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Testing whether Unemployment Represents Intertemporal Labour Supply Behaviour

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In the Lucas-Rapping (1969) model of the labour market, fluctuations in unemployment represent individuals optimally adjusting their labour supply behaviour in response to fluctuations in wage rates over the business cycle. In this paper I propose and implement a misspecification test of the Lucas-Rapping treatment of unemployment as labour supply behaviour using panel data. This test extends previous such work with micro data by simultaneously allowing for intertemporal substitution, uncertainty and endogenous unemployment. Using the standard specification of intertemporal labour supply behaviour, I find strong evidence against this interpretation of unemployment. There are two possible interpretations of the test results. The first is that it is necessary to turn to alternative models of the labour market in which unemployed workers are off a supply function. The second is that the test results indicate the necessity of moving to more complex models of intertemporal substitution. However, given current econometric techniques and data sets, these alternative models of intertemporal substitution will be extremely difficult to test.

1. INTRODUCTION

Lucas and Rapping (1969) present a model of the aggregate labour market where the demand and supply of labour are continuously equated. In this model unemployed individuals are on an intertemporal labour supply function and unemployment is a form of non-market time chosen by individuals on the basis of current and expected future wage rates. Since unemployment depends only on wage rates, it is legitimate to aggregate it with other forms of non-market time using the Hicks' composite commodity theorem to form an aggregate measure of non-market time. Labour supply is simply the complement of this aggregate measure. Thus, in this model unemployment represents labour supply behaviour and fluctuations in unemployment reflect individuals adjusting their hours of work in response to fluctuations in wage rates over the business cycle. The Lucas and Rapping model has played an important role in macroeconomic theory over the past decade and, as a result, this model has been thoroughly investigated and tested in a series of important papers using aggregate time-series data. (See, for example, Altonji (1982), Altonji and Ashenfelter (1980), Andrews and Nickell (1982), and Ashenfelter and Card (1982)).

The purpose of this paper is to implement a test of the hypothesis that unemployment represents intertemporal labour supply behaviour using panel data on individuals from the Panel Study of Income Dynamics (PSID). The motivation for the test is two-fold. First, the use of micro data for investigating this interpretation of unemployment offers at least two advantages over the use of aggregate data:¹ (i) it avoids aggregation biases and (ii) there is more variation in the individual wage series than the mean wage series.

As a result, it may be less difficult with panel data to explain unemployment as the result of intertemporal substitution. The second motivation for this study arises from the importance of obtaining accurate measures of intertemporal labour supply elasticities.² These elasticities play a crucial role in analysing a number of important policy issues, such as the labour supply response to temporary negative income tax plans, the impact on hours worked of temporary tax changes, and the effect of pensions and Social Security on retirement decisions. However, the estimation of intertemporal labour supply models is based on the assumption that unemployment can be treated as an optimally chosen form of non-market time. Thus the test considered here should have important implications for the estimation of life-cycle models. The test also generalizes previous such work with micro data by simultaneously allowing for intertemporal substitution, uncertainty and endogenous unemployment.

The test results unambiguously suggest that the standard treatment of unemployed workers in empirical labour supply estimation represents an important misspecification. Since the test is a diagnostic or misspecification test of the Lucas–Rapping model, rather than a test of the model against a specific alternative, it does not indicate which model of the labour market is appropriate. Thus one must look for a more general model of the labour market, and there are two directions which could be taken. First, one could turn to models which allow for the possibility that unemployed workers are off their labour supply functions. Alternatively, one could turn to more complex models of intertemporal substitution. Unfortunately, the estimation and testing of these alternative or more complex models is likely to be extremely difficult.

The paper consists of five sections. In Section 2, I review the standard model of life-cycle labour supply and briefly consider an alternative model where some workers are constrained in their labour supply decisions. I then propose a test for the null hypothesis that unemployment represents intertemporal labour supply behaviour. The results of implementing this test are presented in Section 3. The test results strongly suggest that it is inappropriate to treat unemployment as labour supply behaviour. In Section 4, I consider some possible alternative sources of misspecification, and investigate the sensitivity of the test results to changes in functional form and the composition of the sample used for estimation. I also consider two possible forms of correlation across individuals' residuals which, if ignored, could lead to invalid test statistics. None of these modifications affects the test results. In Section 5, I discuss the implications of the test results and conclude the paper.

2. A MISSPECIFICATION TEST FOR A MODEL WHERE UNEMPLOYMENT REPRESENTS INTERTEMPORAL LABOUR SUPPLY BEHAVIOUR

In the Lucas–Rapping model workers are on an intertemporal supply function whether or not they experience a spell of unemployment. To test this interpretation of unemployment, I examine whether the hours of work equation is the same for periods when workers experience unemployment as it is for periods when they do not experience unemployment. The natural starting point for this analysis is the worker's intertemporal labour supply function, and I will begin by adopting the specification from MaCurdy's (1981) influential study.

2.1. *An empirical life-cycle model of labour supply*

An individual maximizes his lifetime utility function

$$\sum_{t=0}^T \frac{U_{it}(C_{it}, H_{it})}{(1+\rho)^t} \quad (1)$$

subject to the lifetime budget constraint

$$A_{i0} + \sum_{t=0}^T \frac{w_{it}H_{it}}{(1+r)^t} - \sum_{t=0}^T \frac{C_{it}}{(1+r)^t} = 0. \tag{2}$$

In (1), C_{it} and H_{it} represent his consumption and labour supply in period t respectively while ρ represents the rate of time preference. In (2), r is the real interest rate, A_{i0} is initial assets, and w_{it} is the consumer's real wage rate in period t . To increase the clarity of presentation, I am ignoring, for the moment, the problem of uncertainty and the possibility that the real interest rate changes over time, but both of these factors are considered in the empirical work presented below. The utility function is assumed to take the form

$$U_{it}(C_{it}, H_{it}) = \gamma_{1it}C_{it}^{\beta_1} - \gamma_{2it}H_{it}^{\beta_2}, \tag{3}$$

where $0 < \beta_1 < 1$ and $\beta_2 > 1$.

To allow for taste variation across individuals, assume that γ_{2it} takes the form

$$\gamma_{2it} = \exp(-\gamma_{2i} - \tilde{\phi}'x_{it} - e_{it}), \tag{4}$$

where γ_{2i} is an individual fixed effect capturing permanent tastes toward leisure, $\tilde{\phi}$ is a vector of parameters, x_{it} is a vector of demographic variables, and e_{it} is an error term. Since data on prime-aged males are analysed, the participation decision is ignored and the worker's intertemporal labour supply function takes the form

$$\ln H_{it} = F_i + \alpha t + \phi'x_{it} + \delta \ln w_{it} + \varepsilon_{it}, \tag{5}$$

where $\delta = 1/(\beta_2 - 1)$, $\alpha = \delta(\rho - r)$, $F_i = \delta(\ln \lambda_i + \gamma_{2i} - \ln \beta_2)$, $\varepsilon_{it} = \delta e_{it}$, $\phi = \tilde{\phi}\delta$, and $\ln(1 + \rho/1 + r) \approx \rho - r$. The term δ is the intertemporal substitution elasticity, and reflects how the worker responds to anticipated changes in wages over the life-cycle holding the marginal utility of wealth, λ_i , constant. The term λ_i is unobservable, but because it is a function of initial assets and all wage rates over the life-cycle, it cannot be treated as a component of a random error term. One can eliminate F_i , and thus λ_i , by adopting a fixed-effects model and working in first differences. This yields the following equation for estimation

$$\Delta \ln H_{it} = \alpha + \delta \Delta \ln w_{it} + \phi' \Delta x_{it} + \Delta \varepsilon_{it}. \tag{6}$$

In (6), x_{it} represents demographic variables hypothesized to influence preferences toward leisure. Note that all time-constant variables, (as well as permanent tastes toward leisure), drop out of (6). Among a worker's time varying characteristics, age, marital status and number of children are natural candidates to influence preferences. One can control for age by redefining α to include the age coefficient in the vector ϕ . In the estimation, changes in marital status are controlled for by treating marital status as exogenous and restricting the sample to individuals continuously married to the same person. For expositional ease, I will ignore for the moment that the number of children affects preferences (although this possibility is considered in the empirical work below) and rewrite (6) as

$$\Delta \ln H_{it} = \alpha + \delta \Delta \ln w_{it} + \Delta \varepsilon_{it}. \tag{7}$$

Thus while demographic variables which are usually entered in a cross-section labour supply regression do not appear in (7), this occurs because they difference out, not because they are ignored in the analysis.

In the empirical work presented below, H_{it} does not contain any measure of unemployed hours, $\Delta \ln w_{it}$ is always treated as endogenous and two-stage procedures are used

for estimation.³ For most of the work presented below, standard stochastic assumptions (Kiefer (1980), MaCurdy (1981)) are employed in calculating the standard errors. Specifically, given T years of panel data for N individuals, defining the $(T-1)$ vector $\Delta\varepsilon'_i = (\Delta\varepsilon_{it}, \dots, \Delta\varepsilon_{iT-1})$, I assume that

$$E(\Delta\varepsilon_i \Delta\varepsilon'_i) = V^* \quad (8a)$$

where V^* is a $(T-1) \times (T-1)$ unrestricted variance-covariance matrix. This allows for considerable flexibility in the pattern of autocorrelation and heteroskedasticity in an individual's first-differenced error term.⁴ For most of the work presented below, I again follow the literature and generally assume that error terms are independent across individuals⁵

$$E(\Delta\varepsilon_i \Delta\varepsilon'_j) = 0, \quad i \neq j, \quad (8b)$$

although I also consider two special cases of relaxing (8b).

2.2. An alternative model with hours constraints

MaCurdy's specification provides an empirically tractable method of estimating intertemporal labour supply behaviour when workers do not face binding labour market constraints and unemployment represents labour supply behaviour. As a potential alternative, consider the case where workers face an upper limit \bar{H}_{it} on the hours they can work in each period, but again there is no uncertainty concerning any future variables. Letting T_u denote the periods where the constraint is binding and the worker experiences unemployment, desired labour supply can now be described by the following Tobit structure

$$\ln H_{it} < F_i^* + \delta \ln w_{it} + \alpha t + \phi' x_{it} + \varepsilon_{it}, \quad t \in T_u, \quad (9a)$$

$$\ln H_{it} = F_i^* + \delta \ln w_{it} + \alpha t + \phi' x_{it} + \varepsilon_{it}, \quad t \notin T_u, \quad (9b)$$

where $F_i^* = \delta(\ln \lambda_i^* + \gamma_{2i} - \ln \beta_2)$, and H_{it} now refers to annual hours worked. In (9a) and (9b) λ_i and F_i have been replaced by λ_i^* and F_i^* respectively to reflect the fact that with binding constraints a worker will have a different (higher) marginal utility of wealth than if the worker never experiences unemployment.⁶

2.3. A misspecification test

If unemployment is the result of binding constraints on labour supply decisions, equations (9a) and (9b) offer a possible means of recovering labour supply parameters from hours of work data.⁷ Further, if unemployment does not simply represent labour supply behaviour, (9a) suggests that a labour supply model which incorrectly makes this assumption will overpredict the *level* of hours worked in periods when the worker experiences unemployment. This, in turn, suggests the following test of the hypothesis that unemployment represents life-cycle labour supply behaviour. Define a dummy variable D_{it} which equals 1 if worker i is unemployed in period t and zero otherwise. Next, enter this dummy variable in the equation for the level of hours worked equation to obtain

$$\ln H_{it} = F_i + \delta \ln w_{it} + \alpha t + \phi' x_{it} + \theta_1 D_{it} + \varepsilon_{it}. \quad (10)$$

In first difference form (10) becomes

$$\Delta \ln H_{it} = \alpha + \delta \Delta \ln w_{it} + \theta_1 \Delta D_{it} + \Delta \varepsilon_{it}. \quad (11)$$

Thus $\theta_1 D_{it}$ acts as a proxy for the large negative residuals we would expect in periods when the worker experiences unemployment if he is not on a supply function. If the unemployed are on a supply function, residuals will not be unduly large in periods of unemployment and θ_1 should not be significantly different from zero, while we would expect θ_1 to be significantly less than zero if this assumption is invalid. Alternatively, one can interpret a test of whether θ_1 is significantly different from zero as a test of whether the hours of work equation differs in years when unemployment is experienced from years in which it is absent, since no such difference should arise in the Lucas-Rapping model.

There are several possible problems in using (11) as a misspecification test. First, it considers only the incidence and not the duration of unemployment. However, an alternative test may be obtained by replacing ΔD_{it} in (11) by the change in unemployed hours, ΔU_{it} , to obtain

$$\Delta \ln H_{it} = \alpha + \delta \Delta \ln w_{it} + \theta_2 \Delta U_{it} + \Delta \tilde{\varepsilon}_{it}. \quad (12)$$

A more serious problem in estimating (11) or (12) lies in the fact that under the null hypothesis ΔD_{it} and ΔU_{it} represent labour supply behaviour and must be correlated with the error terms $\Delta \varepsilon_{it}$ and $\Delta \tilde{\varepsilon}_{it}$ respectively. Further, a referee has observed that measurement error in ΔU_{it} may be correlated with measurement error in $\Delta \ln H_{it}$. If the unemployment variables are treated as exogenous, θ_1 and θ_2 could be significantly negative under the null hypothesis simply as a result of bias from simultaneity and measurement error. Thus, I generally treat ΔD_{it} and ΔU_{it} , as well as $\Delta \ln w_{it}$, as endogenous.⁸

2.4. Choice of instruments

Essentially two sets of variables are used as instruments. The first set consists of human capital variables used previously by MaCurdy.⁹ The second set consists of demand variables used to proxy the labour market conditions faced by a worker. These demand variables are the first difference in: the local unemployment rate; a series of dummy variables indicating the difference between the number of applicants and vacancies in the individual's local labour market; the unemployment rate in the individual's (one-digit) occupation; the unemployment rate in the individual's (two-digit) industry; and a dummy variable indicating whether an individual reported in the current year that he had lost his previous job because his company went out of business. I also use interactions between human capital variables (age, age-squared, education, and age times education) and some of the first differences in the demand variables (local, occupational and industrial unemployment rates and the lost job dummy) as instruments, since the effect on a worker of demand shocks to a region or industry may depend on his characteristics.¹⁰

This choice of instruments uses the unemployment experience of individuals outside the sample as a control for the unemployment experiences of those in the sample. The crucial identifying assumption is that there are not transitory shocks to tastes specific to workers in the same industry or region. The validity of this assumption does not depend on permanent tastes being uncorrelated across individuals in the same region or industry, since the permanent component of tastes drops out of the first-differenced error term.¹¹ Further, aggregate transitory shocks to tastes will be captured by the time dummies. This assumption is clearly much weaker than that employed in previous studies, and, in the absence of experimental data, an assumption such as this seems necessary. Otherwise, any adjustment to hours in an industry that cannot be explained by wage movements in the industry can always be attributed to an industry-specific shock to tastes. It is also

worth noting that in the Lucas–Rapping model, fluctuations in demand variables affect labour supply only through the fluctuations in the wage, and since wage changes are controlled for in (11) and (12), these instruments have not been inappropriately excluded from these equations. (See Altonji (1981).)

2.5. Uncertainty

The use of (11) and (12) to test the adequacy of the Lucas–Rapping model can be validly criticized on the grounds that ignoring the role of uncertainty may bias the results. The uncertainty case can be addressed by making standard assumptions and drawing on previous work by MaCurdy (1982, 1983), Altonji (1984) and Browning, Deaton and Irish (1985).¹² The worker's labour supply function in the presence of uncertainty (and in the absence of labour market constraints), may be written as

$$\ln H_{it} = \delta(\ln \lambda_{it} + \gamma_{2i} - \ln \beta_2) + \delta \ln w_{it} + \phi' x_{it} + \varepsilon_{it}, \quad (13)$$

where λ_{it} represents the worker's marginal utility of wealth in period t . In each period, individuals choose their labour supply and consumption to satisfy¹³

$$\lambda_{it-1} = \frac{1+r}{1+\rho} E_{t-1} \lambda_{it} \quad (14)$$

where E_{t-1} denotes the conditional expectation given available information at $t-1$. Equation (14) may be rewritten as

$$\lambda_{it} = \frac{(1+\rho)}{(1+r)} \lambda_{it-1} (1+u_{it}), \quad (15)$$

where u_{it} is a forecast error which, under rational expectations, will be a mean innovation relative to information known at time $t-1$ (i.e. it will have zero mean conditional on the information set at $t-1$). Taking logarithms of (15) yields

$$\ln \lambda_{it} \approx \rho - r + b + \ln \lambda_{it-1} + v_{it}, \quad (16)$$

where b is the population mean of $\ln(1+u_{it})$, which can be allowed to vary over time if time dummies are included in the specification. The error term v_{it} is assumed to be a mean innovation relative to variables dated $t-1$ or earlier. Assuming (16) is a valid approximation, one may use it to obtain the following expression for the first difference in hours worked

$$\Delta \ln H_{it} \approx \tilde{\alpha} + \delta \Delta \ln w_{it} + \Delta \varepsilon_{it} + v_{it} \quad (17)$$

where $\tilde{\alpha} = \rho - r + b$.

The presence of the error v_{it} in (17) has two implications for the test procedure outlined above.¹⁴ First, the unemployment dummy (or unemployed hours) may now be *positively* correlated with the error, since a spell of unemployment can indicate a worsening of the worker's economic condition and a subsequent rise in his marginal utility of wealth. This in turn will bias the unemployment coefficients (in an OLS regression) in a positive direction. Second, the current first differences in the demand variables are no longer valid instruments, since current demand variables (dated t) may be useful in predicting v_{it} . To avoid this problem, I use the *lagged* first differences in the demand variables as instruments when considering uncertainty.

2.6. Allowing for underemployment

Finally, some readers may consider the test procedure outlined above as unduly narrow, since workers may be constrained in the sense of working fewer hours per week than they would desire in the absence of unemployment. Such underemployment may arise because of long-term contracting arrangements between firms and workers (Lazear (1981)), because of employer interests in employee hours of work (Lewis (1969)), or because firms institute work-sharing as an alternative to layoffs. In the PSID, individuals were asked whether there was more work available (in the previous year) on a worker's job (any of his jobs) so that he could have worked more if he had wanted to, and if not, whether he had wanted to work more. While there is some ambiguity in how individuals may respond to these questions, individuals who answer no to the first question and yes to the second question would appear to be reporting that they are underemployed.¹⁵

To consider the hypothesis that these workers are not off their labour supply function, define a dummy variable K_{it} coded 1 if individual i reports that he was underemployed in year t , and coded zero otherwise. Then estimate the following equations

$$\Delta \ln H_{it} = \tilde{\alpha} + \delta \Delta \ln w_{it} + \theta_1 \Delta D_{it} + \theta_3 \Delta K_{it} + \Delta \varepsilon_{it} + v_{it}, \quad (18a)$$

$$\Delta \ln H_{it} = \tilde{\alpha} + \delta \Delta \ln w_{it} + \theta_2 \Delta U_{it} + \theta_4 \Delta K_{it} + \Delta \tilde{\varepsilon}_{it} + v_{it}, \quad (18b)$$

and test whether θ_3 and θ_4 are significantly different from zero. Of course, the underemployment dummy may also be endogenous, and one can allow for this possibility by treating it as such using the demand variables as instruments. (In using these instruments, I am implicitly treating underemployment as a work-sharing phenomenon.)

Estimation of (18a) and (18b) provides a misspecification test of the Lucas-Rapping interpretation of unemployment while allowing for uncertainty, heterogeneous taste differences among workers and intertemporal substitution.¹⁶ As a result, it represents a significant extension of previous studies using micro data. It extends the work of Ham (1982) by working in a life-cycle framework and allowing for intertemporal substitution. It extends the work of Ashenfelter and Ham (1979) by explicitly allowing for endogenous wages, unemployment, and uncertainty as well as investigating the treatment of underemployed workers in life-cycle labour supply analysis.¹⁷

3. EMPIRICAL ESTIMATES AND TEST RESULTS

Equations (18a) and (18b) are estimated using 8 years of data (1971–1979) on 473 continuously-married prime-aged males from the PSID, resulting in an overall sample size of 3784.¹⁸ All equations contain a constant (not reported). A code Y signifies the inclusion of time dummies to account for changes in the real interest rate while N indicates their exclusion.

Column 1 of Table I contains the two-stage least squares estimates of the differenced hours equation, while column two contains the same equation when time dummies are included. (In both cases, current demand variables are used as instruments.) These results imply a small, but positive, intertemporal labour supply elasticity, well within the range of results reported by MaCurdy (1981) and Altonji (1984). In columns three and four I add dummy variables for unemployment and underemployment, treating these variables as exogenous.¹⁹ Both dummy variables are very significantly negative, although the coefficient on the underemployment dummy is, as a practical matter, rather small. In columns five and six of Table I hours of unemployment and a dummy variable for

TABLE I
Differenced log hours equation—Wage treated as endogenous

Variable	Column					
	1	2	3	4	5	6
First difference in:						
In wage	0.1667 (0.0956) ¹	0.0768 (0.1240)	0.1085 (0.0894)	0.0586 (0.1198)	0.0177 (0.0800)	-0.1019 (0.1015)
Unemployment Dummy	—	—	-0.1242 (0.0110)	-0.1230 (0.0106)	—	—
Underemployment Dummy	—	—	-0.0489 (0.0087)	-0.0484 (0.0084)	-0.0396 (0.0077)	-0.0389 (0.0071)
Unemployed Hours $\times 10^{-3}$	—	—	—	—	-0.5122 (0.0214)	-0.5097 (0.0198)
Time Dummies	N	Y	N	Y	N	Y
SEE ²	0.2004	0.1887	0.1876	0.1812	0.1661	0.1534

Notes:

1. Asymptotic standard errors in parenthesis.
2. SEE is an estimate of the standard error of the regression.

underemployment are added to the labour supply equation, and again both variables are extremely significant.

Columns 1 and 2 of Table II contain the results of treating the unemployment and underemployment dummy variables as endogenous, but ignoring uncertainty, since the current first differences in the demand variables are used as instruments. The coefficients on both dummy variables rise, but so do the standard errors, and the underemployment coefficient loses its statistical significance when time dummies are included. When the unemployment dummy is replaced by measured hours of unemployment in columns three and four, the results are quite similar: hours of unemployment have a larger, significantly negative, coefficient while the underemployment coefficient is again insignificant when time dummies are included. Columns five and six present the results when unemployment is measured in dummy variable form and the *lagged* first differences in demand variables are used as instruments to allow for uncertainty. Analogous results for the case where unemployment is measured in continuous form are contained in columns seven and eight. The results for the unemployment variables are essentially unchanged, while none of the coefficients on the underemployment dummy is statistically significant at standard confidence levels.

Thus, after allowing for heterogeneity in worker tastes, endogenous unemployment, and uncertainty, these results provide strong evidence against the Lucas–Rapping view that unemployment represents intertemporal labour supply behaviour.²⁰ On the other hand, the evidence against the hypothesis that underemployed workers are not constrained is considerably weaker.

4. ROBUSTNESS OF THE TEST RESULTS

While the results of the previous section seem quite strong, there is the danger (as in all empirical work) that they reflect some other form of misspecification in the labour supply model. In this section I first consider the robustness of the test results to changes in the specification of the hours equation. I then examine whether the results have been biased

TABLE II

Differenced log hours equation—Wage, unemployment and underemployment treated as endogenous

Variable	Current Instruments ¹				Lagged Instruments ²			
	1	2	3	4	5	6	7	8
First difference in:								
In wage	0.0352 (0.0933)	0.0270 (0.1253)	-0.0227 (0.0835)	-0.1406 (0.1055)	-0.0857 (0.1057)	-0.0814 (0.1117)	-0.1503 (0.0955)	-0.1771 (0.1007)
Unemployment Dummy	-0.2592 (0.0733)	-0.2979 (0.0885)	—	—	-0.2482 (0.0662)	-0.2350 (0.0684)	—	—
Under- employment Dummy	-0.1187 (0.0641)	-0.1071 (0.0663)	-0.1060 (0.0556)	-0.0679 (0.0532)	-0.0617 (0.0638)	-0.0635 (0.0636)	-0.0858 (0.0559)	-0.0748 (0.0554)
Unemployed Hours × 10 ⁻³	—	—	-0.5717 (0.1048)	-0.6049 (0.1046)	—	—	-0.4736 (0.0983)	-0.4621 (0.0950)
Time Dummies	N	Y	N	Y	N	Y	N	Y
SEE	0.1862	0.1877	0.1640	0.1512	0.1709	0.1702	0.1514	0.1488

Notes:

1. Current first difference of demand variables used as instruments.
2. Lagged first difference in demand variables used as instruments, and as a result, one year of data per person is lost. The new sample size equals 3311.

by omitting time changing demographic variables from the analysis. I next consider the sensitivity of the test results to changes in sample and to possible data classification problems in the PSID. Finally, I investigate the effect on the test results of allowing (separately) for two special forms of correlation of residuals across individuals. The test results are robust to all of these changes.

4.1. Changes in specification of the hours equation

Although (3) probably represents the most common specification of preferences in empirical work, its use does involve strong assumptions which may affect the testing procedure.²¹ First, goods and hours of work are assumed to be separable, and King (1983) has emphasized that this is a restrictive assumption. Second, it implies a log-linear relationship between hours and wages, and the misspecification test may simply reflect the inappropriateness of the linearity assumption. For example, suppose that the null hypothesis is true, but that unemployment depends nonlinearly on wages while all other forms of non-market time depend linearly on the wage. If one erroneously assumes that the hours equation is linear, an unemployment variable may be significant simply because it is proxying nonlinear wage effects.²²

Browning, Deaton and Irish (1984) derive an hours equation which not only introduces some nonlinearity but also drops the assumption of within period separability between goods and hours. Their specification for the level (as opposed to the logarithm) of hours is

$$H_{it} = a_1 + b_{11} \ln W_{it} + b_{12}(w_{it}^{-1/2}) + b_{11} \ln \tilde{\lambda}_{it} + \varepsilon_{it}, \quad (19)$$

where now

$$\ln \tilde{\lambda}_{it} \approx \ln \tilde{\lambda}_{it-1} + b^* - \ln(1 + j_t) + v_{it}^*. \quad (20)$$

In (19) W_{it} and w_{it} represent nominal and real wages in period t respectively, while in

(20) j_t is the nominal interest rate in period t and v_{it}^* is an error term. Equation (19) can be rewritten as

$$H_{it} = a_1 + b_{11} \ln w_{it} + b_{12}(w_{it}^{-1/2}) + b_{11} \ln \tilde{\lambda}_{it} + b_{11} \ln P_t + \varepsilon_{it}. \tag{21}$$

Taking the first difference of (21) and using (20) yields

$$\Delta H_{it} \approx b^* + b_{11} \Delta \ln w_{it} + b_{12} \Delta(w_{it}^{-1/2}) + b_{11} [\ln(P_t/P_{t-1}) - \ln(1+j_t)] + \Delta \varepsilon_{it} + v_{it}, \tag{22}$$

where $v_{it} = b_{11} v_{it}^*$. Browning, Deaton and Irish (1984) use estimates of j_t in their empirical work. As an alternative one can use time dummies to capture the term in square brackets in (22), which is essentially the negative of the real interest rate. (Note that utility is not discounted here, but adding such a discount rate does not change (22).) Carrying out the misspecification test with this functional form does not change the qualitative test results. (See Table III).

TABLE III
Browning, Deaton and Irish specification of the differenced hours equation¹

Variable	Column						
	1 ²	2 ³	3 ³	4 ⁴	5 ⁴	6 ⁵	7 ⁵
First difference in:							
ln wage	-0.5468 (1.082)	-0.1113 (1.060)	0.2318 (0.9464)	0.2425 (1.139)	0.3110 (0.9746)	0.2504 (1.322)	0.4027 (1.213)
(wage) ^{-1/2}	-2.261 (3.772)	-0.5592 (3.698)	1.749 (3.307)	0.9037 (4.017)	2.205 (3.468)	1.740 (4.831)	2.901 (4.457)
Unemployment Dummy	—	-0.2418 (0.0234)	—	-0.5612 (0.1927)	—	-0.4012 (0.1494)	—
Underemployment Dummy	—	-0.0961 (0.0183)	-0.0796 (0.0163)	-0.1483 (0.1462)	-0.0927 (0.1248)	-0.0757 (0.1382)	-0.0944 (0.1268)
Unemployed Hours × 10 ⁻³	—	—	-0.9449 (0.0465)	—	-1.068 (0.2446)	—	-0.7730 (0.2202)
Time Dummies SEE	Y 0.4063	Y 0.3949	Y 0.3520	Y 0.4051	Y 0.3492	Y 0.3712	Y 0.3414

Notes:

1. Dependent variable is first difference in hours (*not* log hours) × 10⁻³. The mean values of hours (in 000's) and the real wage (in 1967 \$) in the sample are 2.26 and \$4.73 respectively. Using these mean values, the results in column 1 imply an elasticity of hours with respect to the real wage of -0.12.
2. Wage variables treated as endogenous.
3. Wage variables treated as endogenous; unemployment and underemployment variables treated as exogenous.
4. Wage terms, unemployment and underemployment treated as endogenous; current first difference in demand variables used as instruments.
5. Wage, unemployment and underemployment treated as endogenous; lagged first difference in demand variables used as instruments.

For an alternative approach to the nonlinearity issue, consider (5) as a log-linear approximation to the consumer's first order conditions. One can then examine whether the test results are affected by adding a quadratic term in $\ln w_{it}$ to (5), leading to a first difference hours equation of the form

$$\Delta \ln H_{it} = \tilde{\alpha} + \delta_1 \Delta \ln w_{it} + \delta_2 \Delta((\ln w_{it})^2) + \Delta \varepsilon_{it} + v_{it}. \tag{23}$$

The results of adding the first difference in the square of log-wage to the hours equation are reported in Table IV, and it is clear that this modification does not change the test results. (In order to save space, in this table and all remaining tables (except Table IX) I report only the results when time dummies are included. Excluding time dummies from the equation does not change any of the test results.)

As noted above, most demographic variables drop out when one estimates the labour supply equation in first differences. However, the change in the number of children does not, and Browning, Deaton and Irish found that this variable can have a strong influence in the change in hours using the FES data from the U.K. However, this variable is never significantly different from zero in the PSID data, and its introduction does not change the test results. (See Table V.)

TABLE IV
Adding change in log wage squared to differenced log hours equation

Variable	Column						
	1 ¹	2 ²	3 ²	4 ³	5 ³	6 ⁴	7 ⁴
First difference in:							
In wage	0.3468 (0.3241)	0.1534 (0.3166)	-0.2250 (0.2741)	-0.1051 (0.3633)	-0.3861 (0.3011)	-0.0718 (0.3983)	-0.2798 (0.3534)
(In wage) ²	-0.1099 (0.1230)	-0.0386 (0.1203)	0.0500 (0.1042)	0.0531 (0.1372)	0.0965 (0.1114)	-0.0036 (0.1451)	0.0381 (0.1272)
Unemployment Dummy	—	-0.1224 (0.0107)	—	-0.3062 (0.0925)	—	-0.2348 (0.0691)	—
Underemployment Dummy	—	-0.0484 (0.0084)	-0.0389 (0.0072)	-0.1141 (0.0701)	-0.0794 (0.0565)	-0.0635 (0.0635)	-0.0754 (0.0557)
Unemployed Hours × 10 ⁻³	—	—	-0.5121 (0.0206)	—	-0.6266 (0.1106)	—	-0.4678 (0.0969)
Time Dummies	Y	Y	Y	Y	Y	Y	Y
SEE	0.1859	0.1799	0.1552	0.1908	0.1551	0.1702	0.1493

Notes:

1. Wage variables treated as endogenous.
2. Wage variables treated as endogenous; unemployment and underemployment variables treated as exogenous.
3. Wage terms, unemployment and underemployment treated as endogenous; current first difference in demand variables used as instruments.
4. Wage, unemployment and underemployment treated as endogenous; lagged first difference in demand variables used as instruments.

TABLE V
Adding change in the number of children to differenced log hours equation

Variable	Column						
	1 ¹	2 ²	3 ²	4 ³	5 ³	6 ⁴	7 ⁴
First difference in:							
In wage	0.0726 (0.1243)	0.0532 (0.1199)	-0.1061 (0.1017)	0.0235 (0.1255)	-0.1454 (0.1057)	-0.0848 (0.1119)	-0.1811 (0.1009)
Unemployment Dummy	—	-0.1231 (0.0106)	—	-0.2980 (0.0883)	—	-0.2359 (0.0683)	—
Underemployment Dummy	—	-0.0484 (0.0084)	-0.0389 (0.0071)	-0.1054 (0.0662)	-0.0657 (0.0531)	-0.0624 (0.0635)	-0.0736 (0.0553)
Unemployed Hours × 10 ⁻³	—	—	-0.5096 (0.0198)	—	-0.6069 (0.1043)	—	-0.4639 (0.0949)
Number of Children	0.0047 (0.0070)	0.0061 (0.0068)	0.0048 (0.0057)	0.0041 (0.0070)	0.0050 (0.0057)	0.0040 (0.0070)	0.0043 (0.0061)
Time Dummies	Y	Y	Y	Y	Y	Y	Y
SEE	0.1882	0.1806	0.1530	0.1872	0.1507	0.1699	0.1484

Note:

For notes 1 through 4, see Table IV.

4.2. *Changes in sample*

When choosing a sample for estimation from the PSID, one faces the issue of whether to include individuals from the poverty subsample. Individuals were included in this sample on the basis of relatively low earnings in 1966, and thus the inclusion of these individuals may lead to biases as a result of nonrandom sampling. On the other hand, using these individuals does increase the sample size, and one would not expect the biases to be large in a first difference model using data from 1971 on. The results presented above are based on a sample which includes individuals from the poverty subsample, but the test results do not change when these individuals are excluded from the sample. (See Table VI.)

TABLE VI
Differenced log hours equation—poverty subsample dropped⁵

Variable	Column						
	1 ¹	2 ²	3 ²	4 ³	5 ³	6 ⁴	7 ⁴
First difference in:							
In wage	0.1335 (0.1101)	0.1086 (0.1061)	-0.0632 (0.0885)	0.0741 (0.1093)	-0.1059 (0.0954)	0.0632 (0.1366)	-0.0680 (0.1219)
Unemployment Dummy	—	-0.1231 (0.0118)	—	-0.2961 (0.0826)	—	-0.1941 (0.0714)	—
Underemployment Dummy	—	-0.0448 (0.0094)	-0.0394 (0.0078)	-0.0777 (0.0706)	-0.0344 (0.0565)	-0.0619 (0.0795)	-0.0535 (0.0684)
Unemployed Hours × 10 ⁻³	—	—	-0.4913 (0.0220)	—	-0.5903 (0.1023)	—	-0.4401 (0.1002)
Time Dummies	Y	Y	Y	Y	Y	Y	Y
SEE	0.1920	0.1838	0.1538	0.1877	0.1503	0.1790	0.1538

Notes:

For notes 1 through 4, see Table IV.

5. The estimation is based on eight observations for 412 individuals, resulting in a total sample size of 3296. The sample size equals 2884 when the lagged instruments are used.

TABLE VII
Differenced log hours equation—1975 to 1979 data only⁵

Variable	Column						
	1 ¹	2 ²	3 ²	4 ³	5 ³	6 ⁴	7 ⁴
First difference in:							
In wage	-0.0990 (0.1008)	-0.1551 (0.0958)	-0.1229 (0.0898)	-0.1316 (0.0976)	-0.1257 (0.0903)	-0.1843 (0.1340)	-0.1969 (0.1183)
Unemployment Dummy	—	-0.1664 (0.0151)	—	-0.2611 (0.0850)	—	-0.2676 (0.0700)	—
Underemployment Dummy	—	-0.0470 (0.0116)	-0.0394 (0.0109)	-0.0768 (0.0685)	-0.0821 (0.0621)	-0.0297 (0.0640)	-0.0312 (0.0583)
Unemployed Hours × 10 ⁻³	—	—	-0.5314 (0.0270)	—	-0.5073 (0.1168)	—	-0.4554 (0.0907)
Time Dummies	Y	Y	Y	Y	Y	Y	Y
SEE	0.1772	0.1684	0.1580	0.1697	0.1585	0.1661	0.1530

Notes:

For notes 1 through 4, see Table IV.

5. Sample size equals 1892.

A potentially more serious data problem lies in the classification of unemployed workers in the PSID. In data prior to 1975, (the 1976 interviewing year), workers on strike were also classified as unemployed. To examine whether the results are sensitive to this data classification problem, I repeat the analysis using only observations from 1975 to 1979. Again the test results are qualitatively unchanged. (See Table VII.)

4.3. Changes in the stochastic structure of the residuals

Finally, one could argue that making the standard assumption that the first-difference error terms are independent across individuals leads to biased standard errors and invalid test statistics. While a general treatment of this problem is beyond the scope of this paper, it is possible to consider two special cases. The first is to follow Altonji (1984) and assume that prices are the same within a region but that they differ across regions. In this case, the nominal wage should be deflated by regional price index P_{rt} rather than by the national price index P_t . If P_t is used to deflate the nominal wage, the first-difference log hours equation becomes

$$\Delta \ln H_{it} = \tilde{\alpha} + \delta(\Delta \ln w_{it}) + \Delta \varepsilon_{it} + v_{it} + \delta \Delta \ln (P_t) - \delta \Delta \ln (P_{rt}), \quad (24)$$

Not only will this modification cause the error terms of different individuals to be correlated, but it may also cause problems with the instruments if there is some sort of regional Phillips' curve. Given the possible correlation with the demand variables, I use a fixed-effect approach to control for the term $\Delta \ln P_{rt}$ by interacting time dummies with regional dummies. The results of doing so are reported in Table VIII and this modification does not change the test results.

TABLE VIII
Differenced log hours equation—region dummies interacted with time dummies

Variable	Column						
	1 ¹	2 ²	3 ²	4 ³	5 ³	6 ⁴	7 ⁴
First difference in:							
ln wage	0.0852 (0.1245)	0.0641 (0.1201)	-0.0906 (0.0945)	0.0252 (0.1270)	-0.1305 (0.1055)	-0.0714 (0.1148)	-0.1705 (0.1028)
Unemployment Dummy	—	-0.1234 (0.0107)	—	-0.3269 (0.0983)	—	-0.2460 (0.0676)	—
Underemployment Dummy	—	-0.0478 (0.0085)	-0.0388 (0.0072)	-0.1048 (0.0668)	-0.0654 (0.0530)	-0.0545 (0.0654)	-0.0696 (0.0567)
Unemployed Hours $\times 10^{-3}$	—	—	-0.5105 (0.0199)	—	-0.6095 (0.1042)	—	-0.4697 (0.0936)
SEE	0.1891	0.1813	0.1539	0.1897	0.1514	0.1711	0.1485

Note:

For notes 1 through 4, see Table IV.

I also considered a second possible approach to relaxing the independence across individuals assumption (8b) when individuals face an uncertain environment. Specifically, in calculating the standard errors I assumed that each individual's error term v_{it} in (17) contains a component u_{it} specific to industry l (measured at the one-digit level) in year t ,²³

$$v_{it} = \tilde{v}_{it} + u_{it}. \quad (25)$$

The terms \tilde{v}_{it} are assumed independent across individuals. Further, for expositional ease I will refer to u_{it} as a shock or surprise, which is only approximately correct given (16). In a given year, everyone in the same industry has the same shock, and shocks are assumed to be distributed independently across industries.²⁴ Further, given the interpretation of u_{it} as a surprise, it is assumed to be orthogonal to all variables dated $t - 1$, including past surprises. The variance of a shock is assumed to be constant over time and industries. Thus

$$E(u_{it}^2) = \sigma_l^2 \quad \text{for all } l \text{ and } t \tag{26a}$$

and

$$E(u_{l't'} \cdot u_{lt}) = 0 \quad \text{if } l \neq l' \text{ or } t \neq t'. \tag{26b}$$

Given (26a) and (26b), (8a) remains unchanged

$$E(\Delta \varepsilon_i \Delta \varepsilon_i') = V^* \tag{27a}$$

but (8b) becomes

$$E(\Delta \varepsilon_i \Delta \varepsilon_j') = V_{ij}, \quad i \neq j, \tag{27b}$$

where V_{ij} is a $(T - 1) \times (T - 1)$ diagonal matrix with t th diagonal element equal to σ_l^2 if individuals i and j are in the same industry in year t and zero otherwise. Defining Z_i as the $(T - 1) \times K$ matrix of independent variables (where imputed values have been substituted for endogenous variables), and $\hat{\beta}$ as the vector of estimated parameters from a TSLS regression, then

$$V(\hat{\beta}) = (\sum_{i=1}^N Z_i' Z_i)^{-1} (\sum_{i=1}^N \Omega_{ii} + \sum_{i=1}^N \sum_{j \neq i} \Omega_{ij}) (\sum_{i=1}^N Z_i' Z_i)^{-1}, \tag{28}$$

where

$$\Omega_{ii} = Z_i' V^* Z_i$$

and

$$\Omega_{ij} = Z_i' V_{ij} Z_j \quad i \neq j.$$

For computational purposes, (28) can be rewritten as

$$V(\hat{\beta}) = (\sum_{i=1}^N Z_i' Z_i)^{-1} (\sum_{i=1}^N \Omega_{ii} + \sum_{i=1}^N \sum_{j > i} (\Omega_{ij} + \Omega_{ij}')) (\sum_{i=1}^N Z_i' Z_i)^{-1}. \tag{29}$$

The variance of the industry surprise is estimated from

$$\hat{\sigma}_l^2 = (\sum_t \sum_{i \in l_t} \sum_{j > i, j \in l_t} \hat{\varepsilon}_{it} \hat{\varepsilon}_{jt}) / \bar{N}, \tag{30}$$

where \bar{N} represents the number of cross products in (30), $\hat{\varepsilon}_{it}$ is individual i 's first-difference residual in year t (based on the actual values of the endogenous variables) and the notation $i \in l_t$ indicates that individual i is in industry l in year t .

I used equation (29) to recalculate the standard errors of the estimated coefficients reported above in columns (5) through (8) of Table II. In general, the use of equation (29) causes the standard errors to increase. The percentage increase in these standard errors is indicated in columns (1) through (4) of Table IX. It is clear from Table IX that allowing for contemporaneous correlation across individuals by industry has a negligible effect on the standard errors, and none of the test results change when the independence across individuals assumption is dropped in this manner.²⁵

TABLE IX

Percentage increase in standard errors from allowing for contemporaneous correlation across individuals by industry
(Calculated for Columns (5) through (8), Table II)

Variable	Column			
	1	2	3	4
First difference in: ln wage	0.8%	0.1%	1.6%	0.2%
Unemployment Dummy	3.0%	0.3%	—	—
Underemployment Dummy	0.1%	0.0%	0.4%	0.0%
Unemployed Hours $\times 10^{-3}$	—	—	0.3%	0.2%
Time Dummies $\hat{\sigma}_T^2 \times 10^3$	N 0.131	Y 0.038	N 0.169	Y 0.062

Note: Columns (1) through (4) correspond to Columns (5) through (8) in Table II, respectively. For example, using (29) produces a standard error on the coefficient of the unemployment dummy in Column (6) of Table II that is equal to 1.003 (0.3% in Column 2) times the standard error reported for this variable in Column (6) of Table II.

5. CONCLUSION AND INTERPRETATIONS

The results of Sections 3 and 4 indicate that the standard approach to estimating labour supply functions, which treats unemployed workers as if they are on a supply function, leads to an estimating equation that is misspecified. Further, the parameter estimates indicate that controlling for unemployment by simply introducing unemployed hours or an unemployment dummy does not produce a satisfactory empirical model of labour supply behaviour, and thus other approaches must be considered.²⁶ There are two possible responses to the results. One is to turn to models which allow for the possibility that unemployed workers are off a supply function. Another is to consider more complex models of intertemporal substitution.

In terms of the first response, there are several models in which unemployed workers are constrained in their labour supply decisions in either an *ex post* or *ex ante* sense. For example, Barro and Grossman (1971), Benassy (1976), Clower (1965), Dreze (1975), Hahn (1978) and Malinvaud (1977) develop Keynesian models. Alternatively, models of implicit contracts with asymmetric information have been proposed by Azariadas (1983), Farmer (1983) and Grossman and Hart (1981). Abowd and Ashenfelter (1979) consider a compensating wage model while Flinn and Heckman (1983), Kiefer and Neumann (1979) and Nickell (1979a) work within the context of an empirical search model. In the compensating wage and contract models, workers voluntarily enter firms anticipating constraints so that while they are not constrained *ex ante*, they are likely to be constrained *ex post* once they begin work. Since the test presented above is a diagnostic test for the absence of *ex post* constraints, this test cannot distinguish which of the other models of unemployment may be appropriate.

The interesting theoretical search model of Burdett and Mortenson (1979) is more difficult to classify. In this model, workers optimize over leisure, search and hours of work in an intertemporal setting. However, their model differs from the standard labour

supply model in several important respects. First, workers must satisfy a static budget constraint each period. Secondly, search represents a more general form of human capital accumulation than is allowed for in the standard intertemporal labour supply model. Third, workers face *exogenous* probabilities of temporary and permanent layoffs. As a result, the hours of work of an individual who searches while employed, or who experiences any unemployment during the year, will depend on both wages and demand conditions. Essentially this model retains the intertemporal optimization aspect of an intertemporal substitution model, but drops the market clearing assumption.

There are at least three modifications to the intertemporal substitution model which could potentially explain the test results in Sections 3 and 4. First, one could argue for the importance of intertemporal substitution during the year. This study, like all previous work on intertemporal labour supply, assumes that a year is the appropriate time interval for defining the utility function and measuring wages since the data come at this level of time aggregation. Thus the possibility of substitution within the year is ignored. If workers do indeed move in and out of employment in response to wage fluctuations during the year, the observed wage will be an upwardly biased estimate of the mean actual wage facing a worker who experiences unemployment during the year. Further, this sample selection problem will not be eliminated by standard instrumental variables techniques such as those used above. Unfortunately, in the absence of very rich data sets containing information on a worker's wage opportunities while unemployed, there would appear to be no means of testing this hypothesis.²⁷

Alternatively, one could argue that economic decisions are not based on a worker's observed wage, but rather on a shadow wage which represents the worker's marginal product. The observed wage differs from the shadow wage because workers dislike highly variable wage paths (over time), and employers respond by offering a wage stream which represents a smooth version of workers' marginal products over time. (See Barro (1977) or Rosen (1984).) Thus an intertemporal substitution model based on shadow wages may be appropriate. Unfortunately, shadow wages are unobserved and testing this version of the model will be extremely difficult.

Finally, one could drop the assumption that the life-time utility function is separable over time.²⁸ One possibility is given by Hotz, Kydland and Sedlacek (1982), who work with a model where current utility depends on a distributed lag in hours worked. However, to generalize preferences in this manner, they must impose much more restrictive stochastic assumptions. While trade-offs of this sort are always present in empirical work, their stochastic assumptions make it much more difficult to carry out a convincing test of the hypothesis considered here. First, one must give up the control on tastes that a first difference model provides. Second, in such models it is always difficult to determine whether lagged variables are important because of preferences, or because of worker heterogeneity, or because they simply represent some sort of disequilibrium or costs of adjustment.²⁹

To summarize, if one adopts the standard life-cycle labour supply model, the evidence is quite strong and robust against the Lucas-Rapping hypothesis that unemployment represents intertemporal labour supply behaviour. Whether these test results continue to hold in more complex versions of the intertemporal substitution model is an important, but extremely difficult, area for future research.

Earlier versions of the paper were circulated under the titles "Testing for the Absence of Constraints in a Life-Cycle Model of Labour Supply" and "Testing Whether Unemployment Represents Leisure in a Life-Cycle Model of Labour Supply". Portions of Section 2 of the paper are drawn from my thesis, and I owe a substantial debt to my thesis committee members, Orley Ashenfelter, James Brown, and Richard Quandt. The basic ideas for the paper were developed at the Summer Labour Workshop, University of Warwick, July 1982 and at a Conference on Labour Supply Estimation, Princeton University, March 1983. The paper was presented at a Conference on Labour Economics, McMaster University, April 1983, the SSRC Study Group in Econometrics, July 1983, the 1983 Christmas meetings of the Econometric Society, and a conference on Search, Unemployment and Labour Supply, University of Manchester, July 1984. It was also presented in workshops at Bristol, Hull, Manchester, Michigan, Queens and Wisconsin. I am extremely grateful for the important and useful comments received from participants in these seminars and conferences, as well as other individuals, including J. Altonji, R. Blundell, M. Browning, G. Chamberlain, A. Deaton, Jane Ham, J. Hausman, J. Heckman, D. Hendry, C. Hsiao, G. Jakubson, M. King, B. Lalonde, G. Mizon, T. Mroz, J. Pencavel, I. Walker and two anonymous referees. I am solely responsible for any errors. Generous financial support was provided by the Social Sciences and Humanities Research Council of Canada, the Institute for Policy Analysis, University of Toronto, and the Summer Labour Workshop at the University of Warwick.

NOTES

1. Browning (1983) provides additional motivation for using micro data when testing hypotheses in an intertemporal framework.

2. Heckman and MaCurdy (1980), MaCurdy (1981, 1982, 1983) and Altonji (1984) argue forcefully for the importance of intertemporal models. Also see these papers for references to important previous work on intertemporal labour supply models such as Ghez and Becker (1975), Heckman (1971, 1974) and Smith (1977).

3. The hourly wage is formed by dividing annual earnings by annual hours and is likely to contain significant measurement error; see Altonji (1984).

4. Given (8a), another possible estimation strategy would be to use generalized (three-stage) least squares. However, once one allows for uncertainty, standard GLS procedures will not, in general, produce consistent parameter estimates. (See Cumby, Huizinga and Obstfeld (1983) and the references they cite.) Further, the general structure in (8a) prevents a straightforward application of the Cumby *et al.* procedure. One possible means of obtaining more efficient estimates in this framework (which I have not explored) is to adopt the approach of Hayashi and Sims (1983).

5. Note that since first differences are used, this assumption is not violated if, for example, individuals in the same region have similar permanent tastes towards work.

6. Of course, this distinction is of little consequence for the test considered below since these terms will disappear when one works in first differences. However, it is important to note this distinction if one attempts to estimate labour supply parameters in the presence of constraints, or if one attempts to measure how much an individual who experiences unemployment in some periods would have worked in the absence of unemployment in any period. To estimate the latter quantity one needs λ_i , not λ_i^* .

7. Such a procedure was first used as a means of dealing with constrained workers in male labour supply estimation on cross-section data by Ham (1977). It has been extended to the case of male labour supply on longitudinal data by Ham (1980), and family labour supply on longitudinal data by Lundberg (1982). All of these papers assume perfect foresight.

8. Heckman, Killingsworth and MaCurdy (1981) emphasize the importance of treating unemployment as endogenous when carrying out this type of test. Note that the two-stage estimates of θ_1 and θ_2 will be consistent, even though the first-stage parameter estimates in the equations for ΔD_{it} and ΔU_{it} will not be consistent. See Heckman (1978).

9. The human capital variables consist of age, education, age-squared, education-squared, age times education, father's education, mother's education, a series of dummy variables indicating the economic status of the family when the individual was growing up, whether or not the individual was a veteran, and whether or not the individual had received additional training. Time dummies are also used as instruments, except in the case where uncertainty is considered and time dummies are not entered in the hours equation.

10. For example, seniority provisions may make younger workers more likely to be laid-off, while training costs may make it much more difficult for an older worker to find alternative employment once separated from his firm. Further, a firm's propensity to lay-off a worker may vary inversely with the worker's stock of firm specific human capital, and his education may form a proxy for this human capital (Nickell (1979b)).

11. One possible objection to the use of these instruments is that some workers change industry and occupation over the sample period, and these changes may reflect, in part, changes in transitory labour supply tastes. I recently investigated this issue by conditioning only on 1971 industry and occupation when forming the demand variables. (That is, I recalculated the occupation and industry unemployment rates assuming that everyone stayed in his 1971 occupation and industry over the sample period. I dropped the regional demand variables since they are taken from the PSID tape.) I then re-estimated the basic equation for the period 1975-1979 using the lagged first difference in the alternative demand variables as instruments. This modification did not change the test results reported below.

12. See also Blundell and Walker (1983) and King (1983). This treatment of uncertainty rules out complete contingent claims markets and self-insurance. See Hart (1983), King (1983) and Rosen (1984) for discussions of these issues.

13. To simplify the presentation, r is taken outside the expectation operator. A sufficient condition for this is the existence of an asset with a risk-free rate of return; see MaCurdy (1983).

14. For completeness, one can also consider uncertainty in the upper bound model given by (9a) and (9b). If one assumes that future values of \bar{H} cannot be affected by current behaviour, and maintains the assumption that the utility function is additive over time, this does not create a serious theoretical problem. One takes expectations with respect to future values of \bar{H} and w , and in each period separates the cases where $H^s(w) > \bar{H}$ from its complement. (Also see King (1983). However, introducing uncertainty will make econometric estimation of a model based on (9a) and (9b) much more difficult.

15. For example, these individuals may be indicating that they would like to work more hours only at an overtime premium.

16. One possible criticism of this approach is that it ignores the role of taxes. In the presence of taxes, the error in (7) implicitly contains a term of the form $\Delta \ln(1 - \tau_{it})$ where τ_{it} the marginal tax rate. (See MaCurdy (1983).) However, this omission will tend to bias the unemployment coefficients in a positive direction, since ΔU_{it} and $\Delta \ln(1 - \tau_{it})$ will be positively correlated.

17. Rea (1974) was the first author to suggest the type of test used here and in Ashenfelter and Ham (1979). For references to earlier testing procedures using micro data, see Ham (1982).

18. I used males aged 25–50 in 1971, while MaCurdy used males aged 25–46 in 1967. I also included individuals from the poverty subsample. Otherwise, my selection criteria is identical to the one MaCurdy outlines in his footnote 23. The effect of dropping the poverty subsample is discussed below.

19. Note that in column four the time dummies will, outside a Lucas-Rapping framework, also pick up aggregate demand shocks. This, in turn, may make it more difficult to reject the null hypothesis considered here.

20. Complementary evidence is provided by Flinn and Heckman (1983). Using discrete data on labour market states for a sample of young men from the NLS data, they reject the null hypothesis that the state of being out of the labour force is not behaviourally different from the state of being unemployed.

21. Variations on (3) have been used by Heckman and MaCurdy (1980) and Altonji (1982, 1984).

22. Alternatively, one could argue that individuals experiencing unemployment will have the largest changes in hours worked and thus a significant unemployment dummy may simply reflect extrapolation error in a linear model.

23. The problem that error terms may be correlated across individuals because of surprises is raised in Hotz *et al.*, who in turn attribute the point to Professor G. Chamberlain. To the best of my knowledge, this study represents the first attempt to empirically address this issue.

24. This assumption may be more appropriate when time dummies are included in the hours equation.

25. One could also experiment with other forms of surprises (such as those across regions or occupations) and surprises at different levels of aggregation (e.g. two-digit industries or different age and education classes.) I considered allowing for regional surprises in addition to industrial surprises. Define σ_R^2 as the variance of the regional surprise, and assume that the two surprises are independent. Then one has three sums of cross-products with which to calculate the respective variances: S_1 , the sum over individuals in the same region and industry; S_2 , the sum over individuals in the same region but not the same industry; and S_3 , the sum over individuals in the same industry but not the same region. Denote the number of cross-products in each sum by N_1 , N_2 and N_3 , respectively. Then $s_1 = S_1/N_1$ estimates $\sigma_R^2 + \sigma_I^2$, $s_2 = S_2/N_2$ estimates σ_R^2 and $s_3 = S_3/N_3$ estimates σ_I^2 . Unfortunately, using s_2 directly or using the least squares estimator $1/3(s_1 + 2s_2 - s_3)$ produces a very small, but negative, estimate of σ_R^2 , although using $s_1 - s_3$ produces a small but positive estimate. One interpretation of this problem is that σ_R^2 is quite close to zero, and the negative estimate simply reflects sampling error.

26. Given this evidence of misspecification, the question arises as to what extent the estimate of δ would change in a properly specified model. One possibility is to estimate a model along the lines of (9a) and (9b), although once one allows for uncertainty it is no longer legitimate to treat λ as a fixed effect. In a preliminary investigation of this issue, Ham (1980) found that using a model like (9a) and (9b) (but ignoring uncertainty) for prime age males had little effect on the wage coefficient but did affect the estimates of the individual constants. While the preliminary nature of this result must be emphasized, it is interesting to note that it is similar to that found in Ham (1982). That study found that controlling for unemployment and underemployment in the estimation of a static labour supply equation had a significant impact on the coefficients of the demographic variables but had little impact on the wage coefficient.

27. A similar problem arises with overtime wages. If a worker can only work overtime in certain weeks of the year, it is invalid to use annual hours as an aggregate measure of labour supply. Unfortunately, there is insufficient information on overtime wages and hours in the PSID for the sample period to investigate even a very simple model of overtime.

28. Heckman (1981, Appendix A) reports evidence that suggests the possibility of nonseparability over time when estimating a life-cycle model of labour force participation for married women.

29. The latter explanation is often given in dynamic studies of consumer demand; see, for example, Anderson and Blundell (1982, 1983).

REFERENCES

- ABOWD, J. and ASHENFELTER, O. (1979), "Unemployment and Compensating Wage Differentials" (Working Paper No. 120, Industrial Relations Section, Princeton University).
- ALTONJI, J. (1981), "Does the Labor Market Clear? A Test Based on Alternative Expectations Assumptions in the Intertemporal Substitution Framework" (Working Paper No. 110, Columbia University).
- ALTONJI, J. (1982), "The Intertemporal Substitution Model of Labour Market Fluctuations: An Empirical Analysis", *Review of Economic Studies*, **49**, 783-824.
- ALTONJI, J. (1984), "Intertemporal Substitution in Labor Supply: Evidence from Micro Data", *Journal of Political Economy*, (forthcoming).
- ALTONJI, J. and ASHENFELTER, O. (1980), "Wage Movements and the Labour Market Equilibrium Hypothesis", *Economica*, **47**, 217-245.
- ANDERSON, G. and BLUNDELL, R. (1982), "Estimation and Hypothesis Testing in Dynamic Singular Equations Systems", *Econometrica*, **50**, 1559-1571.
- ANDERSON, G. and BLUNDELL, R. (1983), "Testing Restrictions in a Flexible Dynamic Demand System: An Application to Consumers' Expenditure in Canada", *Review of Economic Studies*, **50**, 397-410.
- ANDREWS, M. and NICKELL, S. (1982), "Unemployment in the United Kingdom Since the War", *Review of Economic Studies*, **49**, 731-760.
- ASHENFELTER, O. and CARD, D. (1982), "Time Series Representation of Economic Variables and Alternative Models of the Labour Market", *Review of Economic Studies*, **49**, 761-782.
- ASHENFELTER, O. and HAM, J. (1979), "Education, Unemployment and Earnings", *Journal of Political Economy*, **87**, S99-116.
- AZARIADAS, C. (1983), "Employment with Asymmetric Information", *Quarterly Journal of Economics*, **98**, 157-172.
- BARRO, R. (1977), "Long-Term Contracting, Sticky Prices and Monetary Policy", *Journal of Monetary Economics*, **3**, 305-316.
- BARRO, R. and GROSSMAN, H. (1971), "A General Disequilibrium Model of Income and Employment", *American Economic Review*, **61**, 82-93.
- BENASSY, J. P. (1976), "The Disequilibrium Approach to Monopolistic Price Setting and General Monopolistic Equilibrium", *Review of Economic Studies*, **43**, 69-81.
- BLUNDELL, R. and WALKER, I. (1983), "Empirical Approaches to Life-Cycle Labour Supply" (Discussion Paper ES149, University of Manchester).
- BROWNING, M. (1983), "A Non-Parametric Test of the Life-Cycle Rational Expectations Hypothesis" (mimeo, University of Bristol).
- BROWNING, M., DEATON, A. and IRISH, M. (1985), "A Profitable Approach to Labour Supply and Commodity Demands Over the Life-Cycle", *Econometrica*, **53**, 503-543.
- BURDETT, K. and MORTENSON, D. (1979), "Labour Supply Under Uncertainty", *Research in Labor Economics*, **2**, 109-157.
- CLOWER, R. (1965), "The Keynesian Counter-Revolution: A Theoretical Appraisal", in Hahn, F. and Brechling, F. (eds.), *The Theory of Interest Rates* (London: Macmillan) 103-125.
- CUMBY, R., HUIZINGA, J. and OBSTFELD, M. (1983), "Two-Step Two-Stage Least Squares Estimation in Models with Rational Expectations", *Journal of Econometrics*, **21**, 333-355.
- DREZE, J. (1978), "Existence of an Exchange Equilibrium Under Price Rigidity", *International Economic Review*, **16**, 301-320.
- FARMER, R. (1985), "Implicit Contracts with Asymmetric Information and Bankruptcy", *Review of Economic Studies*, **52**, 427-442.
- FLINN, C. and HECKMAN, J. (1983), "Are Unemployment and Out of the Labor Force Behaviorally Distinct Labor Force States", *Journal of Labor Economics*, **1**, 28-42.
- GHEZ, G. and BECKER, G. (1975), *The Allocation of Time and Goods Over the Life-Cycle* (Columbia University Press).
- GROSSMAN, S. and HART, O. (1981), "Implicit Contracts, Moral Hazard and Unemployment", *American Economic Review Papers and Proceedings*, **71**, 301-307.
- HAHN, F. H. (1978), "On Non-Walrasian Equilibria", *Review of Economic Studies*, **45**, 1-17.
- HAM, J. (1977), "Rationing and the Supply of Labor: An Econometric Approach", Industrial Relations Section, Princeton University, Working Paper No. 103.
- HAM, J. (1980), *Three Empirical Essays on Constraints in the Labor Market*, (unpublished Ph.D. Thesis, Princeton University).
- HAM, J. (1982), "Estimation of a Labour Supply Model with Censoring due to Unemployment and Underemployment", *Review of Economic Studies*, **49**, 335-354.
- HART, O. (1983), "Optimal Labour Contracts under Asymmetric Information: An Introduction", *Review of Economic Studies*, **50**, 3-35.
- HAYASHI, F. and SIMS, C. (1983), "Nearly Efficient Estimation of Time Series Models with Predetermined, but not Exogenous, Instruments", *Econometrica*, **51**, 783-798.
- HECKMAN, J. (1971), *Three Essays on the Supply of Labor and Demand for Goods*, (unpublished Ph.D. Thesis, Princeton University).

- HECKMAN, J. (1974), "Life Cycle Consumption and Labor Supply: An Explanation of the Relationship Between Income and Consumption over the Life Cycle", *American Economic Review*, **64**, 188-194.
- HECKMAN, J. (1978), "Dummy Endogenous Variables in a Simultaneous Equation System", *Econometrica*, **46**, 931-959.
- HECKMAN, J. (1981), "Heterogeneity and State Dependence", in Rosen, S. (ed.), *Studies in Labor Markets* (Chicago: University of Chicago Press), 91-139.
- HECKMAN, J., KILLINGSWORTH, M. and MACURDY, T., "Empirical Evidence on Static Labour Supply Models: A Survey of Recent Developments", in Hornstein, Z., Grice, J. and Webb, A. (eds.), *The Economics of the Labour Market* (London: Her Majesty's Stationery Office), 75-122.
- HECKMAN, J. and MACURDY, T. (1980), "A Life-Cycle Model of Female Labor Supply", *Review of Economic Studies*, **47**, 47-74.
- HOTZ, V. J., KYDLAND, F. and SEDLACEK, G. (1982), "Intertemporal Substitution and Labor Supply" (mimeo, Carnegie-Mellon University).
- KIEFER, N. (1980), "Estimation of Fixed Effect Models for Time Series of Cross-Sections with Arbitrary Intertemporal Covariance", *Journal of Econometrics*, **14**, 195-202.
- KIEFER, N. and NEUMANN, G. (1979), "An Empirical Job-Search Model, with a Test of the Constant Reservation-Wage Hypothesis", *Journal of Political Economy*, **87**, 89-107.
- KING, M. (1983), "The Economics of Saving" (Working Paper 1247, NBER).
- LAZEAR, E. (1981), "Agency, Earnings Profiles, Productivity and Hours Restrictions", *American Economic Review*, **71**, 606-620.
- LEWIS, H. G. (1969), "Employer Interests in Employee Hours of Work", unpublished. English version of "Interes del Empleador en las Horas de Trabajo del Empleado", *Cuadernos de Economia*, **18**, 38-54.
- LUCAS, R. E., Jr. and RAPPING, L. A. (1969), "Real Wages, Employment, and Inflation", *Journal of Political Economy*, **77**, 721-754.
- LUNDBERG, S. (1982), "Involuntary Unemployment as a Constraint on Household Labour Supply" (mimeo, Hoover Institution).
- MACURDY, T. (1981), "An Empirical Model of Labor Supply in a Life-Cycle Setting", *Journal of Political Economy*, December 1981, **89**, 1059-1085.
- MACURDY, T. (1982), "Interpreting Empirical Models of Labor Supply in an Intertemporal Framework with Uncertainty" (mimeo, Stanford University).
- MACURDY, T. (1983), "A Simple Scheme for Estimating an Intertemporal Model of Labor Supply and Consumption in the Presence of Taxes and Uncertainty", *International Economic Review*, **24**, 265-289.
- MALINVAUD, E. (1977), *The Theory of Unemployment Reconsidered* (New York: Halsted).
- MIZON, G. (1977), "Inferential Procedures in Nonlinear Models: An Application in a UK Industrial Cross Section Study of Factor Substitution and Returns to Scale", *Econometrica*, **45**, 1221-1242.
- NICKELL, S. (1979a), "Estimating the Probability of Leaving Unemployment", *Econometrica*, **47**, 1249-1266.
- NICKELL, S. (1979b), "Education and Life Time Patterns of Unemployment", *Journal of Political Economy*, **87**, S117-S131.
- REA, S. (1974), "Unemployment and the Supply of Labor", *Journal of Human Resources*, **9**, 279-289.
- ROSEN, S. (1984), "Implicit Contracts: A Survey" (mimeo, University of Chicago).
- SMITH, J. (1977), "Family Labor Supply Over the Life-Cycle", *Explorations in Economic Research*, **4**, 205-276.