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MODELLING THE DYNAMIC RELATIONSHIP BETWEEN WAGES AND PRICES IN FINLAND†

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by

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Abstract. The paper reports results on modelling the wage-price relationship in Finland, with an emphasis on dynamics. The models in this study are linear in parameters and based on seasonally unadjusted quarterly data from 1961(ii) till 1979(iv). They are specified in first differences with error correction mechanisms to ensure proper long-term behaviour. Particular attention is devoted to modelling the collective wage bargaining mechanism which is central in shaping the annual pattern of the development of earnings. The so-called stabilisation period at the end of the 1960s, during which the ordinary data generation process has not been operating, is also treated with care. At the specification stage, the models are estimated using two stage least squares. The final estimations, after finding a satisfactory dynamic structure, are carried out by FIML. The specification and estimation results indicate that it is possible to describe the wage-price relationship adequately with relatively few lags and that in the long run the real wages have followed the development of productivity. They are also in agreement with the purchasing power parity restriction. The quarterly wage and price developments of the years 1980 and 1981 are forecast with the estimated structure, and the results are in favour of the specification arrived at in the paper.

1. Introduction

The wage-price block of a macroeconomic model is a block which has often been analysed separately. The interaction between wages and prices in Finland has been a subject of analysis previously, and published studies include work concentrating on the wage-price interrelationship only, e.g. Molander (1969) and Korkman (1980), or related to it, Paunio and Suvanto (1981), as well as work done in the context of macroeconomic models, e.g. Vartia (1974).

During the years, some kind of a consensus seems to have emerged concerning the relevant causal variables in explaining the Finnish wage-price behaviour with a linear relationship. This paper does not aim at contributing much to the existing bulk of knowledge in this respect, and the theory behind these variables will not be discussed here. Nevertheless, we feel that insufficient attention has been paid to structural dynamics in all previous models, and this paper is an attempt to take account of the fact that the wage-price interaction is a dynamic phenomenon and should be modelled accordingly. The dynamic properties of the wage-price model will thus be the main concern of this paper.

2. The equations and the data

The initial form of this quarterly model is largely based on the equations in the annual macroeconometric model of Vartia (1974) with the estimation period of the years 1952 to 1970. In his model the relative change of the consumption price index (CPI) is explained by the relative changes in the earnings index (EI), import price index (IPI, in domestic currency) and indirect taxes less subsidies. The last-mentioned variable is not available on the quarterly basis for the whole estimation period which comprises the quarters 1961(ii) to 1979(iv). It will in our models be replaced by the rate of the turnover tax which is the dominant component of indirect taxes, whereas the rôle of the government subsidies in affecting consumption prices has been less important in the sixties and seventies than it was in the fifties.

In Vartia's wage equation the relative change of the unit cost of labour is explained by the relative changes in consumption prices and productivity, and the change in the rate of unemployment. The equation is dynamic while the price equation is static. Both are built on relative changes without regard to long-term properties.

The wage equation of this paper can be written as

$$a_{11}(L)\nabla w_t = \mu_1 + f_1(a^*_{12}(L)p_t, a^*_{13}(L)u_t, a^*_{14}(L)r_t, d_t, d^s_t) + \varepsilon_{1t} \qquad (2.1)$$

where w_t is the logarithm of EI, p_t is the logarithm of CPI, u_t is the rate of unemployment, r_t is the logarithm of productivity[1)], d_t and d^s_t are two binary variables to be discussed later on and μ_1 is a constant. The error process $\{\varepsilon_{1t}\}$ is a stationary ARMA process. Symbol L is the lag operator, $\nabla_h = 1 - L^h$ and, in particular, $\nabla_1 = \nabla$. The lag polynomials $a^*_{1k}(L) = a^*_{1k0} + \sum_{j=1}^{p_{1k}} a^*_{1kj}L^j$, $k = 1,\ldots,4$, where $a_{110} = 1$. Since it is our task to specify the structural dynamics of the equation and economic theory is of little help, we assume that p_{1k}, $k = 1,\ldots 4$, are unknown.

The general form of the price equation is

$$a_{22}(L)\nabla p_t = \mu_2 + f_2(a_{21}^*(L)\, w_t, a_{23}^*(L)p_t^m, \nabla s_t, d_t^s) + \varepsilon_{2t} \quad (2.2)$$

where p_t^m is the logarithm of IPI, s_t is the rate of the turnover tax, μ_2 is a constant, $a_{2k}^*(L) = a_{2k0}^* + \sum_{j=1}^{p_{2k}} a_{2kj}^* L^j$, $k = 1,2,3$, and $a_{220} = 1$, and $\{\varepsilon_{2t}\}$ is a stationary ARMA process which may be correlated with $\{\varepsilon_{1t}\}$. Again, p_{2k}, $k = 1,2,3$, are supposed to be unknown and have to be estimated from data. Equation (2.2) presupposes the long-term constant percentage mark-up pricing by firms but allows for changes in the turnover tax rate.

Two important choices have to be mentioned before proceeding further. First, both equations are in first differences and will be linear in parameters. Because of the difference form, special attention has to be paid to ensuring reasonable long-term behaviour of the model. This will be discussed below. Second, all the variables are seasonally unadjusted. Individual seasonal adjustment of the time series would have obscured the study of dynamics and has therefore been out of the question, for a discussion, see Wallis (1974). As will be seen shortly, seasonal adjustment would have caused particular problems in specifying the wage equation.

In this paper, we define the wage and price variables as endogenous and treat the rest as exogenous. Unemployment has traditionally been considered to be exogenous to the price-wage block, and this practice will be maintained in this research. Another variable, whose exogeneity should be discussed here, is the import price variable. Since the import prices contained in IPI are expressed in the domestic currency, the logarithm of the index consists of two additive components, the logarithmic import prices in international currency and the exchange rate. Obviously, the former component is genuinely exogenous for a small open economy, whereas the latter one is endogenous, depending on economic policies of the country in general and the domestic inflation in particular.

The question then is whether the import price variable should be regarded as endogenous in the model. Our answer is negative for the following reasons. For the first, there is no stable policy rule relating the exchange rate to the development of domestic and international inflation. The exchange rate policy has been changing with governments, and the decisions to change the external value of the currency have been taken on different grounds at different times. Were there a stable feedback mechanism from domestic prices to the exchange rate, it would certainly be worth an effort to model it into the system. For the second, if we leave it to the data and use standard methods, we do not find evidence for the hypothesis that domestic prices would Granger-cause the import prices. This does not necessarily mean that there is no feedback, it only implies that possible feedback is not systematic enough to be revealed by simple statistical methods. Finally, it should be mentioned that the Finnish mark has not been floated during the observation period, which also makes the notion of exogeneity of the import price variable more palatable on a priori grounds.

3. The identification of the model

So far we have made no assumptions about the error processes in (2.1) and (2.2) other than that they are correlated stationary ARMA processes. Furthermore, the orders of the lag polynomials have been assumed unknown. In order to identify the wage and price equations we therefore make use of an identification result by Hatanaka (1975), see also Harvey (1981), Chapter 9. This result says in essence that when the orders of the lag polynomials are unknown, a variable with all its lags can be substituted for a variable in the traditional theory of identification, and the results of that theory are applicable to our case after this modification. This does not, however, concern constant terms or seasonal dummy variables.

The above entitles us to claim that both structural equations in system (2.1)-(2.2) are overidentified: without further assumptions of the error process the system is in fact identified up to a 2 x 2 diagonal matrix of lag polynomials of arbitrary order. The system will remain overidentified during all phases of the work reported here.

4. Steady state variables or ECM

Both equation (2.1) and (2.2) are basically assumed to be in logarithmic first differences. In the pure first difference form there would be no constraint in the system to prevent wages and prices from diverging from each other into completely different directions in the long run. Since this does not happen in practice, we shall make use of steady state variables which describe an error correction mechanism (ECM), forcing the system, allowed to be temporarily in disequilibrium, nearer the equilibrium path. These variables customarily have their roots in economic theory. This idea was first put into practice in the U.K. wage equation by Sargan (1964). For further application and discussion see Davidson et al. (1978), Davidson and Hendry (1981), Hendry (1980) and Sargan (1980).

Considering the relationship between wages and prices we assume that in equilibrium

$$W_t/P_t = M_1R_t \tag{4.1}$$

where M_1 is constant, i.e. the real wages stand in constant proportion to the productivity of labour.[2] In (2.1), the steady state condition (4.1) is translated into

$$\mu_1 + a_{15}(w_{t-g}-p_{t-g}-r_{t-g}),\ g > 0,\ a_{15} < 0.$$

Lag g cannot always be specified by theoretical considerations. If productivity has increased more rapidly than real wages, this has created more room for wage increases, whereas in the opposite situation the growth in real wages will eventually slow down.

Sargan (1964, 1980) is considering in his wage rate equations a real wage variable of type $w_{t-g} - p_{t-g}$, which is interpreted through the theory of bilateral monopoly as something that both sides have in their mind as a point of reference in wage bargaining.

However, Sargan's wage equations also contain a time trend which could tempt one to give an interpretation to the difference $s(t) = w_{t-g} - p_{t-g} - c(t-t_0)$, where c and t_0 are constants. This would mean that the equilibrium path of the logarithm of the real wage is assumed to be a linear function of time. Since c is an unknown parameter, the coefficient of s(t) can only be estimated by having both $w_{t-g} - p_{t-g}$ and t in the equation as separate variables, as in Sargan (1980).

The productivity variable in (4.1) contains a positive trend, which might speak in favour of the above interpretation of s(t). Unfortunately, the U.K. data strongly discourage that kind of interpretation. When the estimate of c is significant, which is not always the case, see Sargan (1980), it is positive, indicating together with the negative coefficient of $w_{t-g} - p_{t-g}$ that the equilibrium time path of real wages in the U.K. from 1952 to 1973 would have been downward sloping.

On the other hand, we require that in equilibrium

$$P_t/P_t^m = M_2 \qquad (4.2)$$

where M_2 is constant. This is a proper assumption in a small open economy like Finland. Thus the price equation (2.2) will contain a term $a_{24}(p_{t-h}-p_{t-h}^m)$, $h > 0$, $a_{24} < 0$, where lag h cannot be specified a priori. Thus (4.2), which is a purchasing power parity (PPP) restriction, tells us that the country cannot for instance have an inflation rate steadily exceeding the international inflation rate without this either having consequences to the exchange rate or leading to measures attempting to bring the inflation rate down, or both. Constant ratio (4.2) also implies that the long-term price elasticity with respect to import prices equals unity.

Although the long-term behaviour of wages and prices is now incorporated in the model, the equations are not yet specified in sufficient detail as to allow estimation. A few problems still await attention and next we turn to them.

5. Wage bargaining procedure

A crucial feature of the Finnish wage bargaining system is the collective negotiation mechanism. Negotiations for a new wage contract in the private sector are usually started on the top level between the representatives of the Federation of the Trade Unions and the Confederation of Employers. Only if these negotiations break down do the talks continue on a lower level, between member unions and their opposite numbers. In such a case it is customary that a big and influential union, e.g. the metalworkers' one, concludes a settlement first, and the terms stipulated in that settlement will serve as a guideline in the other negotiations, also in the public sector. Most of the contracts will generally follow that guideline fairly closely and in a relatively short time.

This system has the effect that the earnings take a big leap once or possibly twice a year as shown in Figure 1, depending on the contents of the agreement. The contract quarter with a peak in the first differences of the earnings has not remained the same during the whole observation period but has been switching between the first and the second one. A mechanical seasonal adjustment by moving averages would therefore do considerable damage to a modelling effort of the wage and price dynamics based on quarterly data.

An obvious idea to handle the peaks in the earnings variable would be to construct a dummy variable to account for the quarters at which a general wage adjustment occurs. It is, however, insufficient as such and does not bring acceptable results. Instead, we have chosen to model the bargaining procedure in a more detailed way. A number of authors have proposed the use of price expectations in wage equations, e.g. Sargan (1980). When a centralised wage bargaining mechanism is in operation, the formation of price expectations may be a very complex procedure. Nowadays both wage negotiation partners are fully aware of the fact that the outcome of the negotiations will affect the price level during the period of settlement. This makes the use of price expectations expressed as a function of present and past prices and generated using e.g. Box-Jenkins techniques as in Kirby (1981) a doubtful approach in this context, although they could be expected to be a viable alternative when the wage contracts are more disaggregated, concluded fairly independently of each other, and are consequently more uniformly spread over time.

Instead, we propose a feasible yet simple solution which suggests the use of the rate of inflation to describe the behaviour of the agents in the wage bargaining procedure. For the first, any notion on future price developments is at least partially based on this rate. For the second, the unions often seem to have declared during the negotiations that they also seek compensation for the past price increases. Incidentally, this may have happened in the U.K. as well, see Shorey (1977). Thus we just couple together the past annual rate of inflation $\nabla_4 p_{t-1}$, known to the bargaining parties at time t and a dummy variable d_t, basically with value one at the contract quarters and zero elsewhere. When a two-year wage contract is concluded, the same inflation rate is used for both years and then $d_{t+h}\nabla_4 p_{t-1}$ obtains a non-zero value for the quarter t+h at which the second year's wage increase is due. A few times the annual wage increase has been divided on two quarters within the year, and in that event the dummy variable has been given the value one half at the quarters with an increase and zero elsewhere, while the inflation rate has again been the one known to the bargainers at the moment of negotiation. All these details have not been accommodated into the notation, which would apparently have become unnecessarily complicated, but it is useful to keep them in mind.

Another problem related to the centralised wage bargaining is the steady state condition which should describe long-term behaviour. The condition as such was clearly rejected by data and using a smoothed variant was no remedy. Eventually, the equilibrium condition was attached to the wage bargaining mechanism. Variable $d_t(w_{t-1} - p_{t-1} - r_{t-1})$ then has an instant interpretation: the wage bargaining is also affected by the development of productivity. If the industry has enjoyed sustained productivity growth, the trade unions probably find it easier to negotiate their members substantial wage increases than if the opposite has been true. It can also be argued that the movements in earnings between the contract quarters have little significance from the equilibrium point of view and the really important changes in wages emanate from the contracts.

6. Stabilisation

In this section we discuss the so-called "stabilisation period" following a considerable devaluation of the Finnish mark in October 1967 and its consequences to the present model building effort. Following the devaluation the prices were frozen down and the unions showed voluntary restraint in their wage bids. This was commonly called stabilisation of the economy. The usual data generating mechanism was clearly not in operation during the stabilisation in 1968 and 1969. This was noticed empirically through early specification efforts which yielded models with very unsatisfactory fit for observations of 1968 and 1969.

In order to describe the structural change in the stabilisation period properly we first supposed that the usual wage bargaining mechanism did not operate between 1968(ii) and 1969(iv) so that the variables representing this phenomenon were temporarily "switched off" by setting them to zero. The wage bargaining procedure was now represented by a dummy variable $d_t^s d_t$, where d_t^s was a binary variable having value of unity from 1968(ii) till 1969(iv) and zero otherwise. Variable d_t^s was also used to model the switch-off, and the wage equation could now be represented in the form

$$a_{11}(L)\nabla w_t = \mu_1 + a_{12}(L)\nabla p_t + a_{13}^*(L)u_t + a_{14}(L)\nabla r_t + a_{15}d_t(1-d_t^s)(w_{t-h} - p_{t-h} - r_{t-h}) + a_{16}d_t d_t^s + \varepsilon_{1t} \qquad (6.1)$$

Similar measures were taken when the price developments in 1968 and 1969 were modelled. The ECM in the price equation was supposed to be inoperative, because prices were controlled. The import price variables ∇p_t^m, $\nabla p_{t-1}^m, \ldots$, were assumed not to contribute to the domestic inflation for the same reason. The effects of price controls did, however, accumulate in the steady state variable. We also accounted for the possibility that some exogenous factors, which were left undefined, affected the domestic prices during the stabilisation period, and we used d_t^s to represent them. It turned out later that this was not necessary. The turnover tax rate remained unchanged during the stabilisation period so that no modification was needed.

Thus the price equation became

$$a_{22}(L)\nabla p_t = \mu_2 + a_{21}(L)\nabla w_t + (1-d_t^s)a_{23}(L)\nabla p_t^m + a_{24}(1-d_t^s)(p_{t-h} - p_{t-h}^m)$$
$$+ a_{25}\nabla s_t + a_{26}d_t^s + \varepsilon_{2t} \qquad (6.2)$$

and, together with (6.1), this form was the starting-point for the specification of the dynamics and estimation of parameters.

7. Preliminary structural specification

In specifying the lag structure of a dynamic relationship, a trade-off may occur between the structural and error dynamics. In this work the goal has been to leave as little dynamics as possible in the error process and represent the dynamic features of the wage-price interaction mainly by structural dynamics. Nevertheless, no simplifying assumptions have been made about the error process of the system during the specification.

The specification of structural dynamics was started with equations (6.1) and (6.2) with relatively long lags on all explanatory variables with lag polynomials. A simplification at the first stage was to allow no lags of the wage variable in the wage equation and no lags of the price variable in the price equation, respectively. However, if the visual inspection of results of preliminary estimation suggested lags in them, such a possibility was allowed for. This procedure for finding the orders of lag polynomials thus resembled the one Harvey (1981), p. 245, calls the direct approach to the specification of transfer function models.

No strict procedure of testing a sequence of nested hypotheses from general to specific to find the correct orders of lag polynomials was followed in this study. The model with two structural equations was found too complicated for finding a sensible unique path for testing down. Preliminary experiments also showed that rigid tests left us with a more general structure than necessary. Such structures were often difficult to interpret as they frequently contained estimates with "wrong signs".

If a significant lag was removed from such a structure it sometimes happened that another lag still in the model lost its significance and could be deleted as well. The mere removal of both lags was generally not considered to be a final solution, but a situation like this was interpreted to indicate some kind of structural inadequacy, for instance a missing variable. Hence, an important cause for the specification and estimation to proceed without rigid rules was the fact that not only was the specification of the lag structure an open question but the structure of the model in the wider sense was further improved as well when the work went on. In the respecified structure the peculiar significant estimates were usually less prominent, and sometimes they virtually disappeared.

8. Preliminary structural estimation

The preliminary estimation was carried out separately for both equations using IVE. The period of estimation comprised quarters 1961(ii) to 1979(iv). Although no simplifying assumptions of the error process were made, both equations were first estimated by 2SLS. The residual autocorrelations were then checked to see whether 2SLS indeed was a consistent method of estimation. Had the residuals turned out to be autocorrelated but not cross correlated with the possible exception of lag zero, IVE with autoregressive errors could have been used. If the residuals were also cross correlated, limited information estimation would become more complex. One possibility would have been the use of AIV with all instruments strictly exogenous and all lagged endogenous variables treated as endogenous. This is apparently a rather inefficient method if there is no serial correlation in the errors, and that is why it was not blindly applied from the start. On the other hand, the limited information methods in general do have a lot to recommend at the early stages of specification as they are computationally easy and prevent the effects of serious misspecification from spreading from one structural equation to the other.

In the wage equation, 2SLS eventually boiled down to OLS, since the unlagged price variable was omitted as insignificant and the residuals were appreciably close to white noise, see Table 1. The estimated wage equation was

$$\nabla w_t = \underset{(5.34)}{0.013} + \underset{(1.97)}{0.21}\, \nabla p_{t-1} + \underset{(7.71)}{0.51}(1 - d_t^s) d_t \nabla_4\, p_{t-1}$$

$$+ \underset{(2.38)}{0.018}\, d_t^s d_t - \underset{(-2.03)}{0.0019}(1 - d_t^s)\, d_t\, (w_{t-1} - p_{t-1} - r_{t-1})$$

$$+ \underset{(1.60)}{0.039}\, \nabla r_t + \underset{(2.10)}{0.27}(1-d_t^s) d_t \nabla_4 r_{t-1} - \underset{(-4.00)}{0.77}\, \nabla u_{t-3} - \underset{(-3.15)}{0.59}\, \nabla u_{t-4}$$

$$- \underset{(-2.99)}{0.56}(1-d_t^s) d_t u_{t-1} + \hat{\varepsilon}_{1t} \qquad (8.1)$$

$$s_w = 0.0097, \quad R_w^2 = 0.844, \quad T = 75$$

and the price equation, which was estimated by 2SLS, became

$$\nabla p_t = - \underset{(-2.45)}{0.0049} + \underset{(-4.93)}{0.20}\, \nabla w_t + \underset{(5.40)}{0.18}\, \nabla w_{t-1} + \underset{(2.85)}{0.10}\, \nabla w_{t-2}$$

$$+ \underset{(3.26)}{0.11}\, \nabla w_{t-3} + \underset{(4.80)}{0.095}\, (1 - d_t^s)\, \nabla p_t^m + \underset{(3.09)}{0.067}\, (1 - d_t^s)\, \nabla p_{t-1}^m$$

$$- \underset{(-3.66)}{0.030}\, (1 - d_t^s)(p_{t-4} - p_{t-4}^m) + \underset{(4.61)}{0.45}\, \nabla s_t + \hat{\varepsilon}_{2t} \qquad (8.2)$$

$$s_p = 0.0060, \quad R_p^2 = 0.780, \quad T = 75$$

where the figures in parentheses are t-values.

The results show that the hypothesis of real wages following the development of productivity in the long run is not contradicted by the data. The variable $d_t d_t^s$ is needed for the characterisation of the outcome of the wage bargaining during the stabilisation. In the short-term, wages respond to prices after a delay of one quarter and the coefficient estimate for the contribution of prices on the wage drift is 0.21.

The rôle of the unemployment rate in the wage equation deserves a comment. In earlier work the rate has been either in first differences or in levels. First differences have been employed by Vartia (1974) and Korkman (1980), whereas Paunio and Suvanto (1981), using the period 1968(i)-1974(iv), found empirical support for a Phillips curve type relationship but none for the differences. During the present work, repeated specification exercises indicated without any ambiguity that the rate of unemployment should be differenced. The differenced rate of unemployment appeared only with a lag of at least three quarters. This made the assumption of exogeneity of the unemployment easier to sustain. At a later stage, it was tentatively assumed that unemployment is also a factor influencing the outcome of wage bargaining. Strong excess supply of labour should weaken the bargaining positions of the trade unions and vice versa. This possibility was taken into account by introducing a variable $(1 - d_t^s)\ d_t\ u_{t-1}$, whose regression coefficient in (8.1) is significant in agreement with our assumption. We also tried $(1 - d_t^s)\ d_t\ \nabla_4\ \dot{u}_{t-1}$ in line with the price variable, but it could not compete with the levels specification.

It can be asked whether the differenced unemployment rate can at all be interpreted as representing the situation in the labour market. The wage drift and changes in earnings due to the extent of and variation in piece rates may be related to the economic performance in general rather than to the labour market in particular. Then the differenced unemployment rate would be a proxy for changes in economic activity. It may also pick up seasonal effects, since the unemployment rate contains seasonal variation.

The productivity increase may also be a source of wage drift, although the evidence is not overwhelming. Recent productivity development also seems to be used as an argument in the wage bargaining, as the variable $(1 - d_t^s)\ d_t\ \nabla_4\ r_{t-1}$ has a significant coefficient estimate. If this variable is omitted, the steady state variable, in which the productivity is included, receives a slightly larger coefficient with a larger t-value. This is not unexpected, since in that case the impact of productivity on outcome of wage bargaining is modelled solely though the ECM.

As a whole, the specification and preliminary estimation indicate that the most important feature in the Finnish wage equation is the wage bargaining mechanism, and its adequate specification is crucial for the success in describing the behaviour of wage and prices in Finland. The wage drift is obviously of much less importance, which might also be guessed from Figure 1.

Turning to the price equation, it can be noticed that the PPP condition is supported by the data, and the best fit is obtained when the lag is four quarters. The short-term import price elasticity is in accordance with that reported in Vartia (1974). The wage differences appear in the price equation up to lag three, which is natural because the wage increases stipulated in the collective wage agreements do not immediately translate into price increases, but this happens gradually. The estimated coefficients show how the impact of a wage increase is spread upon the four quarters of the year, the most common length of a wage settlement. Any remaining impact cannot in general be separated from the effects of the next wage agreement when this type of lag function is used.

The rate of the turnover tax affects prices, and the specification of (8.2) indicates an immediate adjustment of the prices to a new level when s_t changes. A separate stabilisation dummy variable is not needed in the price equation.

As mentioned earlier, the residual autocorrelation of the equations (8.1) and (8.2) were generally small in absolute value with two slight exceptions in the price equation, albeit not at crucial lags, see Table 1. The cross correlations were reasonably small as well except for the value 0.28 at lag ten. As mentioned above, the preliminary estimation was carried out using limited information methods, and the idea was to apply FIML only in the final estimation. As Table 2 shows, there is no evidence of the cross correlation of errors at lag zero in the system, so that the use of FIML appears redundant. Since the full information methods are more sensitive to the specification errors than 2SLS, we nevertheless decided to apply FIML. Large differences in results as compared to (8.1) and (8.2) would then compel us to go back and check the specification of the model once more.

9. Results of FIML estimation

When (8.1) and (8.2) were estimated by FIML, the changes in coefficient estimates were negligible, so that the estimates are not reproduced here. Next the specification was changed by including a lagged price variable ∇p_{t-1} in the price equation. This possibility was considered during the specification and judged to be worth a chance.

When this specification was estimated by FIML the changes in the wage equation were very small, but the estimated equation is given here for reference:

$$\nabla w_t = \underset{(4.63)}{0.013} + \underset{(1.79)}{0.21}\,\nabla p_{t-1} + \underset{(7.66)}{0.52}\,(1 - d_t^s)\, d_t\, \nabla_4 p_{t-1}$$

$$+ \underset{(1.27)}{0.019}\, d_t^s\, d_t - \underset{(-2.29)}{0.0019}\,(1 - d_t^s)\, d_t\,(w_{t-1} - p_{t-1} - r_{t-1})$$

$$+ \underset{(2.76)}{0.28}\,(1-d_t^s)\, d_t\, \nabla_4\, r_{t-1} + \underset{(1.52)}{0.040}\,(1 - d_t^s)\, \nabla r_t$$

$$- \underset{(-2.53)}{0.73}\, \nabla u_{t-3} - \underset{(-2.35)}{0.58}\, \nabla u_{t-4} - 0.57\, d_t\, u_{t-1} + \hat{\varepsilon}_{1t} \qquad (9.1)$$

$s_w = 0.0097, \quad T = 75.$

The price equation became

$$\nabla p_t = -\underset{(-1.84)}{0.0044} + \underset{(2.90)}{0.24}\, \nabla p_{t-1} + \underset{(3.82)}{0.17}\, \nabla w_t$$

$$+ \underset{(3.07)}{0.12}\, \nabla w_{t-1} + \underset{(1.71)}{0.065}\, \nabla w_{t-2}$$

$$+ \underset{(2.53)}{0.10}\, \nabla w_{t-3} + \underset{(2.14)}{0.092}(1 - d_t^s)\, \nabla p_t^m + \underset{(1.19)}{0.0040}(1 - d_t^s)\, \nabla p_{t-1}^m$$

$$- \underset{(-2.25)}{0.021}(1 - d_t^s)(p_{t-4} - p_{t-4}^m) + \underset{(0.54)}{0.40}\, \nabla s_t + \hat{\varepsilon}_{2t} \qquad (9.2)$$

$s_p = 0.0059, \quad T = 75.$

The changes in the coefficients of the price equation are what could be expected, as the lagged price variable now implies a geometric lag on all variables, including the PPP condition. Some t-values are radically smaller in FIML estimation. In the price equation the turnover tax variable loses its significance, but it is still needed to explain the observation 1964(i), cf. e.g. Figure 2, and in the wage equation the same happens to the stabilisation wage bargaining dummy. Note that these two variables only have two non-zero values so that the increase in the standard deviation in FIML may be attributed to the asymptotic approximation used. In the price equation the lagged IPI difference is now redundant, although it was still significant in the preliminary estimation and was therefore included in the model.

The residual auto- and cross correlations of (9.1) and (9.2) are in Tables 3 and 4. In the wage equation there is little change as compared to (8.1). The lagged price variable in (9.2) has halved the relatively large autocorrelation estimate at lag six. A large negative cross correlation at lag ten remains, but it is not considered alarming as far as the specification is concerned.

The fitted values of wage and price variables are in Figures 1 and 2. The fit in the wage equation is quite reasonable. The largest residual is 1971(i) in the beginning of a series of contracts with accelerating nominal wage increases. The price equation contains some large residuals, albeit smaller than the biggest residuals in the wage equation, and in some cases their causes can be traced. For instance, the residual of 1973(iii) is largely due to the (exogenous) dismantling of the rent controls causing a sudden upward jump in rents, which had a sizable effect to the CPI. Modelling factors like this would call for further disaggregation, which would go beyond the goals of this study.

10. Forecasting with the model

To test the specification, the equations (9.1) and (9.2) were used for predicting the wage and price developments for the quarters 1980(i) till 1981(iv) which were saved for this purpose. The forecast values are in Figures 1 and 2. It has to be pointed out that the forecasts are not one-step-ahead predictions, but have been generated using the system and realised values of exogenous variables, starting from 1980(i). The prediction errors of one-step-ahead forecasts have useful asymptotic properties, cf. e.g. Davidson et al. (1978), but, on the other hand, a multi-step prediction is a more severe test to the multiple equation system.

In predicting the changes in the EI the wage contract quarters (the values of d_t) were of course assumed known in advance. The forecasts are quite accurate. The root mean square error (RMSE) $s_w^* = 0.0098$ so that the squared Janus quotient of Gadd and Wold (1964)

$$J_w^2 = T\, s_w^{*2} / \sum_{t=1}^{T} (\nabla w_t - \nabla \hat{w}_t)^2 = 1.021.$$

The changes in CPI are predicted too low during an inflationary spurt in 1980 but the errors are mainly rather small in absolute value, so that the RMSE $s_p^* = 0.0065$ and $J_p^2 = 1.120$ which are quite acceptable figures.
It can be concluded that the results are satisfactory and do not reveal any inadequacies in the estimated equations (9.1) and (9.2).

11. Conclusions

This work amply demonstrates the fact that the Finnish wage-price dynamics can adequately be described by means of a linear difference model with a rather sparse amount of lags, completed with ECM's to assure proper long-term behaviour. Careful specification of the collective wage bargaining procedure turns out to be a very important part of model building in our example.

Another thing that needs comment here is the specification of dynamics. One of the necessary prerequisites for testing dynamics is that the structure of the model is completely specified except for the lag structure. The situation is not always so simple in practice, where new alternatives for setting up the equations of the model may emerge after gaining experience from unsuccessful or partially unsatisfactory specification attempts, as has been the case here. A more flexible approach with less rigid practices as applied for instance by Tiao and Box (1981) would therefore appear necessary and it has been adopted in this work. The results indicate that such an approach can be fruitful in practical econometric work.

Footnotes

1) The productivity is defined as the real GDP divided by the real wage sum of the economy. An asterisk indicates that the corresponding lag polynomial may contain unit roots, whereas a lag polynomial without an asterisk has its roots outside the unit circle.

2) Capital letters refer to the original variables and lowercase letters to their logarithms.

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Table 1. Residual autocorrelations of equations (8.1) and (8.2) estimated by OLS and 2SLS, respectively

Equation	Lag											
	1	2	3	4	5	6	7	8	9	10	11	12
(8.1)	-0.03	0.08	0.07	-0.14	0.00	-0.03	-0.03	-0.07	0.05	-0.02	-0.22	-0.05
(8.2)	0.10	0.06	-0.06	0.06	0.10	0.21	0.10	-0.00	-0.01	0.02	-0.21	-0.10

Note: $1/\sqrt{T} \approx 0.12$

Table 2. Residual cross correlations of equations (8.1) and (8.2) estimated by OLS and 2SLS, respectively, wages lead prices at positive lags

Lag	0	1	2	3	4	5	6	7	8	9	10	11	12
Cross correlation	-0.02	-0.08	-0.09	-0.19	-0.09	0.05	-0.01	-0.00	-0.09	0.06	0.28	0.11	-0.05
Lag	0	1	2	3	4	5	6	7	8	9	10	11	12
Cross correlation	-0.02	-0.10	-0.02	-0.05	0.16	-0.06	-0.20	0.03	-0.03	-0.13	-0.11	-0.10	-0.16

Table 3. Residual autocorrelations of equations (9.1) and (9.2) estimated by FIML

Equation	Lag											
	1	2	3	4	5	6	7	8	9	10	11	12
(9.1)	-0.03	0.07	0.08	-0.14	0.01	-0.03	0.04	-0.07	0.05	-0.02	-0.22	-0.05
(9.2)	-0.09	-0.04	0.06	-0.11	0.03	0.11	0.08	-0.04	0.03	0.01	-0.21	0.00

Note: $1/\sqrt{T} \approx 0.12$.

Table 4. Residual cross correlations of equations (9.1) and (9.2) estimated by FIML, wages lead prices at positive lags

Lag	0	1	2	3	4	5	6	7	8	9	10	11	12
Cross correlation	0.05	-0.06	-0.08	-0.18	-0.06	0.05	-0.05	0.02	-0.13	0.11	0.26	0.02	-0.10
Lag	0	1	2	3	4	5	6	7	8	9	10	11	12
Cross correlation	0.05	-0.10	-0.07	0.03	0.17	0.05	-0.17	-0.01	0.02	-0.11	-0.10	-0.09	-0.16

Figure 1: Logarithmic first differences of the EI 1961(ii)-1981(iv) (continuous line), the fitted curve from equation (9.1) 1961(ii)-1979(iv) and the system forecast for 1980(i)-1981(iv) (dotted line)

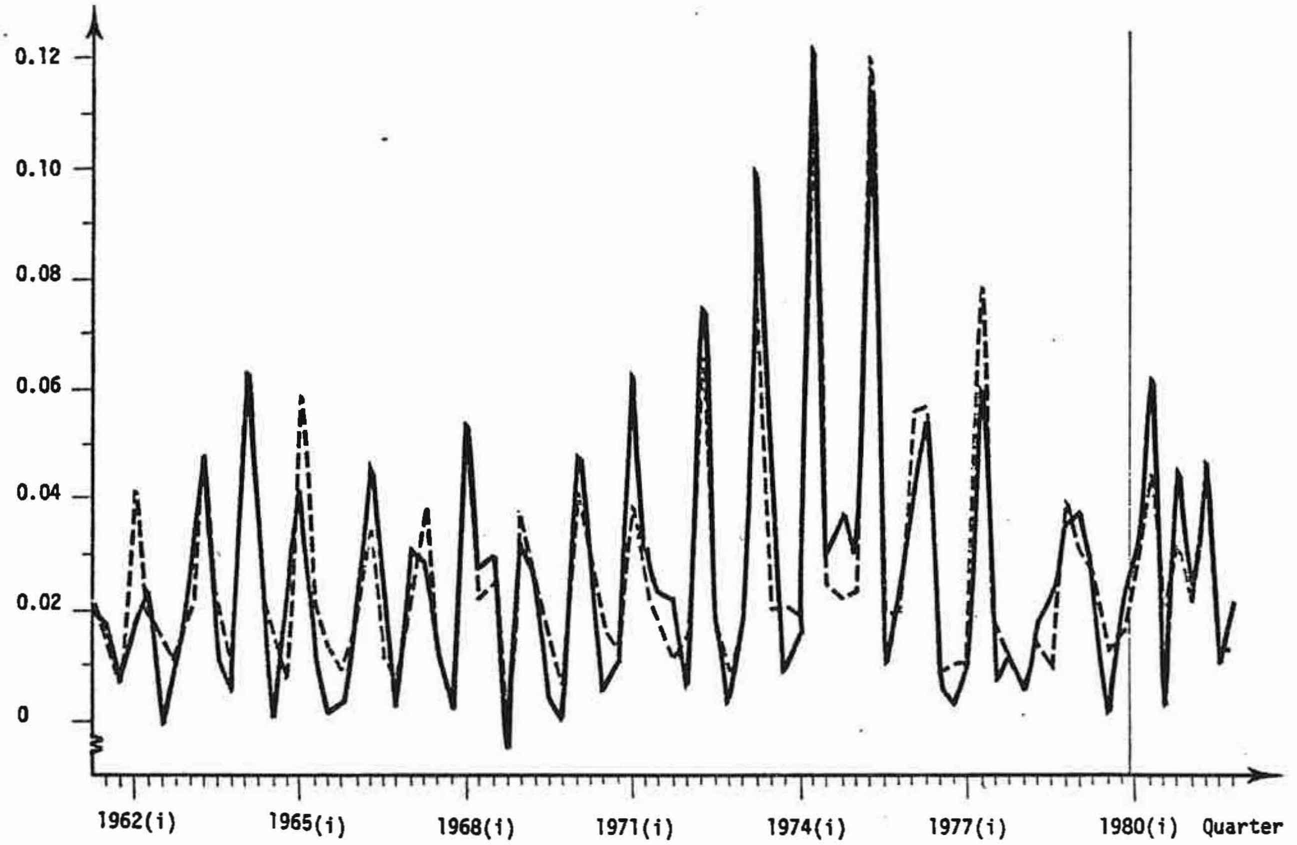

Figure 2. Logarithmic first differences of the CPI 1961(ii)-1981(iv) (continuous line), the fitted curve from equation (9.2) 1961(ii)-1979(iv) and the system forecast for 1980(i)-1981(iv) (dotted line)