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Intertemporal Labor Supply in the Presence of Long Term Contracts*

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In spite of rapid progress over the last decade in modelling long term employment contracts,[1/] and recent evidence on the importance of lifetime jobs in the economy,[2/] microeconometric analyses of labor supply continue to interpret individual hours and earnings data in terms of an auction model of the labor market. Advocates of a contracting paradigm, on the other hand, have argued that it may be more appropriate to interpret observed earnings as installment payments on workers' lifetime productivity.[3/] In this paper, we offer a first step toward reconciling the lifecycle labor supply model with the possibility that wages are not equal to marginal productivity in every period.[4/] Specifically, we consider the empirical implications of the assumption that observed earnings contain both a current productivity component, and a smoothed component reflecting lifetime productivity. Our findings suggest that, for a given level of variability in annual hours, workers with continuous tenure enjoy significantly less earnings variability than those who change jobs. At the same time, however, we find that most of the observed changes in individual earnings and hours are unsystematic, and attributable to measurement error or shifts in preferences unrelated to underlying changes in productivity.

Our analysis begins with a very simple specification of preferences and the assumption of perfect foresight. These conditions generate a determinant lifecycle path for consumption and hours, and an associated stream of lifecycle earnings, assuming that individuals are paid according to their productivity in each period. If the desired lifecycle path of consumption is less variable than the projected flow of earnings, however, employers may find it advantageous to act as credit institutions, smoothing the earnings of their employees over the lifecycle by offering earnings higher than a spot labor market in periods of low productivity in return for earning lower than a spot labor market in periods of high productivity. We assume that this smoothing takes a particularly simple form: namely, that earnings represent a weighted average of spot market earnings and discounted average lifetime earnings. Under these conditions, we derive reduced forms for earnings and hours as functions of the extent of earnings smoothing in the labor market, the current realization of individual productivity, and the intertemporal elasticity of substitution. These reduced forms imply simple parameterizations of the means, variances, and covariances of individual changes in earnings and hours over the lifecycle.

The first section of the paper presents the theoretical model and develops its implications for individual earnings and hours data. We show that earnings smoothing reduces the responsiveness of measured wage rates to individual productivity. This fact, in turn, introduces an ambiguity into the interpretation of conventional labor supply equations.

The second section describes an empirical implementation of the model based on the covariances of changes in earnings and hours from longitudinal data. Individual productivity is modelled as a component of variance in hours and earnings. The other components of variance include changes in tastes for leisure and measurement error. The variance components scheme we adopt does not permit separate identification of the elasticity of substitution and the extent of earnings smoothing in the labor market. By making a comparison across groups of workers, however, we can estimate the extent of earnings smoothing enjoyed by one group of workers vis-a-vis another.

The third section summarizes the earnings and hours data used to estimate the model. We consider a sample of ten consecutive changes in log earnings and log hours from the Panel Study of Income Dynamics, and a sample of five changes in log earnings and hours over a ten year period from the National Longitudinal Survey of Older Men. In section four we present estimates of the model under the assumption of no earnings smoothing. The estimated elasticities of substitution from the Panel Study of Income Dynamics are substantially larger than previous estimates. Our estimates of the elasticity of substitution from the National Longitudinal Survey of Older Men, on the other hand, are on the same order of magnitude as previous estimates. In both cases, we find that unsystematic changes in earnings and hours, attributable to measurement error or random taste components, contribute significantly to the covariances of the data. Section five describes the estimation of a two sector version of the model in which the relative extent of earnings smoothing in one sector is identifiable. Panel members with a single employer over the sample period are found to have substantial earnings stability relative to panel members with multiple employers. We also consider the extent of smoothing in union relative to nonunion earnings. Finally, in Section six we present a summary and conclusions.

I. A Model of Labor Supply with Smoothed Earnings

To keep things as simple as possible, we consider a world of perfect certainty in which individuals evaluate alternative streams of consumption (c_t) and labor supply (h_t) according to the preference function

$$\sum_{t=o}^{T} \beta^t (U(c_t) - \phi_t(h_t)) \ ,$$

where $U(\cdot)$ is concave and increasing, $\phi_t(\cdot)$ is convex and increasing, and $0 < \beta < 1$ is a discount factor. Individual marginal productivity in period t is represented by $\theta_t > 0$, and is taken as exogenous by each consumer-worker. Assuming unrestricted borrowing, an optimal sequence of consumption and labor supply is a solution to

(1) $$\max_{h_t, c_t} \sum_t \beta^t (U(c_t) - \phi_t(h_t)) \ ,$$

subject to the lifetime budget constraint

(2) $$\sum_t \beta^t c_t = \sum_t \beta^t \theta_t h_t \ .$$

For convenience, the interest rate and the discount rate are taken to be equal, although relaxing this assumption simply adds a trend to the path of lifetime consumption.[5/]

The first order condition for consumption in period t can be written as

(3) $$U'(c_t) = \lambda$$

for some positive constant λ which represents the marginal utility of wealth, while the first order condition for labor supply in t is

(4) $$\phi_t'(h_t) = \lambda \theta_t \ .$$

According to equation (3), desired consumption is independent of productivity. This conclusion reflects the separability of goods and leisure within each period: for more general time separable utility functions the marginal utility of consumption is not independent of labor supply, and optimal consumption in period t depends on both the marginal utility of lifetime income, λ, and the wage rate θ_t. In the absence of consumption data, however, there is little loss of generality of assuming separability between goods and leisure in each period.[6/]

For simplicity, assume that

$$\phi_t(h_t) = \exp(-(A+\delta_t)/\eta)\ (\frac{\eta}{1+\eta})\ h_t^{\frac{1+\eta}{\eta}} \ , \ \eta > 0 \ ,$$

where A represents a permanent component of individual tastes for leisure, and δ_t represents a transitory component of tastes. Substituting this expression into (4) implies that hours of labor supply in period t are given by

$$(5) \qquad \log h_t = A + \delta_t + \eta \log \theta_t + \eta \log \lambda \ .$$

Furthermore, in the absence of any income smoothing, earnings in period t are given by $g^o_t = \theta_t h_t$, with

$$(6) \qquad \log g^o_t = A + \delta_t + (1+\eta) \log \theta_t + \eta \log \lambda \ .$$

If wages are equal to marginal productivity period by period then equations (5) and (6) provide an appropriate description of the joint distribution of hours and earnings over the life cycle. Substituting the observed wage for θ_t in equation (5) leads to an estimating equation similar to one fit in first difference form by MaCurdy (1981) and Altonji (1983). In this formulation, the parameter η represents the (marginal utility of income constant) elasticity of intertemporal labor supply--the response of labor supply to a parametric increase in wage rates, along a given life-cycle trajectory. Convexity of preferences implies that the elasticity of intertemporal substitution is positive. Along a life-cycle trajectory, anticipated increases in wage rates necessarily increase labor supply.[7/]

Recently, however, considerable attention has focused on models in which wages systematically deviate from their spot market values as a consequence of long term employment contracts. Suppose for example that moral hazard considerations make it difficult to borrow against future earnings. In that case, if firms have access to perfect capital markets, employers will find it optimal to offer a smoothed profile of earnings--eliminating employees' capital market contraints.[8/] One particularly simple way of incorporating this possibility into the data analysis is to assume that observed earnings (g_t) represent a weighted geometric average of spot market earnings $(g^o{}_t)$ and a constant (K) whose value depends on average productivity during tenure with the current employer:

$$\text{(7)} \qquad \log g_t = \gamma \log K + (1-\gamma) \log g^o{}_t \ .$$

If $\gamma = 0$, then the labor market is a spot market, while if $\gamma = 1$, labor contracts offer constant earnings period by period.[9/] We shall also assume that labor contracts maintain a jointly optimal distribution of hours across periods, as described by equation (5). Note, however, that if $\gamma > 0$, this distribution is not generated by individual hours choice subject to the average wage rate g_t/h_t. Thus unilateral hours determination by employers may be necessary to achieve an appropriate level of labor supply in any given period, whenever earnings are smoothed according to equation (7).

In the presence of income-smoothing contracts, observed earnings take the form:

$$(8) \qquad \log g_t = \gamma \log K + (1-\gamma) A + (1-\gamma)\delta_t + (1-\gamma)(1+\eta) \log \theta_t + (1-\gamma)\, \eta \log \lambda \; .$$

From this equation it is apparent that increases in the extent of earnings smoothing reduce the covariance between earnings and productivity implied by the conventional spot market model of the labor market. By the same token, since the assumed relationship between hours and productivity is independent of the extent of earnings smoothing, increases in γ reduce the covariance between earnings and hours relative to an auction market model.

Income smoothing has a number of important implications for the measured wage rate $w_t = g_t/h_t$. Subtraction of equation (5) from equation (8) implies that the log of the measured wage rate is given by:

$$(9) \qquad \log w_t = \text{constant} - \gamma\, \delta_t + (1-\gamma(1+\eta)) \log \theta_t \; .$$

Whenever earnings are smoothed by employers, the ratio of earnings to hours responds less than unit-elastically with respect to productivity.[10/] In fact, if γ is equal to $\frac{1}{1+\eta}$, the measured wage is independent of individual productivity, while if γ exceeds $\frac{1}{1+\eta}$, measured wages respond negatively to increases in productivity. Income smoothing may also contribute toward sectoral differences in the wage-tenure relationship, in so far as unionized employers, for example, amortize long term trends in individual productivity over the lifecycle.[11/]

The possibility that wage rates do not fully reflect current productivity introduces an ambiguity into the interpretation of conventional labor supply functions. For a given level of earnings smoothing, equations (5) and (9) imply the following relationship between hours and measured wage rates:

$$\text{(10)} \qquad \log h_t = \text{constant} + \frac{\eta}{1-\gamma(1+\eta)} \log w_t + \frac{1-\gamma}{1-\gamma(1+\eta)} \delta_t \ .$$

Maintaining the auction market interpretation of the labor market, the regression coefficient of hours on wages (or changes in hours or changes in wages) is an estimate of the intertemporal substitution elasticity η. In the presence of income smoothing contracts, however, the interpretation of this regression coefficient depends on both the elasticity of substitution and the extent of income smoothing. Given a positive estimate of the regression coefficient, the largest estimate of the intertemporal substitution elasticity is associated with the auction market assumption $(\gamma=0)$, while increases in the assumed level of income smoothing lead to smaller estimates of η.[12/]

II. Econometric Implementation of the Model

The model of labor supply in the last section yields a pair of reduced form equations for earnings and hours in terms of individual-specific constants, individual-specific taste shifts, and the realization of current period productivity. Our empirical strategy is to use these equations to model the covariance matrix of changes in annual earnings and hours from a panel data set, treating productivity as an unobserved component in both earnings and hours. This strategy allows us to model measurement error in observed earnings and hours data directly, and yields theoretical covariance restrictions which are readily testible. At the same time, since the covariances of the data are easily computed and displayed, it is straightforward to summarize the empirical success or failure of the model in terms of its fit to the actual data.

According to equations (5) and (8), individual hours and earnings contain person-specific fixed effects relating to the permanent component of tastes A, the marginal utility of income λ, and the smoothed flow of earnings K. Following MaCurdy (1981), a convenient method for handling these fixed effects is to take first differences of (5) and (8).[13/] Suppose that the logarithms of observed earnings and hours differ from their true values by a pair of measurement errors u^*_t and v^*_t, respectively. Appending these errors to equations (5) and (8) and taking first differences leads to:

$$(11) \qquad \Delta \log g_t = (1-\gamma)(1+\eta)\, \Delta \log \theta_t + (1-\gamma)\, \Delta\delta_t + \Delta u^*_t ,$$

and

$$(12) \qquad \Delta \log h_t = \eta\, \Delta \log \theta_t + \Delta\delta_t + \Delta v^*_t .$$

These two equations express individual changes in earnings and hours in terms of a bivariate components of variance model. The components of variance represent the change in individual productivity, the change in individual tastes for leisure, and the first differences of a pair of measurement errors.

To complete the model, we require a stochastic specification for each of these variance components. While productivity and taste variables are assumed to be non-stochastic from the point of view of the individual, from the point of view of the econometrician each individuals' lifetime productivity sequence $\{\theta_t\}$ or taste shock sequence $\{\delta_t\}$ can be usefully interpreted as a realization from some common distribution over all such sequences. The parameters of the cross-sectional covariances and autocovariances of changes in earnings and hours therefore depend on the parameters of the distributions from which productivity and taste shocks are drawn, the parameters of the distribution of the measurement errors, and the behavioral parameters η and γ.

A general linear scheme for individual productivity is one that includes an permanent component for the i^{th} individual ω_i, a period specific aggregate effect d_t, an individual-specific trend ξ_i, and an autoregressive-moving average error component z_{it}:

$$\log \theta_{it} = \omega_i + d_t + \xi_i a_{it} + z_{it}$$

where a_{it} represents the age of the individual i in period t and

$$z_{it} = \alpha_1 z_{it-1} + \dots + \alpha_p z_{it-p} + \varepsilon_{it} - \psi_1 \varepsilon_{it-1} - \dots \psi_q \varepsilon_{it-q} ,$$

with $E(\varepsilon_{it}) = 0$ and $E(\varepsilon_{is}\varepsilon_{it}) = 0$ for $s \neq t$.[14/] Under this scheme, the first difference of the logarithm of individual productivity consists of the individual-specific growth rate in productivity, the first difference of aggregate productivity, and the first difference of the individual productivity shock:

$$(13) \qquad \Delta \log \theta_{it} = \xi_i + \Delta d_t + \Delta z_{it} .$$

For simplicity, in this paper we assume that both the measurement errors u^*_{it} and v^*_{it} and the individual-specific preference shocks δ_{it} are serially uncorrelated. We also assume that u^*_{it} and v^*_{it} have an unrestricted contemporaneous covariance. In that case, we can define a pair of random variables

$$(14) \qquad \begin{aligned} u_{it} &= (1-\gamma)\ \delta_{it} + u^*_{it} \\ v_{it} &= \delta_{it} + v^*_{it} \end{aligned}$$

which are serially uncorrelated, with an arbitrary contemporaneous correlation, such that the changes in log earnings and log hours in period t for a given individual are represented by:

$$(15) \qquad \Delta \log g_{it} = (1-\gamma)(1+\eta)(\Delta d_t + \xi_i + \Delta z_{it}) + \Delta u_{it}$$

$$(16) \qquad \Delta \log h_{it} = \eta(\Delta d_t + \xi_i + \Delta z_{it}) + \Delta v_{it} \ .$$

The assumption that the measurement error components of variance and the taste shock component of variance in earnings and hours have the same stochastic structure has an important implication for the identification of the parameters η and γ. By inspection of equations (15) and (16), it is clear that η and γ are not separately identified in the absence of prior information, since the right hand sides of these two equations are invariant to a transformation that doubles η and $(1-\gamma)\ (1-\eta)$, and halves the magnitudes of the productivity components Δd_t, ξ_i and Δz_{it}. While in principle η and γ are separately identified if measurement error components and taste shock components have different stochastic structures, in this paper we do not distinguish between these sources of variance, but concentrate instead on distinguishing the systematic component of variance in earnings and hours from the unsystematic component represented by the combination of measurement errors and changes in preferences.

The implications of equations (15) and (16) for the autocovariances and cross-covariances of earnings and hours are summarized in Table 1. Assuming that measurement errors and preferences shocks are serially uncorrelated, the higher order autocovariances and cross-covariances of earnings and hours reflect only systematic productivity components. Accordingly, equations (15) and (16) impose a number of restrictions on these higher order autocovariances and cross-covariances. For example, the ratio of the j^{th} order autocovariance of earnings to the j^{th} autocovariance of earnings is constant for any $j > 1$, and equal to $(1-\gamma)^2 (1+\eta)^2/\eta^2$. By the same token, the ratio of the j^{th} order autocovariance of earnings to the j^{th} order cross-covariance of earnings and hours is constant for all $j > 1$ and equal to $(1-\gamma)(1+\eta)/\eta$. These restrictions are independent of the time series process of individual productivity shocks, and can be tested without specifying that process.

On the other hand, serially uncorrelated preference shocks and/or measurement error introduce a distinctive pattern into the first order autocorrelations of earnings and hours. In the absence of systematic productivity components, in fact, the first order autocorrelations of earnings and hours, and the first order cross-correlation of earnings and hours are all equal to $-1/2$, while the higher order auto- and cross-correlations of earnings and hours are zero. This pattern reflects the negative covariance between consecutive first differences of a serially uncorrelated series, and the lack of correlation between first differences more than one period apart.

Our empirical analysis of labor supply under long term contracts consists of fitting the observed covariance matrix of consecutive first differences in log earnings and log hours from a panel data set to the formulas summarized in Table 1. A general description of such method-of-moments estimators is contained in Chamberlain (1982). In view of potential simultaneity problems between year to year changes in aggregate productivity (as represented by Δd_t) and year to year changes in the aggregate shock to labor-leisure preferences (as represented by the sample average of $\Delta\delta_t$) we do not use equations (15) and (16) to model the mean changes in earnings and hours in the panel.[15/] Rather, we leave the mean changes in earnings and hours in each year of the panel unrestricted, and consider the implications of equations (15) and (16) for the cross-sectional covariances of changes in earnings and hours.

In Section IV of the paper, we present estimates of equations (15) and (16) under the normalizing assumption that $\gamma=0$. If the labor market actually functions as an auction market, then this assumption allows us to identify the intertemporal substitution elasticity. If, on the other hand, the extent of earnings smoothing in the labor market is $\gamma > 0$, then we obtain an estimate of the intertemporal substitution elasticity equal to $\eta/(1-\gamma(1+\eta))$, where η is the true intertemporal substitution elasticity.[16/] Any unaccounted earnings smoothing in the labor market leads to a positively biased estimate of the intertemporal substitution elasticity.

In Section V, we present estimates of equations (15) and (16) based on comparisons of two alternative groups of workers. Again, we make the normalizing assumption that one group of workers participates in a spot labor market, with no implicit earnings smoothing. This assumption allows us to identify the intertemporal substitution elasticity η and the extent of earnings insurance enjoyed by the second group, γ_2 . If the first group actually has earnings smoothed to the extent γ_1 , however, then we obtain an estimate of the intertemporal substitution elasticity equal to $\eta/(1-\gamma_1(1+\eta))$, and an estimate of the extent of earnings insurance for the second group equal to $(\gamma_2-\gamma_1)/(1-\gamma_1)$.[17/]

III. Sample Selection and Data Description

In this section we provide a brief description of the earnings and hours data that form the basis of our empirical analysis. Our data are drawn from two sources: The Panel Study of Income Dynamics (PSID) and the National Longitudinal Survey of Older Men (NLS). From the PSID, the sample consists of 1531 male heads of households between the ages of 21 and 64 who reported previous year's earnings and hours in every survey from 1969 to 1979.[18] From the NLS, the sample consists of 1321 males who were less than 65 in 1975, and who reported previous year's earnings and hours in each of the survey years 1966, 1967, 1969, 1971, 1973, and 1975.[19] Table 2 shows means and standard deviations of the changes in the logarithms of real earnings and hours for the two samples and several subsamples. The PSID sample is stratified in two alternative ways: by the number of employer changes over the sample period, and by union membership. In the first instance we distinguish between sample members who reported no change of employer between 1969 and 1979 (638 individuals), and sample member who reported at least one change of employer during the sample period (893 individuals). Secondly, we distinguish sample members who reported union membership in at least two survey years. On this basis, 607 individuals are classified as union workers, and 924 as nonunion workers.[20] The NLS sample is also stratified into individuals with one employer during the sample period (738 individuals) and individuals with more than one employer during the sample period (583 individuals). No comparable division of the NLS sample into union and nonunion workers is possible, however, since union membership information is only available in 1969 and 1971 for the NLS. Instead, we subdivided NLS sample members with one employer into union workers (328 individuals) and nonunion workers (410 individuals) on the basis of reported union membership in 1971.

Each pair of columns in Table 2 gives the means and standard deviations of the changes in the logarighms of earnings and hours for a particular subgroup. For the NLS samples, the 1967 changes are based on the differences in the logarithms of earnings and hours between 1966 and 1967, while subsequent changes are taken over two year intervals and expressed at annual rates. For the PSID samples, all changes are over one year intervals.

A prominent feature of the means in Table 2 is the sharp decline in earnings and hours between 1973 and 1975. This pattern is shared by all the subgroups, although the decline was smaller among individuals who worked for one employer, and among union as compared to nonunion members of the NLS panel. PSID sample members' real earnings grew rapidly in 1972 and 1973, fell in 1974 and 1975, and then increased dramatically in 1976. NLS sample members' earnings grew at declining rates throughout the late 1960's and early 1970's, then dropped at an 8.4 percent annual rate between 1973 and 1975. This decline was coincident with a 6 percent per year drop in annual hours, after relative stability in hours from 1966 to 1973.

The cross-sectional variances of the changes in log earnings and hours show a mixed pattern. In the PSID sample, the variances of hours and earnings declined in 1973 and 1974, and rose in 1975 and 1976. On the other hand, in the NLS sample, the variances of the changes in log earnings and hours were fairly stable from 1969 to 1973, and then increased substantially in 1975. Comparing across subsamples, the dispersion of changes in log earnings and log hours is lower and more stable among individuals with one employer. Comparing union and nonunion members of the PSID panel, the variance of earnings is slightly larger for nonunion members, while the variance of hours is about the same. Among NLS panel members with one employer, union members' earnings and hours show slightly less cross-sectional dispersion than nonunion members'.

Table 3 presents the average autocovariances and cross-covariances of the changes in log earnings and log hours for the two samples and the various subsamples.[21] In calculating the covariances for the NLS samples, the 1966 to 1967 changes in earnings and hours have been ignored: the data represent averages based on 4 two year changes (not adjusted to annual rates). The covariances for the PSID samples represent averages based on 10 one year changes. In spite of this difference in underlying data, however, the autocovariances and cross-covariances obtained from the two samples are remarkably similar. Comparing the moments of the two complete samples, the variance of the change in log earnings is about .18 in each case; the first order autocovariance of the change in log earnings is about -.06 in each case; and the higher order autocovariances of changes in log earnings are all insignificantly different from zero. The autocovariances of the change in log hours display the same pattern, although the magnitudes are smaller: the variance of the change in log hours is about .13 in both samples; the first order autocovariance of the change in log hours is about -.04 in both samples; and the higher order autocovariances of the changes in log hours are all insignificantly different from zero. The cross-covariances of changes in log earnings and hours are also comparable across samples. The zero-order cross-covariance is about .075 in both samples, the first-order cross-covariances are between -.01 and -.02, and the higher order cross-covariances are small and mixed in sign, and generally insignificant. It is interesting to observe that the cross-covariances are very nearly symmetric in both samples, although there are some minor discrepancies.

The comparability between the PSID and the NLS data extends to the subsamples of individuals with one employer and more than one employer. The latter group have uniformly larger autocovariances and cross-covariances.

However, the general pattern of the covariances is preserved. Specifically, the first order autocorrelations of the change in log earnings and hours are about -1/3, and the higher order autocorrelations are negligible. The zero order cross-correlation is about .50 for both full samples, about .15 for both subsamples of workers with one employer, and about .60 for both subsamples of workers with more than one employer. The first order cross-correlations are between -.10 and -.20, and the higher order cross-correlations are small and mixed in sign.

Since our empirical strategy is to treat the model of the previous section as a description of the second moments of the changes in earnings and hours, it is worth commenting on the likely success of the theory in parameterizing the data in Tables 2 and 3. One obvious problem for any model of the covariances is the apparent non-stationarity of the cross-sectional variances displayed in Table 2. This phenomenon is especially prominent among the older men in the NLS, although there is some evidence of non-stationarity in the PSID sample. While a longer panel from the NLS would allow us to check if the increase in dispersion of hours and earnings between 1973 and 1975 was permanent or transitory, the available data present a puzzle that cannot be easily described by either a stationary or smoothly trending covariance model.

A second major puzzle is the conformity of the covariance data from the two surveys, in spite of the difference in timing intervals between them. The simplest hypothesis consistent with this fact is that a major component of the variance of earnings and hours is measurement error. Measurement error introduces the same stochastic structure into the changes in log earnings and hours, regardless of the interval over which the change is taken. However, the first order autocorrelations of both variables are smaller than a pure measurement error model would suggest. Whether or not a more complete model of earnings and hours can better fit the data is pursued in the next section.

Finally, it is interesting to consider the relationship between wages and hours implied by the covariances in Table 3. Define the average hourly wage rate (w) as the ratio of earnings to hours, and observe that

$$\Delta\log w = \Delta\log g - \Delta\log h.$$

Therefore, the sample covariance of the change in log hours with the change in log wage rates is

$$\text{cov}(\Delta\log w, \Delta\log h) = \text{cov}(\Delta\log g, \Delta\log h) - \text{var}(\Delta\log h).$$

In none of the subsamples in Table 3 is this covariance positive. The regression coefficient of the change in hours on the change in wages is just

$$\frac{\text{cov}(\Delta\log w, \Delta\log h)}{\text{var}(\Delta\log w)}$$

which is -.36 in the complete PSID sample and -.28 in the complete NLS sample. These facts illustrate the difficulty of obtaining a positive estimate of the intertemporal elasticity of substitution from a simple cross-sectional regression of changes in hours on changes in wage rates.

IV. Single Sector Estimates of the Model with No Insurance

In this section we report method of moments estimation results for the model comprised of equations (15) and (16), fit to the second moments of earnings and hours from the PSID and NLS data sets. While these equations also describe the first moments of the data, we have only fit the covariances and cross-covariances of earnings and hours, leaving the means unrestricted.[22] For the PSID samples, the data consist of 210 covariance elements. For the NLS samples, the data consists of 55 covariance elements, 10 of which depend on a one year change in log earnings and log hours, and 45 of which depend on two year changes.

The estimation procedure minimizes an expression of the form

$$[m-f(\phi)]' \; A \; [m-f(\phi)],$$

where m is the vector of distinct sample covariance elements, f is the vector of predicted covariance elements, considered as a function of the vector of parameters ϕ (including the elasticity of substitution, the parameters of the ARMA process generating productivity shocks, and the variances of individual productivity shocks, individual productivity trends, and the combined measurement errors/preference shocks in earnings and hours), and A is a suitably chosen matrix: either the identity matrix in the case of least squares estimates, or the inverted fourth moment matrix of the data in case of optimal minimum distance estimates.[23] For models of the productivity shock process that contain an autoregressive component, the parameter vector ϕ also includes the cross-sectional variances of the pre-sample productivity shocks, which we leave unrestricted, rather than imposing stationarity on the covariances of the productivity shocks.[24]

Table 4 contains least squares (LSQ) and optimal minimum distance (OMD) estimates of the model of equations (15) and (16), under the normalizing assumption that the labor market provides no earnings insurance. Individual productivity shocks are assumed to follow an AR(1) process in first differences. The first three columns of the table refer to the estimates of the model on the PSID data, while the last three columns refer to estimates on the NLS data. For comparative purposes, we also provide OMD estimates of a pure measurement error model of the covariances of earnings and hours in the third and sixth columns of the table.

The results show a number of contrasts and similarities between the two samples. First, the estimated elasticities of substitution are very different between the PSID and NLS samples. The former estimates are considerably larger than most estimates of the elasticity of substitution in the literature, while the latter are in the neighborhood of previous estimates.[25] Second, the estimated measurement error/preference shock variances, and their correlation coefficient, are fairly similar between the samples. Third, relative to an AR(1) specification of the first difference of productivity shocks, we find very little evidence against a random walk specification of productivity shocks in either data set. Fourth, we find no evidence for a significant cross-sectional variation in individual productivity trends in either data set, maintaining an AR(1) specification of the first difference of productivity shocks. These two findings together imply that the predicted cross-sectional autocovariances of earnings and hours are all zero, apart from the first order autocovariances.

The shares of the observed variances of the first differences of earnings and hours attributable to productivity shocks, productivity trends, and measurement error are tabulated in rows 9 through 14 of the table.[26] In spite of differences between the samples in the estimated elasticities of substitution, the variance shares are very similar. In each case, the major component of variance of the changes in log earnings and hours is measurement error/preference shifts. The least squares estimates attribute a higher variance share to systematic productivity shocks, relative to the OMD estimates. This reflects a general characteristic of the OMD estimates, which tend to underfit the variances of earnings and hours relative to the LSQ estimates.

The overall fits of the model to the data are not good: the chi-squared statistics reported in line 16 of Table 4 are all in excess of their one percent critical values. However, relative to a pure measurement error/ preference shift specification, the model does reasonably well. Although we have not determined the reasons for the poor fit of the model, considerable experimentation with the NLS data revealed no major improvement in fit relative to that recorded in Table 4. In particular, a completely unrestricted specification of the covariances of the first differences of the individual productivity shocks yields as good a fit and virtually identical estimates of the elasticity of substitution as the simpler specification presented in Table 4.[27] By the same token, an unrestricted parameterization of the variance of individual productivity shocks in 1975 improves the fit of the model to the NLS data only slightly, and hardly affects the other parameters of the model.

The fit of the model to the NLS panel is also largely unaffected by removing the outliers in the data. Previous authors, noting the presence of outliers in the NLS and other panel data sets, have adopted ad hoc exclusion rules: usually on the basis of the magnitude of year to year changes in earnings and/or hours.[28] An alternative procedure is to order the observations and select outliers on the basis of the criterion function

$$(m_i - m)' \, V^{-1} (m_i - m),$$

where m_i is the individual vector of corrected squares and cross-products, m is the vector of sample average second moments, and V is the sample fourth moment matrix.[29] In Table 5 we present alternative estimates of the model on the NLS panel, with 10 percent of the outliers removed.[30] Despite the appearance of some rather startling outliers in the data, the estimation results are extremely robust. Removing the outliers tends to reduce the share of measurement error attributed to the variances of earnings and hours, and actually causes the fit of the model to deteriorate somewhat. However, the estimate of the elasticity of substitution is unaffected by inclusion or exclusion of the outliers. We tentatively conclude that the minimum distance estimation technique is fairly robust to outliers, and that the poor fit of the model is not a result of outliers in the data.

The normalizing assumption of no earnings insurance yields the largest estimate of the intertemporal elasticity of substitution and the smallest estimate of the variance of productivity shocks consistent with the covariance data.[31] For example, if labor market contracts offer 20 percent earnings insurance, then the implied estimate of the elasticity of substitution from the PSID sample is 1.79 (based on the first column of Table 4), and the implied estimate of the elasticity of substitution from the NLS sample is .12 (based on the fourth column of Table 4). However, in the absence of other information, there is no way to infer the extent of earnings insurance from the data. By themselves, the covariances of earnings and hours (or wage rates and hours) do not contain enough information to distinguish a spot market interpretation of the labor market from a contractual model of earnings determination.

V. Two Sector Estimates of the Model with Relative Insurance

To address the identification problem posed by equations (15) and (16), we analyze two sector estimates of the model. Assuming that workers in one sector receive no earnings insurance (or any arbitrary level of insurance) and comparing them with workers in another sector, we obtain an estimate of the relative earnings insurance in the second sector. Our first set of estimates are based on comparisons of workers who changed employers during the sample period with workers who did not. Here, an attractive hypothesis is that workers who changed employers had relatively less earnings insurance, on average, than workers who stayed with the same employer. In both the PSID and NLS samples we find support for this hypothesis. Next, we compare union and nonunion workers - first among sample members of the NLS who had the same employer from 1966 to 1975, and then among all members of the PSID sample. In both instances we find weak evidence of earnings smoothing in the union sector.

Tables 6a and 6b report least squares and optimal minimum distance estimates of a two sector version of the model fit to the PSID sample stratified by number of employers.[32] The first two columns of each table also contain estimates of a one sector version of the model, fit to the two subsamples independently. The least squares estimates on the subsamples are fairly close to the estimates obtained on the combined sample. However, the OMD fit to the sample of individuals with one employer is less satisfactory. In fact, a pure measurement error/preference shift model gives the best fit to the data for this subgroup.[33] The third column of each table contains estimation results for a two sector model in which the two sectors are constrained to be identical.[34] The LSQ results for the combined sample are roughly similar to the sectoral results. The OMD estimation procedure, however, yields a negative estimate of the elasticity of substitution. As the χ^2 statistics in the bottom row of Table 6b reveal, the restriction that the two sectors are identical is overwhelmingly rejected. The fourth column of each table presents estimation results for a two sector version of the model in which the extent of earnings insurance in the two sectors is not constrained to be equal. For both estimation procedures, relaxing this constraint improves the fit of the model. Comparing χ^2 statistics for the OMD estimates in Table 6b, the unconstrained estimates generate a highly significant improvement in the fit of the model.[35] On the other hand, both the least squares and the optimal minimum distance estimates of the extent of earnings insurance for workers with one employer are in excess of unity. Furthermore, the OMD estimate of the elasticity of substitution is negative and significant. Apparently, the differences between the sectors are not fully captured by allowing for more earnings insurance among workers with one employer.

The fifth columns of Tables 6a and 6b present estimation results for a two sector model in which both the measurement error/preference shift variances and the extent of earnings insurance are allowed to vary by sectors. Here, the OMD and LSQ estimates are in fairly close agreement. Both sets of estimates attribute significantly more measurement error/preference shift in earnings and hours to the sector of job movers. While this conclusion is intuitively plausible, more research will probably be required to draw a reliable inference on the source of the discrepancies between the sectors. The χ^2 statistics in Table 6b show that the improvement in the fit of the model by relaxing the equality of the measurement error/preference variances across sectors is dramatic: the χ^2 value is 1804 with 4 degrees of freedom.

The LSQ estimate of the elasticity of substitution is 1.8, with a standard error of .3 and the LSQ estimate of the earnings insurance parameter is .91, with a standard error of .03. These estimates are larger than the corresponding OMD estimates, which put the elasticity of substitution at .82, with a standard error of .06, and the extent of relative earnings insurance at .78, with a standard error of .02. Both sets of estimates support the hypothesis that workers who stay with the same employer had their earnings smoothed relative to other workers.

A similar conclusion emerges from the NLS data. Table 6c presents OMD estimation results for one sector and two sector versions of the model fit to the NLS subsamples of individuals with one employer and more than one employer. As in Tables 4 and 5, the estimated elasticities of substitution for the NLS samples are in the neighborhood of .10. Comparing estimates of the model on the two sectors, the variance shares of measurement error/ preference shift and productivity shocks are very similar between sectors, although the variances themselves are uniformly higher for individuals who changed employers. The third column of Table 6c presents a two sector version of the model in which both sectors are constrained to have the same earnings insurance and measurement error variances. Comparing χ^2 statistics in the last row of the table, the cross-sector constraints are easiliy rejected at conventional significance levels. The estimates in the fourth column of Table 6c, which allow for different insurance components in the two sectors, give a better fit. The estimated relative insurance parameter for individuals with one employer is .48, which indicates considerable smoothing in the earnings of workers who stayed with the same employer over the sample period. Finally, in the last column of Table 6c, we present two sector estimates that permit both earnings insurance and measurement error/preference changes to vary between the sectors. While the estimated measurement errors are significantly larger for individuals who changed employers, the estimates of the elasticity of substitution and the extent of earnings insurance for individuals with one employer are largely unchanged from the estimates in the fourth column of the table. The NLS data provides additional evidence in favor of the hypothesis of earnings insurance among labor market participants who remain with the same employer for extended period of time.

Further insight into the extent of earnings insurance among labor market participants can be obtained by comparing union and nonunion workers. Union workers are often described as having lower turnover rates and longer tenure than nonunion workers.[36] Accordingly, one would expect to observe a larger insurance component in the earnings of unionized workers. Some evidence is presented in Table 7, which reports one sector and two sector estimates of the model on the union and nonunion subsamples of individuals with one employer in the NLS panel. The estimates for the union and nonunion workers taken separately look fairly similar. In each case the estimated elasticity of intertemporal substitution is about .10. However, the share of measurement error/preference shift in earnings of nonunion workers is larger. The fit of the model to these two subsamples is relatively good, and the χ^2 statistics in the bottom row of the Table are not significant at conventional levels for either the union or nonunion subsample.

The third and fifth columns of Table 7 present estimates of the model over union and nonunion workers jointly: constrained to have equal earnings insurance and measurement error/preference shift variances in the third column of the table, constrained to have equal measurement error/preference shift variances in the fourth column, and unconstained in the fifth column. Comparing χ^2 statistics against the fit of the one sector models, the two sector models with equal measurement error/preference shift variances are both rejected at the 5 percent significance level, while the two sector model that allows for more earnings insurance in the union sector and different measurement errors between the sectors is not rejected at that level of significance.[37] The estimates of the insurance parameter confirm that union members have smoother earnings than their nonunion counterparts, although the difference is not large or statistically significant. This finding may reflect more on the nature of the samples than on the general comparability of union and nonunion jobs, however. The samples both consist of older men with considerable tenure at their place of employment, and are not representative of the union or nonunion populations as a whole.

Our final pair of Tables present LSQ and OMD estimates of the model fit to the union and nonunion subsamples of the PSID data. Strictly speaking, the union sample consists of panel members who reported union membership in at least two out of the eleven years in the sample period. As the data in Table 3 suggests, the distinction between union and nonunion individuals by this criterion is less pronounced than the distinction between panel members with one and more than one employer over the sample period. The LSQ estimates of the model (Table 8a) on union and nonunion workers separately confirm the similarity of the two subgroups. For both union and nonunion workers the estimated elasticities of substitution are large and imprecise. The shares of measurement error/preference shift and productivity shocks in the variances of the changes in log earnings and log hours are also similar for the two groups. On the other hand, the OMD estimates (Table 8b) are quite different between the groups. The best fit to the union subsample is obtained by a pure measurement error model.[38]

The third through fifth columns of Tables 8a and 8b report two sector versions of the model fit to union and nonunion workers in the PSID. In the third column of each Table we report estimates of the model under the assumption that the two sectors offer the same earnings insurance. This restriction has only a small impact on the LSQ estimates. However, the OMD estimates are more sensitive, and the OMD estimate of the elasticity of substitution on the combined data is extremely large. The fourth column of each table presents a combined model that allows for a greater degree of earnings insurance in the union sector. The LSQ and OMD estimates of the relative earnings insurance parameter for union workers are fairly similar. However, the estimates of the elasticity of substitution are quite different: the LSQ estimate is 1.85, while the OMD estimate is 6.35. As noted in Table 4, the LSQ estimates attribute a larger share of the variance of earnings and hours to productivity shocks, relative to the OMD estimates. Finally, the fifth columns of Tables 8a and 8b present two sector estimates of the model that permit different measurement error/preference shift variances in the union and nonunion sectors. For the OMD estimates, this generates a significant improvement in the fit of the model and increases the estimate of the elasticity of substitution to 7.5. However, the estimate of the relative extent of earnings insurance in the union sector is unaffected. For the LSQ estimates, sector-specific measurement error parameters increase the estimated elasticity of substitution and yield a negative, but insignificant, estimate of the relative extent of earnings insurance in the union sector.

The comparison of union and nonunion workers in the PSID sample is generally consistent with the comparison of union and nonunion workers in the NLS subsample of individuals with one employer. Apparently, union workers' earnings contain a small insurance component relative to nonunion workers. The estimate of the relative extent of earnings insurance is about .10 from the NLS sample, and between .10 and .20 from the PSID sample. However, the fit of the model to the PSID sample is poor, and the discrepancy between the estimated elasticities of substitution in the two samples makes it difficult to draw firm conclusions.

VI. Summary and Conclusion

This paper has presented a model of intertemporal labor supply in the presence of income smoothing contracts. The model delivers an empirically tractable description of the means and covariances of a panel of earnings and hours data without the assumption that observed wage rates equal current marginal productivity. It also demonstrates the observational equivalence between conventional labor supply models and models where earnings contain both insurance and productivity components. In the absence of prior information, the intertemporal elasticity of substitution, the extent of earnings insurance, and the cross-sectional variance of individual marginal productivity are not separately identifiable. To solve this identification problem, we use cross-sectoral comparisons of earnings and hours variability to estimate the relative degree of earnings stabilization between sectors.

We fit the model to data from the National Longitudinal Survey of Older Men and the Panel Study of Income Dynamics. Adopting the conventional normalization of no earnings insurance, the NLS data consistently give estimates of the intertemporal labor supply elasticity of about .1. On the other hand, the PSID data give estimates of about 4. The discrepancy in these results may be due at least in part to differences in the methods of measuring annual hours and earnings employed in the two surveys. The NLS uses standard Bureau of the Census methods for eliciting annual hours, whereas the PSID uses a detailed set of auxiliary questions. While we find evidence of measurement error in both surveys, it remains a puzzle that the two data sets produce such different estimates.

A comparison between employees with a single employer during the sample period and others reveals that those with one employer had significantly less earnings variability. This is consistent with our hypothesis that workers in long term employment relationships enjoy some degree of earnings insurance. A similar comparison of union and nonunion workers shows more stable earnings in the union sector, although the magnitude of the effect is not nearly as large as for individuals with one employer.

On the basis of our results we conclude that survey measures of earnings and hours convey very imperfect information about current marginal productivity, particularly for adult males in stable employment situations. Nevertheless, our theoretical and empirical framework permits the estimation of an intertemporal labor supply model that is consistent with optimal hours allocation and earnings smoothing. The estimated parameters imply that some fraction of the variance of the change in individual hours is attributable to changes in marginal productivity, while some fraction is apparently due to the combined effects of survey measurement error and preference shifts. By the same token, a significant share of the variance of the change in individual earnings is apparently due to changes in marginal productivity. The importance of marginal productivity in current earnings falls, however, as earnings are smoothed by employers.

Footnotes

1/ See in particular Bailey (1974), Azariadis (1975), and the recent survey by Hart (1983).

2/ Especially Hall (1982).

3/ Hall (1980).

4/ The study of labor supply in a lifecycle framework dates at least to Friedman's (1962) distinction between current and permanent real wage rates. Lucas and Rapping (1969) use a two period version of the lifetime labor supply function. Multiperiod labor supply is considered by Heckman (1974, 1976), Ghez and Becker (1975), and many subsequent authors (see, in particular, MaCurdy (1981)). Most of this literature is summarized in Killingsworth (1983).

5/ See for instance Ashenfelter and Ham (1979). Their estimate of the difference between the market real interest rate and the subjective time discount rate is positive and significantly different from zero.

6/ See Altonji (1983) for a microeconomic analysis of labor supply and consumption. Browning, Deaton and Irish (1983) analyze aggregated labor-supply and consumption data in an explicit lifecycle framework.

7/ The proposition that hours increase with wages, holding constant the marginal utility of income, is independent of any particular parameterization of preferences. Thiel (1971) Appendix A (pp. 674-678) presents the algebraic relation between the uncompensated, compensated, and marginal utility of income constant derivatives of the consumer demand function. See also MaCurdy (1981).

8/ This argument is advanced by Bailey (1974).

9/ Note that the constant K may reflect an implicit premium that employees pay in return for smoother earnings. Our only empirical requirement for K is that it be constant for each individual whose earnings are smoothed.

10/ Brown (1982) presents a time series analysis of two digit industry wage data which suggests that the elasticity of wage rates with respect to short term changes in productivity is about .35.

11/ See Lewis (1983) on union-nonunion wage profiles.

12/ For a given estimate b of the regression coefficient of hours on wages, the implied estimate of the intertemporal substitution elasticity η is $\eta = \frac{b(1-\gamma)}{1+\gamma b}$.

13/ First differencing, of course, discards sample information on individual mean levels of earnings and hours. In principle, this information is useful in testing the implications of the theory for the marginal utility of income.

14/ See MaCurdy (1982) for a discussion of alternative error processes in a panel data context. We do not have to impose the assumption that all roots of the autogressive part of z_{it} are less than unity, or the assumption that ε_{it} has constant variance.

15/ Ashenfelter (1984) presents some estimates of the intertemporal substitution elasticity based on mean changes in earnings and hours from a fixed panel of individuals.

16/ Suppose that the extent of earnings smoothing is γ . From equation (15), the product $(1-\gamma)^2(1+\eta)^2$ var (Δz_t) is identifiable, and from equation (16), the product η^2 var (Δz_t) is identifiable. If we (mistakenly) assume that $\gamma=0$, we set the first of these products equal to $(1+\eta^e)^2$ var (Δz_t) and the second equal to $(\eta^e)^2$ var (Δz_t) , where η^e is the resultng estimator of the intertemporal substitution elasticity. It follows that $\eta^e = \eta/(1-\gamma(1+\eta))$.

17/ For each of the two groups, the product $(1-\gamma)^2(1+\eta)^2$ var (Δz_t) is identifiable. If group 1 has earnings smoothed to the extent γ_1 , and group 2 has earnings smoothed to the extent γ_2 , and the groups are otherwise identical, then the ratio $(1-\gamma_2)/(1-\gamma_1)$ is identifiable. If we (mistakenley) assume that $\gamma_1=0$, then the implied estimator of γ_2 is $(\gamma_2-\gamma_1)/(1-\gamma_1)$.

[18]While a slightly longer span of data is available from the PSID, computational considerations led us to restrict the panel to 10 annual changes in earnings and hours.

[19]The NLS administered a survey in 1968, but comparable earnings and hours data were not collected.

[20]Most individuals who reported union membership in at least two years reported union membership in all years. Potential difficulties with measurement error in union membership responses are described by Freeman (1982).

[21]The covariances in Table 3 were estimated by fitting a stationary second moment matrix to the data by least squares. The standard errors are calculated according to the formulas in Chamberlain (1982a).

[22]This avoids any simultaneity problems between the aggregate productivity effect d_t and the aggregate change in tastes. It also reduces the number of parameters under consideration by 9 in the case of the PSID, and by 4 in the case of the NLS.

[23]Chamberlain (1982a) shows that among the class of minimum distance estimates, the optimal choice for A is the inverted second moment matrix of the vector of moments m. The appropriate asymptotic variance-covariance matrices of the least squares and optimal minimum distance parameter estimates are described in Chamberlain (1982a).

[24]See MaCurdy (1982). There are as many unrestricted pre-sample variances as the order of the autoregressive component of productivity shocks: in all cases reported here, this amounts to one extra parameter.

[25]See Killingsworth (1983).

[26] The component of variance due to productivity shocks is computed at the steady state variance of the change in individual productivity.

[27] With an unrestricted specification of the covariances of the individual productivity shocks, the estimated elasticity of substitution is .108 with a standard error of .051. The goodness fit statistic for the unrestricted model is 98.8, with 36 degrees of freedom. A χ^2 test of the AR(1) specification recorded in Table 4 against the generalized model yields a test statistic of 12.3, with 11 degrees of freedom. The AR(1) specification also compares favorably to an ARMA(1,1) specification of individual productivity shocks.

[28] For instance, in analyzing the PSID data, MaCurdy (1981) eliminated observations with any year to year real wage rate change in excess of 200 percent, or any year to year change in annual hours in excess of 190 percent.

[29] See Barnett and Lewis (1978) pp. 208-220.

[30] We also estimated the model with 15 percent of the outliers removed, and obtained virtually identical results to those in Table 5.

[31] The three parameters η, γ, and σ are related by the two equations $\eta\sigma$ = constant and $(1 - \gamma)(\frac{1+\eta}{\eta})$ = constant.

[32] The estimation method for the two sector version of the model minimizes the criterion

$$\frac{N_1}{N_1 + N_2}(m_1 - f(\delta_1))V_{11}^{-1}(m_1 - f(\delta_1)) + \frac{N_2}{N_1 + N_2}(m_2 - f(\delta_2))V_{22}^{-1}(m_2 - f(\delta_2)) ,$$

where N_j is the number of observations in the j^{th} sector, m_j is the vector of covariance elements from the j^{th} sector, δ_j is the vector of parameters for the j^{th} sector, and V_{jj} is the estimated fourth moment matrix for the j^{th} sample.

[33]A better fit than the pure measurement error model is obtained by a model with an arbitrarily large elasticity of substitution and an arbitrarily small variance of individual productivity shocks. Among the class of models with parameters in the interior of the parameter space, however, the measurement error model does best.

[34]These estimates differ from the one sector estimates obtained over the combined sample unless the moments of the two subsamples are identical.

[35]The χ^2 test statistic is 87 with one degree of freedom.

[36]See for instance Freeman and Medoff (1982), and the references cited there.

[37]The test statistic for the model in the third column of Table 7 is 15, with 5 degrees of freedom: the 5 percent critical value is 11. The test statistic for the model in the fourth column of Table 7 is 14 with 4 degrees of freedom: the 5 percent critical value is 9.5. The test statistic for the most general two sector model in the fifth column of Table 7 is 1.0, with 1 degree of freedom: the relevant 5 percent critical value is 3.8.

[38]A better fit is generated by a model with an arbitrarily large elasticity of substitution and an arbitrarily small variance of productivity shocks. Among the class of models with estimated parameters in the interior of the parameter space, the measurement error/preference shift model gives the best fit.

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Table 1

Theoretical Autocovariance and Cross-covariance Functions of the First Differences of Log Earnings and Log Hours

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1. $\mathrm{Var}[\Delta\log g_{it}] = (1-\gamma)^2(1+\eta)^2\ (\mathrm{Var}[\Delta z_{it}] + \sigma_p^2) + 2\sigma_u^2$
2. $\mathrm{Cov}[\Delta\log g_{it}, \Delta\log g_{it-1}] = (1-\gamma)^2(1+\eta)^2\ (\mathrm{Cov}[\Delta z_{it}, \Delta z_{it-1}] + \sigma_p^2) - \sigma_u^2$
3. $\mathrm{Cov}[\Delta\log g_{it}, \Delta\log g_{it-j}] = (1-\gamma)^2(1+\eta)^2\ (\mathrm{Cov}[\Delta z_{it}, \Delta z_{it-j}] + \sigma_p^2)$ $(j > 1)$

4. $\mathrm{Var}[\Delta\log h_{it}] = \eta^2\ (\mathrm{Var}[\Delta z_{it}] + \sigma_p^2) + 2\sigma_v^2$
5. $\mathrm{Cov}[\Delta\log h_{it}, \Delta\log h_{it-1}] = \eta^2\ (\mathrm{Cov}[\Delta z_{it}, \Delta z_{it-1}] + \sigma_p^2) - \sigma_v^2$
6. $\mathrm{Cov}[\Delta\log h_{it}, \Delta\log h_{it-j}] = \eta^2\ (\mathrm{Cov}[\Delta z_{it}, \Delta z_{it-j}] + \sigma_p^2)$ $(j > 1)$

7. $\mathrm{Cov}[\Delta\log g_{it}, \Delta\log h_{it}] = \eta(1-\gamma)(1+\eta)\ (\mathrm{Var}[\Delta z_{it}] + \sigma_p^2) + 2\rho\sigma_u\sigma_v$
8. $\mathrm{Cov}[\Delta\log g_{it}, \Delta\log h_{it-1}] = \eta(1-\gamma)(1+\eta)\ (\mathrm{Cov}[\Delta z_{it}, \Delta z_{it-1}] + \sigma_p^2) - \rho\sigma_u\sigma_v$
9. $\mathrm{Cov}[\Delta\log g_{it}, \Delta\log h_{it-j}] = \eta(1-\gamma)(1+\eta)\ (\mathrm{Cov}[\Delta z_{it}, \Delta z_{it-j}] + \sigma_p^2)$ $(j > 1)$
10. $\mathrm{Cov}[\Delta\log g_{it}, \Delta\log h_{it+j}] = \mathrm{Cov}[\Delta\log g_{it}, \Delta\log h_{it-j}]$

Notes: η is the elasticity of intertemporal substitution.

γ is the extent of implicit earnings insurance.

σ_p^2 is the variance in the trend component of productivity.

σ_u^2 is the measurement error/preference shift variance in log earnings.

σ_v^2 is the measurement error/preference shift variance in log hours.

ρ is the correlation of the measurement errors/preference shifts.

Δz_{it} is the time series component of productivity.

Table 2

Means, Standard Deviations and Sample Sizes of Changes in Log Earnings and Log Hours For the Major Samples and Subsamples

PSID Data 1969 - 1979 and NLS Data 1966 - 1975

Sample (Observations)	PSID All (1531)	PSID One Employer (638)	PSID More Employers (893)	PSID Union (607)	PSID Nonunion (924)	NLS All (1321)	NLS One Employer (738)	NLS More Employers (583)	NLS One Employer Union (328)	NLS One Employer Nonunion (410)
Change in Log Earnings										
1967						.045 .33	.026 .20	.070 .44	.021 .18	.030 .22
1968										
1969						.020 .18	.020 .12	.019 .24	.004 .11	.034 .13
1970	.032 .42	.039 .26	.027 .51	.027 .40	.036 .44					
1971	.030 .42	.025 .25	.034 .50	.031 .32	.029 .47	.015 .18	.015 .12	.015 .24	.010 .11	.017 .13
1972	.072 .42	.055 .30	.084 .49	.065 .39	.077 .44					
1973	.048 .36	.035 .28	.058 .41	.052 .34	.046 .37	-.010 .21	.006 .15	-.031 .27	.010 .15	.004 .15
1974	-.051 .36	-.032 .26	-.065 .42	-.052 .32	-.051 .39					
1975	-.041 .42	-.029 .27	-.049 .50	-.061 .43	-.027 .42	-.084 .29	-.035 .16	-.146 .38	-.024 .16	-.043 .15
1976	.046 .47	.025 .30	.060 .56	.048 .53	.044 .43					
1977	.024 .44	.028 .26	.021 .53	.049 .44	.008 .44					
1978	.005 .44	.000 .27	.008 .52	-.001 .36	.009 .48					
1979	-.055 .42	-.034 .28	-.070 .50	-.035 .39	-.069 .44					
Change in Log Hours										
1967						.002 .34	-.002 .25	.007 .42	-.022 .33	.014 .17
1968										
1969						.000 .14	-.002 .11	.003 .18	.009 .10	-.012 .10
1970	-.011 .36	-.012 .21	-.010 .44	-.012 .36	-.010 .36					
1971	.003 .37	-.003 .17	.007 .46	-.009 .35	.011 .38	-.005 .13	-.002 .10	-.008 .16	-.008 .09	.002 .10
1972	.021 .37	-.004 .18	.039 .46	.019 .40	.023 .35					
1973	.021 .29	.021 .18	.022 .36	.031 .31	.015 .27	-.008 .15	.005 .09	-.024 .21	.008 .08	.003 .10
1974	-.042 .27	-.022 .17	-.056 .33	-.049 .28	-.037 .27					
1975	-.027 .34	-.013 .19	-.037 .41	-.044 .36	-.016 .32	-.057 .25	-.015 .11	-.111 .34	-.011 .08	.019 .13
1976	.012 .39	-.002 .20	.022 .48	.010 .45	.014 .34					
1977	.002 .38	.006 .20	-.002 .47	.008 .40	-.003 .36					
1978	-.003 .41	-.012 .26	.003 .49	.027 .36	-.023 .44					
1979	-.042 .43	-.009 .30	-.065 .50	-.045 .43	-.040 .43					

Notes: For each sample the first number in the column is the sample mean, the second number is the sample standard deviation. All changes calculated from the PSID data are year to year changes. For the NLS data 1967 entries are based on the change from 1966 to 1967; later entries are based on two year differences stated at annual rates.

Table 3

Autocovariances and Cross-covariances of Changes in Log Earnings and Log Hours For the Major Samples and Subsamples (Corrected Least Squares Standard Errors in Parentheses)

PSID Data 1969 - 1979 and NLS Data 1966 - 1975

Sample (Observations)	PSID All (1531)	PSID One Employer (638)	PSID More Employers (893)	PSID Union (607)	PSID Nonunion (924)	NLS All (1321)	NLS One Employer (738)	NLS More Employers (583)	NLS One Employer Union (328)	NLS One Employer Nonunion (410)
Autocovariance of Change in Log Earnings										
Gap 0	.176 (.010)	.075 (.006)	.247 (.017)	.157 (.017)	.187 (.013)	.193 (.023)	.074 (.010)	.338 (.050)	.067 (.015)	.078 (.014)
-1	-.059 (.005)	-.031 (.003)	-.079 (.009)	-.049 (.007)	-.066 (.007)	-.060 (.014)	-.028 (.006)	-.103 (.031)	-.027 (.007)	-.029 (.009)
-2	-.007 (.003)	-.002 (.002)	-.011 (.004)	-.010 (.004)	-.005 (.004)	-.006 (.005)	.002 (.002)	-.014 (.011)	.001 (.003)	.002 (.002)
-3	-.003 (.003)	-.001 (.002)	-.005 (.004)	-.004 (.004)	-.003 (.004)	.006 (.009)	-.002 (.003)	.016 (.020)	.003 (.003)	-.005 (.003)
Autocovariance of Change in Log Hours										
Gap 0	.132 (.009)	.044 (.006)	.194 (.013)	.140 (.004)	.127 (.011)	.119 (.011)	.039 (.005)	.216 (.023)	.031 (.004)	.046 (.009)
-1	-.046 (.004)	-.018 (.004)	-.066 (.007)	-.052 (.007)	-.043 (.005)	-.038 (.006)	-.018 (.003)	-.066 (.013)	-.014 (.002)	-.021 (.005)
-2	-.005 (.002)	.000 (.001)	-.009 (.003)	-.005 (.003)	-.006 (.002)	.008 (.005)	.001 (.003)	.017 (.011)	.002 (.002)	-.000 (.004)
-3	-.004 (.002)	-.002 (.001)	-.006 (.003)	-.008 (.002)	-.002 (.002)	-.013 (.006)	.001 (.004)	-.030 (.013)	-.002 (.003)	.003 (.007)
Cross-covariance of Log Earnings with Log Hours										
Gap 3	.000 (.002)	.000 (.001)	-.001 (.003)	-.005 (.003)	.003 (.003)	-.017 (.007)	.000 (.003)	-.037 (.014)	-.004 (.003)	.003 (.005)
2	-.007 (.002)	-.001 (.001)	-.010 (.004)	-.006 (.004)	-.007 (.003)	.007 (.005)	.000 (.002)	.014 (.010)	.003 (.003)	-.002 (.003)
1	-.024 (.004)	-.004 (.001)	-.038 (.007)	-.028 (.007)	-.021 (.005)	-.009 (.004)	-.002 (.001)	-.021 (.010)	-.002 (.002)	.001 (.002)
0	.077 (.007)	.009 (.001)	.125 (.012)	.086 (.013)	.071 (.008)	.073 (.008)	.009 (.002)	.149 (.018)	.007 (.002)	.010 (.003)
-1	-.021 (.004)	-.003 (.001)	-.035 (.007)	-.020 (.006)	-.022 (.005)	-.016 (.005)	-.002 (.001)	-.035 (.010)	-.004 (.002)	-.001 (.002)
-2	-.002 (.003)	.001 (.001)	-.004 (.005)	-.007 (.004)	.002 (.004)	-.004 (.005)	.000 (.001)	-.008 (.011)	.003 (.001)	-.003 (.002)
-3	-.005 (.003)	-.002 (.001)	-.007 (.004)	-.007 (.003)	-.004 (.004)	.008 (.008)	.001 (.002)	.017 (.018)	-.000 (.002)	.002 (.004)

Notes: Sample autocovariances and cross-covariances were calculated using deviations from annual means and every available pair of data. Sample cross-covariances were calculated using the change in log earnings at t with the change in log hours at (t + gap). For the NLS data sample autocovariances and cross-covariances were calculated using differences taken at an interval of two years (not at annual rates). The 1966-1967 difference in the NLS data was not used in calculating this table.

Table 4

Summary of Results for Several Models Estimated on the Complete Samples
Optimal Minimum Distance and Least Squares Estimates

PSID Data 1969 - 1979 and NLS Data 1966 - 1975

	PSID			NLS		
Model	Full	Full	Measurement Error Only	Full	Full	Measurement Error Only
Method (Number of Observations)	OMD (1531)	LSQ (1531)	OMD (1531)	OMD (1321)	LSQ (1321)	OMD (1321)
Parameter Estimates (standard errors)						
1. Elasticity of Substitution	4.050 (.475)	4.293 (1.360)	.000 --	.147 (.056)	1.462 (.374)	.000 --
2. Extent of Earnings Insurance	.000 --	.000 --	.000 --	.000 --	.000 --	.000 --
3. AR(1) Coefficient of Productivity Process	.157 (.030)	.005 (4.450)	.000 --	.000 (.100)	.000 --	.000 --
4. Standard Deviation of Productivity Shock	.162 (.020)	.042 (.187)	.000 --	.091 (.013)	.090 (.015)	.000 --
5. Standard Deviation of Productivity Trend	.000 --	.000 --	.000 --	.015 (.025)	.000 --	.000 --
6. Standard Deviation of Measurement Error in Earnings	.177 (.005)	.250 (.365)	.214 (.004)	.193 (.010)	.214 (.018)	.186 (.009)
7. Standard Deviation of Measurement Error in Hours	.159 (.004)	.222 (.324)	.210 (.003)	.157 (.007)	.206 (.013)	.141 (.008)
8. Correlation of Measurement Errors	.306 (.026)	.357 (2.050)	.477 (.014)	.168 (.032)	.176 (.062)	.145 (.035)
Share of Variance of Change in Earnings Attributable to:						
9. Individual Productivity Shocks	.10	.28	.00	.13	.35	.00
10. Individual Productivity Trends	.00	.00	.00	.00	.00	.00
11. Measurement Error	.90	.72	1.00	.87	.65	1.00
Share of Variance of Change in Hours Attributable to:						
12. Individual Productivity Shocks	.08	.25	.00	.01	.17	.00
13. Individual Productivity Trends	.00	.00	.00	.00	.00	.00
14. Measurement Error	.92	.75	1.00	.99	.83	1.00
Goodness of Fit						
15. Minimum Distance Function Value	.5656	.0363	1.1295	.0841	.0745	.1784
16. Chi-Squared Statistic (degrees of freedom)	866. (203)	N/A	1729. (207)	111. (47)	N/A	236. (52)

Note: In this table, the individual productivity process follows an AR(1) in first differences.

Table 5

Optimal Minimum Distance Estimates of Model
With and Without Outliers

NLS Data 1966 - 1975

Sample (Number of Observations)	All Complete Data (1321)	10% Outliers Removed (1191)
Parameter Estimates (standard errors)		
1. Elasticity of Substitution	.147 (.056)	.137 (.042)
2. Extent of Earnings Insurance	.000 --	.000 --
3. AR(1) Coefficient of Productivity Process	.000 (.100)	.000 (.186)
4. Standard Deviation of Productivity Shock	.091 (.013)	.080 (.016)
5. Standard Deviation of Productivity Trend	.015 (.025)	.000 (.015)
6. Standard Deviation of Measurement Error in Earnings	.193 (.010)	.127 (.007)
7. Standard Deviation of Measurement Error in Hours	.157 (.007)	.111 (.003)
8. Correlation of Measurement Errors	.168 (.032)	.105 (.030)
Share of Variance of Change in Earnings Attributable to:		
9. Individual Productivity Shocks	.13	.20
10. Individual Productivity Trends	.00	.00
11. Measurement Error	.87	.80
Share of Variance of Change in Hours Attributable to:		
12. Individual Productivity Shocks	.01	.01
13. Individual Productivity Trends	.00	.00
14. Measurement Error	.99	.99
Goodness of Fit		
15. Minimum Distance Function Value	.0841	.1234
16. Chi-Squared Statistic (degrees of freedom)	111. (47)	147. (47)

Note: In this table, the individual productivity process follows an AR(1) in first differences.

Table 6a

Comparisons of Workers with One Employer and Workers with More than One Employer Least Squares Estimates with Corrected Standard errors

PSID Data 1969 - 1979

Sample (Number of Observations)	One Employer (638)	More than One Employer (893)	Combined (1531)	Combined (1531)	Combined with Separate Measurement Errors One Employer (638)	More (893)
Parameter Estimates (standard errors)						
1. Elasticity of Substitution	2.213 (2.560)	3.492 (.999)	2.418 (.557)	1.453 (.166)	1.822 (.290)	
2. Extent of Earnings Insurance	.000 --	.000 --	.000 --	1.132 (.057)	.911 (.027)	
3. AR(1) Coefficient of Productivity Process	.396 (2.393)	.004 (3.558)	.016 (2.103)	-.203 (.032)	.005 (3.198)	
4. Standard Deviation of Productivity Shock	.299E-03 (.016)	.059 (.211)	.066 (.138)	.166 (.016)	.103 (.332)	
5. Standard Deviation of Productivity Trend	.085 (.080)	.000 --	.001 (.027)	.000 --	.000 --	
6. Standard Deviation of Measurement Error in Earnings	.190 (.008)	.287 (.499)	.247 (.215)	.190 (.008)	.189 (.010)	.283 (.512)
7. Standard Deviation of Measurement Error in Hours	.146 (.001)	.267 (.323)	.227 (.117)	.186 (.009)	.082 (.689)	.279 (.197)
8. Correlation of Measurement Errors	.150 (.025)	.426 (1.641)	.370 (.827)	.312 (.069)	.160 (.354)	.455 (1.113)
Share of Variance of Change in Earnings Attributable to:						
9. Individual Productivity Shocks	.00	.33	.30	(1) .04 (2) .70	.01	.35
10. Individual Productivity Trends	.01	.00	.00	(1) .00 (2) .00	.00	.00
11. Measurement Error	.99	.67	.70	(1) .96 (2) .30	.99	.65
Share of Variance of Change in Hours Attributable to:						
12. Individual Productivity Shocks	.00	.25	.20	.47	.72	.17
13. Individual Productivity Trends	.01	.01	.00	.00	.00	.00
14. Measurement Error	.99	.75	.80	.53	.28	.83
Goodness of Fit						
15. Minimum Distance Function Value	.7812E-02	.0918	.2311	.1187	.0576	
16. Chi-Squared Statistic	N/A	N/A	N/A	N/A	N/A	

Notes: In this Table, the individual productivity process follows an AR(1) in first differences.
(1) This column refers to individuals with only one employer.
(2) This column refers to individuals with more than one employer.

Table 6b

Comparisons of Workers with One Employer and Workers with More than One Employer Optimal Minimum Distance Estimates

PSID Data 1969 - 1979

Sample (Number of Observations)	One Employer (638)	More than One Employer (893)	Combined (1531)	Combined (1531)	Combined with Separate Measurement Errors: One Employer (638)	Combined with Separate Measurement Errors: More (893)
Parameter Estimates (standard errors)						
1. Elasticity of Substitution	.000 --	4.484 (.520)	-1.527 (.081)	-.530 (-.024)	.819 (.057)	
2. Extent of Earnings Insurance	.000 --	.000 --	.000 --	1.444 (.057)	.779 (.017)	
3. AR(1) Coefficient of Productivity Process	.000 --	.181 (.028)	-.282 (2.103)	-.264 (.024)	-.108 (.029)	
4. Standard Deviation of Productivity Shock	.000 --	.017 (.002)	.040 (.003)	.116 (.006)	.067 (.006)	
5. Standard Deviation of Productivity Trend	.000 --	.000 --	.000 --	.000 --	.799E-04 (.287)	
6. Standard Deviation of Measurement Error in Earnings	.115 (.003)	.183 (.006)	.129 (.003)	.126 (.003)	.118 (.003)	.200 (.006)
7. Standard Deviation of Measurement Error in Hours	.121 (.001)	.183 (.005)	.092 (.002)	.094 (.002)	.087 (.002)	.240 (.004)
8. Correlation of Measurement Errors	.340 (.015)	.322 (.031)	.229 (.182)	.239 (.069)	.237 (.021)	.517 (.019)
Share of Variance of Change in Earnings Attributable to:				(1) / (2)		
9. Individual Productivity Shocks	.00	.12	.00	.02 / .09	.03	.16
10. Individual Productivity Trends	.00	.00	.00	.00 / .00	.00	.00
11. Measurement Error	1.00	.88	.99	.98 / .91	.97	.84
Share of Variance of Change in Hours Attributable to:						
12. Individual Productivity Shocks	.00	.08	.19	.19	.17	.03
13. Individual Productivity Trends	.00	.01	.00	.00	.00	.00
14. Measurement Error	1.00	.92	.81	.81	.83	.97
Goodness of Fit						
15. Minimum Distance Function Value	2.4212	1.0372	2.7094	2.6529	1.4745	
16. Chi-Squared Statistic (degrees of freedom)	1554. (207)	926. (203)	4148. (413)	4061. (412)	2257. (408)	

Notes: In this Table, the individual productivity process follows an AR(1) in first differences.
(1) This column refers to individuals with only one employer.
(2) This column refers to individuals with more than one employer.

Table 6c

Comparisons of Workers with One Employer and
Workers with More than One Employer
Optimal Minimum Distance Estimates

NLS Data 1966 - 1975

Sample (Number of Observations)	One Employer (738)	More than One Employer (583)	Combined (1321)	Combined (1321)	Combined with Separate Measurement Errors One Employer (738)	More (583)
Parameter Estimates (standard errors)						
1. Elasticity of Substitution	.162 (.068)	.101 (.062)	.145 (.052)	.090 (.029)	.085 (.029)	
2. Extent of Earnings Insurance	.000 --	.000 --	.000 --	.480 (.044)	.467 (.044)	
3. AR(1) Coefficient of Productivity Process	.000 --	-.004 (.639)	.000 --	-.453 (.346)	.000 --	
4. Standard Deviation of Productivity Shock	.058 (.024)	.117 (.082)	.064 (.004)	.167 (.020)	.117 (.007)	
5. Standard Deviation of Productivity Trend	.000 --	.010 (.078)	.000 --	.000 --	.000 --	
6. Standard Deviation of Measurement Error in Earnings	.116 (.011)	.231 (.032)	.130 (.007)	.118 (.010)	.116 (.008	.236 (.012)
7. Standard Deviation of Measurement Error in Hours	.107 (.005)	.189 (.009)	.115 (.004)	.114 (.004)	.107 (.005)	.189 (.009)
8. Correlation of Measurement Errors	.094 (.038)	.255 (.040)	.082 (.028)	.067 (.036)	.092 (.034)	.258 (.036)
Share of Variance of Change in Earnings Attributable to:						
9. Individual Productivity Shocks	.14	.13	.14	(1) .26 (2) .60	.15	.13
10. Individual Productivity Trends	.00	.00	.00	(1) .00 (2) .00	.00	.00
11. Measurement Error	.86	.86	.86	(1) .74 (2) .40	.85	.87
Share of Variance of Change in Hours Attributable to:						
12. Individual Productivity Shocks	.01	.00	.00	.01	.01	.00
13. Individual Productivity Trends	.00	.00	.00	.00	.00	.00
14. Measurement Error	.99	1.00	1.00	.99	.00	.00
Goodness of Fit						
15. Minimum Distance Function Value	.0956	.1942	.2196	.1918	.1397	
16. Chi-Squared Statistic (degrees of freedom)	70. (50)	113. (47)	290. (105)	253. (102)	184. (101)	

Notes: In this Table, the individual productivity process follows an AR(1) in first differences.
(1) This column refers to individuals with one employer.
(2) This column refers to individuals with more than one employer.

Table 7

Comparisons of Union and Nonunion
Employees with One Employer
Optimal Minimum Distance Estimates

NLS Data 1966 - 1975

Sample (Number of Observations)	Union (328)	Nonunion (410)	Combined (738)	Combined (738)	Combined with Separate Measurement Errors Union (328)	 Nonunion (410)
Parameter Estimates (standard errors)						
1. Elasticity of Substitution	.083 (.054)	.149 (.069)	.126 (.044)	.116 (.043)	.108 (.044)	
2. Extent of Earnings Insurance	.000 --	.000 --	.000 --	.079 (.017)	.078 (.090)	
3. AR(1) Coefficient of Productivity Process	.000 --	.000 --	.000 --	.000 --	.000 --	
4. Standard Deviation of Productivity Shock	.057 (.004)	.059 (.006)	.056 (.004)	.059 (.006)	.061 (.005)	
5. Standard Deviation of Productivity Trend	.000 --	.000 --	.000 --	.000 --	.000 --	
6. Standard Deviation of Measurement Error in Earnings	.099 (.005)	.125 (.010)	.101 (.005)	.102 (.005)	.099 (.005)	.125 (.011)
7. Standard Deviation of Measurement Error in Hours	.089 (.005)	.098 (.005)	.091 (.003)	.091 (.003)	.089 (.005)	.098 (.005)
8. Correlation of Measurement Errors	.250 (.056)	.067 (.034)	.137 (.034)	.135 (.034)	.237 (.054)	.075 (.033)
Share of Variance of Change in Earnings Attributable to:						
9. Individual Productivity Shocks	.16	.13	.16	(1) .14 (2) .16	.17	.13
10. Individual Productivity Trends	.00	.00	.00	.00 .00	.00	.00
11. Measurement Error	.84	.87	.84	.86 .84	.83	.87
Share of Variance of Change in Hours Attributable to:						
12. Individual Productivity Shocks	.01	.01	.01	.01	.01	.01
13. Individual Productivity Trends	.00	.00	.00	.00	.00	.00
14. Measurement Error	.99	.99	.99	.99	.99	.99
Goodness of Fit						
15. Minimum Distance Function Value	.2076	.1359	.1883	.1875	.1688	
16. Chi-Squared Statistic (degrees of freedom)	68. (50)	56. (50)	139. (105)	138. (104)	125. (101)	

Notes: In this Table, the individual productivity process follows an AR(1) in first differences.
(1) This column gives the variance shares for non-union members.
(2) This column gives the variance shares for union members.

Table 8a

Comparisons of Workers with At least Two Years Union Experience with Workers with Less than Two Years Union Experience Least Squares Estimates with Corrected Standard Errors

PSID Data 1969 - 1979

Sample (Number of Observations)	Two Years (607)	Less than Two Years (924)	Combined (1531)	Combined (1531)	Combined with Separate Measurement Errors Two Years (607)	Less (924)
Parameter Estimates (standard errors)						
1. Elasticity of Substitution	2.893 (.830)	3.703 (1.642)	3.236 (.854)	1.846 (.430)	3.898 (1.628)	
2. Extent of Earnings Insurance	.000 --	.000 --	.000 --	.173 (.112)	-.091 (.132)	
3. AR(1) Coefficient of Productivity Process	-.002 (9.121)	.002 (3.719)	.004 (4.562)	-.043 (.032)	.003 (4.617)	
4. Standard Deviation of Productivity Shock	.062 (.562)	.046 (.174)	.054 (.245)	.092 (.039)	.045 (.208)	
5. Standard Deviation of Productivity Trend	.000 --	.000 --	.000 --	.000 --	.000 --	
6. Standard Deviation of Measurement Error in Earnings	.223 (1.177)	.263 (.340)	.248 (.473)	.239 (.058)	.224 (.586)	.263 (.419)
7. Standard Deviation of Measurement Error in Hours	.232 (.626)	.218 (.254)	.224 (.306)	.224 (.032)	.233 (.300)	.217 (.320)
8. Correlation of Measurement Errors	.438 (4.053)	.314 (1.680)	.360 (2.049)	.345 (.240)	.443 (1.949)	.314 (2.099)
Share of Variance of Change in Earnings Attributable to:				(1) (2)		
9. Individual Productivity Shocks	.37	.26	.30	.29 .38	.36	.26
10. Individual Productivity Trends	.01	.00	.00	.00 .00	.00	.00
11. Measurement Error	.63	.74	.70	.71 .62	.64	.74
Share of Variance of Change in Hours Attributable to:						
12. Individual Productivity Shocks	.23	.24	.23	.22	.22	.24
13. Individual Productivity Trends	.00	.00	.00	.00	.00	.00
14. Measurement Error	.77	.76	.77	.78	.78	.76
Goodness of Fit						
15. Minimum Distance Function Value	.0867	.0451	.0655	.0643	.0616	
16. Chi-Squared Statistic	N/A	N/A	N/A	N/A	N/A	

Notes: In this Table, the individual productivity process follows an AR(1) in first differences.
(1) This column refers to individuals with at least two years union experience.
(2) This column refers to individuals with less than two years union experience.

Table 8b

Comparisons of Workers with At least Two Years Union Experience
with Workers with Less than Two Years Union Experience
Optimal Minimum Distance Estimates

PSID Data 1969 - 1979

Sample (Number of Observations)	Two Years (607)	Less than Two Years (924)	Combined (1531)	Combined (1531)	Combined with Separate Measurement Error: Two Years (607)	Combined with Separate Measurement Error: Less (924)
Parameter Estimates (standard errors)						
1. Elasticity of Substitution	.000 --	5.322 (.913)	11.034 (2.400)	6.354 (1.446)	7.545 (2.125)	
2. Extent of Earnings Insurance	.000 --	.000 --	.000 --	.105 (.034)	.116 (.037)	
3. AR(1) Coefficient of Productivity Process	.000 --	.115 (.029)	.003 (.020)	-.022 (.020)	-.039 (.021)	
4. Standard Deviation of Productivity Shock	.000 --	.011 (.002)	.006 (.001)	.010 (.002)	.008 (.002)	
5. Standard Deviation of Productivity Trend	.000 --	.000 --	.000 --	.000 --	.000 --	
6. Standard Deviation of Measurement Error in Earnings	.189 (.003)	.168 (.005)	.144 (.003)	.143 (.003)	.140 (.0004)	.159 (.006)
7. Standard Deviation of Measurement Error in Hours	.217 (.002)	.144 (.004)	.139 (.003)	.144 (.003)	.137 (.003)	.137 (.004)
8. Correlation of Measurement Errors	.605 (.010)	.242 (.031)	.378 (.019)	.375 (.020)	.476 (.022)	.177 (.036)
Share of Variance of Change in Earnings Attributable to:				(1) (2)		
9. Individual Productivity Shocks	.00	.08	.10	.10 .12	.09	.09
10. Individual Productivity Trends	.00	.00	.00	.00 .00	.00	.00
11. Measurement Error	1.00	.92	.90	.90 .88	.91	.91
Share of Variance of Change in Hours Attributable to:						
12. Individual Productivity Shocks	.00	.08	.10	.01	.10	.10
13. Individual Productivity Trends	.00	.00	.00	.00	.00	.00
14. Measurement Error	1.00	.92	.90	.99	.90	.90
Goodness of Fit						
15. Minimum Distance Function Value	4.2882	.9382	1.3284	1.3246	1.2594	
16. Chi-Squared Statistic (degrees of freedom)	2602. (207)	867. (203)	2034. (413)	2028. (412)	1928. (409)	

Notes: In this Table, the individual productivity process follows an AR(1) in first differences.
(1) This column refers to individuals with at least two years union experience.
(2) This column refers to individuals with less than two years union experience.

Table

Annual Hours of Continuous Male Heads Aged 21-65

PSID, 1969-1981[1/]

Year[2/]	Average Annual Hours: Entire Sample			Change in Average Annual Hours: Entire Sample			Average Change in Log Annual Hours (x 100)	
	Overall Mean	Proportion Non-Zero	Mean for Non-Zero	Percent Change in Overall Mean	Percentage Point Change in Proportion Non-Zero	Percent Change in Mean for Non-Zero	All Available Pairs[3/]	Sample with Non-Zero Earnings and Hours all Years[4/]
1969	2243	.985	2277	---	---	---	---	---
1970	2189	.981	2231	-2.4	-0.4	-2.0	-2.3	-4.7
1971	2191	.975	2247	0.0	-0.6	0.7	0.8	0.4
1972	2211	.977	2263	0.9	0.2	0.7	1.1	2.8
1973	2220	.973	2282	0.4	- 0.4	0.8	0.8	0.7
1974	2144	.969	2213	-3.4	- 0.4	- 3.0	-3.9	-2.3
1975	2089	.957	2183	-2.6	- 1.2	- 1.4	-3.8	-2.6
1976	2086	.945	2207	-0.1	- 1.2	- 1.1	-0.4	1.2
1977	2069	.942	2196	-0.8	- 0.3	- 0.5	-0.7	0.4
1978	2063	.931	2216	-0.3	- 1.1	0.9	-0.7	-0.9
1979	2009	.925	2172	-2.6	- 0.6	- 1.9	-2.7	-1.2
1980	1943	.911	2133	-3.3	- 1.4	- 1.8	-2.6	-1.8
1981	1865	.892	2091	-4.0	- 1.9	- 2.0	-6.0	-4.6
Regression Coefficient on Change in Unemployment Rate (standard error)								
	---	---	---	-0.81 (0.38)	- 0.12 (0.15)	- 0.52 (0.33)	-0.94 (0.52)	-1.12 (0.50)
Regression Coefficient on Change in Real GNP (standard error)								
	---	---	---	0.50 (0.12)	0.06 (0.06)	0.37 (0.10)	0.56 (0.18)	0.63 (0.17)

1/ The sample consists of 1558 male heads of households whose records indicate no change in household head from 1969 to 1982, and whose age is between 21 and 65 in all years. Age and sex are taken from the 1976 interview.

2/ Year refers to the calendar year for which the data pertain, not the interview year in which the data are measured.

3/ Average of the change in log of annual hours for all sample members with non-zero hours in current and previous year. Sample sizes vary by year.

4/ Average of the change in log of annual hours for all sample members with positive earnings and hours in every year from 1969 to 1981. Sample size is 568.