ETLA ELINKEINOELÄMÄN TUTKIMUSLAITOS
THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY
Lönnrotinkatu 4 B, 00120 Helsinki 12, Finland, tel. 601322

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Matti Virén

TESTING THE LABOR MARKET EQUILIBRIUM HYPOTHESIS

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TESTING THE LABOR MARKET EQUILIBRIUM HYPOTHESIS

by

Matti Virén

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Abstract

This paper contains a number of empirical tests of the labor market equilibrium hypothesis using Finnish quarterly data. The tests are based on an analysis of the stability of parameters, the dynamics of real wages and the independence of labor supply and unemployment residuals. The equilibrium hypothesis is rejected in all the tests. A similar result is obtained when a disequilibrium labor market model is estimated.

1. Introduction

This paper contains some empirical tests of the labor market equilibrium hypothesis. The tests make use of the essential properties of an equilibrium labor market model, especially in terms of parameter stability, the independence of the residuals of the labor supply and unemployment equations, and the differential between current and expected real wages. These tests are complemented by a disequilibrium model estimation.

As a framework we use a Lucas-Rapping type model, which is summarized in Table 1 (cf. equations (1E), (2E) and (3E)). No formal derivation of the equations is presented here, the reader being referred to Lucas and Rapping (1970) and Virén (1981). Instead, we briefly examine the main differences between our specification and that of Lucas and Rapping (1970).

First, the labor supply equation (1E) used here includes a lagged dependent term[1)]. This term's rationalization is that the consumer's utility function may not be intertemporally separable and that, given the possibility of replanning with respect to intertemporal choice, consumption and labor supply equations include past levels of consumption and labor supply (cf. Deaton and Muellbauer (1980), p. 342 for details). Second (2E) represents an 'ordinary' demand for labor schedule, which is preferred here to the 'marginal productivity condition' employed by Lucas and Rapping (1970). Lucas and Rapping use

Table 1. Summary of equations

(1E) Supply of Labor[1)]

$$N_t = a_o + a_1(A/P)_t + a_2M_t + a_3(w_t - w_t^*) + a_4w_t^* + a_5N_{t-1} + u_{1t}$$

(2E) Demand for Labor[1)]

$$N_t = b_o + b_1(w_t - w_t^*) + b_2w_t^* + b_3t + b_4N_{t-1} + u_{2t}$$

(3E) Unemployment Rate[1)]

$$U_t = c_o + c_1(w_t - w_t^*) + c_2t + c_3U_{t-1} + u_{3t}$$

(1DE) Supply of Labor[2)]

$$N_t = a_o' + a_1'(A/P)_t + a_2'M_t + a_3'w_t + u_{1t}'$$

(2DE) Demand for Labor[2)]

$$N_t = b_o' + b_1'w_t + b_2'y_t + b_3't + u_{2t}'$$

(3DE) Unemployment Rate[2)]

$$U_t = (N_t^s - N_t^d)/N_t^s$$

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1) All variables (except t) are expressed in log terms.

2) All variables (except t) are expressed as log deviations from linear trend.

The following notation is used:

- N_t = employment
- $(A/P)_t$ = households´ real wealth
- M_t = population of working-age
- w_t = current real wage
- w_t^* = anticipated real wage
- t = time trend
- U_t = unemployment rate (according to employment survey)
- y_t = real output
- u_{1t}, u_{2t}, and u_{3t} = error terms, which are assumed to be temporally independent, identically distributed multivariate normal variates with zero means and a positive definite co-variance matrix.

a Jorgenson-type derivation for the demand for labor input, so that both the real wage and the level of output (which is considered exogeneous) appear as variables on the right-hand side. Clearly, there is an asymmetry in the Lucas-Rapping approach: households´ behavior is analyzed using a model of intertemporal choice whereas firms´ behavior is analyzed in a completely static setting. One could, however, conceive that the idea of intertemporal substitution is more relevant to firms; for example, because they probably have better access to financial markets[2)].

Therefore, it would appear that the way in which Lucas and Rapping consider the demand side is not completely satisfactory, and that equation (2E) has a better theoretical justification. From the point of view of the empirical tests reported below, this question is, however, of less importance, since the demand equation is not (directly) utilized in them.

Third, the unemployment equation (3E) includes a time trend and a lagged unemployment term to capture eventual changes in equilibrium unemployment; Lucas and Rapping employ only a constant term for this purpose[3)]. Finally, our basic model does not include the real rate of interest, but it does include households´ (non-human) wealth. Lucas and Rapping (1970) make a different 'simplification': they drop the wealth variable and the nominal rate of interest from their (empirical) analysis. Consequently, they are left with the (expected) rate of inflation, which therefore appears in their labor supply and unemployment equations[4)].

Given (1E) - (3E), we must now specify a model for the expected (future) real wage, w_t^*. Referring again to Lucas and Rapping (1970), we note that they use the adaptive expectations hypothesis. We have also carried out some test procedures using this hypothesis (cf. Virén (1981)). However, the adaptive expectations hypothesis suffers from several weaknesses; for example, if the rational expectations hypothesis is accepted. Moreover, using the adaptive expectations hypothesis creates many practical econometric problems. To mention one, the Koyck transformation, which is conventionally used in this context, breaks the serial independence of the error terms of the underlying behavioral equations.

Hence we do not employ adaptive expectations here, preferring instead to use (following e.g. Sargent (1978)) the 'autoregressive expectations' hypothesis; that is, the values of w_t^* are generated by an autoregressive model of w_t.

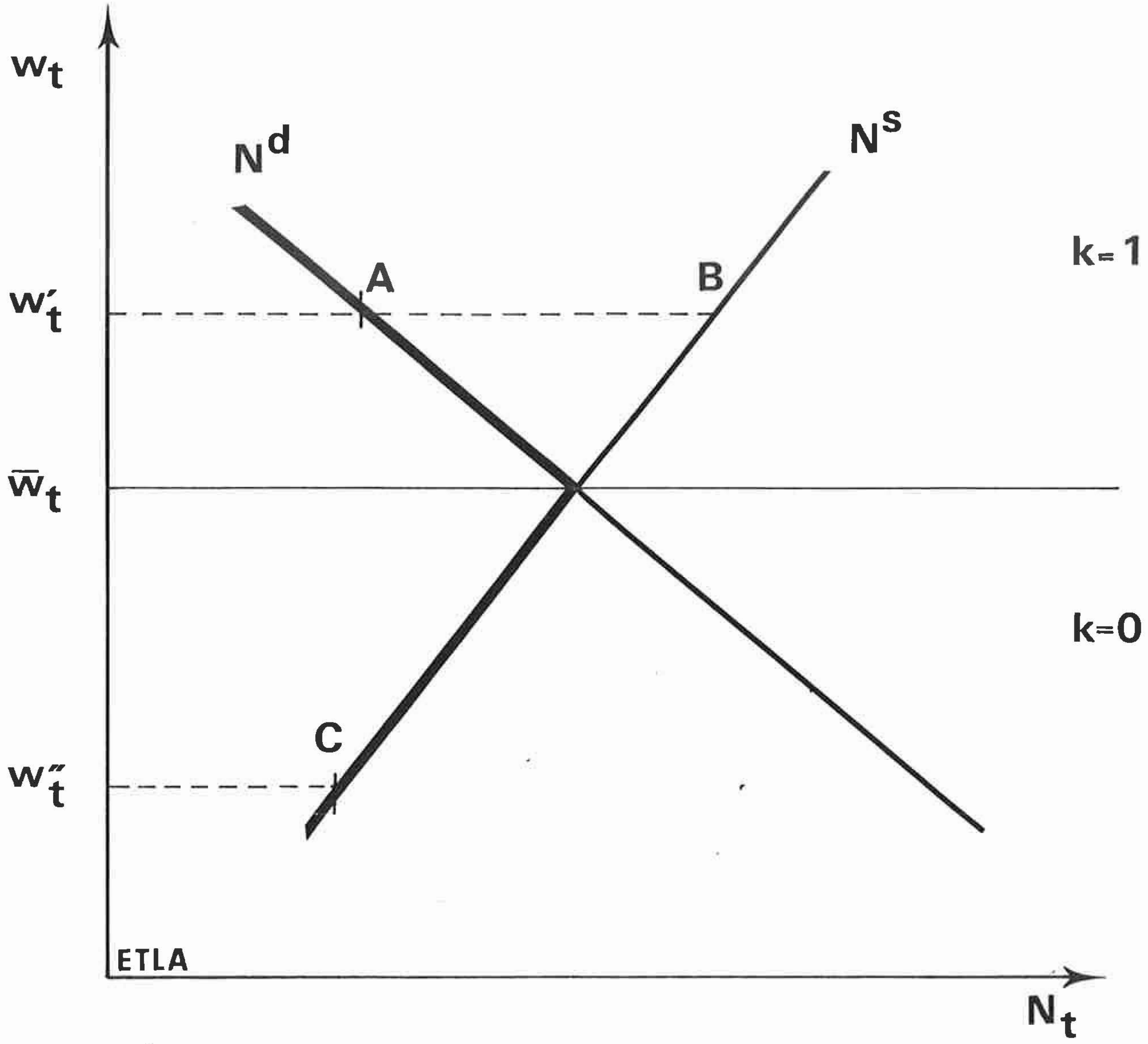
2. Test procedures

A great variety of tests has been performed on the equilibrium model, see e.g. Quandt (1978) and Hwang (1980) for short reviews. The problem is that some of these tests are of little practical use, because of, for instance, computational difficulties. This is especially so in the case where the hypotheses are nonnested. The procedures which have been chosen in the present paper are all computationally rather simple. All of them utilize the essential properties of an equilibrium labor market model.

Beginning with the simplest (even if somewhat informal) test, one can examine the dynamic behavior of the time series of the real wage, as the labor market equilibrium hypothesis explains movements in employment and unemployment in terms of the differential between the current and the expected real wage. Given the observed behavior of employment and unemployment, we need to find out whether this differential fluctuates or whether it stays constant. Altonji and Ashenfelter (1980) point out that this question hinges on whether the aggregate real wage obeys a random walk. Consequently, we start by testing the random walk hypothesis.

We turn now to formal test procedures and deal first with the test of Altonji (cf. Altonji (1978) and Altonji and Ashenfelter (1980)). This test procedure is based on the observation that the labor market equilibrium model implies

Figure 1.



that the residuals of the labor supply and the unemployment equations should be independent, whereas the disequilibrium view suggests that these residuals should be negatively correlated. For example, in a recession unemployment is higher than the corresponding equilibrium level, while at the same time employment is less than the labor supply. In terms of Figure 1 this would mean that, given the real wage rate w_t', for instance, there would be a negative labor supply residual, AB, and a corresponding positive amount of 'dis-equilibrium' unemployment.

Hence we need to estimate (1E) and (3E) and compute the conditional means of N_t and U_t. The deviations of N_t and U_t from these conditional means may be checked for independence, and if they turn out to be negatively correlated, the equilibrium hypothesis is rejected.

Next, we consider the test procedure proposed by Hwang (1980), which utilizes the stability of the parameters of the supply and demand equations. Take, for example, the following set of labor supply and demand equations:

(4) $$N_t = X_{1t}B_1 + a_1w_t + u_{1t}$$

(5) $$N_t = X_{2t}B_2 + a_2w_2 + u_{2t},$$

where (4) stands for the demand, (5) the supply equation, and X_{1t} and X_{2t} for the vectors of exogeneous variables. Now, the postulated hypothesis is that the demand and supply equations are correctly specified and that all the parameters are stable over time. It can be shown (see Hwang (1980) for details) that under the equilibrium hypothesis one can solve from (4) and (5) to obtain

$$(6) \qquad N_t = X_{1t}B_1' + X_{2t}B_2' + a_3 w_t + u_{3t} ,$$

where all the parameters are again stable and all the regressors are independent of the disturbance term, u_{3t}. An equation similar to (6) can, however, be derived under the disequilibrium hypothesis. This can be done by introducing a classification variable k_t, so that

$$(7) \qquad \begin{cases} k_t = 1 \text{ if } N_t^d \leq N_t^s \\ k_t = 0 \text{ if } N_t^d > N_t^s \\ N_t = k_t N_t^d + (1 - k_t) N_t^s \\ \quad = X_{1t}k_t B_1 + X_{2t}(1-k_t)B_2 + (k_t a_1 + (1-k_t)a_2)w_t + \\ \quad (k_t u_{1t} + (1-k_t)u_{2t}). \end{cases}$$

Given (4) and (5), we end up with an equation similar to (6), the main difference being that the 'disequilibrium' version has unstable parameters (coefficients and variance of the error term). This instability is also evident on the basis of Figure 1. The different observed levels of employment - say A and C - cannot be well predicted by constant parameters, given the exogenous variables of the supply and demand equations. (Of course, we should also exclude the possibility of ambiquity with the slopes of the supply and demand curves).

The problem now is how to test stability. One obvious way would be to utilize the Brown-Durbin-Evans type approach, suggested also by Hwang (1980). In our case, however, a more rigorous test could possibly be arranged by applying the technique of threshold (autoregressive) models suggested by Tong and Lim (1980). That is, one could write:

$$N_t = X_{1t}D_1 + X_{2t}D_2 + d_1 w_t + X_{1t}\phi D_1' + X_{2t}\phi D_2' + \phi d_1' w_t + u_t \,, \tag{8}$$

where ϕ is an indicator variable, so that: $\phi = 1$, if $x_t \geq c$, and $\phi = 0$, if $x_t < c$. x_t is the threshold variable and c the corresponding value of the threshold. For example, x_t could be the real wage rate, w_t, and $c = \bar{w}_t$ (see Figure 1). Clearly, (8) is simply a transformation of (7), and only now could one test the hypothesis $D_1' = D_2' = d_1' = 0$.

Obviously, the weak point in this test procedure has to do with the indicator variable. We should know which observation belongs to the demand and which to the supply regime. Here we have applied the MTARSO program. Given a threshold variable x_t, the program selects the value of the threshold, c, which minimizes the Akaike Information Criterion (AIC) over the data sample[5)]. Different variables were tried out as the threshold variable; that is, y_{ct}, U_{ct}, and w_{ct}, where y is the logarithm of real GDP, U the unemployment rate and w the logarithm of the real wage rate. All these variables are expressed as deviations from linear trend (that is because the test procedure is based on the assumption of constancy of c over the data sample).

All the test procedures presented above are based on the equilibrium labor market model. It might, therefore, be useful to complete this series of tests by estimating a disequilibrium labor market model along the lines of Rosen and Quandt (1978). In other words, we assume that the observed levels of employment represent the minimum of supply and demand (see Figure 1). Unemployment - in a disequilibrium sense - would then simply be the difference between supply and demand; for example, given the real wage rate w_t', the distance AB would represent the level of unemployment.

Now, if we accept the idea of persistent disequilibrium in the labor market, it does not make much sense to use an equilibrium model as a framework in the emprical analysis. Consequently, we use equations (1DE), (2DE) and (3DE), which are very similar to those of Rosen and Quandt (1978), the major difference being that in our specification the time trend is eliminated from all variables except t.

After estimating (1DE) and (2DE), we carry out two - somewhat informal - tests of disequilibrium. First, we compare the residual sums of squares, RSS, of the disequilibrium model with those of the reduced form of a corresponding equilibrium model. Second, we compute the disequilibrium unemployment rate according to (3DE) and compare it with the observed (employment survey) unemployment rate.

3. Empirical analysis

3.1. Data

Finnish quarterly data covering the period 1962.4-1979.3 is used in the empirical analysis, the data being seasonally adjusted (for more details, see Virén (1981)). As far as the key variables, N_t, and w_t, are concerned, we can mention that the former is measured in terms of numbers of employees and the latter is the wage index for the whole economy without any tax deductions.

3.2. Testing the random walk hypothesis

The test statistics for the random walk hypothesis are presented in Table 2 (The reader is referred to Altonji and Ashenfelter (1980), Fuller (1976), Section 8.5, and Kendall (1976), Chapter 2). All these tests give the same result: the random walk model for the real wage cannot be rejected at conventional levels of significance.

3.3. The test of Altonji

The estimation results of the labor supply and unemployment equations (1E) and (3E) are reported in Table 3. Both equations are estimated by OLS (because of the endogeneous variable w_t this method does not give consistent estimates) and by Hatanaka's (two-step) residual-adjusted Aitken estimator with instrumental variables with respect to both w_t and the lagged dependent variables[6].

Table 2. Test statistics for the random walk hypothesis

Test procedure	test without time trend	test with time trend
Box-Pierce test, Q(12)[1)]	9.62	11.38
Test based on turning points, z[2)]	.1928	.1928
F- ratio for testing $a_1 = 0$[3)]	3.97	.37
F- ratio for testing $a_1=a_2=a_3=a_4=0$[3)]	1.08	.20
t- ratio for testing $b_1 = 1$, given w_{t-1}[4)]	1.91	.43
t- ratio for testing $b_1 = 1$, given $w_{t-1}, w_{t-2}, w_{t-3}, w_{t-4}$[4)]	1.76	.57
F- ratio for testing $b_2 = 0$[4)]	.25	.21
F- ratio for testing $b_2=b_3=b_4=b_5=0$[4)]	.40	.40

1) The test is performed with respect to the residual of a regression w_t-w_{t-1} regressed on a constant term (and the time trend).

2) z is a normal variate.

3) The test is performed by running a regression: $w_t-w_{t-1} = a_o + \sum_{i=1}^{N} a_i w_{t-1}$, N = 1, 4.

4) The test is performed by running a regression: $w_t = w_o + b_1 w_{t-1} + \sum_{j=1}^{N} b_{j+1}(w_{t-j}-w_{t-j-1})$, N = 1, 4. The approximate critical value of the t- statistic at the 5 % level of significance is 2.93 (cf. Fuller (1976), p. 373).

As mentioned above, the anticipated real wage rate, w_t^*, was obtained by regressing w_t on w_{t-1} and a constant term

$$(9) \qquad w_t = \underset{(.0023)}{.0034} + \underset{(.0087)}{.9827}\, w_{t-1} \qquad R^2 = .9943, \; Q(12) = 9.89.$$

As pointed out in Section 3.2., the hypothesis that the coefficient of w_{t-1} is different from zero cannot be rejected at standard levels of significance (cf. Fuller (1976) p. 373). In other words, we cannot reject the hypothesis that the real wage innovation, $w_t - w_t^*$, is constant over time! For this reason, using our proxy for $w_t - w_t^*$ in this and subsequent tests is not completely justified.

The estimation results of the labor supply equation are very poor. Almost all the signs of the coefficient estimates are 'incorrect', and furthermore the properties of the error term clearly suggest that the model is misspecified. The unemployment equation performs better: all signs are 'correct' and the estimates are fairly precise. Furthermore, the error term of Hatanaka´s two-step (instrumental variable) estimation is white noise.

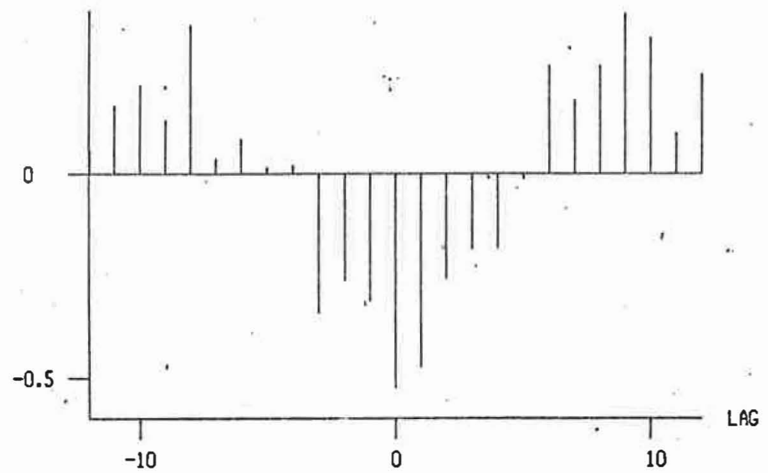
What we are interested in now is the relationship between the residuals of the labor supply and unemployment equations. Computing the coefficient of correlation between these residuals for period t gave -.525 in the case of OLS estimates and -.584 in the case of instrumental variable estimation (with no adjustment for residual autocorrelation; if the adjustment is made, the values -.396 and -.300, respectively, are obtained). These values are clearly significant when the t-test is applied at standard levels of significance. To determine the general pattern of the relationship between these two residuals we computed the cross-correlograms, that of the OLS residuals being reproduced in Figure 2 (the other cross-correlograms were very similar).

Table 3. Estimation results of the labor supply and unemployment equations

explanatory variable	N_t:OLS	N_t:Hatanaka 2S	U_t:OLS	U_t:Hatanaka 2S
constant	2.5199	2.7160	-.0012	.0088
	(2.70)	(2.17)	(0.01)	(0.05)
$(A/P)_t$	.0010	-.0069		
	(0.05)	(0.24)		
M_t	-.1719	-.1836		
	(2.36)	(2.36)		
$w_t - w_t^*$	-.0013	-.0689	-7.6374	-23.8699
	(0.02)	(0.57)	(2.21)	(2.14)
w_t^*	.0520	.0721		
	(1.43)	(0.98)		
N_{t-1}	.8758	.8427		
	(17.16)	(8.13)		
t			.0049	.0075
			(1.50)	(1.57)
U_{t-1}			.9489	.9069
			(27.03)	(17.31)
R^2	.9170	.8101	.9618	.9069
Q(12)	39.35	15.23	42.49	8.54
$\hat{\phi}_1$		.1227		.0376
		(0.77)		(0.22)
$\hat{\phi}_2$		.3771		.0772
		(2.64)		(0.56)

(Asymptotic) t-ratios in parentheses. The values of ϕ_1 and ϕ_2 are the two-step estimates of the AR(2) process.

Figure 2. Cross-correlogram of labor supply and unemployment residuals



3.4. Test of parameter stability

The likelihood ratio test statistics of the threshold model (8) are presented in Table 4. Although our main concern lies with the performance of the equilibrium model (1E) and (2E), we have also carried out the test procedures with the 'dis-equilibrium specification' (1DE) and (2DE). As noted above the optimal value (and, in fact, also the optimal lag) is determined on the basis of the search procedure of the MTARSO program. To discover how robust the test results are, we have also performed the test procedure with an 'arbitrary' threshold value, $c = 0$.

Given standard levels of significance, the chi-square statistics indicate clearly that the null hypothesis $D_1' = D_2' = d_1'$ cannot be rejected. Thus, the parameters of our models seem to change when the 'supply - demand' regime changes. This result is obviously at variance with the basic assumptions of an equilibrium model.

3.5. Estimating a disequilibrium model

The disequilibrium estimation of equations (1DE) and (2DE) was performed by using the CLUSTREG program (cf. Tarkka (1979)) and the method of selective least squares. Table 5 displays the estimates and asymptotic t-ratios. Also included in this table are the OLS estimates of the reduced form of (1DE) and (2DE) with respect to N_t[7].

Table 4. Likelihood ratio tests of the threshold model

explanatory variables in the model[1]	χ^2- statistic[2]	threshold[3]
$(A/P)_t$, M_t, $w_t - w^*_t$, w^*_t, N_{t-1}	20.53	$y_{ct}=-.0177$
-"-	25.09	$U_{ct}=-.8539$
-"-	14.91	$w_{ct-1}=.0078$
-"-	19.50	$y_{ct}=0$
-"-	19.47	$U_{ct}=0$
-"-	7.32	$w_{ct}=0$
$(A/P)_t$, M_t, w_t, y_t	27.27	$y_{ct-1}=-.0177$
-"-	35.48	$U_{ct-1}=.0728$
-"-	34.02	$w_{ct}=.0034$
-"-	16.71	$y_{ct}=0$
-"-	33.99	$U_{ct}=0$
-"-	20.79	$w_{ct}=0$

1) All equations also include a constant term.

2) The critical values of the chi-square statistic are: $\chi^2_{.05,5} = 11.07$, $\chi^2_{.01,5} = 15.09$.

3) The nonzero values of the threshold correspond to the minima of the Akaike Information Criterion (AIC).

Table 5. Results of disequilibrium estimation

$$\text{(I)} \quad N_t^s = \underset{(2.37)}{.0025} + \underset{(3.15)}{.4692M_t} + \underset{(7.42)}{.3969(A/P)_t} + \underset{(0.82)}{.0468w_t} \qquad R^2=.8545,\ n = 40,\ RSS = .00177$$

$$\text{(II)} \quad N_t^d = \underset{(3.41)}{.0100} - \underset{(4.20)}{.2129w_t} + \underset{(12.90)}{.6562y_t} - \underset{(5.19)}{.0003t} \qquad R^2=.9291,\ n = 28,\ RSS = .00088$$

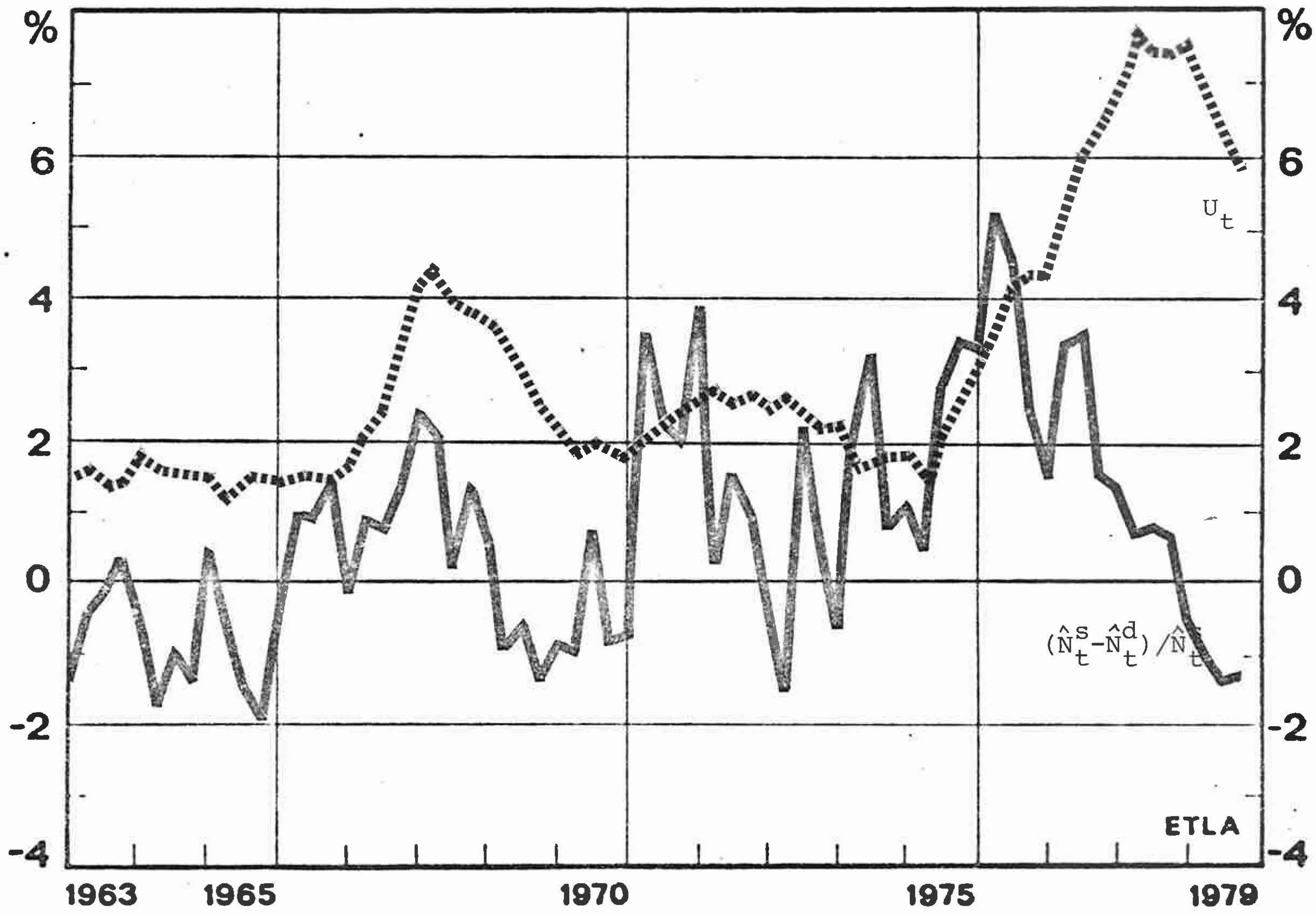
$$\text{(III)} \quad \bar{N}_t = \underset{(0.00)}{-.0000} + \underset{(1.32)}{.2056M_t} + \underset{(5.22)}{.2255(A/P)_t} + \underset{(2.96)}{.1682y_t} + \underset{(0.00)}{.0000t}$$

$$R^2=.7607,\ n = 68,\ RSS = .00575,\ Q(12)= 93.72$$

The parameter estimates of the disequilibrium model generally accord with a priori expectations (there is also a close similarity to the results obtained by Rosen and Quandt (1978)). The only exception is the coefficient estimate of the real wealth variable $(A/P)_t$, a result which runs somewhat counter to intuitive thinking (even if a positive supply elasticity with respect to assets is not a rare exception in empirical analysis, see e.g. Lucas and Rapping (1970) and Rosen and Quandt (1978)). An obvious explanation is that assets in period t represent the labor supply in period t-1.

The estimation results of the reduced form (III) are far from satisfactory. This also applies to the fit; the residual sum of squares is more than twice as large as the corresponding sum of the disequilibrium model. Given the specification (1DE) and (2DE), this result provides further support for the disequilibrium view.

Figure 3. Measured and disequilibrium unemployment



Given the estimates of (I) and (II), we have computed the predicted values of N_t^s and N_t^d and graphed the corresponding disequilibrium unemployment rate in Figure 3. Movements in this series follow those of the series of the observed (employment survey) unemployment rate follow rather closely over most of the period; only during the last two years of the data sample is there is a clear difference.

4. Concluding remarks

We have carried out a number of tests of the labor market equilibrium hypothesis. All these tests have given the same result: the equilibrium hypothesis can be rejected. Obviously, however, this result is conditional on the model specification employed. Although we have followed a fairly standard approach in this respect, there remains much scope for respecification. In particular, the demand for labor schedule and the overall framework for expectations formation need to be reconsidered and possibly respecified.

FOOTNOTES

1) The supply equation of Lucas and Rapping (1970) also includes the lagged dependent term, but it comes from the Koyck transformation, which is used in introducing adaptive expectations into the model.

2) (2E) can be derived from a standard cost of adjustment model, see e.g. Sargent (1980), p. 195. The only variable which is somewhat ambiguous in this equation is the expected (future) real wage. In an 'standard' case it would have a negative coefficient, but the introduction of, for instance, stocks could make it positive.

3) It is not completely clear how one could rationalize unemployment or a Phillips curve in our model, where the employment decisions of firms (in the same way as the decisions of households) are based on the idea of inter-temporal substitution (see Barro and Grossman (1975), Section 7.4, for a discussion about this 'general case'). So, even if we assume (following Lucas and Rapping (1970)) that changes in measured unemployment are related to real wage innovations, the eventual (observed) relationship might have an explanation which is different from that offered by Lucas and Rapping (1970).

4) We also experimented with the real rate of interest variable at an early stage of this study. Because the resulting estimates were very imprecise this variable was omitted in the subsequent analysis.

5) In the first stage of the estimation we, in fact, compute two equations for the sets of observations indicated by the threshold. These equations are then transformed into equation (8) assuming that both equations have the same constant term and the same error process. The MTARSO program has been developed by Ritva Luukkonen and Timo Teräsvirta. Unfortunately no documentation on the program is yet available.

6) Hatanaka´s two-step estimation is performed by using the MELITTA program of the Department of Statistics, of the University of Helsinki. $(A/P)_t$, $(A/P)_{t-1}$, w_t, w_{t-1}, P_t, P_{t-1}, r_t, r_{t-1}, M_t, M_{t-1}, and t were used as instruments for the lagged values of N_t and U_t (cf. e.g. Fuller (1976), section 9.8). The reduced form of w_t was specified in terms of the following exogeneous variables: $(A/P)_t$, M_t, N_{t-1}, w_{t-1}, t, r_t, and P_t.

7) Virén (1981) contains a larger set of results.

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