DOES THE LABOR MARKET CLEAR?
A Test Based on Alternative Expectations Assumptions in the Intertemporal Substitution Framework

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ABSTRACT

This paper tests the market clearing hypothesis by examining the error structures implied by the disequilibrium hypothesis and the intertemporal substitution version of the market clearing hypothesis. The intertemporal substitution hypothesis explains the strong, negatively related cyclical fluctuations in employment and unemployment as the response of labor supply to temporary movements in the real wage relative to expected discounted future real wages. The test is based upon the demonstration that once these movements in the price of leisure have been controlled for, the remaining movement in labor supply and in unemployment should be unrelated. Conversely, in the case of labor market disequilibrium, controlling for intertemporal substitution does not eliminate the negative relationship between employment and unemployment. The test is implemented using variants of Lucas and Rapping's specification of the intertemporal substitution model. The findings indicate that disequilibrium is important in labor market fluctuations.

1. INTRODUCTION AND SUMMARY

The hypothesis that the aggregate labor market clears is a key dividing point between so called monetarist and Keynesian macroeconomic analyses. Over the years, discussion of this hypothesis has featured anecdotal or case study evidence and institutional or psychological theories on one side of the argument,[1] and emphasis on the theoretical implausibility of wage rigidity in a decentralized economy of utility maximizers on the other. But despite its importance, there is little solid evidence on the issue, primarily because it is difficult to test for labor market equilibrium. The hypothesis is hard to study because only employment rather than labor supply and demand is observed. Consequently it is not possible to verify directly whether demand is equal to supply. In a highly stochastic world of imperfect information the measured unemployment series is far from unambiguous. Equilibrium explanations exist for a level of frictional unemployment and (more importantly) for fluctuations in unemployment (see below).

Recently, however, some effort has been made to test the equilibrium hypothesis. Rosen and Quandt (1978) formulate a simple model of labor supply, labor demand, and wage adjustment that may be estimated consistently even if the labor market is in disequilibrium. They are then able to test the assumption that labor supply equals labor demand. They find evidence of disequilibrium, subject to the many caveats they discuss. Ashenfelter (1980) estimates a system of aggregate labor supply and commodity demand functions that are based on utility maximization and are explicitly a mixture of the behavior of households who are constrained and households who are unconstrained in the labor market. Since constraints on labor supply affect consumption behavior, the unemployment rate should affect consumption even after wages, prices, and non-labor income are controlled for if the unemployment rate is related to the fraction of the population who are rationed in labor supply. He finds some evidence that it does, perhaps as a reflection of disequilibrium in the market.

The present paper derives a test of the market clearing hypothesis by examining the error structures implied by the disequilibrium hypothesis and the intertemporal substitution version of the equilibrium hypothesis. The intertemporal substitution theory of labor supply and equilibrium unemployment, which is logically separate from the market clearing hypothesis and is maintained throughout the paper, provides the additional structure needed to test for market equilibrium.

The prominence of the intertemporal substitution hypothesis dates from the work of Lucas and Rapping (1970). Hereafter (LR). In essence, the hypothesis explains the strong, negatively related cyclical fluctuations in employment and unemployment as the response of labor supply to temporary movements in the real wage relative to expected discounted future real wages. The test for market clearing is based upon the demonstration in Section 2 that once these movements in the price of leisure have been controlled for, the remaining movement in labor supply and unemployment should be unrelated. Conversely, in the case of labor market disequilibrium, controlling for intertemporal substitution does not eliminate the negative relationship between employment and unemployment. This is because disequilibrium introduces differences between labor supply and employment and between total unemployment and equilibrium unemployment which are opposite in sign. The Keynesian view is that cyclical fluctuations in the employment and unemployment data are dominated by movements in the fraction of the work force who seek but cannot find jobs at the market wage. Thus it is possible to test the market clearing hypothesis with intertemporal substitution maintained as the model of the cyclically variable component of equilibrium unemployment. The test consists of examining the relationship between the residual components of the labor supply and unemployment equations after controlling for intertemporal substitution.

This paper implements the test using LR's empirical specification. Section 3 presents the LR model with rational expectations and develops the test for equilibrium with a discussion of the error structure of the model in the equilibrium and disequilibrium cases.[2] Section 4 briefly summarizes the methodology used to estimate the model in the rational and adaptive expectations cases. Section 5 reports results for both the rational expectations case and for the adaptive expectations assumption that LR used. In both cases, the results for the many specifications tried indicate that disequilibrium is important in labor market fluctuations. In most instances a strong negative correlation exists between the labor supply and unemployment residuals. That is, a strong negative relationship between employment and unemployment exists even after cyclical movements due to intertemporal substitution are accounted for. The evidence of disequilibrium provides a partial explanation for the poor performance of the intertemporal substitution model with rational expectations in Altonji (1981), Essay I and provides further evidence against the LR model. The results for the adaptive expectations case casts serious doubts upon LR's interpretation of their results as supportive of their intertemporal substitution - market equilibrium approach.

The concluding section discusses several important caveats. It is possible (though unlikely) that errors in the measurement of the rational expectations of future wages and prices are large enough to introduce large negatively correlated errors in the estimates of the conditional means of employment and unemployment. The tests are specific to LR's formulation, and data, and so the possibility that standard problems such as specification error and/or errors in variables may bias the test in this manner must also be entertained. Finally, I consider the possibility that the results may be consistent with a "contracts" interpretation of market equilibrium in the context of the intertemporal substitution hypothesis.

2. THE RELATIONSHIP BETWEEN EMPLOYMENT AND UNEMPLOYMENT

Define the residual variation in the time series processes of employment and unemployment to be the variation that remains after controlling for the relevant wage and interest rate variables influencing these series. This section argues that the equilibrium hypothesis implies that the residual variations in the two series are independent, while the disequilibrium hypothesis implies that they are negatively related. This result rests heavily on the intertemporal substitution hypothesis and/or a Mortensen (1970) type search hypothesis, which are maintained as a combined model of labor supply and unemployment.[3,4] (The search hypothesis is not incorporated into the empirical model below.)

Let labor supply per capita n_t be determined by the labor supply function

(1) $$n_t=f_n(X_t, \varepsilon_t, w_t, \hat{w}_t, w_t^*/\bar{r}_t^*) .$$

In (1) t is a time subscript, w_t is the current real wage, $\hat{w}_t$ is the expected value of the current wage, and w_t^* is an index of expected future real wages. $[\bar{r}_t^* - 1]$ is an index of expected real interest rates. It is determined by the nominal interest rate, the current price level, and expected future prices. X_t and ε_t are (respectively) vectors of observed and unobserved variables that affect labor supply. ε_t is best regarded as a vector of current and future taste parameters that enter a lifetime utility function. (See Altonji (1981, Ch. I-4) The essence of the intertemporal substitution hypothesis is that n_t increases with w_t, decreases with w_t^*, and increases with $\bar{r}_t^*$. That is, labor supply is an increasing function of the difference between the current real wage and the expected discounted future real wage. Search theory suggests that $\hat{w}_t$ enters with a negative sign. When $\hat{w}_t$ rises holding constant w_t, agents work less and search more for higher paying jobs.[5]

Turning to unemployment, let UE_t denote equilibrium unemployment measured in units still to be specified. The essence of the intertemporal substitution and search hypotheses about UE_t is that the number of persons who are looking for work but not working is a function of the real wage individuals are receiving (or could be receiving with minimal search) relative to

(a) the wages workers believe are available elsewhere in the market ($\hat{w}_t$) (search theory) and

(b) the discounted real wages workers expect to be able to earn in future years ($w^*_t/\bar{r}^*_t$)[6].

That is, given expectations, the level of UE_t relative to any base level or "normal" level for unemployment is a function of the amount of labor people wish to supply given current opportunities (indexed by w_t) relative to the amount they supply when the relationship of w_t to $\hat{w}_t$ and $w^*_t/\bar{r}^*_t$ generates the amount of search and intertemporal substitution that is consistent with the base level. The particular base does not matter for the argument below, but it is natural to choose the base of normal level of unemployment in terms of the amount of unemployment and labor supply that prevails when $\hat{w}_t = w_t = w^*_t/\bar{r}^*_t$.

UE_t is directly related to the value of n_t relative to normal labor supply (n^*_t), where n_t is equal to the conditional labor supply function f_n evaluated at $w_t = \hat{w}_t = w^*_t/\bar{r}^*_t$.

(2) $$n^* = f_n(X_t, \varepsilon_t \;\; w^*_t/\bar{r}^*_t, w^*_t/r^*_t, w^*_t/\bar{r}^*_t).$$

One may define the units of UE_t to depend on the units of n_t such that the relationship may be written in the form

$$UE_t = f_{UE}(X_t, \varepsilon_t, w_t, \hat{w}_t, w^*_t/r^*_t) = n^*_t - n_t$$

Assume, however, that there exists a transformation of the labor supply function which is additively separable in ε_t, with the transformation of f_n equal to $f_{n1}(X_t, w_t, \hat{w}_t \; w^*_t/\bar{r}^*_t) + f_{n2}(\varepsilon_t)$.[7] Fix the units of measure of n_t and UE_t accordingly. Then

$$UE_t = n^*_t - n_t$$

$$= [f_{n1}(X_t, w^*_t/\bar{r}^*_t, w^*_t/\bar{r}^*_t, w^*_t/\bar{r}^*_t) + f_{n2}(\varepsilon_t)] - [f_{n1}(X_t, w_t, \hat{w}_t, \hat{w}^*_t/\bar{r}^*_t) - f_{n2}(\varepsilon_t)]$$

But this reduces to

(3) $$UE_t = f_{nl}(X_t, w_t^*/\bar{r}_t^*, w_t^*/\bar{r}_t^*, w_t^*/\bar{r}_t^*) - f_{nl}(X_t, w_t, \hat{w}_t, w_t^*/\bar{r}_t^*).$$

This implies that $f_{UE}(X_t, \varepsilon_t, w_t, \hat{w}_t, w_t^*/\bar{r}_t^*)$ is a constant function of (ε_t). Consequently, if w_t, $\hat{w}_t$, w_t^*/r_t^*, and possibly X_t are controlled for, the remaining variation in n_t will not be related to UE_t.

Since, excluding consideration of frictional unemployment, the market clearing hypothesis equates employment with labor supply and unemployment with equilibrium unemployment, the theory implies directly that the residual variation in employment and unemployment will be unrelated. Intuitively, variables other than wages and prices which affect labor supply will affect the number of persons who say they wish to work, but in a market clearing world (conditional on actual and expected current wages and prices and expectations for the future), movements in the (appropriate) function of the number of persons who say they wish to work should not be related to fluctuations in the number who have found work. In contrast, disequilibrium implies conditional employment and unemployment are negatively related even after w_t, $\hat{w}_t$, and w_t^*/r_t^* are controlled for. In the disequilibrium case, labor supply often differs from employment and unemployment often differs from equilibrium unemployment by amounts which are opposite in sign. Algebraically

$$E_t = n_t - \mu_t$$

while

$$U_t = UE_t - (E_t - n_t) = UE_t + \mu_t,$$

where E_t is employment, U_t is total unemployment, and μ_t is a disequilibrium component related to the percentage of the work force who are rationed (or coerced) at the current wage. Again, E_t and U_t are random variables that have a distribution conditional upon w_t, $\hat{w}_t$, and $w_t^*/\bar{r}_t^*$. Due to variation in μ_t, a negative relation between E_t and U_t remains even though the incentives for search and intertemporal substitution have been controlled for.

These implications are in principle testable. One may estimate the parameters of the functions and control for the effects of the wage and interest rate on UE_t and n_t. The unemployment and labor supply "residuals", which are the deviations of U_t (unemployment) and n_t from the estimates of their conditional means, may be checked for independence. The finding that disequilibrium has the specific implication that the unemployment and employment residuals will not only be dependent, but will be negatively related is useful. It reduces the possibility of rejecting spuriously the equilibrium hypothesis if positive dependence is found, although in practice complications discussed briefly below involving frictional unemployment conceivably could produce such a dependence.

A difficulty exists with the above analysis that deserves discussion before I turn to the application using variants of the specific labor market model presented by LR.[8] The intertemporal substitution theory, as usually stated, explains UE_t in terms of the amount people wish to work given current opportunities relative to the amount they would wish to work given "tastes" (X_t and ε_t) at expected future wage levels. The presence of ε_t in the labor supply function makes clear that labor supply depends on the value of the taste parameter ε_t at t. Since the model is intertemporal, ε_t is an index of the vectors of <u>lifetime</u> tastes for members of various demographic groups.[9] It is natural to model equilibrium unemployment in terms of substitution of leisure between the present and future as determined by relative tastes for work as well as relative wages. Since labor supply in the next period (for example) relative to current labor supply is determined by the relative values of ε_t and ε_{t+1} as well as w_t and $w_t^*/\bar{r}_t^*$, it is probably more consistent with intertemporal substitution theory to model the amount of "wait" unemployment as a function of the difference between ε_t and ε_{t+1} as well as the relative values of current and expected discounted future wages. Let $\underline{X}_t$ equal $h_1X_t+(1-h_1)X_{t+1}$ and $\underline{\varepsilon}_t=h_1\varepsilon_t+(1-h_1)\varepsilon_{t+1}$. $(0<h_1<1.)$ In terms of the formal analysis this argument suggests formulating n_t^* as

(2') $$n_t^* = f_n\,(\underline{X}_t, \underline{\varepsilon}_t \mid w_t^* / \bar{r}_t^*,\ w_t^* / \bar{r}_t^*,\ w_t^* / \bar{r}_t^*)$$

The corresponding equation (3) for UE_t becomes

(3') $$UE_t = [f_{n1}\,(\underline{X}_t \mid w_t^* / \bar{r}_t^*,\ w_t^* / \bar{r}_t^*,\ w_t^* / \bar{r}_t^*) - f_{n1}(X_t | w_t, \hat{w}_t, w_t^* / \bar{r}_t^*] + [f_{n2}(\underline{\varepsilon}_t) - f_{n2}(\varepsilon_t)]\ .$$

The observed characteristics X_t do not pose a problem because they can be controlled for. However, after controlling for these factors, n_t and UE_t are still not independent. This is because fluctuations in $f_{n2}(\underline{\varepsilon}_t) - f_{n2}(\varepsilon_t)$ will in general be correlated with $f_{n2}(\varepsilon_t)$. However, the degree of dependence is not likely to be very large, since an index of lifetime tastes is likely to obey a very sluggish stochastic process. Consequently, $f_{n2}(\underline{\varepsilon}_t) - f_{n2}(\varepsilon_t)$ is only a fraction of the change in $f_{n2}(\varepsilon_t)$ and is likely to be only weakly related to it. As is clear from the results in Altonji (1981), the labor supply and unemployment residuals obey very similar processes. This should not be the case under the above argument, and so it is not considered in the development of the LR model in Section 3.

3. AN EMPIRICAL FORMULATION USING THE LUCAS-RAPPING MODEL WITH RATIONAL EXPECTATIONS

LR's basic equations and notation are summarized in Figure 1 below.[10] The labor supply equation (4) is based upon consideration of a two-period Fisherian maximization framework in which labor supply is a function of current and expected future wages and prices, a wealth variable, and the interest rate. It is assumed to be log-linear, with $\beta_1, \beta_2, \beta_3'$, and β_4 positive. β_3' is the elasticity of labor supply with respect to the expected intertemporal price of goods, holding constant the current real wage and the expected discounted future real wage. The aggregate marginal productivity condition for labor (5) is derived from a CES aggregate production function under the assumption that output is exogenous. Except where indicated I assume that w_t^* and P_t^* are the rational expectations of indices of future wages and prices implied by the labor

FIGURE I

Some Basic Equations of the LR Model

(4) Labor Supply

$$N_t - M_t = \beta_1 (w_t) - \beta_2 (w_t^*) + \beta_3 [r_t - (P_t^* - P_t)] - \beta_4 (a_t - M_t) + \varepsilon_{2t}; \quad \beta_3 = \beta_2 + \beta_3'$$

(5) Aggregate Marginal Productivity Condition for Labor

$$Q_t + N_t - y_t = C_o - C_1 (w_t - Q_t) + C_4 (Q_{t-1} + N_{t-1} - y_{t-1}) + (C_2 - 1)(y_t - y_{t-1}) + u_{1t}$$

(6) Normal labor supply

$$N_t^* - M_t = \beta_o + \beta_1 (w_t^* - [r_t - (P_t^* - P_t)] - \beta_2 (w_t^*) + \beta_3 [r_t - (P_t^* - P_t)]$$

$$- \beta_4 (a_t - M_t) + \varepsilon_{2t}$$

(7) Equilibrium unemployment

$$UE_t = \beta_1 (w_t^* - w_t) - \beta_1 [r_t - (P_t^* - P_t)]$$

(9) Unemployment

$$U_t = g_0 + g_1 \beta_1 \div (w_t^* - w_t) - g_1 \beta_1 [r_t - (P_t^* - P_t)] + \varepsilon_{3t}$$

(11) Wage Expectations (Rational)

$$w_t^* = \Sigma_{i-1}^{k} d_i \hat{w}_{t+i}$$

(11') Wage Expectations (Adaptive)

$$w_t^* = \lambda w_t + (1 - \lambda) w_{t-1}^* + \lambda'$$

(12) Price Expectations (Rational)

$$P_t^* = \Sigma_{i=1}^{k} d_i \hat{P}_{t+i}$$

(12') Price Expectations (adaptive)

$$P_t^* = \lambda P_t + (1 - \lambda) P_{t-1}^* + \lambda'$$

Figure 1 (continued)

Notation: (All variables except t, r_t, U_t and UE_t are in logs)

t	=	time subscript
w_t	=	real wage
$\hat{w}_{t+i}$	=	rational expectation of w_{t+i}
w_t^*	=	anticipated future real wage
P_t	=	current price level
$\hat{P}_{t+i}$	=	rational expectation of P_{t+i}
P_t^*	=	anticipated future price level
r_t	=	nominal interest rate
a_t	=	real wealth
M_t	=	population over 14 years of age with constant age-sex distribution
y_t	=	real Gnp
Q_t	=	index of labor quality
N_t	=	labor supply
ε_{2t}	=	random component of labor supply
u_{1t}	=	random component, Aggregate Marginal Productivity Condition
ε_{3t}	=	random component, unemployment equation
U_t	=	unemployment proportion
UE_t	=	equilibrium unemployment

market model and models for P_t and other variables taken as exogenous. (See (11) and (12).)

The unemployment equation may be derived by substituting LR's specification (4) for the log transform of the general specification (1). (4) is additive in the unobserved error (ε_{2t}) as well as in the wealth variable ($a_t - M_t$), which corresponds to X_t in the previous section. Equation (6) defines normal labor supply, ($N_t^* - M_t$). It is obtained by evaluating (4) at $w_t = w_t^* - [r_t - (P_t^* - P_t)]$. Equation (7), which defines UE_t, is obtained by subtracting (4) from (6). Note that the ε_{2t} terms cancel and do not appear in the final unemployment equation below. (See 9). Both normal labor supply and labor supply shift with movement in ε_{2t} and ($a_t - M_t$). The effect of shifts in these variables in terms of LR's interpretation of responses to the Census employment survey is to shift both the number of persons who would work if their current wage and price level equaled the expected normal levels and the number of persons who choose to work at the current wage and price level (actual labor supply), without changing the ratio of these quantities.

To proceed further, it is necessary to relate the units of UE_t to the measured unemployment rate. LR observe that $(N_t^* - N_t) \simeq (\exp(N_t^*) - \exp(N_t))/\exp(N_t^*)$ which is in the form of an unemployment rate. This fact, together with the assumption that frictional unemployment and possibly sampling error contribute a constant and a stochastic component to measured unemployment, suggests the linear specification (8), which is what LR assume.

(8) $U_t = g_o + g_1 UE_t + \varepsilon_{3t};\ g_o, g_1 > 0.$ Substitution for UE_t leads to the unemployment equation (9) in Figure 1.

Under disequilibrium an additional error term must be added. This is because the employment variable (E_t) used in empirical estimation of (4) differs from (N_t) by the disequilibrium component μ_t, with

(10) $\mu_t = N_t - E_t$

Furthermore, measured unemployment consists not only of frictional and equilibrium unemployment but also of the number of persons who want to work at current wages and prices but cannot find jobs, as a fraction of those who can find jobs. Formally, the fraction g_2 times μ_t must be added to the unemployment equation (9), yielding (9') below. Given possible discouraged worker effects, g_2 will be near but probably less that 1.

Substitution for N_t in (4) yields (4').

(4') $$E_t - M_t = \beta_o + \beta_1 w_t - \beta_2 w_t^* + \beta_3 \, [r_t - (P_t^* - P_t)] - \beta_4 (a_t - M_t) + \varepsilon_{2t} - \mu_t$$

(9') $$U_t = g_o + g_1\beta_1 (w_t^* - w_t) - g_1\beta_1 \, [r_t - (P_t^* - P_t)] + \varepsilon_{3t} + g_2\mu_t .$$

<u>Note that since g_2 is positive, μ_t enters the employment and unemployment equations with opposite sign. LR's equilibrium assumption amounts to assuming μ_t = 0 for all t.</u>

<u>The Error Structure under Equilibrium and Disequilibrium</u>

We now turn to the random components of (4') and (9'). Since in estimating the model it will be assumed (following LR) that ε_{2t} and ε_{3t} obey first order autoregressive processes, it is convenient to deal with quasi-differences of the error components, which are serially independent under the null hypothesis of equilibrium.

Quasi-differenced Error component, (4'): $u_{2t} - \mu_t'$

where $u_{2t} = \varepsilon_{2t} - \theta_2\varepsilon_{2t-1}$ and $\mu_t' = \mu_t - \theta_2\mu_{t-1}$.

Quasi-differenced Error component, (9'): $u_{3t} + g_2\mu_t'$

where $u_{3t} = \varepsilon_{3t} - \theta_3\varepsilon_{3t-1}$

To avoid distinguishing between the differenced disequilibrium components in the two equations, $\mu_t' = (\mu_t - \theta_2\mu_{t-1})$ has been placed in the error for (9') rather than $(\mu_t - \theta_3\mu_{t-1})$. This is exactly correct if the autoregressive parameters of ε_{2t} and ε_{3t} are the same.

Due to possible interactions between u_{2t}, u_{3t}, and u_t', the following additional assumptions are needed to justify the test for equilibrium.

(i) $\ell_1 \geq \text{cov}(u_{2t},u_{3t}) \geq 0$; where ℓ_1 is small relative to $\text{var}(u_{2t})$ and $\text{var}(u_{3t})$

(ii) $\ell_2 \geq \text{cov}(u_t', u_{2t}) \geq 0$ where ℓ_2 is small relative to $\text{var}(u_t')$ and $\text{var}(u_{2t})$

(iii) $\text{cov}(u_t',u_{3t}) = 0$

As for (i), $\text{cov}(u_{2t},u_{3t})$ is likely to be positive but small relative to the variances of u_{2t} and u_{3t} given that new persons entering the labor force as a result of a positive shock to (4) may undergo a period of search before accepting employment. Since the time period of the analysis is one year, the rise in the amount of employment following the shock may be associated with the initial rise in unemployment even though the steady state level of employment and unemployment (the level for particular sets of constant values of the explanatory variables and (ε_{2t})) are independent. On the other hand, this may be offset if persons report themselves as unemployed for a period after they decide to leave the labor force as a result of a negative shock to labor supply. Unemployment insurance provides those who wish to leave the labor market and are able to arrange to be laid off (rather than quit) with an incentive to stay in the labor force until benefits run out. Which of these effects dominates is not clear. I assume that they approximately balance out.[11]

Assumption (ii) follows naturally from the fact that underlying the disequilibrium hypothesis is the notion that wages do not adjust rapidly enough to clear the labor market following shifts in the supply and demand for labor. Consequently, it is reasonable to assume that μ_t' is a positive function of u_{2t}, with $\text{cov}(\mu_t', u_{2t}) \geq 0$. This will be small relative to $\text{var}(\mu_t')$ since disequilibrium is also presumably caused by other factors affecting labor supply and demand such as changes in P_t, y_t, Q_t and movements in u_{1t} (the random component in (5)), and so the term involving the variance of the disequilibrium components is likely to swamp the other terms. $\text{cov}(\mu_t', u_{2t})$ will be small relative to $\text{var}(u_{2t})$ because some of the effect of movements in u_{2t} are absorbed by wage adjustments. Assumption (iii) states that u_{3t}, the random component in the relationship between equilibrium unemployment and measured unemployment, is uncorrelated with disequilibrium. One might expect a weak negative relationship if the discouraged worker effect is important.

Since $\mu_t' = 0$ for all t under the equilibrium hypothesis, the null hypothesis trivially implies (ii) and (iii), which are important only for the power of the test.[12] Assumption (i) is sufficient to imply that the correlation coefficient, ρ, of the transformed errors from (4') and (9') under market clearing is

$$\rho = \frac{\text{cov}(u_{2t}, u_{3t})}{[\text{var}(u_{3t})]^{1/2}\ \text{var}(u_{2t})]^{1/2}} \simeq 0.$$

Under the disequilibrium hypothesis, additional error components involving μ_t' affect ρ.

$$\rho = \frac{-g_2\ \text{var}(\mu_t') + \text{cov}(u_{2t}, u_{3t}) + g_2\text{cov}(u_{2t},\mu_t') - \text{cov}(\mu_t', u_{3t})}{[\text{var}(u_{2t}) + \text{var}(\mu_t') - 2\text{cov}(u_{2t},\mu_t')]^{1/2}[\text{var}(u_{3t}) + g_2^2\text{var}(\mu_t') + 2g_2\text{cov}(u_{3t},\mu_t')]^{1/2}} < 0$$

The negative sign follows from the assumption that $\text{cov}(\mu_t', u_{3t}) = 0$ and that $-g_2\text{var}(\mu_t')$ dominates the other two terms.

4. ECONOMETRIC METHODS AND DATA

Consistent estimates (under the null hypothesis of equilibrium) of u_{2t} and u_{3t} are needed to perform the test proposed above. This requires consistent estimates of the parameters of the model and of the unobserved expectations variables. In the adaptive case, w_t^* and P_t^* do not pose a serious problem. One may employ the Koyck transformation used by LR to eliminate w_t^* and P_t^* in the labor supply equation between (4'), (11') and (12'), yielding (13) below. Use of the same procedure with (9') yields the unemployment equation (14).

(13) $$E_t - M_t = [\beta_0\lambda - \lambda'\beta_2 - \lambda''\beta_3] + (\beta_1 - \lambda\beta_2)w_t - (1-\lambda)\beta_1 w_{t-1} + (1-\lambda)\beta_3(P_t - P_{t-1}) + (1-\lambda)(E_{t-1} - M_{t-1}) + \beta_3 r_t - \beta_3(1-\lambda)r_{t-1} - \beta_4(a_t - M_t) + \beta_4(1-\lambda)(a_{t-1} - M_{t-1}) + u_{2t} - \mu'_t$$

(14) $$U_t = [\lambda g_0 + \lambda' g_1\beta_1 + \lambda'' g_1\beta_3] - g_1\beta_1(1-\lambda)(w_t - w_{t-1}) - g_1\beta_3(1-\lambda)(P_t - P_{t-1}) - g_1\beta_1 r_t + g_1\beta_1(1-\lambda)r_{t-1} + (1-\lambda)U_{t-1} + u_{3t} + g_2\mu'_t$$

All of the explanatory variables in these equations are observed.[13] LR's unemployment equation is based on a slightly different specification of normal labor supply. They define N^*_t in terms of labor supply when $w_t = w^*_{t-1}$ and $P_t = P^*_{t-1}$ because when this condition holds,"...suppliers will regard the current real wage as normal. This is true if (11') is an exact equation. Their specification leads to an equation like (14) but without r_t and r_{t-1}. For this reason I prefer the condition $w_t = w^*_t - (r_t - (P^*_t - P_t))$ although this issue is not important in practice.

For the rational expectations case, I rely on the estimation methodology and model estimates presented in Altonji(1981, Essay I). A full discussion of the econometric issues and methodology and of the rational expectations results requires a separate (very long) paper,[13a] but the approach may be summarized as follows.

At the outset, it is useful to state the initial assumption made in estimating the model:[14]

(A1) $(u_{1t}, u_{2t}, u_{3t})'$ is i.i.d. normal,

(A2) P_t, M_t, Q_t, Y_t, D_t, and r_t are exogenous with respect to w_t and N_t.

A1 corresponds to LR's error specification. In addition, LR are forced to maintain for econometric purposes that Θ_2, Θ_3 and the adaptive expectations parameters for both w_t^* and P_t^* (in the adaptive expectations case) are the same. This assumption is not needed in the rational expectations case. (A2), also assumed by LR, is made for convenience rather than theoretical appeal, especially in the case of P_t, r_t and y_t. As LR are aware, these variables are endogenous to almost any reasonable macro model of the economy, of which the labor market is just one sector. However, the results of causality tests are consistent with the assumption but do not rule out all forms of simultaneity.[15]

Measuring Expectations

The FIML procedure used in Sargent (1978) and Taylor (1979) is the most elegant way to implement the rational expectations hypothesis. However, it is impractical in the present case given the complexity of the solution to the model.[16] I have employed a compromise procedure. To summarize briefly, w_t^* is generated as the index of forecasts from a multivariate time series model for w_t consisting of (to a close approximation)[17] the unrestricted reduced form for the wage in terms of the exogenous variables entering the rational expectations solution for w_t^* and equations for the exogenous variables. The latter equations include multivariate equations for P_t and y_t, and univariate models for M_t, Q_t, r_t, and the money supply ml_t. ml_t appears in the equations for P_t and y_t. P_t^* is also computed from forecasts from these equations.

The chain rule of forecasting is utilized with the forecasting equations to produce forecasts of w_{t+i} and P_{t+i} for each value of t in the sample conditional on a series of alternative assumptions about the initial conditions or information set on which the forecasts are based. The alternatives employed in Altonji (1981) range from the assumption that agents utilize all variables dated t (or earlier) in forming expectations about the future, including w_t and P_t, to the assumption that they use only variables dated t-1. To save space, I focus on the results for the information set $I3_t$, which is equal to

$$I3_t = \{P_{t-1}, w_{t-1}, ml_{t-1}, Q_t, r_t, M_t, y_t\}$$

Given the forecasts of w_{t+i} and P_{t+i}, a final assumption about the index weights $d_1 \ldots d_k$ must be made to determine w_t^* and P_t^*. I have assumed that the weights follow a slow exponential decay and terminate after 8 periods, although the results are not sensitive to this.

It is natural to generalize the information assumption $I3_t$ above by allowing that agents partially observe the innovations in w_t and P_t and ml_t (u_{wt}, u_{Pt} and u_{mlt} respectively) and that these innovations impact the expectations of w_t, P_t and ml_t (given the information at time t) with coefficients Θ_w, Θ_P, and Θ_{ml} respectively. One can avoid making an explicit assumption about Θ_P, and Θ_{ml} by adding the estimates of u_{Pt} and u_{mlt} from the forecasting models directly to the labor supply and unemployment equations. This is because w_t^* and P_t^* are linear functions of $(w_t^* | I3_t)$ and $(P_t^* | I3_t)$ and the shocks $(u_{wt}, u_{Pt}, u_{mlt})$. A number of the estimates of ρ reported below are based on the labor supply and unemployment residuals from specifications including the money and price shocks. However, both the inclusion of u_{wt} in the labor supply equation and the use of w_t^* conditional on w_t introduce simultaneity bias. Despite this, Altonji (1981) reports a set of results that are based on the residuals from estimates of the model with w_t^* and P_t^* conditional on $(w_t, P_t, r_t, y_t, ml_t, Q_t, M_t)$. The results are similar to those for the information sets that exclude w_t.

Estimating the Model

The adaptive expectations specifications (13) and (14) may be estimated consistently under the equilibrium hypothesis with two stage least squares, the technique used by LR. In the rational expectations case, 2SLS is inconsistent. Consequently, Fair's (1970) two stage instrumental variables procedure with a correction for the first order serial correlation is used for the labor supply and unemployment equations. Estimation is conducted conditional on the estimates of w_t^* and P_t^* described earlier. They are predetermined in the model under the assumption $I3_t$.

Assuming that the forecasting models for w_t^* and P_t^* are correctly specified, the estimates of w_t^* and P_t^* are consistent. The labor market model is identified, and assuming that the equilibrium hypothesis is true, the instrumental variables estimates of the parameters are consistent and asymptotically normal. The residuals converge in distribution to the true errors (under the equilibrium hypothesis) u_{2t} and u_{3t}. This permits a simple test of whether or not a significant negative relationship exists between the labor supply and unemployment residuals based on a regression of the unemployment residuals against the labor supply residuals. Under the null hypothesis of 0 correlation, the errors in the regression are asymptotically i.i.d. normal. Consequently, a one-tailed t test may be used to test for a significant negative correlation. The same procedure may be used with the adaptive expectations version of the model. If the market clearing hypothesis is false, then the presence of the μ_t terms in the error structure will render the equation estimates inconsistent. Part of the effects of μ_t on E_t and U_t are likely to be attributed to variables such as w_t, r_t, P_t, and the lagged dependent variables introduced in some of the specifications.

The results below also deal with an alternative stochastic specification for the LR model with rational expectations. Altonji (1981) reports estimates of the model with the assumption that labor supply and unemployment depend on their first two lags with white noise errors substituted for LR's assumption of first order serial correlation. This is done in part because low Durbin Watsons (around 1.0) for some variants of the model suggest that LR's assumption is inadequate in the rational expectations case. A second reason is that costs of adjustment in labor supply, (or preferences for leisure that are not additively separable) provide justification for inclusion of the lagged variables, at least in the labor supply equation.[18] If this alternative specification is correct, the labor supply and unemployment equations may be consistently estimated using 2SLS conditional on w_t^* and P_t^*. The regression procedure just described may be used with the unemployment and labor supply residuals from the 2SLS estimates.

Data

The data are essentially the same as that used by LR, updated to 1976 and with revised estimates for the earlier years. The educational quality index (Q_t) is Denison's (1979) series for 1929, 1940-41 and 1947-1976. Estimates are obtained for the missing years by linking the series to Denison's (1962) series (used by LR) for 1929-1958 via a maximum likelihood procedure under the assumption that they are linearly related with an autocorrelated stochastic term.[19] The same procedure is used to obtain annual hours from Denison's (1979) series for 1929, 1940-1941, 1947-1976, and Christensen and Jorgenson's (1973) series for 1929-1969.

Employment (N_t, E_t) is the log of man-hours engaged in production in the civilian and government sectors. The price level (P_t) is the log of the 1972 implicit GNP price deflator. The real wage (w_t) is the log of compensation per man-hour (deflated by the implicit price deflator), which includes wages and salaries and public and private fringes. Real output (y_t) in the log of GNP in constant (1972) dollars. Labor quality (Q_t) is the log of an index of years of school completed. Population (M_t) is the log of an index of the number households corrected for changes in age-sex composition. The nominal interest rate (r_t) is Moody's Aaa rate. Measured unemployment (U_t) is the fraction of the labor force unemployed, although $\ln(1/(1-U_t))$ is more appropriate than U_t as the unemployment measure in the model and is used in the unemployment equation.[20] The money supply (ml) is log of currency plus demand deposits.

For the adaptive expectations case, LR's 1930-1965 data are also used, corrected for minor errors.[21]

5. RESULTS

The tables below present the results of regressions of the residuals from the estimated unemployment equation on the residuals from the estimated labor supply equation and a constant. The calculations are made using the residuals from several specifications of the LR model in both the rational expectations case and the adaptive expectations case. The model numbers in the tables below refer to the following specifications. In the rational expectations case, model 1a is the basic model around which LR organize most of their discussion and corresponds to (4') and (9') with r_t and the wealth variable excluded. The labor supply equation contains w_t, w^*_t, and $P^*_t - P_t$. The unemployment equation contains $w^*_t - w_t$, and $P^*_t - P_t$. Models 2a - 6a contain these variables plus the following additional regressors.

Model 2a: r_t

Model 3a: r_t, D_t

Model 4a: u_{Pt}, u_{mlt}

Model 5a: u_{Pt}, u_{mlt}, D_t

Model 6a: u_{Pt}, u_{mlt}, r_t, D_t

Models 1b - 6b are identical to 1a - 6a with the assumption of first order serially correlated errors replaced by the assumption that labor supply and unemployment depend on their first two lags and that the errors are serially uncorrelated.

Model 1 is LR's basic model for the adaptive case. The labor supply equation contains a constant, w_t, w_{t-1}, $P_t - P_{t-1}$, and $N_{t-1} - M_{t-1}$. The unemployment equation contains a constant, $w_t - w_{t-1}$, $P_t - P_{t-1}$ and

$\ell n(1/(1 - U_{t-1}))$. Models 2 and 3 correspond to the rational expectations models 2a and b and 3a and b. The labor supply and unemployment equations for these models include the variables in model 1 plus r_t and r_{t-1} (Model 2) and r_t, r_{t-1}, D_t, and D_{t-1} (Model 3). Here D_t is a WWII dummy. The inclusion of D_t in the unemployment equation when it appears in labor supply is justified if the WWII dummy captures the effect of the draft in producing negative disequilibrium.

First the rational expectations results will be presented. Table 1 contains analyses of the residuals from model estimates using $w_t^*|I3_t$ and $P_t^*|I3_t$. Row 3 reports $\hat{\rho}$. Row 1 reports the coefficient of the labor supply residuals in explaining the unemployment residuals and the t-statistic to test for a significant negative correlation between the residuals.[22] For LR's basic model (1a), $\hat{\rho}$ is -.682 and is significant at the .005 level. The estimates of $\hat{\rho}$ from models 2a - 6a are -.666, -.458, -.841, -.600 and -.512 respectively. For a given model number, the correlations of the labor supply and unemployment residuals are usually even more negative for models 1b to 6b. (See columns 1b to 6b.) $\hat{\rho}$ ranges from -.791 for model 1b (-.785 for model 2b) to -.602 for model 6b. The negative correlations always are significant at the .005 level.

In summary, residual correlations from the rational expectations estimates of the LR model differ depending on the model specification, stochastic specification, and information set, but in all cases, they are negative, large in absolute value, and highly significant.

The estimates of ρ calculated from the residuals for the adaptive expectations version of the LR model are reported in Table 2. Results for the (corrected) data used by LR over the 1930 to 1965 sample period may be of interest to readers of their original paper. They are presented in the first three columns. Results for the author's data for 1930-1976 are in the second three columns.[23] For the 1930 - 1965 sample using LR's data, $\hat{\rho}$ ranges from

TABLE 1: REGRESSIONS OF UNEMPLOYMENT RESIDUALS ON LABOR SUPPLY RESIDUALS

SOURCE OF RESIDUALS: Rational Expectations Estimates of Labor Supply and Unemployment Equations for 1931-1976 Using $w_t^*|I3_t$ and $p_t^*|I3_t$

Sample Period of Residual Regression	Row No.		Model # Used to Produce Residuals: 1a	2a	3a	4a	5a	6a	1b	2b	3b	4b	5b	6b
1931 to 1976	1	Coefficients of Labor Supply Residuals	-.409[1]	-.424[1]	-.372[1]	-.483[1]	-.383[1]	-.390[1]	-.417[1]	-.497[1]	-.561[1]	-.443[1]	-.427[1]	-.456[1]
			(6.18)	(5.92)	(3.42)	(10.3)	(4.98)	(3.95)	(8.56)	(8.40)	(5.78)	(7.80)	(5.73)	(5.00)
	2	Durbin Watson	1.31	.957	.777	1.39	.986	.940	1.87	2.10	1.57	2.00	1.89	1.65
	3	$\hat{\rho}$	-.682	-.666	-.458	-.841	-.600	-.512	-.792	-.785	-.657	-.762	-.653	-.602
	4	GLS Coefficient of Labor Supply Residuals	-.360[1,3]	-.399[1,3]	-.462[1,3]	-.461[1,3]	-.385[1,3]	-.466[1,3]	-.460[1]	-.511[1]	-.623[1]	-.478[1]	-.440[1]	-.482[1]
			(5.67)	(6.59)	(6.30)	(9.32)	(5.66)	(5.94)	(9.17)	(8.50)	(6.26)	(7.95)	(5.54)	(5.03)
1931 to 1941	5	Constant	-.002	.005	.011	.000	.007	.011	.004	.002	.003	.001	.001	.001
			(.20)	(.436)	(.695)	(.017)	(.53)	(.910)	(.533)	(.243)	(.356)	(.210)	(.168)	(.249)
	6	Coefficient of Labor Supply Residuals	-.772[1]	-.844[1]	-.277	-.634[1]	-.367	-.207	-.446[2]	-.573[2]	-.473[2]	-.326[2]	-.283[2]	-.328[2]
			(4.48)	(3.50)	(.788)	(5.14)	(1.42)	(.71)	(2.80)	(2.83)	(2.38)	(2.89)	(1.97)	(2.40)
	7	Durbin Watson	1.57	1.19	.688	1.47	.616	.711	2.03	2.53	2.40	2.65	2.74	2.67
	8	$\hat{\rho}$	-.831	-.759	-.254	-.863	-.426	-.232	-.682	-.687	-.621	-.694	-.549	-.625
	9	Var $(\hat{u}_{3t})\ 10^3$	1.88	1.42	.142	1.39	.320	.076	.433	.412	.331	.161	.104	.137
	10	GLS Coefficient of Labor supply	-.675[1]	-.661[1]	-.618[1,3]	-.519[1]	-.340[2]	-.490[2,3]	-.815[1]	-.682[2]	-.524[2]	-.327[2]	-.248	-.319[2]
			(4.62)	(3.98)	(4.28)	(4.02)	(2.24)	(2.43)	(4.76)	(2.54)	(2.14)	(2.24)	(1.45)	(1.90)
1947 to 1976	11	Constant	-.002	-.004[2]	-.003	-.002	-.003	-.003	-.002	-.001	-.000	-.001	-.000	-.000
			(0.88)	(2.17)	(1.42)	(1.17)	(1.43)	(1.15)	(1.95)	(.416)	(.131)	(.521)	(.165)	(.177)
	12	Coefficient of Labor Supply Residuals	-.350[1]	-.409[1]	-.335[1]	-.430[1]	-.254[2]	-.342[1]	-.535[1]	-.617[1]	-.835[1]	-.583[1]	-.623[1]	-.714[1]
			(3.03)	(4.67)	(3.31)	(4.64)	(2.27)	(2.90)	(18.6)	(15.2)	(8.28)	(9.08)	(6.45)	(5.45)
	13	Durbin Watson	2.15	1.73	1.75	2.15	2.15	2.07	2.62	2.36	1.17	2.25	1.77	1.34
	14	$\hat{\rho}$	-.497	-.662	-.531	-.659	-.395	-.482	-.981	-.944	-.843	-.864	-.773	-.717
	15	Var $(\hat{u}_{3t})\ 10^3$	.007	.0085	.0066	.0088	.0051	.045	.445	.445	.373	.256	.207	.193
	16	GLS Coefficient of Labor Supply Residuals	-.381[1]	-.459[1]	-.429[1]	-.430[1]	-.242[2]	-.313[1]	-.540[1,3]	-.641[1]	-.757[1,3]	-.594[1]	-.615[1]	-.648[1]
			(3.24)	(5.10)	(4.12)	(5.26)	(2.24)	(2.76)	(22.9)	(16.9)	(8.85)	(9.40)	(6.46)	(5.70)

t-values in parentheses.

1) One-tail t test significant at the 0.005 level for the residual coefficients. Two-tail t test significant at 0.01 level for intercepts.
2) One tail t test significant at the 0.05 level for labor supply residual coefficients. Two-tail test significant at the 0.05 level for intercepts.
3) Autocorrelation parameter significant at 0.05 level.

TABLE 2: REGRESSIONS OF UNEMPLOYMENT RESIDUALS ON LABOR SUPPLY RESIDUALS
Source of Residuals: Adaptive Expectations Models

DATA AND ESTIMATION PERIOD USED TO PRODUCE RESIDUALS

Sample of Residual Regressions	Row #		Corrected LR, 1930-1965			Author, 1930-1976			Author, Darby Unemployment, 1930-76		
			1	2	3	1	2	3	1	2	3
	1	Sample Period of Residual Regression	1930-65	1930-65	1930-65	1930-76	1930-76	1930-76	1930-76	1930-76	1930-76
FULL SAMPLE	2	Coefficient of Labor Supply Residuals	-.284[1] (5.80)	-.300[1] (6.32)	-.404[1] (6.36)	-.356[1] (11.9)	-.325[1] (9.93)	-.481[1] (14.4)	-.346[1] (11.3)	-.318[1] (9.72)	-.481[1] (15.1)
	3	Durbin Watson	1.01	1.00	1.31	.926	.878	1.10	.828	.815	1.17
	4	ρ	-.705	-.735	-.737	-.871	-.824	-.906	-.862	-.825	-.916
	5	GLS Coefficient of Labor Supply Residuals	-.300[1,3] (8.09)	-.326[1,3] (9.22)	-.467[1] (8.98)	-.359[1,3] (17.9)	-.339[1,3] (16.3)	-.496[1,3] (20.6)	-.351[1,3] (18.2)	-.333[1,3] (16.9)	-.486[1,3] (20.5)
GREAT DEPRESSION (1930-1941 for all columns)	6	Constant	.005 (1.095)	.005 (1.00)	.005 (0.76)	.004 (.91)	.005 (1.28)	.005 (1.47)	.002 (0.33)	.004 (0.69)	.002 (0.54)
	7	Coefficient of Labor Supply Residuals	-.341[1] (4.72)	-.379[1] (5.25)	-.516[1] (4.86)	-.380[1] (9.46)	-.361[1] (8.93)	-.527[1] (13.8)	-.362[1] (7.44)	-.347[1] (7.25)	-.522[1] (14.0)
	8	Durbin Watson	1.50	1.35	0.95	1.45	1.42	1.13	1.01	1.01	1.23
	9	ρ	-.831	-.857	-.838	-.948	-.943	-.975	-.927	-.924	-.978
	10	$Var(u_{3t}) \cdot 10^3$	.576	.718	.673	1.62	1.51	2.28	1.62	1.521	2.39
	11	GLS Coefficient of Labor Supply Residuals	-.342[1] (5.27)	-.381[1] (6.23)	-.610[1] (10.4)	-.378[1] (10.7)	-.360[1] (10.3)	-.534[1] (20.0)	-.361[1] (10.8)	-.346[1] (10.6)	-.518[1] (19.7)
POSTWAR	12	Sample Period of Residual Regressions	1947-65	1947-65	1947-65	1947-76	1947-76	1947-76	1947-76	1947-76	1947-76
	13	Constant	-.007[1] (3.01)	-.007[1] (3.22)	-.003 (1.34)	-.004[2] (2.10)	-.005[2] (2.60)	-.002 (.879)	-.004 (2.00)	-.005[1] (2.83)	-.001 (0.70)
	14	Coefficient of Labor Supply Residuals	-.256[2] (2.80)	-.228[2] (2.81)	-.310[2] (2.41)	-.323[1] (7.16)	-.269[1] (5.21)	-.384[1] (5.79)	-.328[1] (7.77)	-.269[1] (5.94)	-.390[1] (6.52)
	15	Durbin Watson	1.33	1.25	1.03	.970	1.07	.808	.912	1.12	.761
	16	ρ	-.562	-.563	-.504	-.804	-.701	-.738	-.826	-.747	-.776
	17	$Var(u_{3t}) 10^3$	.050	.037	.036	.196	.100	.146	.202	.102	.151
	18	GLS Coefficient of Labor Supply Residuals	-.286[1] (3.95)	-.248[1] (3.91)	-.368[1] (3.96)	-.321[1,3] (8.99)	-.281[1,3] (6.61)	-.419[1,3] (9.09)	-.323[1,3] (9.90)	-.283[1,3] (7.44)	-.419[1,3] (10.3)

t-values in parentheses.
1,2,3) See Table 1.

-.705 to -.737. For the 1930-1976 sample, $\hat{\rho}$ is -.871 for the residuals from the basic model. The estimates for model 2 and model 3 are -.824 and -.906 respectively. The correlations are thus very large in absolute value, and highly significant. In summary, the results for the adaptive expectations case as well as the rational expectations case indicate that a strong negative relationship exists between movements in employment and unemployment even after responses to intertemporal fluctuations in the price of leisure have been controlled for.

Additional Results

Once the assumption of market equilibrium is rejected, it becomes interesting to try to determine the sample periods in which disequilibrium is most important. Tables 1 and 2 also present residual correlations from the Great Depression years and the postwar years based on estimates of the models for the entire sample. Taken at face value, the evidence on the hypothesis that disequilibrium is relatively more important in explaining cyclical movements in employment and unemployment during the Depression years than in the postwar years is positive for the adaptive expectations estimates. The evidence is mixed for the rational expectations estimates. However, the justification for the subsample comparisons is very weak and I have relegated an abbreviated discussion of them to footnote 24.

A number of additional experiments were performed that deserve mention. Darby (1976) proposes that participants in the Depression work relief programs be counted as employed in calculating the unemployment series. While Kesselman and Savin (1978) argue forcefully against Darby's interpretation of the work relief jobs as close substitutes for other jobs in the economy, the question deserves further exploration. In both the rational expectations and adaptive expectations cases, the findings for the entire sample and subsample comparisons basically are insensitive to use of the Darby data to estimate the unemployment equation. Altonji (1981) reports results based on the residuals from estimates of models 1, 2, 3, 5, and 6 with trends added to both the labor supply and unemployment equations. The trends have little effect on results.

For a number of reasons, I have also examined the unemployment residuals and labor supply residuals based on rational expectations estimates of the LR model for the sample period 1948-1976. These are a check on the possibility that structural shifts in the labor market model are contaminating the residuals based on estimates of the model for the entire sample. They are also of interest if one takes the position that the labor market was not in equilibrium during most of the Great Depression, but that for the range of fluctuations in aggregate demand and supply that usually prevail, the market equilibrium assumption is a good approximation. As was emphasized above, the parameter estimates and the estimates of the true errors of the models are inconsistent if disequilibrium is present during the sample period. Consequently, it is possible to take the view that the labor market was in equilibrium during the postwar years and attribute the negative estimates of ρ for the entire sample (and also the sub-sample comparisons) to disequilibrium in the Depression years and/or inadequate controls for the effects of WWII. As it turns out, the estimates of ρ using the residuals from the postwar estimates of the LR model range from -.586 for model 2a to -.748 for 5a and are significantly negative (at the .005 level) in all cases. These estimates are larger (except for 2a) than the residual correlations for 1947-1976 based on model estimates for 1931 to 1976. Use of Barro's (1978) money surprise series in model 5a makes little difference. For the adaptive expectations case models 1 and 2 were estimated using data from 1948-1976. The residual correlations remain large, negative, and highly significant. These findings indicate that the strong correlation between the labor supply and unemployment residuals cannot be attributed solely to structural shifts or to disequilibrium during the Great Depression or WWII years.

In summary, the results for the different model specifications, expectations assumptions, data series, and sample periods used to estimate the LR model all support the hypothesis that disequilibrium is important in explaining cyclical movements in employment and unemployment. A strong negative relationship remains between employment and unemployment even after intertemporal substitution is controlled for.

It should be pointed out that the results of this section do not indicate how much of the variance of employment and unemployment reflects disequilibrium. The problem, once again, is that the labor supply and unemployment equations are estimated under the assumtion of market equilibrium, and the estimates are inconsistent if this hypothesis is false. An undetermined portion of the effects of disequilibrium is likely to be statistically attributed to the regressors in the labor supply and unemployment equations. Satisfactory assessment of the relative importance of disequilibrium and equilibrium movements in employment and unemployment requires a more elaborate framework in which disequilibrium is explicitly modeled and consistent estimates of the labor supply and equilibrium unemployment parameters may be obtained along with a labor demand equation and an equation for disequilibrium.[25] The finding in Section 2 that conditional labor supply and conditional equilibrium unemployment are independent may be useful in developing such a framework.[26]

6. CAVEATS AND CONCLUDING REMARKS

This section discusses a few caveats that conceivably could reconcile the results with the equilibrium hypothesis. The empirical tests will be biased against the equilibrium hypothesis if the errors in the estimates of the conditional means of employment and unemployment are negatively correlated. Errors in measurement of w_t^* and P_t^* are likely to have this effect (if present). So will errors in w_t, r_t, and P_t, and errors in the unemployment and labor supply variables that have a negative covariance. Ignoring the question of the effects on the parameter estimates, which complicates matters considerably, this may be seen by observing that w_t, w_t^*, P_t, r_t and P_t^* enter (4') and (9') with coefficients of opposite signs. The importance of the problem is hard to assess a priori. On the other hand, errors in variables which appear in only one of the two equations (M_t, r_t, a_t) and errors in N_t and U_t which are not negatively correlated probably bias the estimator of ρ in favor of the equilibrium hypothesis.[27] Some forms of misspecification of labor supply equation (4) may also introduce negative dependence in the estimated labor supply and unemployment residuals. The problems raised by errors in variables and misspecification may both be understood as the consequences of failure to properly condition labor supply and unemployment on (w_t, w_t^*, P_t, P_t^* and r_t).

A rigorous analysis of the importance of these problems and of possible remedies (if needed) is not attempted in this paper. To keep matters in perspective, note that most of the data employed in this paper are widely used in economics, and the failure to deal conclusively with possible effects of errors in variables and specification error on hypothesis tests is the rule rather than the exception. However, a number of additional observations can be made. First, with reference to error in measurement of w_t^* and P_t^*, it must be admitted that the problem of estimating the future expectations held by rational agents is an exceedingly difficult one. Some error in measurement is likely. In Altonji (1981) I address in two ways the question of whether mismeasurement of w_t^* and P_t^* has a large effect on the rational expectations estimates of the model. The first is to estimate the model under the assumption of perfect foresight. I point out that use of perfect foresight values of w_t^* and P_t^* (without instrumental variables) when people do not in fact have perfect foresight introduces measurement error into the model, but I argue that since wages (and to a lesser extent prices) may be predicted with a very high degree of accuracy from a first order autoregression with a trend, rational expectations cannot be very different from the perfect foresight value of w_t^*.[28] The results show that the correlation between the labor supply and unemployment residuals remains large and negative when the perfect foresight indices of future wages and prices are used to measure w_t^* and P_t^*.

Altonji (1981) also reports estimates of the labor supply equation using the log of consumption of nondurables per capita as a proxy for expected future wages and expected real interest rates. It is not possible to go into the details of the analysis, in which labor supply and consumption functions are derived using a specific additively separable utility function along with a simple aggregation scheme. The basic idea is that both labor supply and consumption are determined as a function of current and expected future wages and prices, interest rates, wealth and preferences. The least squares and instrumental variables estimates of the labor supply equation using consumption to proxy expectations are remarkably consistent with the estimates based on the forecasts of future wages and prices, and thus suggest that the measures of w_t^* and P_t^* are adequate. In addition, the residuals from the labor supply and unemployment equations estimated with consumption have a strong negative relationship.

The results for the perfect foresight case and for the use of consumption to proxy expectations, plus the insensitivity of the results to choice of information set all suggest that the large negative relationship between the unemployment and labor supply residuals is not easily explained in terms of error in measurement of expectations.

Second, a crude analysis of the problem of errors in the observed variables of the model is contained in Altonji (1978). It indicates in the context of the adaptive expectations model that errors in variables cannot account for the large negative values of $\hat{\rho}$, but it is difficult to present a tight case against this possibility.

Third, with reference to specification error, note that several models have been tried with rational expectations in addition to the adaptive expectations models estimated by LR. It is true that all of the models are log-linear, however, and there are obviously many reasonable alternatives which could be proposed.[29] Beyond the question of functional forms is the issue of whether a more drastic overhaul of the LR model can reconcile with market equilibrium the strong negative relationship between unemployment and labor supply that remains after intertemporal substitution has been controlled for.

An Implicit Contracts Interpretation

One might consider the possibility that the results (accepted at face value) may be reconciled with a reformulation of market equilibrium into the framework of long-term implicit contracts.[30] Since only labor market models in which the employment level is always Pareto optimal are of interest here, I limit consideration to a model in which employment is determined so that labor supply and labor demand are equal when the value of leisure time equals the marginal value product of work. However, the "price" on the basis of which supply and demand are chosen is not the observed "contract" wage, but rather a shadow wage.[31] The implicit contracts model may be summarized as follows.

(i) Labor supply and labor demand N_t are chosen so that the marginal utility of leisure equals the marginal value product of labor at all times. Let MP_t represent the marginal value product at t. It equals the shadow wage that clears the labor market in the conventional sense.

(ii) The reduced form for the equilibrium shadow wage determined by the supply and demand functions is assumed to be decomposable into a deterministic trend and a stochastic component γ_t, with

$$MP_t = \gamma_t + \beta t$$

(iii) The actual real wage paid (w_t) is set as a weighted average of the current value of the shadow wage MP_t and the trend value for MP_t. That is,

$$w_t = \Gamma MP_t + (1 - \Gamma)\beta t$$
$$= \Gamma\gamma_t + \beta t$$

If Γ is equal to 0, then real wages are completely smoothed and do not reflect short-term fluctuations in the determinants of labor supply and demand. If the labor market is a standard competitive market as in LR, then $\Gamma = 1$ and $w_t = MP_t$. The value of Γ is a function of the various factors cited in the implicit contracts literature as determinants of an optimal contract. Here I consider the intermediate case $0 < \Gamma < 1$.

Labor supply is determined by MP_t, and MP_t^*, the index of rational expectations of future values of MP_t, ($MP_t^* = \Sigma_{i=1}^{k} d_i \hat{MP}_{t+i}$). Unemployment is determined as before, but the effect of intertemporal substitution on equilibrium unemployment is determined by the relative values of MP_t and MP_t^* rather than w_t relative to w_t^*. With these modifications, the labor supply and unemployment equations (4) and (9) become

(4") $$N_t - M_t = \beta_1(MP_t) - \beta_2(MP_t^*) + \beta_3[r_t - (P_t^* - P_t)] + \beta_4(a_t - M_t) + \varepsilon_{2t}$$

and

(9") $$U_t = g_o + g_1\beta_1 \cdot (MP_t^* - MP_t) - g_1\beta_1[r_t - P_t^* - P_t)] + \varepsilon_{3t}$$

At issue is the impact of the modifications (i), (ii) and (iii) on interpretation of the results based on estimation of (4) and (9). Superficially, differences between w_t and MP_t on one hand and w_t^* and MP_t^* on the other would seem to enter the error components of (4) and (9) with opposite sign and introduce a negative correlation between the residuals of the two equations. However, it is easy to show that except for an irrelevant constant, w_t^*, w_t and t may be written as an exact linear function of MP_t, MP_t^* and t:

$$\begin{pmatrix} w_t \\ w_t^* \\ t \end{pmatrix} = \begin{pmatrix} \Gamma & 0 & (1-\Gamma)\beta \\ 0 & \Gamma & (1-\Gamma)\beta \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} MP_t \\ MP_t^* \\ t \end{pmatrix}$$

Consequently, the residuals are unaffected by use of w_t, w_t^* and a trend in place of MP_t and MP_t^* in the labor supply and unemployment equations, although the estimates of β_1 and β_2 are biased upward in absolute value. Furthermore, the effect on the residuals should be minimal even if the trends are excluded.

This analysis suggests that the residual correlations based on equations both with and without time trends may be robust with respect to the possibility that labor market behavior is determined by the combination of market equilibrium, intertemporal substitution, and implicit contracts sketched above. Note, however, that the above analysis is based upon a specific formulation of implicit contracts. The choice is appropriate given the interest here in market clearing models, but others are possible. Also, the argument used above is not directly applicable to the instrumental variables estimation scheme used in the paper. Furthermore, a given amount of transitory measurement error in the wage series will constitute a higher fraction of the fluctuations in w_t and w_t^* the larger value of Γ. It is possible that measurement error obscures the connection between (w_t, w_t^*) and (MP_t, MP_t^*) with serious effects on the residual correlations and parameter estimates. Nevertheless, it is reasonable to conclude that the strong negative correlations reported in this paper are not easily explained by implicit contract determination of actual wages in the context of arrangements between workers and firms which mimic a labor market that clears instantaneously. Further analysis of this issue is needed.

Concluding Remarks

The returns to careful consideration of the stochastic structure implied by alternative models of economic behavior have been demonstrated in a number of areas of economics in recent years. The proposition that the equilibrium assumption in the context of the intertemporal substitution hypothesis implies independence and that disequilibrium implies negative dependence between conditional employment and conditional unemployment is another example. Much work remains to be done before implementation of the test proposed in this paper can yield a definitive answer to the old question: "Does the labor market clear?", a question that is as difficult as it is important to resolve. However the present findings do provide hope that the test will be useful in the quest for an answer, as well as some indication that the answer is "no".

The results cast doubt upon the evidence offered by LR in favor of their intertemporal substituion model as an explanation for labor market fluctutations. They are consistent with and help explain the inability of the unemployment and labor supply functions to explain employment and unemployment movements when rational expectations are imposed (See Altonji (1981, Essay I) and Altonji and Ashenfelter (1980).) The role of intertemporal substitution may well be obscured by disequilibrium. My reading of the labor market literature is that intertemporal subsitution (probably in an implicit contracts setting) and disequilibrium associated with labor demand shifts are both part of the full story of labor market fluctuations. Combining them in an empirical model raises many econometric difficulties but deserves a high research priority.

FOOTNOTES

1. Solow (1980) is typical of the argument in favor of disequilibrium. The recent "implicit contracts" literature (see below) is a major effort to provide a theoretical understanding of wage and price adjustment. The large literature on the empirical Phillips curve obviously has some bearing on the issue of wage rigidity, but a major point of Lucas and Rapping (1970) is that the existence of a short-run Phillips curve is perfectly consistent with the equilibrium labor market model they propose.

2. A parallel presentation of Section 3 for the adaptive expectations case is in Altonji (1978).

3. In search theory, cyclical movements reflect movements in the number of individuals who seek but have not found jobs at what they believe to be current wage levels and who may have left or refused jobs at the actual current wage. See fn. 5 below.

4. I wish to emphasize that although it is convenient to use the term "equilibrium hypothesis", in Section 2, the term refers to a joint hypothesis of 1) market equilibrium and 2) the intertemporal substitution (or search) model of labor supply and equilibrium unemployment. As noted earlier, the additional structure provided by the second hypothesis (which is independent of the first and is maintained throughout) permits the test of market equilibrium.

5. $\hat{w}_t$ is included in (1) below to account for search theoretic explanations of unemployment fluctuations of the type in Mortensen (1970) and Phelps (1970). Both Lucas (1973) and Mortensen use isolated market paradigms to introduce uncertainty about the current local wage relative to the wage generally available. However, in Lucas' setup individuals do not move between markets in the short run and respond only to the perceived differential between the current local wage and the permanent wage. In Mortensen's setup, they move at a cost (become unemployed) in response to the differential between the expected current local wage and the expectation about current wages elsewhere. Altonji and Ashenfelter (1980) merge Lucas' (1973) discussion with the model in Lucas and Rapping (1970), and show it is not necessary to introduce $\hat{w}_t$ independently of w_t and w_t^* in the combined model (if individuals know the local real wage). If individuals do not know the price level, price and money shocks must be added to the model, as is done below. In Mortensen's setup $\hat{w}_t$ must be added. This point is not pursued in the empirical work, and the emphasis in this paper is on intertemporal substitution. For a variety of reasons, a search theoretic explanation of cyclical fluctuations is implausible. See Lucas (1977) and Gordon (1976).

6. See LR's discussion pp. 272-279. They comment, "These LR's observations suggest strongly that the labor force as measured by the employment survey consists of those who are employed plus those who are unemployed but would accept work at what they regard as their normal wage rates (or, equivalently, their normal occupation)." (p. 273)

7. This assumption does not hold for all labor supply functions. This means that given data limitations on what is observed, the test procedure developed in this section cannot be used in all cases.

8. I am indebted to David Lilien for helpful discussions on this point.

9. This is shown explictly in MaCurdy (1980) who derives a labor supply equation similar to LR's from a specific utility function. It is also shown in Altonji (1981, Ch. I-4), which draws upon MaCurdy's analysis but combines it with a simple aggregation story that is more compatible with the aggregate time series framework of the LR model.

10. For a detailed discussion of the model, see LR (1970) and the references in Altonji (1981), fn. 3, pg. 102. The exchange between LR(1972) and Rees (1970, 1972) is particularly relevant.

11. Note that these considerations strain the assumption that (u_{2t}, u_{3t}) is serially independent but are consistent with the assumption that ε_{2t} and ε_{3t} are serially dependent. It should be pointed out that the present paper is concerned only with cyclical variations of employment, labor supply and unemployment. Changes in the unemployment laws and in the institutional framework of the labor market may have changed the constant g_o. Partly for this reason a time trend has been added to the labor supply and unemployment equations for some of the estimates. (The secular increase in the female labor force adds a positive trend to the labor supply equation. It would also add a trend to g_o if female job attachment is less permanent than males. This would produce a positive correlation between the labor supply and unemployment disturbances.)

12. These assumptions (and the assumption that ℓ_1 is small) are used only in the argument that the correlation of the labor supply and unemployment residuals is negative if disequilibrium is present. If these assumptions are false, the probability of accepting the equilibrium hypothesis when it is false may be increased. In view of the large highly significant negative correlations found, this issue is not very important.

13. In (13) and (14) the definitions of u_{2t}, and u_{3t} and μ'_t differ slightly from the rational expectations case.

$$u_{2t} = \varepsilon'_{2t} \qquad \varepsilon'_{2t} = \varepsilon_{2t} - (1-\lambda)\varepsilon_{2t-1};$$

$$u_{3t} = \varepsilon'_{3t} \qquad \text{and } \varepsilon'_{3t} = \varepsilon_{3t} - (1-\lambda)\varepsilon_{3t-1}.$$

$$\mu'_t = \mu_t - (1-\lambda)\mu_{t-1}.$$

λ is the adaptive expectation parameter. In estimation $(1-\lambda)$ is assumed to equal Θ_2 and Θ_3. A problem arises if one allows that the expectations equations (11') and (12') may not be exact. If ω_{1t} and ω_{2t} are error terms in the equations for w^*_t and P^*_t, then the term $-\beta_2[\omega_{1t} + \omega_{2t}] - \beta'_3\omega_{2t}$ must be added to (13). The term $\beta_1[\omega_{1t} + \omega_{2t}]$ must be added to (14). Since these additional terms are unobserved and cannot be controlled for, they provide a potential source of negative correlation between the composite labor supply and unemployment error terms. To perform the test for equilibrium, it is necessary to maintain that these components do not dominate the error structure. I consider this a reasonable assumption in the context of the adaptive expectations model.

13a. The paper is available as Altonji (1981a).

14. In restating their model in econometric notation (pp. 276-277), LR introduce u_{1t}, u_{2t} and u_{3t} into the marginal productivity condition, labor supply equation and unemployment equation (respectively). They state that "The error vectors (u_{1t}, u_{2t}, u_{3t}), t - 1. . . .T, are assumed to be independent and identically distributed, with a finite covariance matrix and a mean vector (0,0,0). The variables Q_t, y_t, M_t, and P_t are taken to be exogenous; the endogenous variables are N_t, w_t and u_t." (p. 277). For a more detailed discussion of LR's stochastic assumptions see Altonji (1978), p. 33, fn. 10.

15. See the results and discussion in Altonji (1981), Essay I, fn. 12. In addition, if one believes that (except for trends) shifts in the labor supply function are not a major source of macroeconomic disturbances, then the assumption that P_t, y_t and r_t are predetermined in the labor supply equation is a reasonable approximation. The issue of simultaneity is less bothersome in the unemployment equation. This equation does not contain the labor supply disturbance ε_{2t}, and it is a derivative equation in the model rather than part of a system that determined N_t and w_t.

16. The solution is presented and discussed in Altonji (1981), Essay I. Note also that when the LR model is estimated using FIML conditional on the estimates of w_t^* and P_t^* obtained from the forecasting model, $\hat{\rho}$ is -.976. The FIML estimator performs very badly, and I attribute this to the fact that a common disequilibrium component in the labor supply and unemployment equations is likely to have greater impact on a system estimator than on single equation estimators.

17. Due to extreme multicollinearity some of the variables in the model were dropped from the wage forecasting equation. The details of the forecasting models, including the series for w_t^*, P_t^*, u_{mlt} and u_{Pt}, are in Altonji (1981).

18. Costs of adjustment have received attention in theoretical work explaining business cycles with rational expectations, market clearing models. See the discussion in Lucas (1977), p. 22. However, the justification for adding lagged unemployment terms to the unemployment equation is not clear, since lagged labor supply terms in the labor supply equation would disappear between (4), (6) and (7).

19. Altonji (1981) presents the data sources, describes the interpolation procedure for hours worked and Q_t, and gives summary statistics and a listing of the various series. The data will be provided upon request.

20. See Altonji (1981), Essay I, fn. 19. The results are not sensitive to this, however.

21. The only correction of consequence is that LR report (and apparently used) 172.7 as the value of their wage index for 1950, while the correct value is 165.7. This has some effect on LR's coefficient estimates, but does not change their results qualitatively.

22. Row 4 reports a GLS estimate of the coefficient of the labor supply residuals under the assumption of first order serial correlation. Under the equilibrium assumption such a correction should not be required for either the residual regressions from the "a" models or from the "b" models. Disequilibrium might easily result in serial dependence in the errors in the relationship between the labor supply and unemployment residuals if μ_t obeys a different autoregressive process than ε_{2t} and ε_{3t}. Since the distribution of the errors are not known under the disequilibrium hypothesis, it is not clear how to interpret the t-statistics for the GLS estimates.

23. It is possible to include 1930 in estimating the adaptive models, and I have done so. However, the results excluding this year are similar to those reported.

24. Altonji (1981) provides some limited justification for comparing the correlation of the residuals from the Great Depression years with the correlation for the post-WWII period. The upshot of the analysis is as follows. If one assumes that differences in the behavior of the labor supply and unemployment equations are due entirely to differences in var (μ_t') between periods that are unrelated to the behavior of u_{2t} and u_{3t}, and one ignores the effects on the residuals of inconsistent parameter estimates caused by disequilibrium, then one would expect $\hat{\rho}$ to be larger during 1931-1941 than for 1947-1976 if one believes that disequilibrium is particularly important as an explanation of the wide swings in employment and unemployment during the Depression years. There is also reason to believe that var$(\hat{u}_{3t})$, the sample variance of the predicted values of the unemployment residuals based upon the labor supply residuals, is more sensitive than $\hat{\rho}$ to the importance of disequilibrium in the different sample periods.

The results for 1931-1941 and for 1947-1976 of regressing unemployment residuals on the labor supply residuals (from the rational expectations models) and a constant are reported in rows 5 - 15 of Table 1. The estimate of ρ is in fact bigger for 1931-1941 than for the postwar period when computed for models 1a, 2a, 4a and 5a. (Compare row 8 and row 14.) The difference is "large" for 1a, 2a and 4a, but small for 5a. For the latter model, $\hat{\rho}$ is -.426 for the Great Depression years and -.395 for 1947-1976. The estimate of ρ for the models including a WWII dummy (3a and 6a) are larger in the postwar period than in 1931-1941. var$(\hat{u}_{3t})$ is larger during the Depression years than postwar years for models 1a - 6a. The difference is large for all the models except 6a.

For 1b - 6b, $\hat{\rho}$ is larger for 1947-1976 than for 1931-1941. For example, the subsample estimates of ρ for 2b are -.682 for 1931-1941 and -.944 for 1947-1976. The corresponding figures for 6b are -.625 and -.717. Furthermore, var$(\hat{u}_{3t})$ is a bit larger during the postwar period than 1931-1941.

Turning to the adaptive expectations models (Table 2), comparison of rows 8 and 15 and rows 9 and 16 reveals that both $\hat{\rho}$ and var$(\hat{u}_{3t})$ are larger in the Depression period (1930-1941) than in the postwar period (1947-1965 for LR's data, 1947-1976 for the revised and extended data).

In summary, under a very strong set of maintained assumptions, the subsample comparisons of $\hat{\rho}$ and var(u_{3t}) support the hypothesis that the variance in disequilibrium is greater during the Depression years than during the postwar years in the adaptive expectations case. The results for the rational expectations models are mixed. The fact that $\hat{\rho}$ and var($\hat{u}_{3t}$) are larger during the postwar years than the Depression years for some versions of the model is somewhat disturbing. However, it should be emphasized that the argument justifying the subsample comparisons in the event that the hypothesis of equilibrium is rejected is formulated in terms of the true errors and ignores the effects of disequilibrium on the estimated errors. Since the rational expectations parameter estimates (discussed in detail in Altonji (1981)) underlying the residual calculations are broadly inconsistent with LR's formulation of the equilibrium hypothesis, the effects on the residuals are probably serious, invalidating the subsample comparisons.

25. If consistent estimates of the labor supply and unemployment parameters are available, and one is willing to strengthen somewhat the assumptions in Section 3 regarding the covariances of the u_{2t}, u_{3t}, and the disequilibrium component μ_t', it would be possible to infer the importance of disequilibrium relative to equilibrium fluctuations in unemployment. The importance of the wage, price and interest rate terms could be determined from the variance they explain. The relative importance of disequilibrium and the labor supply shock could be sorted out by using the labor supply and unemployment parameters to calculate the true values for the composite error terms for these equations. If one strengthens the assumptions in Section 3 and assumes that the covariances of all the error components are approximately 0, then the regression coefficient of the labor supply residual in the equation explaining the unemployment residual is $-g_2\text{var}(\mu_t')/[\text{var}(u_{2t})+\text{var}(\mu_t')]$. Thus, if one knows g_2 and calculates the variance of the labor supply residuals [var(u_{2t}) + var(μ_t')], one can estimate var(u_{2t}) and var(μ_t'). Assuming that the autoregressive parameter of the error components are known, these estimates may be translated into components of the total variance in employment. The estimates of the LR model with rational expectations reported in Altonji (1981) are so discouraging with respect to the theoretical foundation of the model that there is little point in performing the above calculations until consistent estimates of the LR model modified to account for disequilibrium are available.

26. See Rosen and Quandt (1978) for research in this direction. Ham (1980) develops and implements an estimator for labor supply functions using micro data that is consistent whether or not workers are constrained in the number of hours they can work. His results suggest that they are constrained, although he points out that the source and normative implications of the constraints (e.g., sluggish wage adjustment, equilibrium constraints of the type discussed below, "frictional" constraints related to search costs of finding jobs) is unclear.

27. Note that after 1940 N_t and U_t are measured independently.

28. The simple correlations of the perfect foresight value for w_t^* (based on the actual future wage rates and the index weights used to compute w_t^* for the various information sets) with w_t and a trend are .999 and .996 respectively. The correlation between $w_t^*|I3_t$ and the perfect foresight index is .9995.

29. The strong negative correlation between the residuals from rational expectations estimates of the LR model for the postwar period and from the models with time trends suggests that structural shifts do not readily explain the results.

30. For detailed references to the implicit contracts literature, see Azariadis (1980) and Brown (1980).

31. Barro (1977) argues that implicit contracts should take this form. Note that for a variety of informational reasons discussed in papers such as Hall and Lilien (1980) the implicit contract which is optimal relative to informational and institutional constraints may not be consistent with equality between the marginal utility of leisure and the marginal value product of work. In this case, the labor market does not clear in the usual sense, and the negative correlations found in this study are to be expected. Such discussions are the first stage of a full-scale model of the labor market with disequilibrium.

32. Brown (1980) studies the relationship between real wages and the marginal value product of labor for various industries using estimates from a production function estimated in the context of an implicit contracts model.

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