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DETERMINATION OF EMPLOYMENT WITH WAGE AND PRICE SPECULATION

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DETERMINATION OF EMPLOYMENT WITH WAGE AND PRICE SPECULATION*

by

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ABSTRACT

This paper studies whether aggregate fluctuations in employment may be explained within a market clearing framework as intertemporal substitution in labor supply and demand. An intertemporal substitution model for the firm is derived; this model is estimated with a Lucas-Rapping-type supply equation. Empirical results with Finnish data given strong support to this intertemporal substitution model.

1. INTRODUCTION

Since 1969, when the famous Lucas-Rapping analysis of labor market dynamics was published, the supply of labor has increasingly been analyzed in an intertemporal substitution framework (this choice is also advocated in Lucas (1970)). In this framework households respond to the deviation between current and future real wages; besides this "essential" factor labor supply is affected by the real rate of interest and real wealth.

It is hard to deny that this kind of framework has many appealing features, not the least being that it is consistent with the principles of individual maximizing behavior. Furthermore, the empirical analyzes of Lucas and Rapping (1969) gave support to the basic propositions of this model. As far as other evidence is concerned, most of the results have, however, been at variance with the intertemporal substitution hypothesis (cf. Altonji (1982) and Altonji and Ashenfelter (1980)).

One feature of the Lucas-Rapping framework which is particularly puzzling is the treatment of firm behavior. In fact, Lucas and Rapping assume that intertemporal substitution is relevant only to households. In their original article this is reflected in the static Jorgenson-type demand for labor schedule, which links labor demand to actual output and real wages only. Obviously, this asymmetric treatment of intertemporal substitution possibilities is not meaningful. One can even argue that the whole idea of intertemporal substitution is of more relevance for firms than it is for households because firms (may) have better possibilities to manage stocks, better access to financial markets and so on.

There are very few analyses dealing with the case where "speculative elements" affect the behavior of both labor supply and labor demand. A notable exception is Barro and Grossman (1976). Barro and Grossman show that allowing for speculative behavior among both firms and households makes it very difficult to obtain unambiguous and meaningful results with respect to the cyclical behavior of real wages, output and employment, in particular.[1)]

Before discussing the possibilities of testing the intertemporal substitution hypothesis with firms and households we briefly present the main elements determining the role of intertemporal substitution among firms, on the one hand, and households, on the other.

2. HOUSEHOLD BEHAVIOR

It is assumed in this intertemporal substitution set-up that households maximize their expected discounted utility over the life-cycle. The maximization problem is formulated here in terms of a simple two-period model with perfect foresight, i.e.:

$$(1) \qquad \max_{c_1, c_2, (1-h_1), (1-h_2)} u = u(c_1, c_2, (1-h_1), (1-h_2), A_2/p_2)$$

subject to: $A_0 + w_1 + R_2 w_2 = p_1 c_1 + R_2 p_2 c_2 + w_1(1-h_1) + R_2 w_2 (1-h_2) + R_2 A_2$

where c_i denotes consumption in period i, $(1-h_i)$ leisure, R the discount factor (with $R_1 = 1$), A_2/p_2 the bequest, w_i the wage rate, p_i the price level and A_0 the asset endowment. By solving (1) with respect to the c_i's and $(1-h_i)$'s gives the following "consumption and labor supply functions":

(2) $c_1 = d(A_0, p_1, R_2p_2, w_1, R_2w_2)$

(3) $h_1 = g(A_0, p_1, R_2p_2, w_1, R_2w_2)$

cf. Lucas and Rapping (1969) and Deaton and Muellbauer (1980), p. 310, for details. The crucial factor determining the properties of d(.) and g(.) is the degree of separability of the intertemporal utility function. Here, only weak separability is imposed on it. This, in turn, makes it very difficult to derive any unambiguous results with respect to p_2 and w_2 (see Hall (1980), pp. 10-11, for details). We prefer, however, having this most general form and allowing empirical analysis to determine the signs and magnitudes of the effects of p_2 and w_2.

3. FIRM BEHAVIOR

For firms there is no unique counterpart of the utility function of households as a source of intertemporal substitution effects. Instead, there are several elements which can be used in modelling these effects. Perhaps, the most important element is the fact that much of firms' output is storeable. (Of course, households can also hold stocks of goods; however, it is not necessary in the present context to introduce these stocks explicitly into households' maximization problem.) Thus, firms can make use of intertemporal relative prices in timing their output and demand for labor. Another possible explanation concerns "labor hoarding" in the sense that firms as dynamic monopsonies might try to recruit workers during periods of slack labor and thus escape the extra costs due to the spillover effects of hiring costs during periods when the labor market is tight (cf. Mortensen (1970 a,b) for a more formal analysis).[2] Using this discussion as a point of reference, we build a simple two-period model of firm behavior. It is assumed that the firm faces the following demand and (flow) labor supply schedules:

$$(4) \qquad p_t = k(s_t/\bar{y}_t)\bar{p}_t$$

$$(5) \qquad w_t = v((h_t-h_{t-1})/h_{t-1})\bar{w}_t$$

where p_t is the firm's price, s_t its sales, $\bar{p}_t$ its estimate of the average price level that will prevail in the market at time t, $\bar{y}_t$ its estimate of the aggregate level of sales, and $\bar{w}_t$ its estimate of the average (market) wage rate. The following standard assumptions are made with respect to k(.) and v(.): $k' < 0$, $k'' > 0$, $v' > 0$ and $w'' > 0$; see Mortensen (1970a,b) and Maccini (1976) for a microeconomic rationalization of these schedules.[3)]

Given (4) and (5), we can write the firm's maximization problem (in the case of positive inventory accumulation) in the following form:

$$(8) \qquad \max_{s_1,h_1,h_2} k(s_1/\bar{y}_1)\bar{p}_1 s_1 + R_2 k(s_2/\bar{y}_2)\bar{p}_2 s_2$$

$$- v((h_1 - h_0)/h_0)\bar{w}_1 h_1 - R_2 v((h_2 - h_1)/h_1)\bar{w}_2 h_2$$

subject to: $q_1 = f(h_1)$, $q_2 = f(h_2)$, $s_2 = q_2 + q_1 - s_1$

$$q_1 - s_1 > 0, \; q_1, \; q_2, \; s_1, \; s_2 > 0$$

where the production function, f(.), is assumed to be concave (not necessarily strictly concave). Moreover, it is assumed that the firm starts period 1 with zero stocks, and thus output in period one must be equal to or greater than sales in this period. As far as the labor input is concerned, however, it is assumed that the firm starts with the stock

$h_0 \cdot h_0$ represents, in fact, the endowment of this "dynamic monospony" firm.[4)]

The effects of these two "inventory" speculation hypotheses can readily be seen from the following first-order conditions with respect to h_1, h_2 and s_1 (assuming an interior solution with respect to all constraints):[5)]

$$(7)\qquad R_2k(.)\bar{p}_2f'(h_1) + R_2k'(.)\bar{p}_2(1/\bar{y}_2)s_2f'(h_1) - v(.)\bar{w}_1$$

$$- v'(.)\bar{w}_1(h_1/h_0) + R_2v'(.)(h_2^2/h_1^2)\bar{w}_2 = 0$$

$$(8)\qquad R_2k(.)\bar{p}_2f'(h_2) + R_2k'(.)\bar{p}_2(1/\bar{y}_2)s_2f'(h_2) - R_2v(.)\bar{w}_2$$

$$- R_2v'(.)(h_2/h_1)\bar{w}_2 = 0$$

$$(9)\qquad k(.)\bar{p}_1 + k'(.)\bar{p}_1(1/\bar{y}_1)s_1 - R_2k(.)\bar{p}_2$$

$$- R_2k'\bar{p}_2(1/\bar{y}_2)s_2 = 0$$

It is of some interest to compare (7) with the standard "marginal revenue product equals marginal cost"-identity of a static model. Now, the relevant price for the firm's extra output is the (expected) discounted price level for period 2. For wages, however, one must take into account the effect recruitment in period one has on the recruitment costs in period 2. By hiring more labor during the first period the firm can manage with a lower marginal cost of labor in the second period.[6)]

Next, we consider the comparative statics properties of our model. The corresponding results obtained from the first-order conditions (7) - (9) are tabulated below.

TABLE 1. Comparative statics results

Parameter increased	dh_1^*	dh_2^*	ds_1^*
$\bar{p}_1$	+	+	+
$\bar{p}_2$	+	?+	?-
$\bar{w}_1$	-	+	-
$\bar{w}_2$	+	-	-
$\bar{y}_1$	+	+	+
$\bar{y}_2$	+	?+	?-
h_0	+	-	+
r_n 1)	?-	+	?+

1) r_n is the nominal rate of interest. The indicated probable results require that $\partial^2(w_2h_2)/\partial h_1h_2$ is small relative to $\partial^2(w_2h_2)/\partial h_2^2$.

Clearly, the results conform rather well with intuitive beliefs. In particular, it can be pointed out that an increase in (expected) aggregate demand and the wage level in period 2 tends to increase inventory investment and thereby also the demand for labor.

Using these comparative statics results as a frame of reference we specify the following demand function for the firm's labor input in period 1:

$$(10) \qquad h_1 = h(\bar{w}_1, R_2\bar{w}_2, \bar{p}_1, R_2\bar{p}_2, \bar{y}_1, R_2\bar{y}_2, h_0)$$

where all variables, except w_1 (and r_n), should have a positive effect on h_1.

4. AGGREGATE DEMAND AND SUPPLY EQUATIONS

By exploiting the zero-degree homogeneity of equations (3) and (10), by using a simple log approximation and, finally, by aggregating over households and firms we end up with the following specifications:

$$\text{(11)} \qquad \log h_t^s = a_0 + a_1 \log(A_{t-1}/p_t) + a_2 \log(w/p)_t + a_3 \log(w/p)^* + a_4 r^* + a_5 \log N_t$$

$$\text{(12)} \qquad \log h_t^d = b_0 + b_1 \log(w/p)_t + b_2 \log(w/p)^* + b_3 \log y_t \quad b_4 \log y^* + b_5 r^* + b_6 \log h_{t-1}$$

where the asterisks denote (expected) future values, N being the number of households and r^* the real rate of interest, $r^* = r_n - \Delta \log p^*$.

Obviously, (11) and (12) are only first approximations of the supply and demand equations. For instance, labor supply should also try to take into account the effects of different demographic variables, taxes and schooling. Similarly, the demand for labor should consider, in particular the role of initial inventories, the stock of capital and the indirect labor costs. Thus, altogether one could end up with the following "final specifications":

$$\text{(13)} \qquad \log h_t^s = a_0 + a_1 \log(A_{t-1}/p_t) + a_2 \log(w/p)_t + a_3 \log(w/p)^* + a_4 r_t^* + a_5 \log N_t + a_6 \log N_d + a_t t + a_8 tax$$

$$(14)\qquad \log h_t^d = b_0 + b_1\log(w/p)_t + b_2\log(w/p)^* + b_3\log y_t + b_4\log y^* + b_5 r^* + b_6\log h_{t-1} + b_7\log I_{t-1} + b_8\log K_{t-1} + b_9 soc$$

where N_d refers to the number of children relative to the whole population, t to time trend, tax to the (average) tax rate, I to the stock of inventories (in constant prices), K to the stock of capital and soc to the indirect labor costs (relative to wages).[7)]

Before turning to the empirical analysis, we should consider the question of whether the labor market clears or not. A fairly standard assumption is that wages are exogeneous and do not clear the market. Thus, the supply schedule is dropped and only the demand schedule is estimated.[8)] We also allow for this possibility in the subsequent analysis, even though the basic assumption is that real wages clear the market so that $\log h_t^s = \log h_t^d$.

5. EMPIRICAL RESULTS

Equations (13) and (14) were fitted to Finnish quarterly data covering the period 1960.3-1978.4. Empirical analyses were performed for both the whole economy and the non-agricultural sector. The results presented in this paper correspond to the data for the non-agricultural sector only. All time series are seasonally adjusted; employment corresponds to man-hours and the real wage rate to the wage per man-hour deflated by the implicit price deflator of private consumption expenditure; for other details see the Appendix.

The important point about the data which should be considered here is the way in which the (expected) future values of $\log(w/p)^*$, $\Delta\log p^*$ and $\log y^*$ were derived (in the absence of suitable survey data). Two different methods were used. First, these values were determined as least squares predictions from the following information set of variables:

$$(15) \qquad I1 = (p_t, r_{nt}, p_{xt}, U_t, M2_t, y_t, (w/p)_t)$$

where r_n denotes nominal interest rate, p_x export prices, U the unemployment rate, M2 broad money and y GDP in constant prices. Secondly, ARIMA models were used to produce the forecasts.[9)] In both cases the forecasts were made for 12 future periods so that the weights were normalized to sum to one. The decay parameter was set to .95 (a similar approach is followed by Altonji (1982)).

We turn now to the estimation results. A set of results which was obtained by using the least squares predictions is presented in Tables 2 and 3 for the demand and supply equations, respectively. The results obtained by using the ARIMA technique were of the same flavour but - as is shown below - they were somewhat inferior in terms of accuracy of estimation and properties of the error terms, particularly in the case of the supply equation. Accordingly, we concentrate on the results achieved with least squares predictions.

All equations were estimated by OLS and TSLS to take into account the possibilities that the wage rate is exogenous, or that wages adjust to equalize labor supply and demand. (If the wage rate is exogenous, estimating the supply equation does not necessarily make sense - particularly, if the Keynesian idea of involuntary unemployment is used as a frame of reference).

TABLE 2.

Estimation Results for the Demand Equation

	Constant	w/p	(w/p)*	y	y*	r*	h_{-1}	K_{-1}	I_{-1}	soc.	R^2	h
(1)	-.300	-.170	.104	.176	-.089	-.064	.896				.992	1.269
	(0.90)	(6.67)	(3.74)	(5.34)	(3.32)	(1.70)	(23.13)					
(2)	.173	-.120	.064	.188	-.072	-.037	.856	-.039			.993	1.642
	(0.43)	(3.40)	(1.91)	(5.71)	(2.63)	(0.95)	(19.90)	(1.97)				
(3)	.163	-.120	.063	.187	-.071	-.037	.856	-.039	.001		.993	1.653
	(0.37)	(3.38)	(1.72)	(5.62)	(2.21)	(0.93)	(19.75)	(1.84)	(0.08)			
(4)	.445	-.114	.065	.182	-.070	-.034	.857	-.062	.002	.092	.993	1.503
	(0.83)	(3.12)	(1.76)	(5.39)	(2.16)	(0.86)	(19.73)	(1.87)	(0.22)	(0.89)		
(5)	-.470	-.205	.128	.198	-.099	-.066	.900				.992	0.890
	(1.35)	(6.86)	(4.28)	(5.70)	(3.60)	(1.75)	(22.89)					
(6)	-.237	-.177	.107	.198	-.090	-.055	.883	-.016			.993	1.157
	(0.48)	(3.42)	(2.41)	(5.80)	(2.97)	(1.32)	(18.69)	(0.65)				
(7)	-.250	-.177	.106	.198	-.089	-.054	.883	-.017	.001		.993	1.178
	(0.48)	(3.39)	(2.26)	(5.71)	(2.55)	(1.30)	(18.55)	(0.65)	(0.09)			
(8)	-.030	-.168	.103	.194	-.086	-.051	.881	-.034	.002	.060	.993	1.107
	(0.05)	(3.08)	(2.20)	(5.47)	(2.47)	(1.21)	(18.49)	(0.85)	(0.18)	(0.57)		

Equations (1) - (4) are estimated by OLS and equations (5) - (8) by TSLS the list of instruments being: $(w/p)^*$, y, y^*, r_n, h_{-1}, K_{-1}, I_{-1}, t, A_{-1}, N, N_d, w_{-1}, and the following variables: public consumption, volume of exports, export prices and volume of lending by commercial and other banks. h indicates Durbin's autocorrelation statistic. t-ratios are inside parentheses. All variables, except r* and soc, are expressed in natural logs.

On the whole, the results presented in Tables 2 and 3 are strikingly good, particularly those for the demand equation. The coefficient estimates are very precise (of expected sign and magnitude), error terms are practically white noise, and parameters are very stable.[10)]

It is, perhaps, only the coefficient estimates of the expected future aggregate demand variable, y^*, which do not correspond to "expectations". The negative sign implies that, given some level of current demand, an increase in future demand decreases the demand for labor (man-hours). It seems that this can only be explained by referring to substitution between capital and labor; an increase in y^*, given y, makes the firm accumulate its stock of capital, which may in the short run affect the demand for labor negatively. Notice that the "long-run" total effect of an increase in aggregate demand is almost unity; according to Table 2 these elasticities vary between .783 and .990.

As far as the wage variables are concerned, we get a clear negative effect (the long-run elasticities vary between -.389 and -.770). However, we find that indirect labor costs (irrespective of the measure used) do not significantly effect employment; the same is, in fact, true for inventories (although we hasten to add that the inventory series used here is very "noisy" and may not correspond very well to the proper variable).

The estimation results for the supply equation are somewhat mixed. The parameter estimates are in general very precise, being of correct sign and magnitude. The error terms are, however, highly autocorrelated, and - what is still more important - stability tests suggest that the parameters of (13) are not stable.[11)] These findings could, of course, be used as evidence

TABLE 3.

Estimation Results for the Supply Equation

	Constant	w/p	(w/p)*	A_{-1}	N	N_d	t	r*	tax	R^2	D-W
(9)	-4.073	.320	-.502	.219	1.233	-.383	-.013	.165		.944	0.936
	(0.85)	(4.58)	(5.92)	(4.96)	(2.16)	(5.63)	(3.02)	(1.63)			
(10)	-.694	.298	-.518	.216	.779	-.321	-.009	.177	.003	.944	0.903
	(0.11)	(4.02)	(5.96)	(4.87)	(1.01)	(3.29)	(1.32)	(1.73)	(0.88)		
(11)	-1.580	.452	-.545	.203	.951	-.335	-.014	.176		.941	1.171
	(0.30)	(5.45)	(6.18)	(4.45)	(1.61)	(4.69)	(3.04)	(1.69)			
(12)	-.782	.446	-.548	.206	.843	-.321	-.013	.179	.001	.941	1.161
	(0.12)	(4.92)	(6.09)	(4.41)	(1.07)	(3.19)	(1.80)	(1.70)	(0.20)		

Equations (9) - (10) are estimated by OLS and equations (11) - (12) by TSLS (for the respective list of instruments, see Table 1). t-ratios are inside parentheses. All variables, except t, r and tax, are expressed in natural logs.

against the labor market equilibrium hypothesis. The overall performance of the estimation results, particularly in the case of TSLS estimation, appears, however, to be at variance with the (Keynesian) hypothesis of a completely horizontal supply curve over the whole sample period.

Some further comments on the results for the supply equation are worth noting. The coefficients of the wage variables suggest that the short-run effect of a wage increase is positive while the long-run effect is neglible or slightly negative. This neglible long-run effect can be interpreted as some kind of support for the intertemporal substitution hypothesis (cf. Lucas and Rapping (1969) and Clark and Summers (1982)).[12)] The fact that assets affect labor supply positively is somewhat perverse - even though this kind of effect is very often found in empirical analyses (cf. e.g. Lucas and Rapping (1969)). An obvious explanation is autocorrelation between h_t and h_{t-1} (which follows from the definition $A_t = w_t h_t - p_t c_t + (1+r_{nt-1})A_{t-1}$). Finally, one can point out that all other variables, except the tax rate, have correct signs and are of expected magnitude. Even the real interest rate term behaves according to the intertemporal substitution hypothesis.

As mentioned earlier, these is no significant change in the flavour of the results, if the least squares predictions are replaced by ARIMA forecasts.[13)] The major change as regards the demand equation concerns the real interest rate; the respective coefficient becomes positive. For the supply equation, the corresponding changes are much greater: the wage terms have very imprecise coefficient estimates and the scale variable, $\log N_t$, even becomes negative.

6. CONCLUDING REMARKS

The main issue in this paper is the proposition that intertemporal substitution also applies to firms, not only to households as in the original Lucas-Rapping framework. Empirical analysis with Finnish data gives strong support for a demand for labor equation based on the idea that firms have inventories both in the form of storable goods and labor. Contrary to some recent empirical evidence we can thus conclude that the intertemporal substitution hypothesis might, after all, be of great relevance in explaining the short-run behavior of employment and output.[14)]

FOOTNOTES

1) See, however, Maccini (1976), who shows that a speculation model incorporating inventories might well be compatible with data in terms of the cyclical behavior of real wages, employment, and production.

2) The fact that inventories of labor may be partial substitutes for inventories of goods has been stressed by Blinder (1982). The effects of inventories on firm behavior over time is analyzed by e.g. Blinder (1982), Reagan (1982) and Reagan and Weitzman (1982). The main result of these studies is that inventories rationalize some kind of (asymmetrical) price rigidity.

3) When deriving (5) one could start by specifying the reservation wage on the basis of the household labor supply function (3), as done in e.g. Clark and Summers (1982). We do not, however, go into the details of this derivation here.

4) There would be no change in the basic results, even if linear inventory costs, $c(q_1 - s_1)$ were introduced into (6). Strictly convex inventory costs would, however, make a difference: $c'' > 0$ would imply that q_1 and s_1 are closely related. Cf. also Blinder (1982), who shows that a firm with a linear inventory costs structure does not change its production at all in face of fluctuations in demand, even though these fluctuations are quite persistent. Finally, reference can also be made to Arvan and Moses (1982), who consider a dynamic (cyclical) model of a firm's inventory and sales behavior. Owing to convex inventory costs, this model predicts that production jumps to zero at some critical level of inventories, starting again with zero inventories.

5) One (standard) way of rationalizing the interior solution is to assume that the demand and cost schedules are shifting upwards according to exponential trends with constant growth rates larger than the rate of interest and such that the growth rate of the cost schedule is larger than the growth rate of the demand schedule. Then the expectation of increasing costs and prices makes it profitable to build up inventories to be sold later on (cf. Phlips (1980) and (1983)).

6) We do not here explicitly consider the case in which demand is expected to decrease during the second period. Obviously, the effects depend very much on the way wages behave in such a situation. In particular, the relevant question is whether v(.) is symmetric around zero, i.e. whether a decrease or an increase in the firm's labor force have precisely similar absolute effects on the wage rate.

7) Through time trend we try to take into account the effects of schooling (which are presumably negative); the inclusion of I_{t-1} in the demand equation can be justified by the simple fact that $I_0 \neq 0$ in (8), while the role of K_{t-1} becomes apparent if one assumes that $q = q(h,K)$, and that the capital input is given to the firm in the short run.

8) Genuine disequilibrium models with a min-condition represent a further possibility.

9) The following ARIMA models were used in producing the forecasts for periods t+1, t+2,...,t+12.

(i) $\bar{w}_t = \underset{(5.82)}{.011} + (1 - \underset{(0.81)}{.088}B)(1 + \underset{(2.44)}{.253}B^4)a_t$ $\quad Q(14) = .960$

where $\bar{w} = (1-B)\log_e(w/p)$

(ii) $(1 - \underset{(1.71)}{.186}B - \underset{(2.35)}{.261}B^2)(1 - \underset{(5.85)}{.556}B^4)\bar{p}_t = .005 + a_t$

where $\bar{p} = (1-B)\log_e p$ $\quad Q(13) = 13.67$

(iii) $(1 + \underset{(1.39)}{.150}B)(1 + \underset{(3.21)}{.331}B^4)\bar{y}_t = \underset{(6.31)}{.017} + a_t$ $\quad Q(14) = 14.36$

where $\bar{y} = (1-B)\log_e y$

Q indicates the Box-Pierce statistics for 17 lags (the figures in parentheses are the respective degrees of freedom). As one can see, the real wage variable is nearly white noise. This, in turn, implies that the expected future change rate of real wages is almost constant. Obviously this has something to do with the relatively poor performance of the ARIMA forecasts in the demand and supply equations.

10) Various sets of instruments were used in the TSLS estimation without any noticeable difference in results. Computing the Breusch (1978) LM autocorrelation statistics for the AR(4) process, and the CUSUM (C) and the CUSUM SQUARES (C^2) test statistics for parameter stability gave the following results for equations (1) - (4) in Table (2):

	α_1	α_2	α_3	α_4	χ^2_4	C_b	C_f	C^2_b	C^2_f
(1)	.163	.149	-.067	-.050	3.474	.443	.392	.093	.086
	(1.20)	(1.04)	(0.47)	(0.34)					
(2)	.186	.202	-.067	-.158	6.236	.840	.355	.166	.072
	(1.41)	(1.41)	(0.47)	(1.07)					
(3)	.202	.209	-.067	-.146	6.528	1.171	.868	.157	.074
	(1.48)	(1.44)	(0.47)	(0.98)					
(4)	.181	.185	-.090	-.176	6.433	1.028	.850	.148	.072
	(1.31)	(1.25)	(0.63)	(1.16)					

t-ratios are shown in parentheses, b indicates that recursive residuals are computed backwards and f that they are computed forwards. Critical values of C and C^2 are at the 5 per cent level of significance: $C_{.05} = .948$, $C^2_{.05} = .192$. As far as equations (5) - (8) are concerned, the autocorrelation statistics are approximately of the same magnitude, as the following values of χ^2_4 indicate: (5) 5.006, (6) 8.176, (7) 8.631 and (8) 8.246.

11) The corresponding test statistics for equations (9) and (10) in Table 3 are:

(9) $C_b = .699$, $C_f = .625$, $C^2_b = .382$, $C^2_f = .393$

(10) $C_b = .845$, $C_f = .543$, $C^2_b = .448$, $C^2_f = .388$

12) Computing the LR test statistic for the parameter restriction $a_2 + a_3 = 0$ gives the following result for equation (9) in Table 3: $\chi_1^2 = 4.0$, which just exceeds the 5 per cent level of significance. On the basis of parameter values, one may assume that, using TSLS estimation, this restriction cannot be rejected.

13) When the demand equation was estimated by using the ARIMA forecasts, the following OLS estimation results were obtained:

	Constant	w/p	(w/p)*	y	y*	r*	h_{-1}	K_{-1}	I_{-1}	soc
(1')	-.060	-.086	.045	.193	-.139	.038	.917			
	(0.21)	(2.45)	(1.40)	(6.42)	(4.05)	(0.68)	(29.57)			
	R^2 = .992	h = 3.004								
(2')	.381	-.084	.048	.166	-.067	.027	.875	-.050		
	(1.14)	(2.45)	(1.54)	(5.26)	(1.47)	(0.48)	(24.71)	(2.29)		
	R^2 = .993	h = 3.026								
(3')	.356	-.087	.047	.169	-.070	.027	.873	-.050	.003	
	(1.04)	(2.47)	(1.51)	(5.14)	(1.51)	(0.48)	(24.24)	(2.29)	(0.41)	
	R^2 = .993	h = 3.038								
(4')	.730	-.081	.040	.176	-.068	.027	.864	-.091	.007	.175
	(1.90)	(2.33)	(1.29)	(5.43)	(1.48)	(0.51)	(24.32)	(3.07)	(0.96)	(2.00)
	R^2 = .993	h = 2.614								

where t ratios are shown in parentheses (for other symbols, see Table 2). The values of the CUSUM test statistics ranged from .337 to .907 and the values of the CUSUM SQUARES test statistics from .080 to .166; thus the null hypothesis of parameter stability could not be rejected.

14) The working of our model can be scrutinized by solving the reduced form in terms of h_t and $(w/p)_t$. For instance, with equations (6) and (11) the following model is then obtained:

$$(13)\quad h_t = -.615 - .077\,(w/p)^* + .142\,y_t - .065\,y^* + .010\,r^* + .635\,h_{t-1} - .011\,K_{t-1} + .057\,A_{t-1} + .268\,N_t - .094\,N_{d,t} - .004t.$$

$$(14)\quad (w/p)_t = 2.135 + 1.037\,(w/p)^* + .315\,y_t - .143\,y^* - .367\,r^* + 1.404\,h_{t-1} - .025\,K_{t-1} - .323\,A_{t-1} - 1.512\,N_t + .533\,N_{d,t} + .022t.$$

It can readily be seen that the resulting wage equation is an "expectations augmented" Phillips curve where the deviations of output from the normal or capacity level affect the wage rate in the short run. Moreover, the wage equation reveals that the real interest rate has a strong deflationary effect.

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Appendix

Variables and data sources

A	Stock of liquid assets, including broad money and bonds, deflated by p
h	Total working hours
I	Stock of inventories at 1975 prices
K	Stock of capital at 1975 prices
N	Working-age population
N_d	Number of children aged four or less relative to whole population
p	Implicit deflator of private consumption expenditure at 1975 prices
r	Real interest rate, equals $r_{nt} - \Delta \log p^*$ where r_{nt} is the banks' average lending rate
soc	Employers' expenditure on social security relative to wages, soc_1 equals soc plus employers' voluntary indirect labor costs
t	Time trend
tax	Average income tax rate
w	Wage rate per man-hour
y	Gross domestic product at 1975 prices

All variables, except r_{nt}, N_d and t, are seasonally adjusted by a modified X-11 adjustment method. The data for A, I, K, N, p, r_n, soc, t and y were obtained from the Bank of Finland (see Bank of Finland, Research department, Research papers No. 2/83). All other variables were constructed by the author; the corresponding data is available upon request. All data, except A, I, K, N, N_d, p, r_n, t and tax, used in empirical analyses above concern the non-agricultural sector. The data sample covers 1960.3-1981.4, twelve last observations were lost in making the forecasts for p, (w/p) and y.

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Luettelossa mainittuja keskustelualoitteita on rajoitetusti saatavissa kansantalouden osastolta. Kokoelma sisältää tutkimusprojekteja ja selvityksiä, joista osa on tarkoitettu myöhemmin julkaistavaksi sellaisenaan tai edelleen muokattuna. Keskustelualoitteina taltioidaan myös vanhempaa julkaisematonta aineistoa. - Koska keskustelualoitteet joissakin tapauksissa ovat raportteja keskeneräisestä tutkimustyöstä tai ovat tarkoitetut lähinnä sisäiseen käyttöön, mahdollisiin tekstilainauksiin tai -viittauksiin olisi varmistettava kirjoittajan suostumus.
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