AN INVESTIGATION OF DYNAMIC LABOR SUPPLY ADJUSTMENT

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This paper is circulated for discussion purposes only and its contents should be considered preliminary.

I. Introduction *

Since the late 1960s there has been a considerable number of labor supply studies based on individual household data {1}. Virtually all have derived income and substitution elasticities from the cross-sectional dispersion of labor supply, wages and income. The empirical estimation of actual labor supply change remains relatively unexplored terrain, [1/] although actual labor supply change is really the variable of policy interest.

Unfortunately, reliable predictions of actual labor supply change for a given policy milieu may not be obtainable from cross-sectionally derived parameter estimates. There is first of all the question of the speed with which labor supply adjustments are made. Static labor supply regressions by construction provide no insight into this question although it would seem to be an issue of considerable importance not only to drawing inferences concerning the design and implementation of income maintenance policies but also to an improved understanding of how labor markets work. Moreover, it should not be assumed that cross-section studies, by failing to model the dynamic process, are therefore obtaining unbiased estimates of equilibrium responses. The more likely result is that the cross-sectionally estimated coefficients reflect an undetermined fraction of full adjustment, that fraction varying with the speed and magnitude of the adjustment. [2/]

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1/ See {3} for the only major exception.

2/ The econometric issues involved here which seem to have been largely ignored in the labor supply area were first explored by Kuh {8} and Grunfeld {5}.

Beyond this issue there is a serious question as to the reasonableness of the underlying cross-sectional assumption that two households differing in wage rates or other income, but otherwise identical in the cross-sectional variables controlled for, will generate the same labor supply responses that a single household would ultimately generate if it were presented with first one and then another set of wages or income. Given that included explanatory variables account for only a modest fraction of the total variation in labor supply among individuals, important behavioral determinants may not be adequately controlled. If for example there is not an adequate control for motivation toward work, a factor presumably positively correlated with wage rates, a cross-section regression would convert this difference in motivation between low and high wage populations into a static supply schedule with a spuriously positive slope. The estimation of coefficients for actual labor supply change thus seems greatly overdue.

This study is an exploratory effort at estimating labor supply coefficients relatively free of cross-sectional biases. The estimation of an appropriately specified dynamic labor supply function will permit the exploration of the speed of adjustment to disequilibrium and to changes in the determinants of labor supply. Panel data of a survey or experimental nature collected for a limited number of time periods can not completely avoid biases due to heterogeneous population groups treated as homogeneous, but it does permit some escape. In the following three sections the theoretical models are developed, specified and estimated. Comparisons with cross-sectionally estimated parameters are also presented. The final section summarizes our conclusions.

II. Models of Dynamic Labor Supply Adjustment

An explanation of the labor supply behavior of a set of N persons over a time horizon of T periods may be factored into two component parts: the specification of desired labor supply for individual n in time period t, L^*_{nt}, and the specification of the adjustment mechanism by which observed labor supply, L_{nt}, is related to the time path of L^*_{nt} and to emerging discrepancies from this desired path. Desired labor supply at time t is of course not synonomous with observed or actual labor supply, but equals it up to an error term, ω_{nt}:

$$(1) \quad L_{nt} = L^*_{nt} + \omega_{nt}$$

A simple theory of labor supply adjustment can be obtained by taking the first difference of (1) across time:

$$(2) \quad \Delta L_{nt} = \Delta L^*_{nt} + \Delta\omega_{nt}$$

where the Δ notation subscripted t indicates the change from time period t-1 to t. However, equation (2) is overly restrictive in confining adjustments to emerging disequilibriums induced by ΔL^*. Workers face constraints in changing hours or jobs and are confronted at any moment of time with only a limited number of options or opportunities for change. The shorter the time period, the thinner is the local labor market. Labor supply adjustments may be made rapidly. However, in most instances, transaction cost and transaction time make immediate and continuous adjustment prohibitively expensive. A more realistic adjustment model would take account of the possibility of an existing disequilibrium, of a gap between desired and actual as of t-1, $(L^*_{t-1} - L_{t-1}) \neq 0$, as well as an emerging disequilibrium due to changes in desired labor supply from t-1 to t, $\Delta L^*_t \neq 0$:

$$(3) \quad \Delta L_{nt} = \beta \Delta L^*_{nt} + \gamma(L^*_{nt-1} - L_{nt-1}) + \varepsilon_{nt}$$

where the error term ε_{nt} assumed independently distributed with zero mean captures both the inability to make precise adjustments to disequilibrium as well as any unplanned disturbances.

From the perspective of equation (3) there is implied a systematic bias in the cross-sectionally estimated coefficients of (1) due to the failure to take account of lagged labor supply adjustments. Note that (3) can be written as:

$$(3)' \quad L_{nt} = \beta L^*_{nt} + (\gamma - \beta)L^*_{nt-1} + (1 - \gamma)L_{nt-1} + \varepsilon_{nt}$$

Thus the coefficients of the determinants of desired labor supply in (1) are deflated to the extent that $\beta < 1$. However the "error term" in a regression model of (1), $\omega_{nt} = (\gamma - \beta)L^*_{nt-1} + (1 - \gamma)L_{nt-1} + \varepsilon_{nt}$, will almost certainly be correlated with L^*_{nt}. Putting aside for the moment any correlation between the determinants of L^*_{nt} and ε_{nt} the estimated coefficients of L^*_{nt} will virtually always be biased downward assuming γ and β are not greater than 1.0 and positive but less than perfect correlation of L^*_{nt-1} and L_{nt-1} with L^*_{nt}. Under these assumptions the necessary conditions for an upward bias are that the correlation of L_{nt-1} with L^*_{nt} be much greater than that of L^*_{nt-1} with L^*_{nt}, which is highly unlikely,and that $\beta > \gamma$.

Despite its appearances, equation (3) is not a partial adjustment model. Quadratic cost functions do not seem applicable here. Rather, the costs of making an adjustment do not seem well correlated with its magnitude. Hence, the worker will most frequently find it cost minimizing to eliminate a labor supply discrepancy in one large rather than numerous small changes. 1/ We hypothesize that the individual either attempts to eliminate the full disequilibrium or else defers action to a more propitious time. An adjustment is "all or nothing", subject to the proviso that mobility constraints and market thinness may prevent a precise adjustment. The aggregation of such responses over a cross-section of individuals results in a functional relation resembling the partial adjustment function. To see this, assume the proportion of the sample attempting to adjust labor supply to ΔL^*_t is equal to β while the fraction seeking to eliminate $(L^*_{t-1} - L_{t-1})$ is equal to γ. If the distribution of disequilibriums is identical between those who do and do not make adjustments, the total adjustment, ΔL_t, given unbiased response by those who do adjust, may be represented by a regression model of the form of equation (3). 2/

It is difficult to place prior constraints on β and γ. They need not be invariant across population groups. Adjustment costs and speeds may vary by occupation or industry or with the physical and psychological capacity of the individual. Their values may differ between components of labor supply change. A deterioration in health might for instance induce a

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1/ Even so a partial adjustment function could eventuate if workers were both risk averse and uncertain of the true coefficients of L^*. A worker as he aged, might, for instance, desire more leisure without knowing a priori the optimal reduction in labor input. This hypothesis of a worker making partial or tentative changes as he probed for desired labor supply is appealing, but it receives no support from an inspection of the pattern of changes over time in labor supply.

2/ If it were hypothesized that the disequilibrium, either that existing or emerging, had to reach a certain "critical" value before adjustment occurred, then a version of the "Tobit" technique {11} would be appropriate. However, that is not the hypothesis being made here. Nor does the "two-regime" specification (c.f. for instance {2}), in which labor supply obeys a priori a structure that dictated change, or one that did not, appear to offer a viable approach. Rather the exact timing of labor supply changes is influenced by a number of unobserved, and perhaps unobservable, factors that we here treat as random variables.

much quicker labor supply response than a change in wages. Even the relative magnitudes of β and γ is an empirical question. Since ΔL^*_t is an emerging disequilibrium,there is less time on average to adjust to it than to $(L^*_{t-1} - L_{t-1})$. This implies $\beta < \gamma$. However, changes in L* should be better anticipated than exogenously determined disturbances in L, implying $\beta > \gamma$. If this agnosticism leads to the assumption that the proportions making each type of adjustment are identical, $\beta = \gamma$, then (3) reduces to

$$(4) \qquad \Delta L_{nt} = \beta(L^*_{nt} - L_{nt-1}) + \varepsilon_{nt}$$

Equations (3) and (4) represent a "cross-section of changes" model. Such a model will reduce the potential bias due to lagged adjustments that characterise cross-sectional labor supply regressions. However, we have not yet considered the bias due to cross-sectional dispersion of omitted characteristics that are correlated with the included regressors. Note that the error term in (3) and (4) can be decomposed into an individual specific component, μ_n, which is invariant over time, and a residual component, ν_{nt}, which varies both over time and across individuals. 1/ Thus, $\varepsilon_{nt} = \mu_n + \nu_{nt}$. The bias encountered in cross-section studies due to their omitted characteristics nature should primarily be the result of correlation between μ_n and the determinants of L*. The "cross-section of changes" formulation reduces the bias to the extent that μ_n is less correlated with changes in the determinants of L*, or with the previous disequilibria than it is with L* itself. The next step is to eliminate the pure cross-sectional error by taking the first differences of

1/ See Nerlove {10} for an analysis of such decompositions in a pooled time-series cross-section framework.

equations (3) and (4). This yields true models of labor supply change over time:

$$(5) \qquad \Delta L_{nt} = \beta \Delta L^*_{nt} + (\gamma - \beta)\, \Delta L^*_{nt-1} + (1 - \gamma)\, \Delta L_{nt-1} + \Delta \nu_{nt}$$

and
$$(6) \qquad \Delta L_{nt} = \beta \Delta L^*_{nt} + (1 - \beta)\, \Delta L_{nt-1} + \Delta \nu_{nt}.$$

Given the liberation of (5) and (6) from both cross-sectional limitations, they would seem to be preferred specifications. However, they require at least three waves of conceptually consistent data. Further, measurement error, or slight changes in the question underlying the constructed variable become much more troublesome here than in (3) or (4) since the ratio of noise to signal will be much greater for a change variable than for a level variable. Moving from cross-section of changes to true models of labor supply change involves trading remaining contemporaneous correlation bias for errors in the variables bias. We will estimate both types of model and compare the results.

III. Specification and Data

The form of equations (3) to (6) estimated specifies desired labor, since it is not directly observed, in terms of its hypothesised determinants. Thus L_{nt-1} enters (3) and (4) as a distinct variable and its coefficient provides an estimate of γ in (3) or $\beta = \gamma$ (4). Desired labor supply is specified following {6} as a function of wages of the respondent and of other family members, wealth, attitudes toward work, health and a set of controls. The major variables are described below with their construction being more fully discussed in {6} and {7}. The dependent variable, L, annual manhours of labor supply is constructed as usual hours worked per week multiplied by the sum of weeks employed and unemployed. The major independent variable, wages, is partitioned into a permanent component, W_P, potential wages, and a transitory component, W_T. Both components are measured by instruments created from a two stage regression. The potential wage, W_P, is synonomous with a wage a worker could expect given his human capital. It is the hourly rental price of characteristics embedded in the worker, mainly education, experience, training, race, age, health, propensity for mobility and various personality characteristics and attributes. The transitory wage, W_T, is defined as synonomous with the systematically explainable deviations from W_P, and is estimated on location, occupation, industry and some indication of past luck. Extensive experimentation with various measures of other family members' wages and of wealth generated consistently disappointing results both in the cross-section {6} and here and hence are not shown. The one exception is a dichotomous wealth variable, Eligibility for Pension, indicating eligibility for retirement benefits from a personal, private, government employee or military retirement plan. In addition to indirect there are two direct measures of attitudes: Likes Job is a direct scaling of responses to the question, "How well do you like your current job?". The variable ranges from a minimum value of -2 (dislikes it very much) to a maximum of +2 (likes it very much); Likes Work in common with all the remaining variables, is dichotomous, assuming the value one if respondent indicated he would work even if he otherwise received enough money to live on, zero otherwise. Health is measured by two dichotomous variables, Health Limits Work, which identifies respondent who answered yes to the question: "Does your health or physical condition limit the kind (amount) of work you can do?" and Health Fair or Poor which is constructed on the basis of responses to the question: "Would you rate your health compared with other men as excellent, good, fair or poor?" These two variables capture the direct impact of health on labor supply, its indirect impact operating through wages is captured by the coefficient of W_p. The ΔL^* variables are constructed by simple first differencing of the L^* variables. The most interesting of these dynamic variables, ΔW_p, measures a net change in the market value of the worker's human capital. Some elements of the vector of attributes used to construct W_p are more volatile than others, but no single factor dominates ΔW_p. Changes in age, marital status, health, training and experience, as well as fluctuations in their relative importance as wage determinants all impact on ΔW_p.

The labor supply model was operationally specified with data taken from the National Longitudinal Survey (NLS) for men ages 45-59 in the U.S. in 1966. For labor supply analysis the NLS is a rich source of information and has impressive advantages over earlier data sources. However, its longitudinal character is somewhat impaired by occasional changes in the concept and working of questions between surveys. [1/] Thus while surveys were conducted in 1966, 67, 68, 69, 71 and 73, it was necessary to restrict the analysis to the 1966, 69 and 73 surveys in order to obtain hours information based on comparable questions. The NLS interviewed 5,030 men in June-July 1966 and reinterviewed "survivors" in 1969 and 3,951 "survivors" in 1973. Labor supply change is analysed for the 1966-69 (1969-73) period for the 2,716 (2,061) men who were wage and salary workers and reported hourly earnings in excess of fifty cents in both years. The 1966-69 labor supply change pertains to a period of approximately three and a half years, and the 1969-73 change to a period of approximately four years.

1/ For a complete description of the survey questionnaires and the sampling, interviewing and estimating procedures followed by the NLS, see {12}.

IV Empirical Results

Determinants of L^*_{t-1} and ΔL^*_t. Regression estimates are shown in Table 1 for the cross-section of changes and in Table 2 for the dynamic formulation. The resort to these formulations leaves relatively unimpaired the perspectives generated from cross-section studies on the set of variables important in the determination of labor supply. In particular, the coefficient W_p is positive, significant and robust as a level and as a change variable and across specifications and models. The wage elasticity is, however, very modest.

The relative size and significance of the determinants of L^*_{t-1} shown in Table 1 depends both on their robustness under the dynamic specification of the dependent variable and on the magnitude of the adjustment coefficient, γ, which may assume different values with respect to the different factors affecting desired labor supply. On the whole the estimates are quite consistent with static results (see Table 3), being generally smaller and of the same sign. The number of dynamic or change variables is small but these variables frequently are statistically significant and explain a surprising amount of variation. Aging, health changes and ΔW_p dominate ΔL^*. A priori the fully dynamic specifications should be free of pure cross-sectional bias. The cross-section of changes specification need not be. There is thus the possibility of sharp differences in coefficient values. However, a comparison of the relevant dynamic variables in Tables 1 and 2 reveals neither a clear pattern nor an important magnitude of difference in moving from a partial to a fully dynamic model. Indeed, equations (3) and (5) yield strikingly similar coefficients. This suggests that the partially dynamic equation (3) is relatively free of cross-section bias, an inference whose value will become obvious when we contront the difficulties presented by the fully dynamic model.

TABLE 1 - Partially Dynamic Labor Supply Estimates; 1966-69, 1969-73.

	Δ1966-69			Δ1969-73		
	EQ.3	EQ.3-I.V.	EQ.4	EQ.3	EQ.3.I.V.	EQ.4
Ln_{t-1}	-0.70 (38.83)		-0.70 (38.41)	-0.61 (22.62)		-0.61 (22.34)
Survey Week Hours IV		-0.59 (23.05)			-0.47 (11.45)	
Determinants of ΔLn^*_t						
ΔW_P	135.89 (4.19)	130.25 (3.98)		141.48 (5.69)	146.09 (5.84)	
$\Delta W_T > 0$	-306.36 (3.03)	-306.20 (3.01)		-186.43 (1.07)	-167.64 (0.96)	
$\Delta W_T < 0$	98.43 (0.86)	129.61 (1.12)		86.62 (1.33)	100.86 (1.54)	
ΔHealth Limitation Status: Limitation Ceased (D)	9.47 (0.23)	-0.28 (0.01)		153.48 (2.68)	149.87 (2.60)	
ΔHealth Limitation Status: Became Limited (D)	-73.33 (2.58)	-67.04 (2.34)		-135.19 (4.16)	-130.34 (3.98)	
Relative Health Improvement (D)	147.03 (3.42)	135.36 (3.12)				
Relative Health Decline (D)	-164.95 (5.89)	-161.84 (5.74)				
Wife's Health Change Limited Her Work (D)	1.04 (0.03)	6.79 (0.21)				
Wife's Health Change Prevented Her from Working (D)	11.55 (0.40)	8.20 (0.28)				
Became 53-57 Years of Age in 1969 (D)	9.44 (0.48)	7.66 (0.39)		-38.77 (1.48)	-39.91 (1.51)	
Became 58-62 Years of Age in 1969 (D)	-34.03 (1.55)	-34.71 (1.57)		-340.75 (10.14)	-339.88 (10.05)	
Determinants of Ln^*_t or Ln^*_{t-1}						
W_P	29.90* (2.86)	27.95* (2.66)	46.67* (4.80)	36.33* (2.60)	31.15* (2.21)	85.36* (6.94)
$W_T > 0$	-156.35* (1.92)	-119.60* (1.45)	-189.92* (2.46)	-24.82* (0.22)	10.73* (0.09)	-129.85* (0.99)
$W_T < 0$	-277.49* (3.22)	-244.20* (2.81)	-237.92* (2.58)	-132.14* (1.03)	-73.31* (0.56)	7.21* (0.11)
Eligible for Pension (D)	-47.10* (2.70)	-40.24* (2.29)	-47.62* (2.71)	37.87* (0.88)	35.74* (0.82)	61.56* (1.38)
Likes Job, t-1	14.14 (1.50)	11.29 (1.19)	15.81 (1.68)	35.08 (2.55)	34.07 (2.46)	23.20 (1.64)
Likes Work (D)	29.55 (1.54)	23.25 (1.20)	31.19 (1.61)	41.64 (1.61)	34.28 (1.25)	44.84 (1.60)
Health Limits Work, (D)	-3.60* (0.11)	4.21* (0.13)	-83.31* (3.83)	-101.86* (2.38)	-82.76* (1.91)	-152.00* (5.38)
Health Fair or Poor, (D)	-117.57 (3.64)	-103.58 (3.17)	-39.44 (2.65)	-34.86 (1.67)	-29.87 (1.42)	
Wife's Health Limits Her Work (D)	-48.43 (1.26)	-41.51 (1.07)	-9.42 (0.31)			
Wife's Health Prevents Her Work (D)	-48.75 (1.50)	-46.00 (1.41)	-29.76 (1.15)			
Southern Region (D)	-3.77* (0.15)	-5.15* (0.21)	-5.01* (0.20)	8.60* (0.25)	10.44* (0.30)	3.82* (0.11)
North Central Region (D)	35.89* (1.52)	22.20* (0.93)	39.31* (1.65)	39.72* (1.20)	29.87* (0.89)	44.31* (1.31)
Western Region (D)	41.59* (1.42)	36.96* (1.26)	41.55* (1.43)	-5.32* (0.13)	-10.77* (0.28)	-9.69* (0.23)
Non-White (D)	-28.52 (1.25)	-15.59 (0.67)	-9.62 (0.43	37.63 (1.20)	42.19 (1.33)	89.32 (2.82)
Farm Background (D)	72.68 (3.49)	64.44 (3.07)	68.84 (3.30)	55.35 (1.88)	44.38 (1.49)	92.93 (3.14)
Constant	1384.7	1138.6	1314.4	1003.4	726.7	751.0
F	59.4		94.2	36.3		44.4
R^2	.362		.346	.272		.220

* Level variables pertain to time period t-1 in equation (3) and to time period t in equation (4).

Notes to Table 1: The absolute value of the t statistic appears in parentheses. The symbol (D) indicates that the variable assumes a value of 1.0 if the indicated condition is met and zero otherwise. For the set of regional variables the excluded category is Northeast. Farm background indicates that the respondent lived on a farm at age 15. See Section III for construction of other variables.

<u>Response to Existing Labor Supply Disequilibrium</u> - The proportion of workers responding to existing disequilibrium, γ, can be estimated in a number of ways, with each estimation technique possessing some undesirable property. The level coefficients in the equation (3) cross-section of change formulation shown in Table 1 can be divided by the cross-section coefficients for the same variables in the equation (1) static formulation shown in Table 3. This yields indirect estimates of γ under the extreme assumption of unbiased static coefficients. Averaging these estimates yields a value of γ of .78 in 1966-69 and .57 for 1969-73. 1/ Alternatively γ is directly estimated by the coefficient of L_{nt-1} in equation (3) and by one minus the coefficient of ΔL_{nt-1} in equation (5). Estimates can be obtained similarly from equations (4) and (6) where it is assumed $\gamma \doteq \beta$. Such direct estimates of γ from equations (3) - (6) will be upward biased. Measurement error in 1966 and 1969 man hours introduces a spurious negative correlation between the dependent variable and the lagged endogenous independent variable. The regression error term and the lagged endogenous regressor are correlated due to common measurement error violating a necessary condition for consistent estimates. Bearing this in mind and turning to equation (3) estimates, 70 percent of the workers adjusted labor supply between 1966-69 and 61 percent between 1969-73 so as to eliminate the gap between actual and desired labor supply that existed at the beginning of the period. So far both direct and indirect estimates suggest very substantial but not complete liquidation of initial disequilibrium positions. On the other hand, direct estimates of γ based on equation (5) are greater than 1.0, with standard errors that test out significantly greater than 1.0. The equation (5) estimate of γ would be expected to be higher than the equation (3) estimate since spurious negative correlation is more of a problem in the

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1/ This disregards the results for the Southern Region in 1966-69, a variable never close to significance in any of the equations.

TABLE 2 - Fully Dynamic Labor Supply Estimates: 1969-73

	Equation (5)		Equation (6)
	Instrumental Variable		
ΔLn_{t-1}		-.40 (16.82)	-.41 (16.98)
ΔSurvey Week Hours IV	-.24 (5.59)		
Determinants of ΔLn^*_t			
ΔW_P	151.84 (5.72)	142.72 (5.45)	139.88 (5.59)
$\Delta W_T > 0$	-238.23 (1.31)	-256.76 (1.43)	-238.06 (1.35)
$\Delta W_T < 0$	146.60 (2.15)	146.91 (2.18)	151.85 (2.30)
ΔHealth Limitation Status: Limitation Ceased, 73 (D)	93.53 (1.73)	82.08 (1.53)	71.74 (1.52)
ΔHealth Limitation Status: Became limited, 73 (D)	-120.58 (3.55)	-126.61 (3.77)	-129.22 (3.94)
Became 53-57 Years of Age in 1969 (D)	-48.34 (1.72)	-53.19 (1.91)	-59.92 (2.20)
Became 58-62 Years of Age in 1969 (D)	-348.69 (9.68)	-358.91 (10.09)	-365.73 (10.50)
Determinants of ΔLn^*_{t-1}			
ΔWp	48.70 (0.99)	52.29 (1.07)	
$\Delta W_T > 0$	134.21 (0.91)	91.56 (0.63)	
$\Delta W_T < 0$	-282.13 (1.74)	-231.45 (1.44)	
ΔHealth Limitation Status: Limitation Ceased, 69 (D)	19.26 (0.42)	-16.94 (0.37)	
ΔHealth Limitation Status: Became Limited, 69 (D)	-10.40 (0.21)	-15.88 (0.32)	
Relative Health Improvement, 69 (D)	-57.58 (1.16)	-53.80 (1.10)	
Relative Health Decline, 69 (D)	21.22 (0.49)	-.47 (0.01)	
Constant	-97.57	-89.42	-63.51
F		33.60	62.50
R^2		.197	.196

For definition of variables see Section III and Notes to Table 1.

TABLE 3 - Cross-Section (Equation 1) Labor Supply Estimates

	1966	1969	1973
W_P	19.69 (1.59)	45.55 (3.99)	75.48 (5.89)
$W_T > 0$	-248.17 (2.72)	-230.30 (2.54)	-98.89 (0.74)
$W_T < 0$	-269.47 (2.72)	-357.35 (3.40)	-94.37 (1.41)
Eligible for Pension (D)	-62.68 (3.07)	-82.30 (4.12)	49.25 (1.08)
Likes Job	21.60 (1.95)	22.79 (2.10)	38.55 (2.66)
Likes Work (D)	52.12 (2.29)	43.46 (1.94)	65.73 (2.30)
Health Limits Work (D)	4.74 (0.17)	-109.57 (4.18)	-157.40 (5.46)
Health Fair or Poor (D)	-85.67 (2.95)	-36.63 (2.15)	
Age 50-54 in 1966 (D)	30.91 (1.42)	11.19 (0.52)	-35.50 (1.29)
Age 55-59 in 1966 (D)	38.35 (1.41)	-3.97 (0.15)	-352.79 (10.08)
Wife's Health Limits Her Work (D)	-10.37 (0.30)	-6.72 (0.20)	
Wife's Health Prevents Her from Working (D)	-26.50 (0.76)	-33.81 (1.08)	
Southern Region (D)	2.54 (.08)	-7.74 (0.27)	15.34 (0.43)
North Central Region (D)	121.41 (4.38)	79.15 (2.91)	71.71 (2.07)
Western Region (D)	52.37 (1.53)	32.16 (0.97)	3.46 (0.08)
Non-White (D)	-96.60 (3.58)	-22.86 (0.89)	36.62 (1.13)
Farm Background (D)	81.39 (3.38)	79.80 (3.31)	97.46 (3.23)
Constant	2087.20	1995.80	1680.50
F	7.80	8.17	20.13
R^2	.061	.064	.121

For definition of variables see Section III and the Notes to Table 1 dynamic than in the cross-section of changes formulation. However, values of γ implausibly higher than one indicate the serious magnitudes of the measurement error problem in (5).

It was noted earlier that the value of γ might vary systematically between subpopulations. This possibility was tested by creating variables defining population groups suspected of having different response coefficients and interacting these variables with the determinants of labor supply change. Extensive experimentation yielded null results with one exception. The population of job-stayers, those who remain with the same employer over the time period considered, react differently than do job-changers, those who change employers at some point during the period. Direct estimates of γ for these two populations obtained from regressions not shown in the text are presented in Table 4 along with estimates for the full sample from Tables 1 and 2. As would be expected, job-changers are more likely to react to disequilibrium during any time period than are job stayers. Still, the proportion of job-stayers adjusting is quite high.

We resorted to an instrumental variable (IV) technique to cope with the upward bias in the estimates of γ. 1/ Since the primary source of measurement error in annual manhours is likely to reside in hours rather than weeks, an instrument was constructed in which survey week hours was substituted for usual hours. The results for equations (3) and (5) are shown in Tables 1, 2 and 4. The estimated γ coefficients were moderately smaller, but showed the same pattern as the direct estimates. More job-changers than stayers responded to disequilibrium, and equation (5) continued to yield estimates greater than 1.0. An experiment with an instrument based on average

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1/ For a discussion of the instrumental variable technique, see Goldberger {4}. Since an IV routine was not available, we followed a two-stage (analogous to 2SLS) procedure suggested by Murply {9}. In the first stage the variable to be instrumental was regressed on its instrument plus all the other regressors.

TABLE 4 - Estimates of Initial Disequilibrium Adjustment Coefficient, γ

	1966-69	1969-73
Equation 3 Models		
Direct		
Full Sample	.70	.61
Job Stayers	.70	.55
Job Changers	.72	.76
Survey Week Instrument		
Full Sample	.59	.47
Job Stayers	.58	.39
Job Changers	.64	.64
Equation 5 Models		
Direct		
Full Sample		1.40
Job Stayers		1.39
Job Changers		1.44
Survey Week Instrument		
Full Sample		1.24
Job Stayers		1.18
Job Changers		1.39
1966-71 Labor Supply Instrument		
Full Sample		.81
Job Stayers		.87
Job Changers		.73

hours worked on the current job yielded similar outcomes. Since equation (5) seemed bedeviled by measurement error in weeks as well as in hours, an instrument was constructed in which 1966-71 labor supply change proxied for the 1966-69 change. As can be seen, this results in estimated values for γ less than 1.0. However, the value of γ is now higher for job-stayers than for job-changers, an outcome which contradicts all other results and the logic of the adjustment process.

There seems no useful way around the measurement error problem for euqation (5). Instruments uncorrelated with the error term turn out to be so weakly correlated with the variables to be instrumented that the resulting estimates have very low efficiency. On the other hand, estimates based on the partially dynamic or cross-section of changes variant are plausible and reassuring though possibly somewhat upwardly biased.

Unfortunately, the extent of measurement error in equations (3) and (5) cannot be gauged with any precision. However, the magnitude of bias can be approximated for a given relative degree of measurement error. The procedure is as follows. Define $L_t = \bar{L}_t + \delta_t$, where $\bar{L}_t$ is true labor supply and δ_t is random measurement error uncorrelated with all other variables (including in particular L_{t-1}) except of course, L_t. Assume that ΔL_{t-1} is uncorrelated with (the determinants of) ΔL^*_t, and in (3) and (5) that L_{t-1} and ΔL_{t-1} are uncorrelated with ΔL^*_t and L^*_{t-1} respectively. These last two assumptions are strictly incorrect Still the operating assumption of orthogonality between L^*_t and L_t and between ΔL^*_t and ΔL_t is not unreasonable, given that the proxies for L* explain such a small proportion of labor supply. Now define the following two variance ratios:

$$\rho = \frac{\sigma^2_\delta}{\sigma^2_L} \quad ; \qquad \lambda = \frac{\sigma^2_\delta}{\sigma^2_{\Delta L}}$$

i.e. ρ is the ratio of the variance in measurement error to the variance in the true level of labor supply; λ is the ratio of the variance in measurement error to the variance in the true change in labor supply. Denote by g_1 the regression estimate of γ in equation (3) and by $(1-g_2)$ the regression estimate of $(1-\gamma)$ in equation (5). It is then a straightforward matter to demonstrate that the following probability limits hold;

$$\text{(7)} \qquad \text{plim}\ (g_1) = \frac{\gamma + \rho}{1 + \rho}$$

$$\text{(8)} \qquad \text{plim}\ (1-g_2) = \frac{(1-\beta) - \lambda}{1 + 2\lambda} \quad \text{or, plim}\ (g_2) = \frac{\beta + 3\lambda}{1 + 2\lambda}$$

Equations (7) and (8) clearly reveal the upward bias in g_1 and g_2 when $\gamma, \beta < 1$ and $\rho, \lambda > 0$. The most insightful way of using (7) and (8) is to insert the actual estimates into the left-hand side and observe the resulting values of γ and β as ρ and λ are progressively increased from zero. The results of this exercise are shown in Table 5 using the estimated coefficients of Table 4.

TABLE 5

	Estimated Values of γ Assuming Alternative Values of ρ and λ			
	Equation (3) 1969-73		Equation (5) 1969-73	
	ρ	γ	λ	γ
Full Sample	0	.61	0	1.40
	.5	.42	1.0	1.20
	1.0	.22	2.0	1.00
	1.5	.03	3.0	.80
			5.0	.40
Job Stayers	0	.55	0	1.39
	.5	.33	1.0	1.17
	1.0	.10	2.0	.95
			3.0	.73
Job Changers	0	.76	0	1.44
	.5	.64	1.0	1.32
	1.0	.52	2.0	1.20
	1.5	.40	4.0	.96

Table 5 reveals a sharp contrast between the partially and the fully dynamic formulations, given that the bias formulas are approximately valid. The variance should be greater in the cross-sectional level of true manhours than in the cross-sectional changes in true manhours, hence $\lambda > \rho$. However, roughly comparable values of γ between equations (3) and (5) would seem to require values of λ on the order of 5.0. Measurement error variance five times as large as true variation in labor supply changes would greatly hinder the ability of the fully dynamic methodology to obtain estimating precision. At the same time, plausible values of ρ - say on the order of 0.5 or less - would suggest that one-third of the job-stayers and two-thirds of the job-changers adjusted to disequilibrium over the 1969-73 period, a range of estimates which is not unreasonable.

Response to Concurrent Changes in Desired Labor Supply. We begin our analysis of β, the coefficient for concurrent change in desired labor supply by testing the hypothesis $\beta = \gamma$. This can be readily done since equations (4) and (6) are the counterparts, respectively of (3) and (5) when the hypothesis holds. Simple F tests of explanatory superiority were performed for each pair across populations and periods, with results shown in Table 6.

TABLE 6

F-Statistics for H_o: $\gamma = \beta$

	1966-69	1969-73
Eq. (3) vs. Eq. (4)		
Full Sample	6.84**	3.64**
Job Stayers	1.88*	3.20**
Job Changers	3.93**	0.70
Eq. (5) vs. Eq. (6)		
Full Sample	-	0.69
Job Stayers	-	0.35
Job Changers	-	1.21

** indicates significance at 1% level.
* indicates significance at 5% level.

As can be seen, the null hypothesis can be rejected within the cross-section of changes formulation for all populations and time periods except job changers in 1969-73. The fully dynamic formulation is another matter. Remember that the estimates of equation (5) shown in Table 2 include the determinants of the lagged change in desired labor supply. The coefficients compound desired labor supply impacts with the adjustment parameters, $(\gamma - \beta)$. The frequent sign changes for the ΔL^*_{t-1} variables in Table 2 suggest that $\beta \neq \gamma$; however the low t-values is more consistent with the hypothesis of equality, a suggestion reinforced by the F test comparison of (5) and (6). Even equality would of course imply an implausibly high value for β.

Probing further requires direct inferences about the value of β. To obtain such inferences, recourse was had to a two-stage estimation technique which offered direct estimates of both response coefficients, γ and β, and which served as an additional check on the sensitivity of the earlier results. The technique follows directly from our assumptions regarding L^*. In particular, an estimate of L^*_{nt} can be obtained by regressing L_{nt} on the determinants of desired labor supply in period t (Table 3). Cross-sectionally predicted values of L^*_{nt} and L^*_{nt-1} obtained in this way are then entered directly into the specification of the adjustment models. The results for equation (3) are shown in column 1 of Table 7. The variable $\hat{L}^*_{nt} - \hat{L}^*_{nt-1}$ corresponds to ΔL^*_{nt} and hence provides an estimate of β. The proportion of responders to concurrent changes in desired labor supply is high though reassuringly less than one. The hypothesis that β is not significantly less than one however cannot be rejected. The initial disequilibrium is captured by $\hat{L}^*_{nt-1} - L_{nt-1}$, the coefficient of which is then an estimate of γ. The value obtained, .62, is almost exactly the same as that found in the non-instrumental version of equation (3) in Table 1. Moving to the fully dynamic specification in column (2), the estimate of β does not change perceptibly thus reinforcing the finding of small cross-section bias. Unfortunately, the measurement error bias is still unacceptably high in this formulation as the estimate of $(1-\gamma)$ manifested by the coefficient of $L_{nt-1} - L_{nt-2}$ implies a value of γ in the range of 1.4. Once again the partially dynamic model appears to give superior results.

TABLE 7

Direct Estimates of Equations (3) and (5) from Two-Stage Procedure, 1969-1973

	Equation (3)	Equation (5)
$\hat{L}^*_{nt} - \hat{L}^*_{nt-1}$	0.93 (15.26)	0.93 (14.44)
$\hat{L}^*_{nt-1} - L_{nt-1}$	0.62 (22.81)	
$\hat{L}^*_{nt-1} - \hat{L}^*_{1nt-2}$		0.34 (2.18)
$L_{nt-1} - L_{nt-2}$		-0.41 (17.25)

V. Conclusions

The methodology of this paper breaks with the traditional cross-section approach to labor supply determination and moves two steps toward a fully dynamic approach. The first step is represented by equations (3) and (4) which specify a cross-section of labor supply changes. This specification should greatly reduce any bias due to the lagged adjustment component of the pure cross-sectional error term. The second step is given by equations (5) and (6) which additionally are formulated to eliminate the household specific component of the error term. Empirical investigation of these models suggests the following results for the mature men in this sample:

(1) The resort to dynamic specifications leaves relatively unimpaired the perspectives generated from cross-sectional studies on the set of variables important in the determination of labor supply. In particular the W_p coefficient is positive, significant and robust though the implied wage elasticity is rather small. The fact that the coefficient of W_p tends to be smaller in the cross-sections compared to the dynamic formulations is not necessarily an anomoly. Intertemporal correlation of W_p is quite high. If then $\beta > \gamma$, for which there is fairly strong evidence, and the correlation of L_{nt-1} with L^*_{nt} is low, the resulting cross-sectional bias can reduce the estimated coefficient of W_p (see equation (3')) below the value estimated for an unbiased dynamic formulation.

(2) Coefficient values for change variables obtained from the cross-section of changes formulation are strikingly similar to those obtained from the more fully dynamic formulation. Although the partially dynamic model is potentially vulnerable to cross-section bias, it appears to be little affected by such bias. It thus emerges as the superior formulation for probing labor supply. Moving to a fully dynamic model involves a substantial loss of efficiency due to greater sensitivity to measurement error in the dependent variable without any compensating advantages.

(3) Workers appear capable of making quite rapid changes in actual labor supply. The values of β, the coefficient of response to changes occurring in desired labor supply, is unambiguously high. Over 90 percent of workers adjusted to ΔL^* within a two year period so as to remain on their labor supply curve. The response to pre-existing disequilibrium

while still substantial is considerably smaller. Only between 40 and 70 percent of workers eliminated a 3 1/2 - 4 year old gap between desired and actual labor supply. The reason for these differences in values between β and γ requires further research probing.

(4) Labor supply response is expedited by job change but substantial adjustment occurs under a single employer, or by means of secondary employers.

References

{1} Cain, G.C., and Watts, H.W. (eds.) Income Maintenance and Labor Supply (Chicago: Markham, 1973).

{2} Fair, R.C., and Jaffee, D.M. "Methods of Estimation for Markets in Disequilibrium", Econometrica, May 1972.

{3} Fleisher, B.M., Parsons, D.O. and Porter, R.D. "Asset Adjustments and the Labor Supply of Older Workers", in Income Maintenance and Labor Supply, eds., G.C.Cain and H.W.Watts (Chicago: Markham, 1973).

{4} Goldberger, A.S. Econometric Theory (New York: John Wiley and Sons, 1964).

{5} Grunfeld, Y., "The Interpretation of Cross-Section Estimates in a Dynamic Model", Econometrica, July 1961.

{6} Kalachek, E.D., Mellow, W.S., and Raines, F.Q. "The Male Labor Supply Function Reconsidered", Industrial and Labor Relations Review, 1977.

{7} ———— and Raines, F.Q. "The Structure of Wage Differences Among Mature Male Workers", Journal of Human Resources, Fall 1976.

{8} Kuh, E., "The Validity of Cross-Sectionally Estimated Behaviour Equations in Time Series Applications", Econometrica, April 1959.

{9} Murphy, J.L. Introductory Econometrics, (Homewood, Ill.; Irwin, 1973), p.296.

{10} Nerlove, M. "Further Evidence on the Estimation of Dynamic Relations from a Time Series of Cross-Sections", Econometrica, March 1971.

{11} Tobin, J. "Estimation of Relationships for Limited Dependent Variables", Econometrica, 1958.

{12} U.S.Department of Labor, Manpower Administration, The Pre-Retirement Years, Volumes 1-5 (Washington, D.C.: GPO, 1970-75).