment in a union mine. As discussed in Section II, this is a probability weighted sum of various alternative wage rates. In the absence of an appropriate summary measure, average hourly earnings in durable goods manufacturing was used. Although this measure probably overstates the alternative income possibilities available in mining communities, it may be an accurate reflection of earnings available in the more urbanized areas to which unemployed miners would consider migrating.

The likelihood function (L*) was formed by assuming that each of the nine equations in the system has an additive error and that the errors are distributed as a multivariate normal. The likelihood function was maximized numerically, and, assuming that the global optimum was found, Table 3-1 contains the maximum likelihood estimates of the parameters of the utility function.

Before continuing to the discussion of the estimates it should be mentioned that, although some statistical tests are performed in the next section, the sample size is too small to confidently invoke the large sample properties of the FIML estimators. Therefore, the results need to be interpreted with caution.

Table 3-1. Maximum Likelihood Estimates of the Parameters of the Utility Function[a]

Parameter	Estimates, α=1	Estimates, α free
δ	2.723* (.2437)	1.977* (.2327)
r	.0461* (.0074)	.0356* (.0189)
α	1[b]	1.390* (.5560)
Log-Likelihood Value	-339.73	-336.67

[a]The numbers in parentheses asymptotic standard errors. Estimates of the other parameters of the system are contained in Farber (1977).

[b]By assumption.

*Significantly greater than zero at the 5 percent level.

IV. PROPERTIES OF THE MODEL

A. Preferences of the Union Members

In Section II various hypotheses were discussed concerning the parameter α which represents the value to the median aged member of the union of a dollar of fixed benefits relative to the value of a dollar of wage or pension income. The estimates in the first column of Table 3-1 were computed subject to the constraint that $\alpha = 1$ or, in other words, that fixed benefits and discretionary income are valued equally while the estimates in the second column were computed without this constraint.

The estimate of α in the unconstrained model is 1.39 with an asymptotic standard error of .5560.[24] Assuming asymptotic normality of the maximum likelihood estimators, $\hat{\alpha}$ is not significantly different from one at conventional test levels. A likelihood ratio test of the null hypothesis that $\alpha = 1$ yields $\chi^2 = -2[-339.73 - (-336.67)] = 6.12$. $\chi^2_{.05}(1) = 3.84$ and $\chi^2_{.01}(1) = 6.63$ which implies that the hypothesis that $\alpha = 1$ can be rejected at the 5 percent level. These results are ambiguous, and the likelihood ratio test contradicts the test based on the asymptotic normality of the estimators. This is clearly due to the fact that the sample size is much too small to confidently invoke the large sample properties of maximum likelihood estimators. Therefore, in the interest of caution, the estimated value of 1.39 is interpreted as suggestive of the true value of α, but the hypothesis that $\alpha = 1$ is not rejected.

The estimated value of α in the second column of Table 3-1 of 1.39 seems quite reasonable in light of the discussion in Section II. It implies that members of the union value a dollar spent on fixed benefits 40 percent more than a dollar spent on discretionary income. This is probably due to the tax free status of fixed benefits and perhaps to the existence of economies of scale in the provision of the fixed benefits. If all of the difference in relative valuation is due to the tax free status of fixed fringe benefits, equation (2-22) implies that the marginal tax rate equals $(1 - \frac{1}{\alpha}) = .28$ for $\alpha = 1.39$. In 1960, the approximate midpoint of the sample, a married miner with two children who worked two thousand hours per year had a taxable income of approximately 4,350 dollars per year.[25] The marginal tax rate implied by this income was .22 which is remarkably close to the tax rate of .28 computed above.

The estimate of δ in the first column of Table 3-1 of 2.7 implies that the relative risk aversion of union members is 3.7. Similarly, $\hat{\delta}$ from column two of Table 3-1 is 2.0 which implies relative risk aversion of 3.0.[27] These results seem reasonable in light of the work of Friend and Blume (1975) which estimated the risk aversion of households based upon data on household asset holdings. They found that ". . . the coefficient of proportional risk aversion is more likely to be in excess of two."[28]

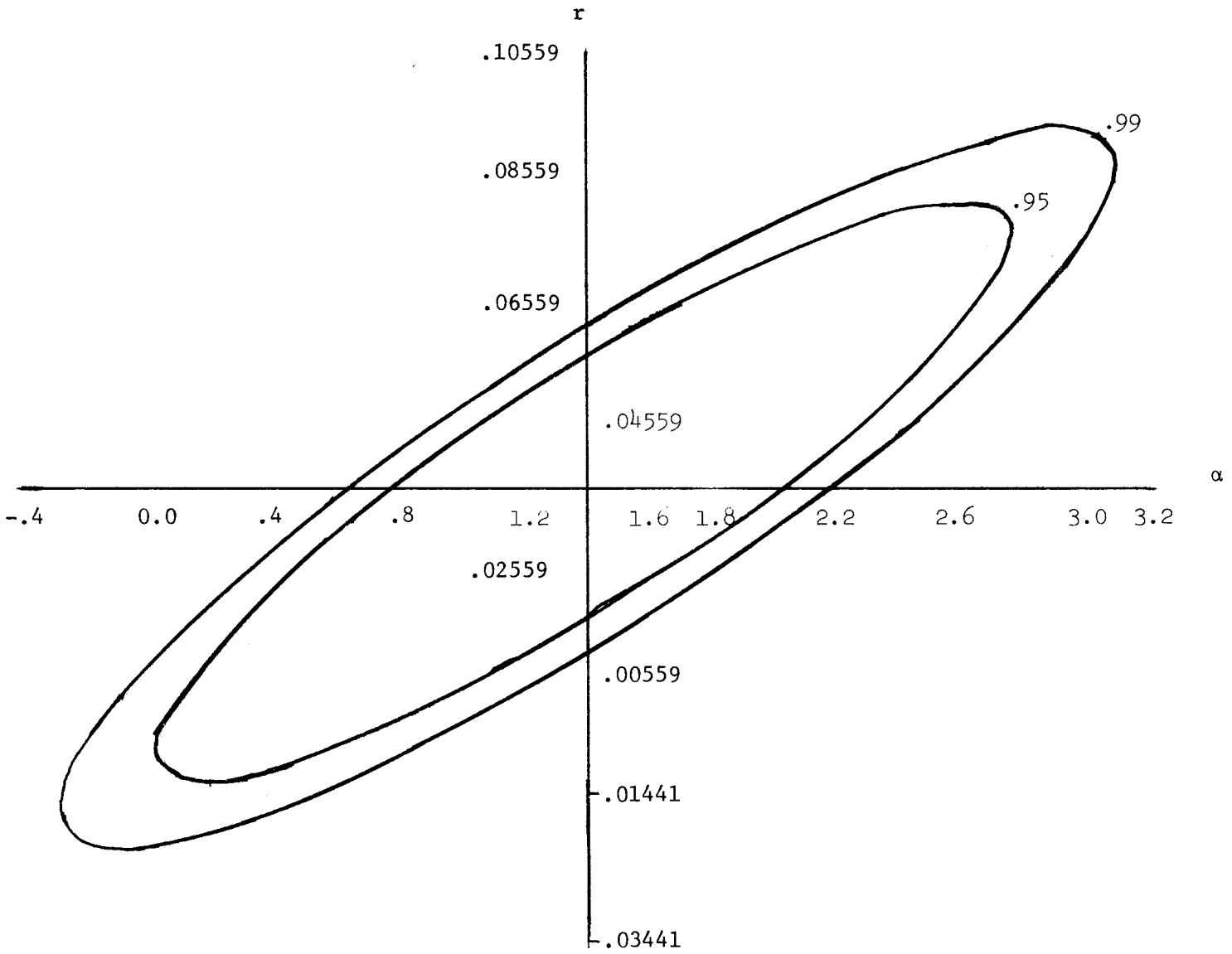
The conclusion to be drawn from the estimated δ is that the union members are quite concerned about the employment effects of

the union wage-ton tax policy. As a benchmark, the wage bill maximization hypothesis of Dunlop (1944) is operationally equivalent to the special case of the utility function used in the study (equation 2-1) where $\delta = -1$.[29] The estimates of δ in Table 3-1 are asymptotically significantly greater than minus one at any reasonable level which implies that members of the UMW put significantly greater stress on employment relative to wages than would be implied by wage bill maximization. The result is that employment in union mines is greater (at the expense of the level of compensation) than would be the case if the union members were wage bill maximizers.[30]

The estimates of r ($\hat{r}$), the rate at which union members discount future earnings, contained in Table 3-1 range from approximately 3.5 to 4.5 percent. These are lower than even the lowest of the discount rates estimated from human capital models. Rosen (1976), for instance, obtains estimates of r that range from 7 to 9 percent. Most other estimates are larger. Heckman (1976) estimates interest rates of 17 to 20 percent while Landsberger (1971), studying consumption-savings behavior, estimates discount rates of 9 to 27 percent.

Since both r and α are, in a sense, directly associated with the observed split of compensation between the wage and the ton tax, it was found that when α was allowed to vary, the estimate of the rate of discount became less well determined. Figure 4-1 contains 95% and 99% asymptotic confidence ellipses about the estimates of r and

Figure 4-1. Asymptotic Confidence Ellipses of α and r



α contained in the second column of Table 3-1. It is clear that higher values of the discount rate are associated with higher values of α, i.e., if the future is discounted more heavily, fixed fringe benefits (received largely in the future) must have been worth relatively more than wage payments in order to account for the observed wage-ton tax split. It is interesting to note that values of α less than one occur with a significant probability, conditional on r, only for values of r which might be considered unreasonably low.

B. The Solution Vector

The estimates of the parameters of the system contained in the first column of Table 3-1 are used to find a solution to the system at the sample means of the exogenous variables. The results, contained in Table 4-1, imply that the solution is reasonably close to the observed mean vector. The largest proportional difference between the solution and mean is for X. The observed mean of .75 is approximately 20 percent lower than the predicted solution value of .92. This overprediction of the extent of unionization is what is responsible for the overprediction of the prices (P_u and P_s).

C. The Response of Union Policy to Exogenous Factors

It is interesting to examine the sensitivity of union policy to certain key exogenous variables. Because the focus of this study is on union wage-ton tax policy and the cost of producing

Table 4-1. Solution of System of Equations About the Means of the Exogenous Variables

Variable[a]		Observed Mean	Solution
Y_1	W_o	3.72	3.50
Y_2	T	.38	.45
Y_3	Q_u	337780.	338319.
Y_4	Q_s	163921.	174243.
Y_5	X	.75	.92
Y_6	P_u	8.98	9.53
Y_7	P_s	7.23	7.52
Y_8	ℓ_u	.874	.874
Y_9	ℓ_s	.345	.345

[a]The units are as follows:

W_o = \$/hour

T = \$/ton

Q_u, Q_s = thousand tons

P_u, P_s = \$/ton

ℓ_u, ℓ_s = manhours/ton

coal, two summary measures were computed from each solution vector. The first is average union labor cost per ton which equals the sum of wage income per ton and the ton tax ($W_o \ell + T$). ℓ represents average unit labor input in the surface and underground sectors. Second, the average price of coal in the two sectors (P) was computed. Only the wage (W_o), ton-tax (T), labor cost ($W_o \ell + T$), and price (P) are presented because it is felt that these convey most of what is interesting about a particular solution. Table 4-2 contains point elasticities, computed at the maximum likelihood estimates of the parameters, of W_o, T, $W_o \ell + T$, and P with respect to changes in selected exogenous variables.[31] The chosen variables are not the only variables that can have an impact on union policy, but the analysis of their effect serves to illustrate some of the important properties of the model. These elasticities are computed, as will be the case throughout, at the solution implied by the means of the exogenous variables.

Before examining the effect of each exogenous variable, it is interesting to note (in Table 4-2) that the optimal wage (W_o) and the ton tax (T) are generally quite responsive in opposite directions to shifts in the exogenous variables. On the other hand, labor cost per unit ($W_o \ell + T$) and the average price (P) are not nearly as sensitive.

The implied volatility of the wage and ton tax are not reasonable on common sense grounds because large shifts in the composition of the union compensation not only are not expected but also are not observed. However, this is not quite so serious a problem as may

Table 4-2. Point Elasticities of W_o, T, $W_o\ell + T$, and P with Respect to Changes in Selected Exogenous Variables[a]

Exogenous Variable	Elasticity of W_o	T	$W_o\ell + T$	P
W_A	-1.02	8.15	.407	.187
W_n	1.60	-6.62	.315	.049
A_M	-6.24	45.0	1.74	1.28
PO	-.080	.481	.007	.010
EC	0.	0.	0.	0.
TR	.352	-1.02	.138	.395

[a]Computed at maximum likelihood estimates of parameters and the means of the exogenous variables. See Tables 4-1 and 5-1.

W_A = Alternate Wage

W_n = Non-union Wage

A_M = Median Age of Union Membership

PO = Price of Oil

EC = Energy Consumption

TR = Transportation Cost/Ton

first be felt if what is of interest is the impact of changes in exogenous factors on union policy as it affects the cost of coal. This impact may be conveniently summarized by unit labor costs and average price, which are not nearly as volatile as W_o and T. Finally, note that the elasticities in Table 5-2 are computed ceteris paribus and it is not reasonable to expect that these exogenous variables are uncorrelated. In fact, the sums of the elasticities of W_o and T with respect to changes in the monetary exogenous variables in Table 4-2 (W_A, W_n, PO, and TR) are .85 and .99 respectively. These sums are smaller in absolute value than the most extreme elasticities in Table 5-6, and the fact that they are close to one implies that an increase in the general price level would have an almost equiproportional effect on W_o and T.[32]

As one would expect, an increase in the alternative wage (W_A) or the nonunion wage (W_n) results in a general increase in the compensation of union members. Thus, the union acts to preserve its relative position. Indirectly, the union also acts to preserve its position in the face of changes in the nonlabor elements of the cost of producing coal such as transportation costs (TR). An increase in TR reduces labor's share of total costs, and the response of the union, as indicated in Table 4-2, is to increase unit labor costs further raising the price and maintaining labor's share.

It was expected that the age of the median member of the union (A_m) would have a substantial effect on W_o and T. The results support this expectation with an increase in A_m causing a large

proportional decrease in the wage and a huge proportional increase in the ton tax. Intuitively, this is because as the median miner becomes older he becomes more concerned with his retirement benefits and less concerned with the income he will receive over the remainder of his working life. While the effect of a change in A_m on unit labor costs and price are small relative to the effect on W_o and T, they are surprisingly large in absolute value. The only explanation that can be offered is that the median age of the union membership realistically cannot vary over a very large range, and, as a result, a large proportional change in A_m will never be observed. In fact, an extreme change in the age distribution of the UMW membership would very likely invalidate this model.

The last two exogenous variables (EC and PO) affect the demand for coal in two sectors. The fact that a change in energy consumption (EC) has no effect on union policy is an interesting, though not unexpected, result. The lack of an effect of EC on union policy is a direct result of the specification of the production functions as exhibiting constant returns to scale in both sectors and the coal demand functions as exhibiting constant elasticity of demand with respect to changes in coal prices. These assumptions imply that union wage-ton tax policy, as determined by equations (2-17) and (2-18), depends only on the relative demand for coal in the surface and underground sectors and not on the absolute level. In other words, equations (2-17) and (2-18) are zero degree homogeneous in Q_u and Q_s. Since a change in energy consumption affects the demand

for coal in the two sectors equiproportionately, it has no effect on the relative demand for coal in the two sectors. Therefore, changes in EC can have no effect on union policy.[33]

A change in the price of oil (PO) also represents a change in the demand for coal. Its effect, though small, is not zero because a change in the price of oil affects the demand for coal differently in the two sectors, i.e., the point estimate of the elasticity of demand for underground coal with respect to a change in the price of oil does not equal the point estimate of the elasticity of demand for surface coal with respect to a change in the price of oil. If these two elasticities were equal, then the price of oil, like energy consumption, would have no effect on union policy.

V. SUMMARY AND CONCLUSIONS

The results and implications of this study fall into two borad categories. First, the estimation of the parameters of the union members' utility function, contained in Sections III-IV yielded some interesting insights into their preferences: (1) the union members were found to be quite risk averse; their coefficient of relative risk aversion was estimated to be approximately 3.0 to 4.0, (2) their discount rate was estimated to be quite low at approximately 3.5 to 4.5 percent annually, and (3) it was estimated that union members value a dollar spent on fixed fringe benefits almost 40 percent more than a dollar spent on discretionary income for coal miners. This lends support to the argument that the income tax makes nontaxable fringe benefits a more attractive method of compensation than taxable income.

The second class of results is of substantive interest and concerns the response of union policy to its economic environment. Union wage-ton tax policy was found to be most sensitive to the alternative wage rate, the nonunion wage rate, and the age distribution of the membership. It was also sensitive to nonlabor elements of costs such as transportation costs. The most interesting result was that union policy is not very responsive at all to shifts in the demand for coal whether they are the result of a general increase in energy consumption or of an increase in the price of substitute fuels (notably oil).

In general, the results were reasonable and lend support to the analytical framework, but there are some qualifications that need to be made. First, the sample used in the empirical work was

rather small, and, given the nature of the model, it would be desirable to have a longer time series. Second, and related to this, is the fact that the model is essentially static in nature while union behavior is a dynamic process. This is probably the cause of the volatility of the wage rate and ton tax when shifts in the exogenous variables occur. A more realistic model would be dynamic in nature and take into account expectation about the future as well as the fact that contracts are negotiated at discrete intervals in time. On the other hand, an important reason that these factors were not included in the model used in this study is that, given the data constraints as well as technical and monetary limitations, their consideration would most likely prove to be empirically intractable.

In conclusion, the model of union behavior developed in this study has proved interesting and useful, both from a methodological and substantive standpoint. Certainly more data would be useful and, while care must be exercised so as not to lose empirical relevance, it would be interesting to reformulate the model in a more dynamic context. The framework developed here provides an indication of the power of economic and statistical analysis when applied to the specific problems of union behavior.

FOOTNOTES

[1] For example, the Federal Energy Administration (1975, pp. 12-16) and (1976, pp. 184, 264) assumed that all factor prices were fixed in real terms when making cost projections for the extraction of coal. Gordon (1975) in making the same projections, computed future labor costs by extrapolating from past rates of change. It is quite an assumption to assume that as powerful an organization as the United Mine Workers acts in such a naive manner.

[2] Wages constitute approximately 35 percent of coal costs in the United States. MIT Energy Laboratory Policy Study Group (1975, p. 2-13).

[3] Other investigations in this area have been performed by Cartter (1959), Pen (1959), and Simons (1944, pp. 8-9). These studies as well as some others are discussed in an excellent review of the earlier work done on union bargaining goals contained in Atherton (1973, pp. 3-30).

[4] Dunlop (1944, p. 4).

[5] The wage bill is a special case of the objective function developed in the next section, and the hypothesis that the wage bill is, in fact, the maximand of the UMW is tested in Section IV.

[6] The bituminous coal industry consists of a number of large firms and thousands of smaller firms existing on the margin of the industry.

It is fair to characterize the industry as having a competitive market structure, and, in fact, cooperation among firms in the coal industry generally has been motivated by a desire to match the bargaining power of the United Mine Workers. The four firm concentration ratio in bituminous coal mining was .266 in 1965 while the average four firm concentration ratio in U.S. manufacturing industries was .39 in 1966. See Council on Wage and Price Stability (1976, pp. 40-41) and Baratz (1955, pp. 82-83). Actually, in no collective bargaining situation does one party have absolute power to impose any settlement it wishes on the other. There are limits (both economic and political) beyond which no union may go. Just as the competitive nature of the coal industry makes this assumption defensible, the concentrated nature of many manufacturing industries argues for a different approach to the question of union wage determination. See Farber (1976).

[7] The implication is that, at least in form, the UMW is a democratic union. Given the autocratic nature of the UMW leadership over the past fifty years this may seem a bit farfetched. However, it is quite reasonable when considered in the context of a long run model. John L. Lewis was said to have ruled the union with an iron hand, but in the long run he survived only because he satisfied the desires of the rank and file. See Karsh and London (1954, pp. 415-436). Following Lewis's retirement, W. A. "Tony" Boyle ran the union with a total lack of regard for the rank and file, and the result was that (with a ten year lag and much violence) he lost his office. See Finley (1972) for

a recent history of the UMW.

The current rather chaotic situation within the UMW indicates a breakdown of the traditional strong central leadership, and to the extent that this persists the model will lose its validity with regard to the UMW.

[8] In the twenty-seven year period from 1947 through 1973 over 96 percent of fund receipts were paid out as benefits. United Mine Workers of America (1973, p. 5). More recently, through the impetus of the Employee Retirement Income Security Act of 1974, the Funds have been moving toward fuller funding of their liabilities. See United Mine Workers of America (1975).

[9] Note that the expressions for income in equations (2-4) and (2-5) do not include income received by all workers regardless of their employer. The major example of this is social security income.

[10] See Luce and Raiffa (1957, pp. 12-38).

[11] In the presence of seniority provisions in the union contract, older employees, who generally have more seniority, will have a higher probability of retaining employment in union mines. This aspect of the employment relation is neglected here.

[12] See Luce and Raiffa (1957, pp. 12-38).

[13] See Farber (1978) for the derivation and specification of the constraint equations.

[14] This is asserted without proof.

[15] See Kramer (1976, p. 500).

[16] It is interesting to note that retired miners are entitled to vote in UMW elections, and this substantially raises the age of the median member of the union. The average median age of a member of the UMW in the post World War II period was 45.6 years.

See Arrow (1950) and Black (1948) for discussions of the problems encountered in majority voting schemes and of the median voter rule.

[17] $e_{L_oW_o}$, e_{L_oT}, $e_{Q_oW_o}$, and e_{Q_oT} are defined as functions of the parameters of the demand and production functions as well as the variables of the system. See Farber (1978), Appendix A.

[18] See Friend and Blume (1975).

[19] See, for example, Heckman (1976) and Rosen (1976).

[20] There is a small class of benefits which are paid to survivors of union members as either health and welfare benefits, pensions, or lump sum death benefits. All but survivors pensions are subsumed under health and welfare benefits in the analysis. During the twenty-seven year

period from 1947 through 1973 the total amount paid as survivors' benefits was less than 8 percent of total benefits paid. United Mine Workers of America (1973, p. 4).

[21] In the postwar period the proportion of total coal output derived from underground mines was 68 percent while the proportion of total labor in the coal industry used in underground mines was 84 percent.

[22] See Warren-Boulton (1977) for a discussion of the uses of the ton-tax as a means of vertical control by the UMW.

[23] See Farber (1978) for the derivation of the likelihood function and a description of the data.

[24] The asymptotic standard errors were computed from the elements of the negative of the inverse of the second partial derivative matrix of the log-likelihood function. The derivatives are symmetric numerical derivatives. See Goldfeld and Quandt (1972, pp. 19-20).

[25] This was computed at average hourly wage of $3.77. The gross income of $7540 was reduced by $2400 for four $600 exemptions and by a further 15 percent for the standard deduction. See Goode (1976, pp. 172-174, 213).

[27] See equation (2-2) for the definition of relative risk aversion used here and its relationship to δ.

[28] Friend and Blume (1975, p. 920).

[29] The wage bill is interpreted here as the product of union compensation (wages plus fringe benefits) per manhour and employment in union mines. $\delta = -1$, or equivalently, wage bill maximization implies that the individuals are risk neutral.

[30] The finding of risk aversion or serious concern about the employment effects of union wage-ton tax policy runs counter to the conventional wisdom concerning the UMW which has held that the UMW is a union that raises wages with little regard for the employment consequences. Rees (1962, p. 52) argues that "There is only one important case (of a union which raises wages with little concern for the employment effects) . . . -- the United Mine Workers . . . [The] Mine Workers have pursued a high-wage policy in the face of shrinking employment with announced unconcern."

[31] Farber (1977) contains the point elasticities of W_o, T, $W_o\ell$ + T, and P with respect to changes in the selected exogenous variables for values of certain key parameters that are plus and minus one and two asymptotic standard errors from their maximum likelihood estimates. These numbers were computed, because of the small sample size, in order to determine if the elasticities in Table 5-6 are very sensitive to the

particular point estimates of the parameters. It was concluded that, in fact, the elasticities are not critically sensitive.

[32] This conclusion is not rigorously drawn because there are other exogenous dollar variables in the system which were not considered.

[33] The validity of these specifications was examined in Farber (1978). The conclusion was that relaxation of these assumptions did not substantially alter the results.

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