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n the Use of Two Stage Least Squares with Principal Components

An Experiment with a Quarterly Model

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PREFACE

This study is a part of the work carried out at the Bank of Finland under the direction of Dr. Pertti Kukkonen on the construction of an econometric model for the Finnish economy. The original Finnish version of this report has been completed in spring 1974. The English translation has been prepared by Mrs. Kristina Puranen and Mr. Gavin Bingham. The Yrjö Jahnsson Foundation and the University of Helsinki have granted financial support for this study.

Helsinki, January, 1975

Juhani Hirvonen

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I INTRODUCTION

Modern macroeconometric models are made up of dozens or hundreds of different equations. The observation period is usually either a year or a quarter, depending on the availability of empirical data. However, the lags in the causal relationships to be captured by the model are frequently much shorter than the observation period. In this case, attempts are made to approximate these recursive causal relationships in the model by means of simultaneous relationships between the variables.

Non-linearity with respect to the variables is also typical of these models, even though individual equations are generally either linear, or can be made linear, because of the nature of estimation techniques. Non-linearities in macroeconomic models are primarily the result of the fact that economic hypotheses are usually framed in volume terms, whereas the national accounting identities are mainly in value terms. Furthermore, these hypotheses, or the empirical experiments with the data, may suggest non-linear equations.

So far there is only little practical experience of methods suitable for estimating large, simultaneous and non-linear models. Structural equations of the model are often estimated directly with the ordinary least squares (OLS) method, even though simultaneity makes the estimators thus obtained inconsistent. The major reason for using OLS has been the simplicity of the method, and the fact that there is so far no evidence on the extent to which the asymptotic properties of the estimators affect the results in small samples, especially in practical situations where specification errors in the model are probable. However, the growth of empirical experience is gradually making it possible to obtain information on the practical implications of the asymptotic properties of the estimators.

Traditionally the two-stage least squares (TSLS) method has been considered to be the most suitable way to obtain consistent estimators for the parameters of simultaneous linear models. Non-linearity in the model makes this method even more useful, because, unlike several other simultaneous estimation methods, it is typically a one-equation method. It can be viewed as a normal instrumental variable method, i.e., a method by which each structural equation of the model is estimated separately with the OLS, after obtaining values for the current endogenous explanatory variables by running the least squares regressions for the reduced form of the model. Accordingly, the non-linearity of the model tends to affect the TSLS method only to the extent that the current endogenous explanatory variables are non-linear and unknown functions of predetermined (exogeneous and lagged endogenous) variables in the model. This does not greatly limit the use of the method, since these functions can be approximated polynominally.

However, the non-linear version of the TSLS method is not suitable for large systems of simultaneous equations because the estimation of the first stage becomes difficult, if not impossible when the number of predetermined variables is too large in comparison with the number of observations. There are two basic ways to solve this degrees of freedom problem: in the first stage a priori information can be used to reduce the number of predetermined variables or a smaller number of new ancillary variables can be constructed.

The present study concentrates on the latter alternative: in the first stage of the TSLS method, all or some of the predetermined variables are replaced by a few of their first principal components, while the second stage estimation is carried out in the normal way. In the following, the symbol TSLSPC is used to refer to the method.[1]

1. This method was first applied to linear models in 1960. Cf., T. Kloek and L.B.M. Mennes: "Simultaneous Equations Estimation Based on Principal Components of Predetermined Variables", Econometrica, Vol. 28. In practice the TSLSPC method has been used only infrequently and generally in its most primitive form; it was used in the estimation of so-called Wharton and Brookings models. Cf., e.g. K.M. Evans and L.R. Klein: The Wharton Econometric Forecasting Model, Philadelphia 1968 and B. Mitchell: "Estimation of Large Econometric Models by Principal Component and Instrumental Variable Methods", The Review of Economics and Statistics, Vol. 53 (1971). In Finland an application has been reported in J. Hirvonen: An Empirical Experiment with a Simultaneous Econometric Model for International Economy, University of Helsinki, Institute of Economics, Research Reports, Nr. 14, 1971.

The study is empirical. Its purpose is to assess the usefulness of the TSLSPC method in the estimation of the macroeconomic model built at the Bank of Finland.[1] This model is a large macroeconomic quarterly model similar to many others in existence, so that this experiment contributes to our understanding of the suitability of the TSLSPC method in a wider sense.

The OLS estimates have been chosen as objects of comparison, for they will generally be calculated in any case when specifying the model. Since the "actual" values of the parameters to be estimated are unknown in this sort of an empirical experiment, the performance of the model forms the primary basis for assessing alternative estimates.

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1. A Quarterly Model of the Finnish Economy, Bank of Finland Institute for Economic Research Publications, Series D:29, 1972.

II THE METHOD

2.1. The starting point

A typical structural equation of a macroeconomic model can be expressed as

(1) $y = Fa + X_1b + e,$

where y is the T×1 vector of observations on a (current) endogenous[1] variable used in the model, F is the T×M matrix of observations on M endogenous functions, X_1 is the $T \times N_1$ matrix of observations on N_1 predetermined variables[2], a and b are the corresponding M×1 and $N_1 \times 1$ vectors of the parameters to be estimated, and e is the T×1 vector of the residual term. It is assumed that there are $N > N_1$ predetermined variables in the model. The T×X matrix of observations on the predetermined variables is expressed as $X = [X_1 \; X_2]$, where X_2 is the $T \times N_2$ matrix of observations on N_2 ($N_2 = N - N_1$) predetermined variables not included in X_1.

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1. In the following the term 'endogenous variable' refers explicitly to a current endogenous variable.

2. It is assumed that these include a variable taking the value of 1, if the equation includes a constant term.

The endogenous functions mentioned above do not include unknown parameters. They depend upon at least one endogenous variable of the model and possibly on one or several predetermined variables. Thus we can define $F = [F_1 \ldots F_T]'$, where each $F_t = [f_{1t} \ldots f_{Mt}]$, where, in general, each $f_{it} = f_i(Y_t, X_t)$, where Y_t and X_t are the corresponding observations on all the endogenous and predetermined variables in the model at time t. It may be pointed out that any a priori function containing predetermined variables can be treated in this context as a new predetermined variable.

On normal assumptions, equation (1) implies that $E(e_t) = 0$, $E(e_t^2) = \sigma^2$ and $E(e_t e_r) = 0$ $(t, r = 1,\ldots,T;\ t \neq r)$, where E is an expectations operator. Furthermore, it is assumed that X_t and e_t are independent of each other and generated by such processes where the sample moments converge in probability towards the corresponding population moments.

In addition, it is assumed that equation (1) is identified, because otherwise it could not be estimated. In the linear case (i.e., where each f_i is a linear function, in the extreme case F = Y) this would mean that there could not be more explanatory variables in equation (1) than there are predetermined variables in the whole model. When, as in this case, large models are in question this condition is not a practical constraint. The corresponding sufficiency condition will not be dealt with in this context, because in practice the condition is not operational.[1]

1. See A.S. Goldberger: Econometric Theory, New York 1964, p. 313-317.

The exact definition of identifiability criteria is much more difficult with a non-linear model than with a linear. model. Franklin M. Fisher has presented a method for determining these criteria,[1] but so far it has proven to be too laborious to use it in practice, particularly if the model is large. Moreover, Fisher's results are based on the assumption that endogenous variables are single-valued functions of predetermined variables and residual terms. In fact non-linear models may possess multiple solutions.

However, the problem of identifiability is made less troublesome by the fact that in general non-linearity facilitates rather than hampers the identification of the model.[2] Since for purposes of estimation it is not essential to know to what extent the equations are over-identified, it might be possible to use the necessity condition for linear models as a kind of a substitute criterion for identifiability in the non-linear case. For equation (1) this means that $N \geq M + N_1$ or $N_2 \geq M$. Although this is in fact more than the necessary condition for identifiability, the question of the validity of the corresponding sufficiency condition remains open. Similarly, the importance of possible multiple solutions in this context has not yet been analyzed.[3]

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1. See F.M. Fisher: "Identifiability Criteria in Nonlinear Systems", Econometrica, Vol. 29 (1961).

2. It is then required that the equation concerned include a constant term and at least one predetermined variable. See Fisher: Op.cit., pp. 586-587.

3. See S.M. Goldfeld and R.E. Quandt: Nonlinear Methods in Econometrics, Amsterdam 1972, pp. 231 - 232.

2.2. TSLS estimation

The basic condition for the consistent estimation of the parameters of equation (1) (plim $\hat{a} = a$, plim $\hat{b} = b$) is that residual term e_t be asymptotically uncorrelated with all the explanatory variables in this equation. Generally OLS estimators do not fulfil this requirement, because f_{it} may be a linear function of y_t through other structural equations of the model and thus correlated with e_t.

The idea behind the TSLS method is to replace functions f_{it} with proxy variables which are uncorrelated with residual term e_t (the so-called first stage), and to estimate equation (1) after this adjustment using the OLS method (the second stage). From the instrumental variable point of view, these proxies should be linearly independent of predetermined variables X_{1t} and correlated with functions f_{it}. Harry H. Kelejian has proved that when equation (1) is identified, the ideal TSLS instruments are conditional expectation values[1]

$$(2) \quad E[f_{it}|X_t] = h_{it} = h_i(X_t) \; ; \quad i = 1,\dots,M \quad t = 1,\dots,T.$$

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1. Cf., H.H. Kelejian: "Two-Stage Least Squares and Econometric Systems Linear in Parameters but Nonlinear in the Endogenous Variables", Journal of the American Statistical Association, Vol. 66 (1971), pp. 373 - 374. Identifiability guarantees explicitly the linear independence of h_{it} and variables X_{1t}.

In practice formula (2) is not operational, since functions h_{it} are generally unknown. However, they can be polynomially approximated by using Taylor's expansion, i.e.,

$$(3) \quad h_i(X_t) = \lim_{r\to\infty} Q_i^r(X_t),$$

where r refers to the degree of polynomial Q. We thus obtain a regression equation for calculating the instrument for each f_{it}

$$(4) \quad f_{it} = Q_i^r(X_t) + u_{it},$$

in which the parameters to be estimated are unknown coefficients of the polynomial and u_{it} is the residual term, which is uncorrelated with the elements of the polynomial.

The OLS estimates $\hat{f}_{it} = \hat{Q}_i^r(X_t)$, based on equation (4), are asymptotically uncorrelated with residual term e_t in equation (1), for as the sample size tends to infinity, plim $\hat{Q}_i^r(X_t) = Q_i^r(X_t)$. Moreover, each $\hat{f}_{it}$ is actually a polynomial approximation to corresponding h_{it} and hence linearly independent of predetermined variables X_{1t}, providing that the identifiability assumption for equation (1) is valid. In addition, $\hat{f}_{it}$ and f_{it} are naturally correlated with each other, so that estimates $\hat{f}_{it}$ meet the requirements placed on the TSLS instrumental variables of equation (1). Since the degree of the polynomial has not been changed in the preceding manipulations, the result holds for any value of r ($r \geq 1$). However, equation (3) suggests that instruments are the "better", the larger r is.

Present computer technology places limits on the choice of the degree of the polynomial. Since the number of predetermined variables in a typical macroeconomic model can easily exceed, say, one hundred, it seems obvious that it would not even be possible to estimate second-order polynomial ($(N^2 + N)/2$ elements).[1] For this reason, it is assumed in the following that $r = 1$.[2] Thus, analogously with the linear case, the TSLS estimators for the parameter of equation (1) are defined by the formula

$$(5) \quad \begin{bmatrix} \hat{a} \\ \hat{b} \end{bmatrix} = \begin{bmatrix} F'F - U'U & F'X_1 \\ X_1'F & X_1'X_1 \end{bmatrix}^{-1} \begin{bmatrix} F' - U' \\ X_1' \end{bmatrix} y,$$

where $U = F - \hat{F} = F - X[X'X]^{-1}X'F$, which refers to the $T \times M$ matrix formed by the residual terms u_{it} of equation (4).[3]

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1. This is true for the study at hand. On the other hand, the degrees of freedom problem will not be encountered since principal components are being used.

2. However, it is easy to generalize this examination by replacing observation matrix X by a matrix of observations which consists of elements of an r^{th} degree polynomial ($r > 1$) for the predetermined variables.

3. Cf., e.g. Goldberger: Op.cit., pp. 329 - 332.

As with linear models, a necessary condition for the existence of the inverse matrix in equation (5) is that $N \geq M + N_1$, which is the same criterion as the one presented on page 13 for the identifiability of equation (1).[1] In the estimation of large models, this condition does not pose any real problems, as the number of predetermined variables always greatly exceeds the number of variables in any of the equations to be estimated. However as the model grows, so does N, while T remains unchanged. $X'X$ thus approaches a singular matrix, which tends to reduce the reliability of the estimates.[2] Multicollinearity, which is commonly encountered when using economic data, makes the problem even more difficult. If $N \geq T$, $X'X$ is singular, i.e., its inverse cannot be found, and equation (5) cannot be solved.

2.3. TSLSPC estimation

If the predetermined variables of a model are highly correlated, as they generally are, their variation can be approximated almost completely by using a few of the first principal components. On the other hand, when formulating TSLS instrumental variables, attempts are made to explain the variation in the endogenous variables by means of variation in the predetermined variables,

1. If TSLS instruments are to be based on a polynomial for X_t of an degree higher than the first, N should be replaced by the number of terms in the polynomial in the corresponding condition. Cf. D.L. Edgerton: "Some Properties of Two Stage Least Squares as Applied to Nonlinear Models", International Economic Review, Vol. 13 (1972), p. 30 ff.

2. In practice this also means that, as the degrees of freedom fall, the instrumental variables $\hat{f}_{it}$ approach functions f_{it}, i.e., the TSLS results approach the OLS results.

whereas no attention is paid to the corresponding parameters themselves. Accordingly, it is sensible to replace the predetermined variables in the first stage of the TSLS method by a few of their first principal components when the number of observations is small or too small compared with the number of predetermined variables.[1]

Since principal components are not used frequently in econometrics, they will be described briefly first.[2] Principal components are normalized (the sum of squares of the coefficients concerned = 1) linear combinations of the variables to be examined. They are mutually orthogonal and formed in order so that the variance of each principal component will be maximized on the condition that the preceding linear combinations are given. It is then assumed that the variables are either expressed as deviations from the mean or standardized (mean = 0, variance = 1).[3] In all, there are as many principal components as there are linearly independent variables in the original set of variables. Moreover, the matrix of all the principal components is an orthogonal transformation of the matrix of original observations, which means that the generalized variance and the sum of the variances of the principal components are respect-

1. It is possible to show that in certain conditions this is the optimal way to reduce the number of predetermined variables. See T. Amemiya: "On the Use of Principal Components of Independent Variables in Two-Stage Least-Squares Estimation", International Economic Review, Vol. 7, (1966).

2. A more thorough examination is presented in T.W. Anderson: An Introduction to Multivariate Statistical Analysis, New York 1958.

3. The standardization of the variables is designed to eliminate the impact of different dimensions on the principal components. See Anderson: Op.cit., p. 279.

ively equal to the generalized variance and the sum of the variances of the variables in question. Accordingly, the first principal component captures the greatest possible share of the variation in the original variables, while the second principal component, which is uncorrelated with the first, captures the largest possible share of the remaining variation and so on.

The principal components can be derived with the help of the characteristic roots and vectors of the variance-covariance matrix of the variables in question. Let the T*(N-1) matrix of the mean-deviated or standardized values of the predetermined variables (excluding the constant term) be $\bar{X}$ and the corresponding variance-covariance matrix Σ. Characteristic roots λ and vectors c (assumed to be normalized of the latter matrix are then obtained from equation

(6) $[\Sigma - \lambda I]c = [0]; \quad c'c = 1,$

where I is an identity matrix and [0] a zero matrix.

Equation (6) presupposes that $\Sigma - \lambda I$ is singular, i.e., λ must fulfil the condition $|\Sigma - \lambda I| = 0$. This yields N-1 roots $\lambda_1 \geq \lambda_2 \geq \ldots \geq \lambda_{N-1} \geq 0$, each of which can be used to determine the corresponding characteristic vector c_i on the basis of equation (6). Since Σ is symmetric, $c_i'c_j = 0$ when $i \neq j$ $(i,j = 1,\ldots,N-1)$. Thus the T*(N-1) matrix consisting of the principal components can be defined by equation

$$(7) \quad P = \bar{X}C,$$

in which $C = [c_1 \ldots c_{N-1}]$. The variance of the i^{th} column vector (of the i^{th} principal component) of P is then λ_i.

If the principal components of the predetermined variables are used as the only arguments for the TSLSPC instrumental variables in equation (1), the estimators for parameters a and b will be

$$(8) \quad \begin{bmatrix} \hat{\hat{a}} \\ \hat{\hat{b}} \end{bmatrix} \begin{bmatrix} F'F - V'V & F'X_1 - V'X_1 \\ X'F_1 - X_1'V & X_1'X_1 \end{bmatrix}^{-1} \begin{bmatrix} F' - V' \\ X_1' \end{bmatrix} y,$$

where $V = F - \hat{\hat{F}} = F - \tilde{P}[\tilde{P}'\tilde{P}]^{-1}\tilde{P}'F$, while P refers to the $T\times(k+1)$ matrix consisting of the unit vector[1] and k column vectors of principal component matrix P. Were an inverse matrix for formula (8) to be found, $k \geq M + N_1 - 1$.[2] On the other hand, the condition $k < T - 1$ should be fulfilled, otherwise matrix $\tilde{P}'\tilde{P}$ would be singular.

---

1. The transformation of the predetermined variables require the presence of a constant term, in addition to the principal components, when the instrumental variables $\hat{\hat{F}}_t$ are formed.

2. This condition corresponds to the criterion of identifibiality presented on page 13.

It is desirable (but not necessary) for the consistency and efficiency of estimators $\hat{\hat{a}}$ and $\hat{\hat{b}}$ that matrices $V'X_1$ and VX_1' in equation (6) are zero matrices.[1] This would presuppose that the column vectors of X_1 can be expressed as linear combinations of the column vectors of $\tilde{P}$. In general this is not possible, since $\tilde{P}$ consists only of certain principal components.[2] However, it is worth noting that when the predetermined variables are strongly correlated, the first principal components usually represent the major part of the variation in the X_{1t} variables. In this case $V'X_1$ and VX_1' are nearly zero matrices.

In view of the consistency of the TSLSPC estimators, it would be possible to employ both $\bar{X}_{1t}$ (or X_{1t}) as such and the principal components of $\bar{X}_{2t}$ as arguments for the instruments needed in equation (1).[3] However, at least some of the $\bar{X}_{1t}$ variables would then be highly correlated with certain principal components, so that unnecessary information on the variation of $\bar{X}_{2t}$ variables would be included. For this reason the principal components should in fact be calculated from the residual terms, which are obtained from the regressions of $\bar{X}_{2t}$ on $\bar{X}_{1t}$.

1. See Amemiya: Op.cit., pp. 286 - 287, and J.M. Brundy and D.W. Jorgenson: "Efficient Estimation of Simultaneous Equations by Instrumental Variables", The Review of Economics and Statistics, Vol. 53 (1971), pp. 216 - 217.

2. From the asymptotic point of view, it can be presumed that, k grows (till k = N-1) as T grows. Then the estimators based on formulae (5) and (8) are asymptotically identical, so that the latter can be regarded as consistent. However, the original reason for using principal components, i.e., the inadequate number of degrees of freedom, declines in importance as T grows. See P.J. Dhrymes: Econometrics; Statistical Foundations and Applications, New York 1970, p. 271.

3. A bar above a symbol means that the corresponding variable has been standardized or expressed as deviations from the mean.

If we thus write the $T \times N_2$ matrix[1] of the residuals mentioned the form $S = \bar{X}_2 - \bar{X}_1[\bar{X}_1'\bar{X}_1]^{-1}\bar{X}_1'\bar{X}_2$ and their variance-covariance matrix as Σ_S, we obtain in place of equation (6)

$$(9) \qquad [\Sigma_S - \eta I]g = [0]; \quad g'g = 1,$$

where η is the characteristic root of Σ_S and g the corresponding vector. The principal component matrix is thus

$$(10) \qquad P_S = SG,$$

where $G = [g_1 \; \ldots \; g_{N_2}]$. Then the TSLSPC estimators for parameters a and b are defined by the equation

$$(11) \qquad \begin{bmatrix} \hat{\hat{a}} \\ \\ \hat{\hat{b}} \end{bmatrix} = \begin{bmatrix} F'F - W'W & F'X_1 \\ \\ X_1'F & X_1'X_1 \end{bmatrix}^{-1} \begin{bmatrix} F' - W' \\ \\ X_1' \end{bmatrix} y,$$

where $W = F - \hat{\hat{F}} = F - Z[Z'Z]^{-1}Z'F$, while $Z = [X_1 \; \tilde{P}_S]$ and $\tilde{P}_S$ is the $T \times k$ matrix of the k first column vectors of P_S.[2] Now the fact that an inverse matrix exists and that matrix $Z'Z$ is non-singular imposes limits on k, that is $M \leq k < T - N_1$.

1. If X_2 includes a unit vector, $\bar{X}_2$ and thus even S are $T \times (N_2-1)$ matrices.
2. If X_1 does not include a unit vector, it shall be added to the $\tilde{P}_S$ matrix, and k in the following condition shall be replaced by k+1.

So far it is not possible to present any precise a priori rule on how many principal components should be used in TSLSPC estimation. However, the existence criterion for the inverse matrices in formulae (8) and (11) defines the minimum number of principal components to be used in both cases. On the other hand, it is doubtful whether an upper limit can be set, because the reliability of the TSLSPC instruments will be improved by increasing the number of principal components since information on the predetermined variables will be increased, but, it will be reduced by the fact that the number of degrees of freedom are reduced (presuming that the number of observations is given). Accordingly, in practice it may be best to use the model to experiment with alternative numbers of principal components, starting with the minimum number.[1]

Compared with the method of calculating TSLSPC estimators presented in equation (8), the procedure indicated in equation (11) is very cumbersome. In the former, the estimation of the whole model can be carried out by solving for the principal components once. However, the latter procedure may lead to the calculations of as many principal component sets as there are structural equations with endogenous arguments, because each of these equations may include different combinations of the predetermined variables. The estimation of the residual terms needed for

1. More about this in Chapter 3. Kloek and Mennes recommend experimenting first with the minimum number of principal components, then with one more, etc., until the estimates for the parameters of the structural equations do not change much or their standard errors can be considered small enough. However, if the model is large, this rule is quite impractical. Kloek and Mennes: Op.cit., p. 50 and 54.

calculating the principal components makes the work more complicated in the latter case. The question whether there is any essential difference between the estimates based on equations (8) and (11) from the point of view of the functioning of the model is empirical, and so far only little experience about this has been gained, because practical applications have hitherto been based exclusively on equation (8).[1]

The TSLSPC method has been mainly criticized on the grounds that, with certain endogenous explanatory variables, the principal components chosen for the first stage of the method may place causally unimportant predetermined variables in a dominant position.[2] However, the original TSLS method does not in this sense distinguish between causally important and unimportant predetermined variables, i.e., the method does not take into account the explicit structure of the total model. In fact, Monte Carlo experiments indicate that this is one of the advantages of the method, since the results are influenced only slightly by specification errors in the model.[3] Similar results have also been obtained using the TSLSPC method.[4]

1. The application of the various alternatives by Kloek and Mennes to a small six-equation model did not yield results which differed significantly from one another or from the results obtained using the original TSLS method. The functioning of the model was not, however, analyzed with the different alternatives. See Kloek and Mennes: Op.cit., p. 55 ff.

2. See e.g. F.M. Fisher: "Dynamic Structure and Estimation in Economy-Wide Econometric Models" in The Brookings Quarterly Econometric Model of the United States (ed. J.S. Duesenberry, G. Fromm, L.R. Klein and E. Kuh) Chicago 1965, pp. 624-625.

3. See e.g. Dhrymes: Op. cit., pp. 372 - 380.

4. See L.R. Klein: "Estimation of Independent Systems in Macroeconometrics", Econometrica, Vol. 37 (1969) and M. Dutta and P.K. Sharma: "Alternative Estimators and Predictive Power of Alternative Estimators: An Econometric Model of Puerto Rico", The Review of Economics and Statistics, Vol. 55 (1973).

III THE EXPERIMENT

3.1. Model

The model estimated in the present study is the quarterly macroeconomic model of the Finnish economy constructed at the Bank of Finland. It is primarily designed for short-term (from two to three year) forecasting and the simulation of alternative economic policy measures.[1] The first version of the whole model was solved in 1973, but the model is still being developed for practical forecasting and simulation purposes.

The Bank of Finland model is a medium-sized model. The version chosen for this study is made up of 115 equations, of which 59 are to be estimated. The others are either national accounting identities or equations where the coefficients are known *a priori* (cf., Appendix II). The model contains 180 variables, of which 65 are exogenous.

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1. It is worth noting that the model is connected with the international LINK project which was established in 1968. The aim of this project is to link individual models of different countries or country groupings into a world economy model. Beside most Western European countries, the United States, Canada, Japan and Australia are participating in this project which is led by Prof. L.R. Klein. Furthermore, the project has constructed highly aggregated models for certain groupings of other countries. At present the project produces regular short-term forecasts for its participants. Cf. R.J. Ball (editor): The International Linkage of National Economic Models, London 1973.

The model is simultaneous, i.e. it contains interrelationships between endogenous variables which are based on observations from the same period. For reasons given in the Introduction, the model is non-linear as a whole. It also is extremely dynamic and includes, e.g., equations for periodic changes in variables. Moreover, certain equations contain moving averages of the explanatory variables or polynomially distributed lags.

Like most other short-term macroeconomic models, the Bank of Finland model is a demand-oriented model constructed within the framework of balance identities of national accounting and the banking system. It was not possible to place the model on a uniform theoretical foundation and thus the specification has depended on diverse theoretical considerations, the availability of suitable data and special features of the Finnish economy. To a large extent, the model is based on the business cycle forecasting system developed at the Bank of Finland in the 1960s.

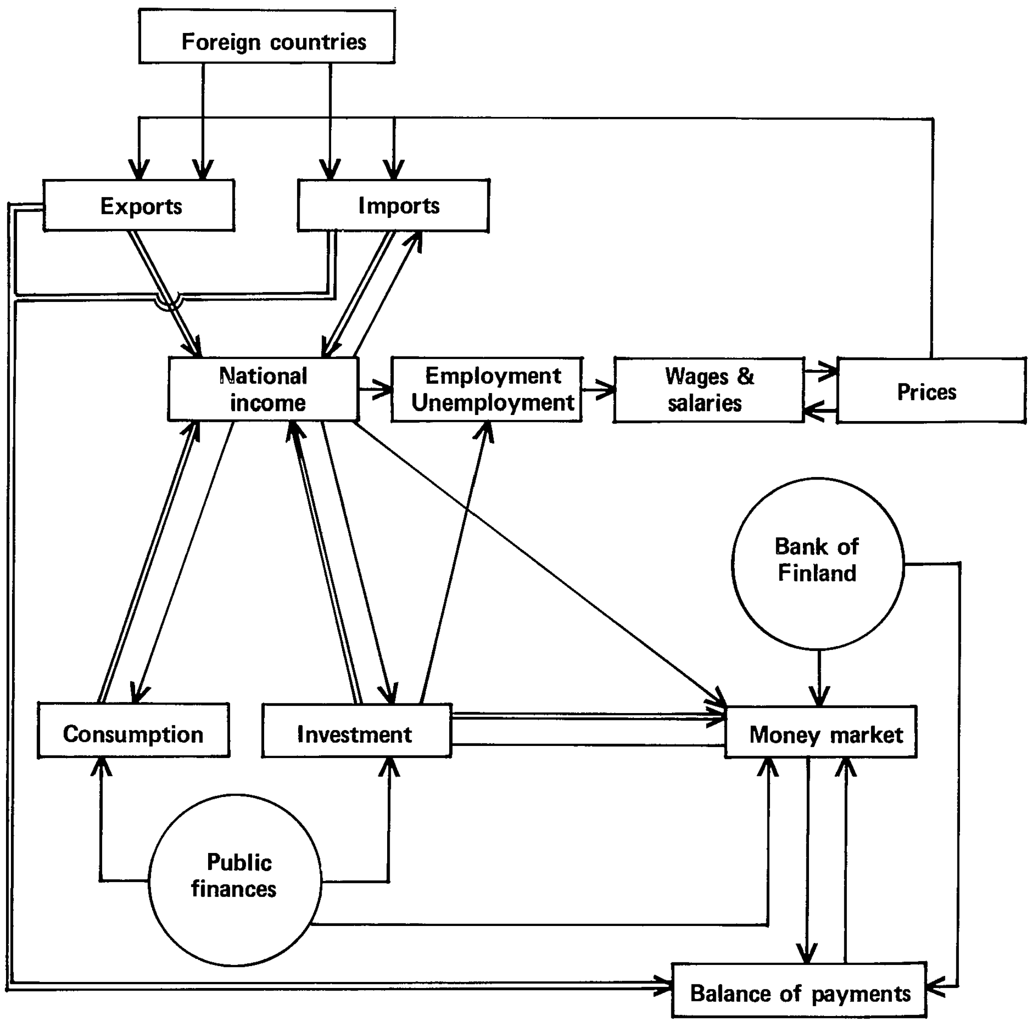
Only the broad outlines of the model are presented here.[1] Chart 1 shows the structure of the model in diagrammatic

1. A more detailed, but slightly out-of-date picture of the total model is given in op.cit. A Quarterly Model ... In addition, various blocks and their theoretical underpinnings have been dealt with, e.g. in the following publications: H. Halttunen: Production, Prices and Incomes in the Quarterly Model of the Finnish Economy, Bank of Finland Publications, Series D:30, 1972 (in Finnish); S. Lahtinen: Demand for Labour in the Quarterly Model of the Finnish Economy, Same series D:31, 1973 (in Finnish); E. Aurikko: The Foreign Trade Block in the Quarterly Model of the Finnish Economy, Same series D:33, 1973 (in Finnish); I. Pohjola: An Econometric Study of the Finnish Money Market, Same series D:35, 1974 (in Finnish); P. Kukkonen: Features of the Finnish Monetary Relationships, Ekonomiska Samfundets Tidskrift, 1973:2.

form. The relationships between the sub-blocks of the model are marked with arrows. A single arrow indicates a causal relationship and a double arrow a definitional relationship. The circles denote economic policy variables and parameters.

Chart 1.

OUTLINES OF THE STRUCTURE OF THE BANK OF FINLAND MODEL



The model consists of ten blocks representing various subsectors of the Finnish economy: consumption, investment, foreign trade, production, prices, non-wage incomes, wage incomes, employment, the money market and public finances.

In the model, private consumption depends mainly on real disposable income and the unemployment rate, the latter being used as a proxy for prevailing cyclical expectations. Different equations are specified for different consumption categories. The flexible acceleration principle has been used in the productive investment function, and a polynomially distributed (Almon) lag has been employed. Beside production, the availability of credit is included as a explanatory variable. Housing investment depends mainly on real disposable income and the availability of credit. Inventory investment (plus the statistical error) is accounted for by a flexible accelerator model including only lagged values of production.

In this version of the model, the foreign trade block includes explanatory equations only for the volume of commodity imports by category, while import prices, exports and service items are exogenous. The import demand equations are based on traditional foreign trade theory, where the main explanatory variables are domestic activity variables, such as production, investment and income formation, and the ratio between domestic and foreign prices.

Production, domestic prices and non-wage incomes make up separate block system in the model and are based on the input-output framework. The economy has been divided into two sheltered sectors: agriculture and other non-competitive production (mainly services and residential construction) and two exposed sectors: forestry and other competitive production (mainly manufacturing). This sectoral breakdown affects the determination of prices in the model. While agriculture and forestry prices are exogenous, prices in other non-competitive production are determined on the basis of domestic cost developments, whereas other competitive production prices are also affected by foreign price developments. The volume of production by sector is obtained from the demand for final products in accordance with the input-output framework which also allows us to determine income in various sectors since prices and the sectoral volume of production are given.

In the model sectoral wages and salaries depend on general price developments, sectoral productivity and demand conditions in the labour market. In addition to wages and salaries paid, the model presents averages negotiated wages and salaries for the total economy as a function of general price development and the development of productivity. Wage drift is the difference between actual earnings and negotiated wages and salaries. The labour demand equations are based on production theory, supplemented by a dynamic adjustment mechanism. Employment by sector is thus determined by the volume of production, real wages and salaries, the rate of capacity utilization, and previous employment developments. The unemployment rate, rather than being determined by the difference between the supply of the demand for labour, is related directly to the gross domestic product with a distributed (Almon) lag.

The monetary block is linked to the real side of the model primarily through the investment equations which contain the availability of credit indicator defined as the ratio of the central bank debt of the banks to their total lending. On the other hand, the income variables affect the development of bank deposits and the degree of self-financing by firms, which in turn determines, together with the value of investment, the demand for bank credit. As nominal interest rates have been nearly constant in Finland, the instruments of monetary policy are represented in this version of the model mainly by the central bank credit.

The public finance block in the model makes use of the state budgetary framework. On the whole state expenditure items are exogenous. By changing public consumption and investment expenditure it is possible to affect production and employment in the model and thereby total domestic activity. Income transfers influence other blocks of the model through disposable income. State revenue is largely endogenous in the model, and tax revenue is mainly explained by the relevant income or other tax base variables and tax parameters, the latter representing fiscal policy instruments.

3.2. Estimation

The model presented above was estimated with both the OLS and the TSLSPC method. Two versions of this latter method were used, one corresponding to equation (8) and the other to equation (11); they are denoted by TSLSPC,I and TSLSPC,II respectively.[1] In both cases, three alternatives involving a different number of principal components, were used. The principal components were calculated from the standardized values of the predetermined variables of the model.

The estimation period for the majority of the equations was 1958-1971, but in certain cases the period 1959-1971 was used because of the lack of suitable data. The data used were quarterly series which had been seasonally adjusted at the Bank of Finland; allowance was also made for the number of working days and strikes.[2]

When making the TSLSPC,I estimates, only the first principal components of all the predetermined variables[3] of the model

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1. ADB programs had to be written for a UNIVAC 1108. Ilmo Niiranen, M.Sc., and Riitta Jokinen, B.Sc., were responsible for this work.

2. The seasonal adjustment method is described in P. Kukkonen: Analysis of Seasonal and Other Short-term Variations with Applications to Finnish Economic Time Series, Bank of Finland Institute for Economic Research Publications, Series B:28, 1968.

3. There are 135 predetermined variables in the model. However, the number had to be reduced to 120 when calculating principal components because of capacity constraints in the program. This reduction was carried out by combining the Almon weighted lagged variables for production and the availability of credit into new, auxiliary variables. Since the weights concerned are known *a priori*, this procedure can be considered permissible.

were used as arguments for instrumental variables in the equations to be estimated. Three alternative sets of principal components were chosen so that the sum of the variances of the principal components would just amount to 90, 95 and 99 per cent of the sum of the variances of standardized predetermined variables of the whole model.[1] On the other hand, the lowest of these percentage limits was affected by the lower limit placed on the number of principal components by the identifibiality criterion (cf. p. 20). The following alternatives were thus obtained:

- TSLSPC,I,1: 6 principal components, variation ≥ 90 per cent
- TSLSPC,I,2: 10 principal components, variation ≥ 95 per cent
- TSLSPC,I,3: 22 principal components, variation ≥ 99 per cent

When making the TSLSPC,II estimates, both the predetermined variables of each equation and the first principal components of the residual terms, which were obtained from the regressions of the other predetermined variables of the model on the first mentioned predetermined variables, were used as arguments for the instrumental variables. The alternative number of principal components was determined equation by equation so that the sum of the variances of the principal components and the sum of the variances of the predetermined variables in the equation concerned would just exceed the percentage limits mentioned above. The estimation alternatives obtained were thus:

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1. Using the symbols of Section 2.3.: $k = \min (n | \sum_{1}^{n} \lambda_i \geq q(N-1))$, where $n = 1, 2, \ldots, N-1$ and $q = .90, .95, .99$.

- TSLSPC,II,1: as many principal components as necessary to make their total variation and that of the predetermined variables in the equation to be estimated $\geq$ 90 per cent
- TSLSPC,II,2: the variation concerned $\geq$ 95 per cent
- TSLSPC,II,3: the variation concerned $\geq$ 99 per cent

In certain equations there were no endogenous explanatory variables at all. In these cases the TSLSPC estimators were identical with OLS estimators. In certain equations there are no predetermined explanatory variables, so that the TSLSPC,II alternative collapses into the corresponding TSLSPC,I alternative. In the equations with the same combination of predetermined variables, the same principal components could be used when making the TSLSPC,II estimates. Accordingly, for the 59 equations to be estimated in the model, 23 different principal component runs had to be carried out for the TSLSPC,II version, in addition to the run which had to be made for the TSLSPC,I version.[1]

3.3. Results

When the "real" values of parameters to be estimated are unknown, it is not sensible to compare alternative estimation

1. This entailed a fairly large amount of work but it also increased costs substantially as the calculation of principal components was the most laborious phase of the TSLSPC estimation, because of solving for characteristic roots and vectors of a 120x120 correlation matrix. For example, the TSLS estimation of one equation took a few seconds of the central processor time of UNIVAC 1108, but the corresponding time for one principal component run was about three minutes.

results as such. Since the model to be estimated is designed to be used as a whole in the preparation of economic forecasts and the analysis of economic policy, the functioning of the whole model is a natural standard for comparing the alternative estimates. In addition, all possible consistency requirements for the individual equations and parameters, or other similar a priori information should be taken into account.

The functioning of the model can be assessed in many ways. The predictive performance of the ex post forecasts[1] over several periods (mainly for the whole estimation period) has been chosen as the most important criterion.

The first reason for using this criterion is that an ex post forecast provides information on alternative parameter estimates in circumstances which are controlled in the sense that, apart from possible specification errors, the structure of the model represents the structure of the economy. Moreover the forecast can be based on the observed values

1. Since forecasting and simulation terminology often varies from one author to the next, we shall indicate what we mean with the various terms. An ex post forecast refers to the solution of the model for the current endogenous variables over the estimation period when the exogenous variables are given their observed values. An ex ante forecast refers to forecasts produced by the model from the estimation period onwards. It may be pure or non-pure, depending on whether exogenous variables take the values forecast or observed. Both ex post and ex ante forecasts can either be one-period or multi-period forecasts, depending on whether lagged endogenous variables take the values observed or those calculated by the model. The concept simulation refers to the imitation of any economic situation with the help of the model, while the concept forecast is more concise and refers to the imitation of a situation realized, or expected to be realized. All the forecasts calculated here are deterministic in the sense that the residual terms of the equations are set at zero.

of exogenous and, if desired, on observed values of the lagged endogenous variables. It is of course possible that with ex ante forecasts forecasting errors caused by changes in the structure of the economy or by erroneous estimates of the exogenous variables may randomly provide support certain estimation alternatives.[1]

The second reason is that when a quarterly model is being built, even short-term forecasts and economic policy simulations must cover quite a number (e.g., from 8 to 12) of periods. It is thus advisable to assess the functioning of the model on the basis of the accuracy of multi-period forecasts.

The third reason for using the criterion is that experimenting with an ex post forecast for the entire estimation period requires very much of the model, despite the fact that the model has been estimated from data for the same period and that exogenous variables take their observed values, for the errors may cumulate from one equation to another through the endogenous explanatory variables, or from one period to another through the lagged endogenous variables.[2]

1. This is also partly true for ex post forecasts because of specification errors.

2. Cf. B.G. Hickman: "Introduction and Summary" in Econometric Models of Cyclical Behavior (ed. B.G. Hickman), Vol. I, pp. 3-4, New York 1972.

The ordinary RMSE (root-mean-square error) statistic, expressed as a percentage of the mean of the variable to be forecast, was chosen as the measure of predictive performance:

$$\text{RMSE\%} = 100 \left(\frac{1}{T} \sum_{1}^{T} (y_t - y_t^e)^2\right)^{1/2} \left(\frac{1}{T} \sum_{1}^{T} y_t\right) ,$$

where y_t is the observed value of the variable in period t and y_t^e the forecast value and T refers to the number of periods.[1] It was not deemed necessary to break down the RMS error into systematic and random components[2], because the systematic component tends to be clearly dominant in multi-period forecasts (cf. Appendix I).

Table 1 shows the RMSE percentage figures for the <u>ex post</u> forecasts of ten main variables over the whole period. The results for other variables are generally quite similar. In Table 2 the estimation alternatives have been ranked on the basis of Table 1 and the ranks have been summed.[3]

1. By relating the RMS errors to the means of the variables, we reduce the impact of the units used to measure the variables on the size of the errors making them thus more readable but not commensurable. If we wished to achieve commensurability, it would have been more useful to choose the so-called normalized RMSE measure, in which forecasting errors are related to the square root of the second absolute moment of the estimated variable. Then it would have been possible to calculate the RMS error for the whole forecast (covering all periods and variables), so that the prediction accuracy of the whole forecast could have been indicated by one symbol. Cf. <u>J. Hirvonen</u>: "On the Accuracy of the Cyclical Forecasts of the Bank of Finland", Bank of Finland Institute for Economic Research Publications, Series A:34, 1971 (in Finnish and Swedish). However, the simulation programme available calculated only ordinary RMS errors.

2. Cf. <u>J. Hirvonen</u>: Op.cit.

3. This is a very rough way of weighting the prediction accuracies of the different variables, and one estimation alternative may rank above another on account of extremely small differences in predictive performance. Thus Tables 1 and 2 should be examined side by side.

Table 1. Ex post forecast 1959 I - 1971 IV, RMSE% for ten key variables of the model, by estimation alternative

Variable	OLS	TSLSPC,I 1	TSLSPC,I 2	TSLSPC,I 3	TSLSPC,II 1	TSLSPC,II 2	TSLSPC,II 3
CTOT	10.1	7.7	1.8	6.5	1.8	3.4	10.4
ITOT	7.8	6.7	4.5	6.3	4.7	5.1	7.8
II	109.1	84.7	54.6	82.7	58.4	62.5	106.6
M	15.4	11.3	4.8	10.2	5.2	6.2	15.4
GNP	8.9	6.9	1.9	6.0	2.2	3.4	8.9
PCP	10.6	8.4	2.7	6.8	2.1	3.4	11.0
WR	29.6	21.3	4.9	17.4	3.6	8.5	30.1
UR	67.8	60.0	30.8	58.9	38.2	44.7	67.2
LBP	25.2	21.3	4.7	18.4	5.2	11.0	26.3
TCG	39.4	27.9	7.3	23.4	6.0	11.1	42.6

Table 2. Estimation alternatives ranked by RMSE%'s of the variables in Table 1

Variable	OLS	TSLSPC,I 1	TSLSPC,I 2	TSLSPC,I 3	TSLSPC,II 1	TSLSPC,II 2	TSLSPC,II 3
CTOT	5	4	1	3	1	2	6
ITOT	6	5	1	4	2	3	6
II	7	5	1	4	2	3	6
M	6	5	1	4	2	3	6
GNP	6	5	1	4	2	3	6
PCP	6	5	2	4	1	3	7
WR	6	5	2	4	1	3	7
UR	7	5	1	4	2	3	6
LBP	6	5	1	4	2	3	7
TCG	6	5	2	4	1	3	7
Total	61	49	13	39	16	29	64

The symbols used:

CTOT = consumption, volume

ITOT = investment, volume

II = change in business inventories, volume

M = imports of goods and services, volume

GNP = gross domestic product at market prices, volume

PCP = private consumption prices

WR = level of earnings

UR = unemployment rate

LBP = lending by banks to the private sector

TCG = total revenue

According to Tables 1 and 2, the results obtained with the TSLSPC,I,2 and TSLSPC,II,1 estimates are almost identical and slightly better than those obtained with the TSLSPC,II,2 alternative. All these three alternatives yield a forecast which is clearly better than the one obtained with OLS estimates. In contrast, the forecasting errors for alternatives 1 and 3 of the TSLSPC,I version are almost equal to the OLS forecasting errors while the forecasting errors for alternative 3 of the TSLSPC,II version are slightly greater than the OLS forecasting errors. The equality of the results for alternative 3 of both TSLSPC versions with the OLS results can perhaps be explained by the fact that the number of principal components used is so great relative to the number of observations that the TSLSPC instrumental variables are almost equal to the endogenous explanatory variables concerned, which means that the TSLSPC estimates are also close to the OLS estimates (cf., p. 17).

Since the behaviour of a dynamic model depends on initial values of the variables, the picture given by Tables 1 and 2 of the superiority of certain estimation alternatives in terms of predictive performance cannot be generalized without examining how sensitive the results are to the starting point of the forecast. This was examined by varying the starting point of multi-period ex post forecasts. On the basis of these experiments, the above results can be accepted with certain reservations. On the whole, the forecasts obtained with both the TSLSPC versions were almost equivalent and more precise than the OLS forecasts but the results varied substantially with the number of principal components used. However, when a large number of principal components was used in both versions, the results were worse on average than when a smaller number was used. In all the forecasts, the average prediction accuracy of the alternatives was greater and the differences smaller than in Table 1, because of the use of shorter forecasting periods.

In addition to the ex post forecasts, ex ante forecasts with alternative estimates were made for 1972[1], taking the 1971 observed values of the endogenous variables as the point of departure and giving the exogenous variables their observed values. The differences between the alternatives were extremely small because of the shortness of the forecasting period, e.g., for the volume of investment, the average forecasting errors varied between -1.7 and -2.0 percentage points, whereas the corresponding figures for the volume of gross domestic product

1. When the calculations were being carried out at the beginning of 1974, data for 1973 were not available for all variables.

were -0.7 and -1.6 and for unemployment 0.6 and 0.8. In this experiment, the TSLSPC,II estimates were best, and the TSLSPC,I alternative was inferior to the OLS alternative.

Appendix I shows what the differences in the predictive performance of the ex post forecasts mean in practice. It shows graphically the OLS ex post forecast over the whole estimation period for the ten key variables and the time paths of the best solutions obtained with the TSLSPC versions (I,2 and II,1), together with the observed time paths of these variables. The graphs of other variables and other ex post forecasts (with different initial values) are quite similar.

According to Appendix I, the three alternative forecasts follow very closely observed developments for the first four to six years. Even after that the TSLSPC estimates remain close to the observed time paths, whereas in the OLS solution the forecasting errors start to cumulate rapidly.[1] The TSLSPC alternatives are equivalent in practice and fairly precise, given the length of the estimation period. The poorest TSLSPC forecast is the one for unemployment in 1967 - 1969, when the calculated unemployment rate is about two percentage points lower than the observed rate (about four per cent). However, the forecasting error for the quarterly level of the volume of gross domestic product is only about five per cent at its highest and about two percentage points for annual changes. In the

1. It is worth noting that forecasting errors did not cumulate so clearly in the study by Hannu Halttunen on alternative income policies in which he used the Bank of Finland's model to make similar ex post forecasts. However, the specification and data used in this study were slightly different from those used in the present study. Cf. H. Halttunen: The Econometric Model as a Tool for Incomes Policy Decision-making. A laudatur thesis in statistics at the University of Helsinki, 1974 (offset).

forecasting of cyclical swings, all three alternatives seem to work fairly well.

When assessing the model as a tool for short-term forecasting and simulation, the OLS estimation results seem to be almost as good as the TSLSPC results. The superiory of the more sophisticated methods in terms of predictive performance will become clear only in long-term calculations, if it is deemed worthwhile to make them with an econometric model of this type.[1]

The estimation results obtained with the three alternatives just discussed (OLS, TSLSPC,I,2 and TSLSPC,II,1) are shown in the List of Equations in Appendix II. On the whole, the differences between the alternative estimates are surprisingly small. However, this may be explained by the fact that, even though the quarterly model is formally simultaneous, in fact it is fairly close to a recursive model in the sense that the interrelationships between the endogenous variables cannot have very much of an effect during one quarter.[2] In this case, OLS estimators are near-consistent[3] and also close to the TSLSPC estimators.

1. Recently, attempts have been made in the LINK Project (p. 25, footnote 1) to extend the use of quarterly models to medium-term (from four to six year) analysis.

2. A good example of this is provided in the present model by the simultaneous interrelationship between the investment and production equations. Investment affects production with full weight through the balance of resources and expenditure identity, whereas production affects investment over ten quarters, which means that the unlagged production effect is not very great.

3. Cf. F.M. Fisher: Op.cit. "Dynamic ...", pp. 597 - 599.

On the whole, the signs and orders of magnitude of the parameter estimates presented in Appendix II are in keeping with a priori expectations. This requirement is of course placed on the OLS estimates when the equations are being specified. In a few cases, e.g., in the production equations (4.1., 4.2., 4.4. and 4.5) and the forestry wage rate and employment equations (7.3. and 8.3.), both the TSLSPC estimates deviate considerably (even with respect to signs) from the OLS estimates and do not agree with a priori expectations. Since alternative economic policy calculations are questionable if such coefficients are used, experiments were made to replace these estimates with both OLS and the TSLSPC estimates which were calculated using the largest number of principal components and which are in accordance with a priori expectations. This experiment led to the interesting result that ex post forecasts made in this way were inferior to both the original TSLSPC and the corresponding OLS forecasts. This would suggest that even when a so-called one-equation estimation method is used different estimators for individual equations in the model should be viewed with circumspection. It might be more worthwhile to try to change the specification of the equations for which the different estimators yield very different results.

On the other hand, in certain cases the TSLSPC estimates of Appendix II seem to be more reasonable than the OLS estimates. For example, the import equations for consumer and investment goods and for imports of passenger cars (3.3. - 3.5.) may be mentioned. In these cases, the price elasticity estimates obtained with the TSLSPC method were higher than those obtained with the OLS method, which supports the view which has recently been in vogue that foreign trade "elasticity pessimism" is partly a consequence of the simultaneity error involved in using OLS estimators.[1]

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1. Cf. E. Aurikko: Op.cit., pp. 57 - 63 and 79.

IV CONCLUSIONS

The purpose of the study was to test the usefulness of TSLSPC method to the estimation of macroeconomic multi-equation models. The method was applied in both its simplest and most developed forms to the estimation of the Bank of Finland econometric model. This large simultaneous and non-linear quarterly model is typical of many other multi-equation macroeconometric models. The results obtained with the TSLSPC method were assessed mainly by comparing them with OLS results and using the predictive performance of the model as a standard of comparison.

The empirical tests suggest that in general the individual TSLSPC estimates do not deviate much from the corresponding OLS estimates, but that in multi-period forecasts with the whole model these slight differences cumulate and indicate the superiority of the TSLSPC results.[1] In short-term forecasts, however, these differences do not affect on the results materially. For alternative economic policy simulations the results are not entirely conclusive because the OLS estimators may not be as sensitive to specification errors as the TSLSPC estimators.[2]

1. Klein arrived at similar conclusions. Cf. L.R. Klein: Op.cit., p. 183.

2. Support for this view is provided by the minimum variance property of OLS estimators. Cf., e.g., A.S. Goldberger: Op.cit., pp. 357 - 364.

The tests suggest that there is no practical difference between the simplest [equation (8)] and the most developed [equation (11)] version of the TSLSPC method. This is important for the usability of the TSLSPC method, for the latter alternative involves much work and is quite expensive compared with the former. However, both versions seem to be very sensitive to the number of principal components used. The best result, from the point of view of the predictive performance of the whole model was obtained with a rather small number of principal components. The results obtained with the TSLSPC method when the number of principal components is large relative to the number of observations do not differ much from those obtained with the OLS method, which in turn may be preferred when estimating certain individual parameters. However, our experiments indicate that the estimation of different equations in different ways does not improve the functioning of the whole model.

The sensitivity of the TSLSPC results to the number of principal components used makes us suspect that the results may also be sensitive to the set of variables from which the principal components are calculated, even if the importance of an individual variable among the predetermined variables is minor. This means that it may be troublesome to keep the TSLSPC estimates up-to-date in situations where the specification of the whole model changes rapidly.

The TSLSPC method would seem to be a useful, if the structure of the model can be regarded as relatively fixed and if the model is to be used for long-term forecasts over several years. If the model is a quarterly model designed only for short-term forecasting and simulation, there would, on the basis of this experiment, seem to be no real reason to use the TSLSPC method in addition to the OLS method.

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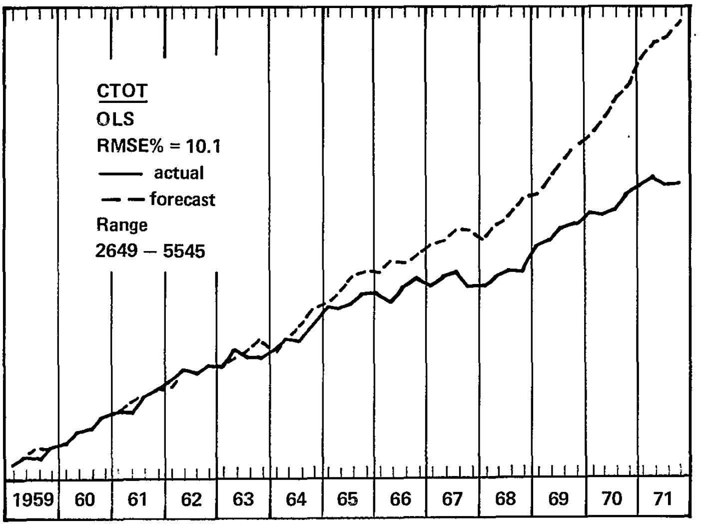
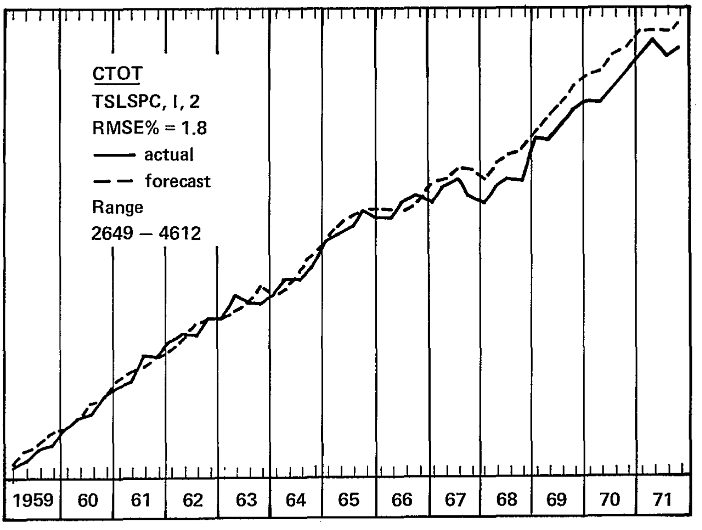
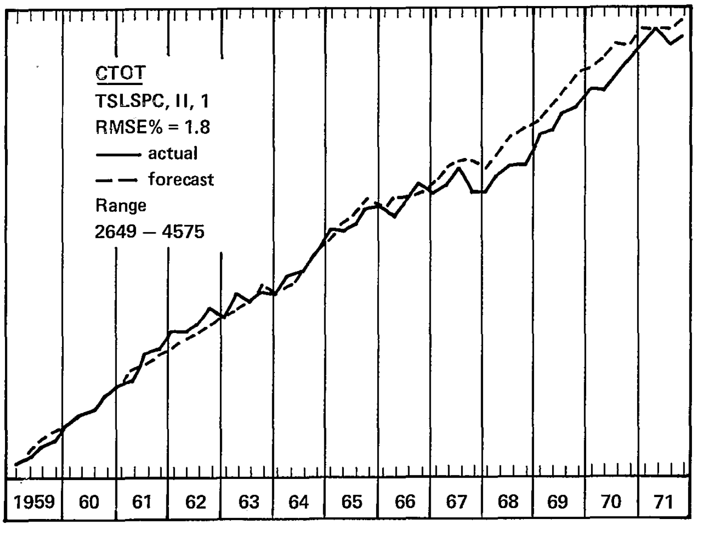
A p p e n d i x I

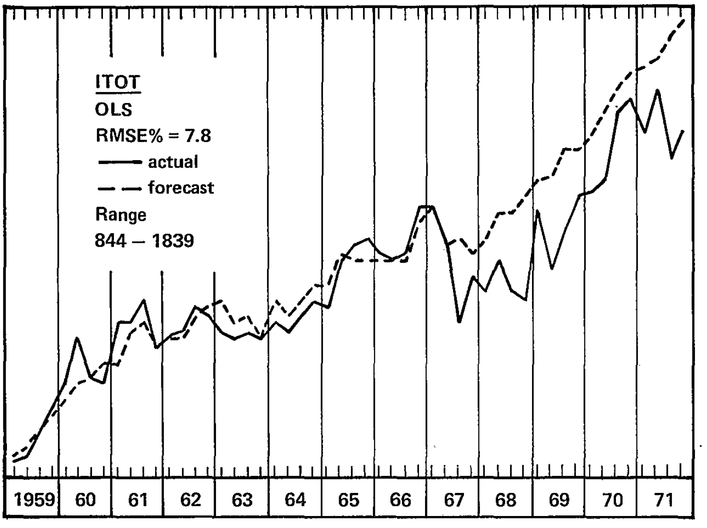
AN ABSTRACT OF THE EX POST FORECASTS

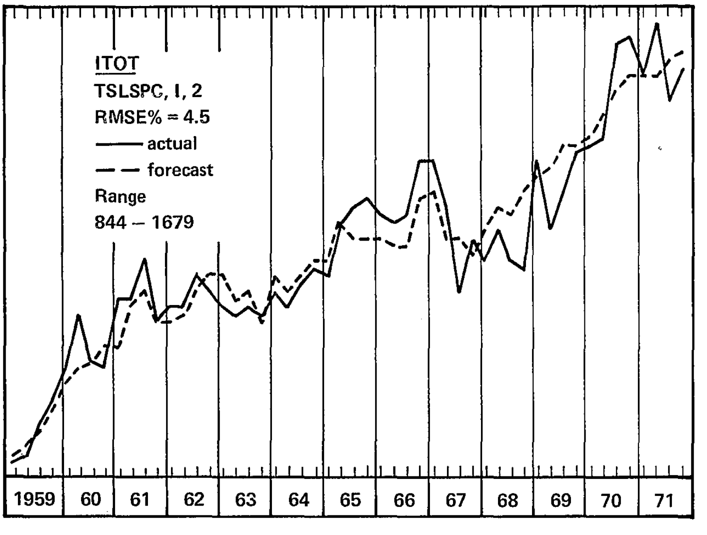
This appendix shows graphically the observed time path and the multi-period ex post forecasts (1959 I - 1971 IV) for some of the key variables of the model. The estimates obtained with estimation alternatives OLS, TSLSPC,I,2 and TSLSPC,II,1 are presented together with the RMSE%-measure (cf. p. 36) for each forecast.

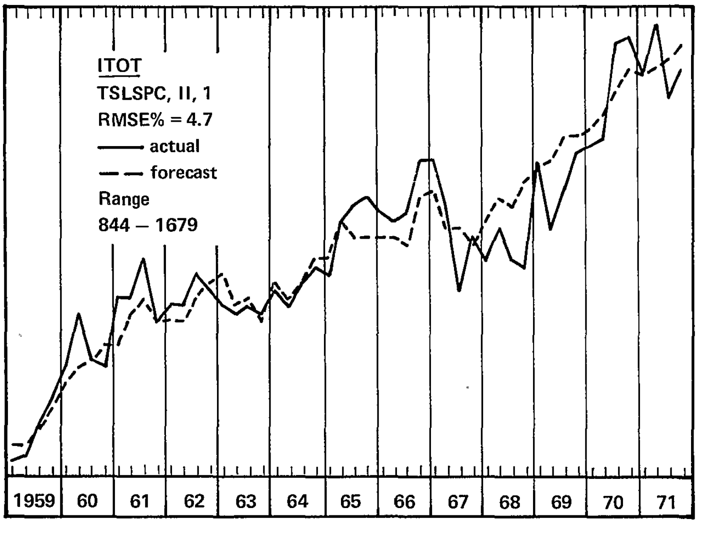

CTOT
OLS
RMSE% = 10.1
actual
forecast
Range
2649 – 5545
1959
60
61
62
63
64
65
66
67
68
69
70
71

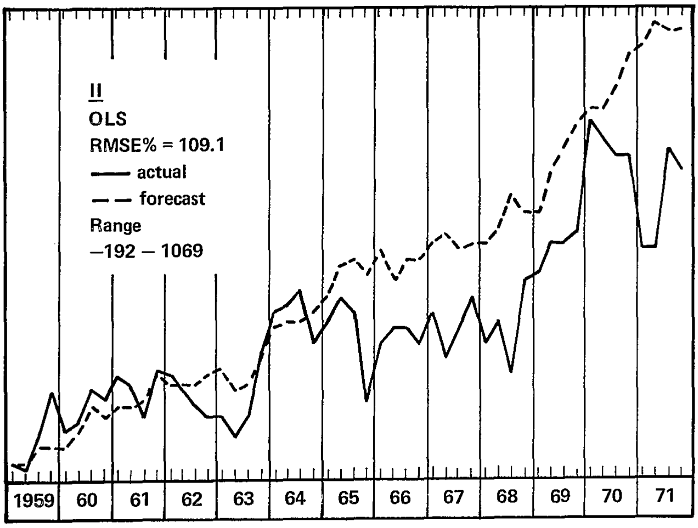

CTOT
TSLSPC, I, 2
RMSE% = 1.8
actual
forecast
Range
2649 – 4612
1959
60
61
62
63
64
65
66
67
68
69
70
71

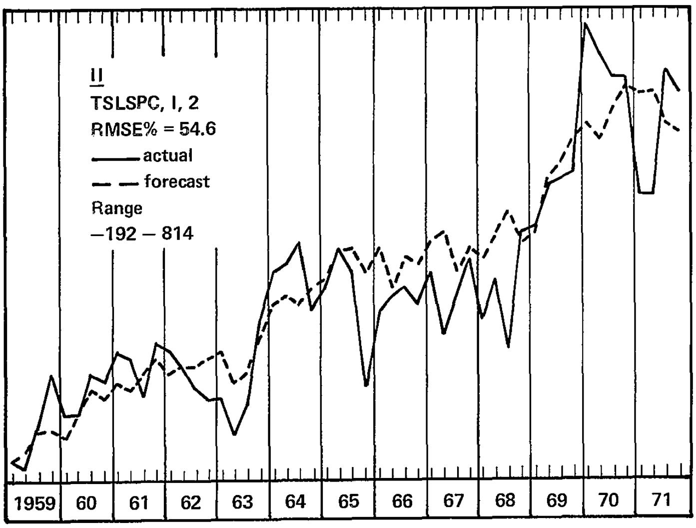

CTOT
TSLSPC, II, 1
RMSE% = 1.8
actual
forecast
Range
2649 – 4575
1959
60
61
62
63
64
65
66
67
68
69
70
71

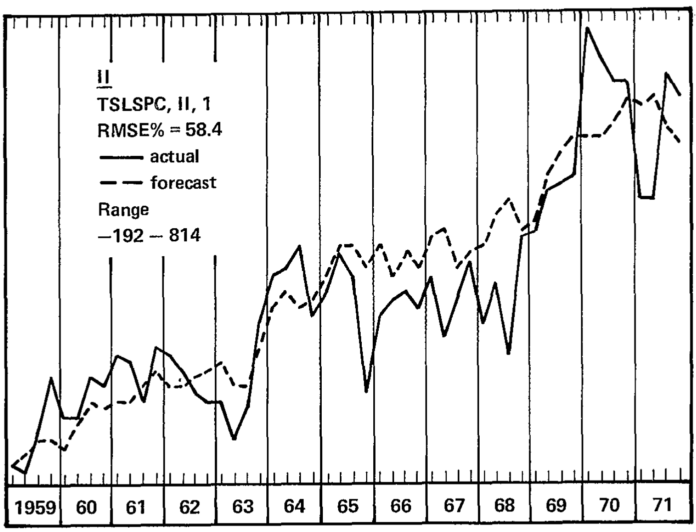

ITOT
OLS
RMSE% = 7.8
actual
forecast
Range
844 – 1839
1959
60
61
62
63
64
65
66
67
68
69
70
71

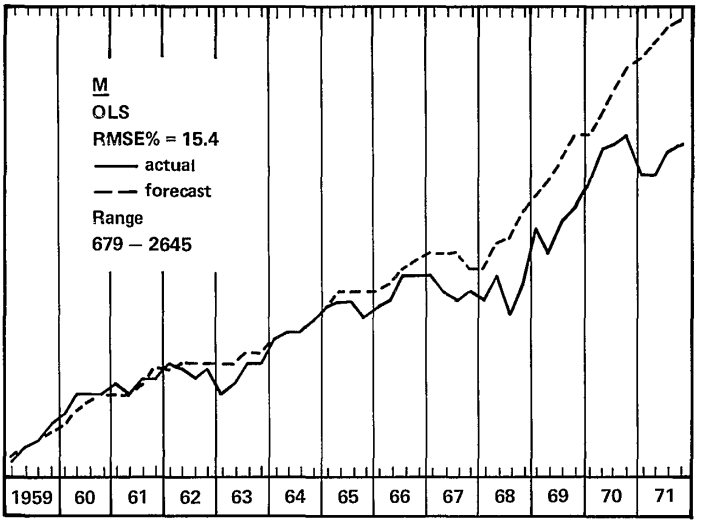

ITOT
TSLSPC, I, 2
RMSE% = 4.5
actual
forecast
Range
844 – 1679
1959
60
61
62
63
64
65
66
67
68
69
70
71

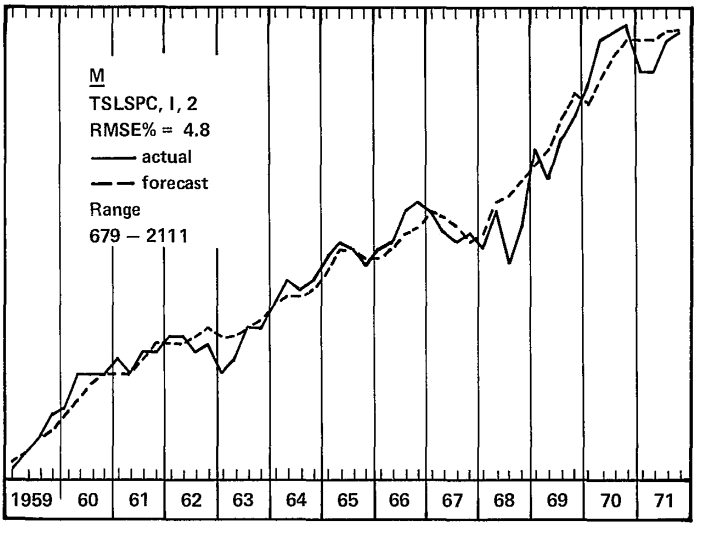

ITOT
TSLSPC, II, 1
RMSE% = 4.7
actual
forecast
Range
844 – 1679
1959
60
61
62
63
64
65
66
67
68
69
70
71

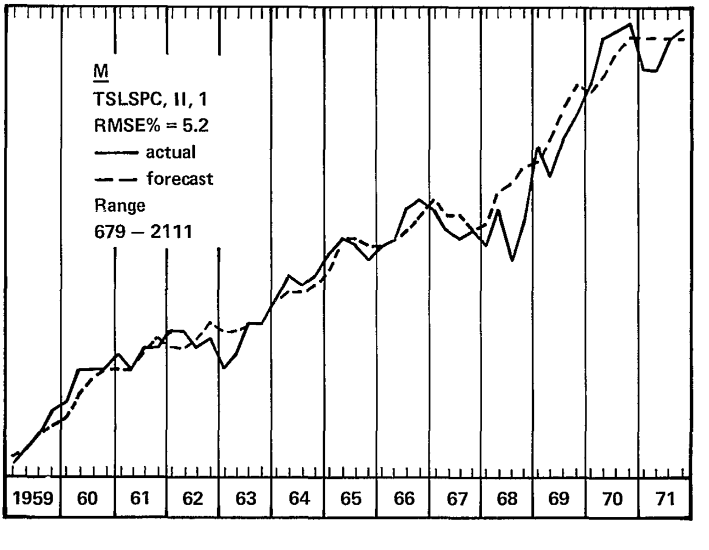

II
OLS
RMSE% = 109.1
—— actual
– – forecast
Range
–192 – 1069
1959
60
61
62
63
64
65
66
67
68
69
70
71

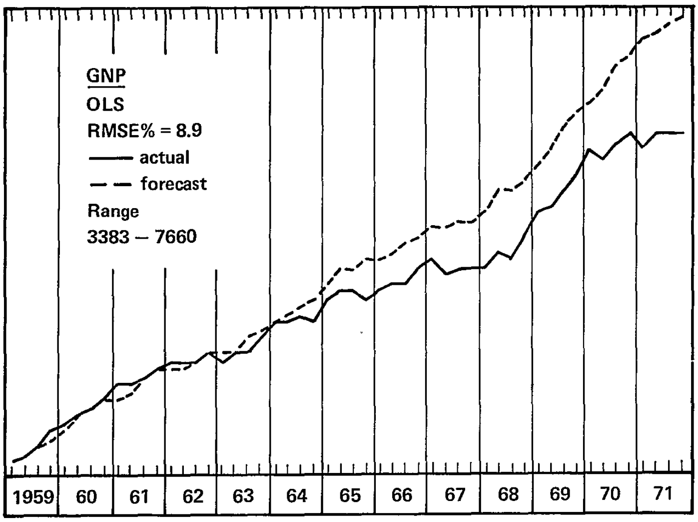

II
TSLSPC, I, 2
RMSE% = 54.6
—— actual
– – forecast
Range
–192 – 814
1959
60
61
62
63
64
65
66
67
68
69
70
71

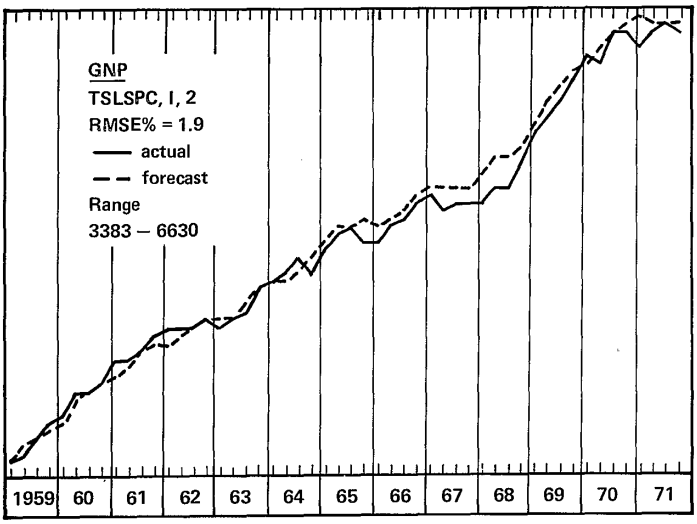

II
TSLSPC, II, 1
RMSE% = 58.4
—— actual
– – forecast
Range
–192 – 814
1959
60
61
62
63
64
65
66
67
68
69
70
71

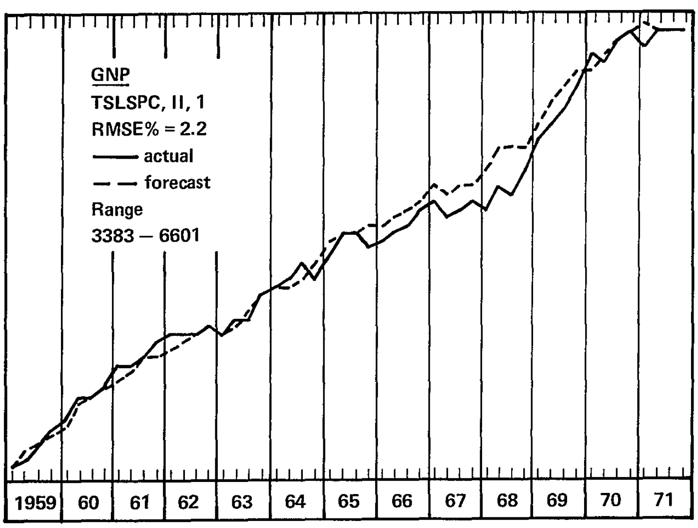

M
OLS
RMSE% = 15.4
actual
forecast
Range
679 – 2645
1959
60
61
62
63
64
65
66
67
68
69
70
71

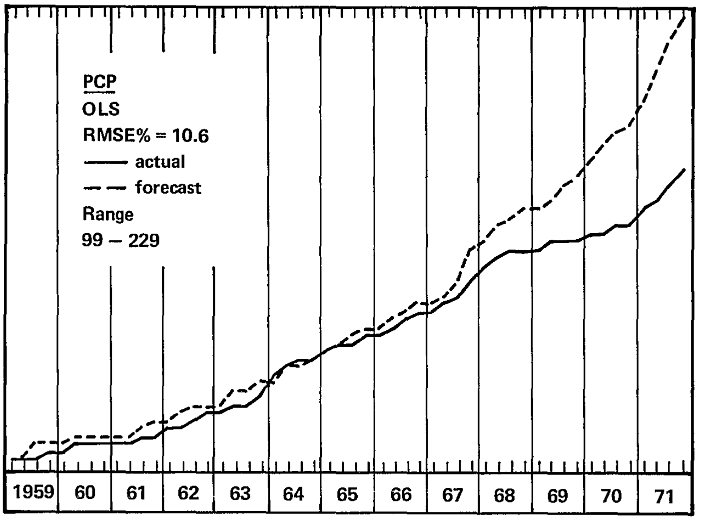

M
TSLSPC, I, 2
RMSE% = 4.8
actual
forecast
Range
679 – 2111
1959
60
61
62
63
64
65
66
67
68
69
70
71

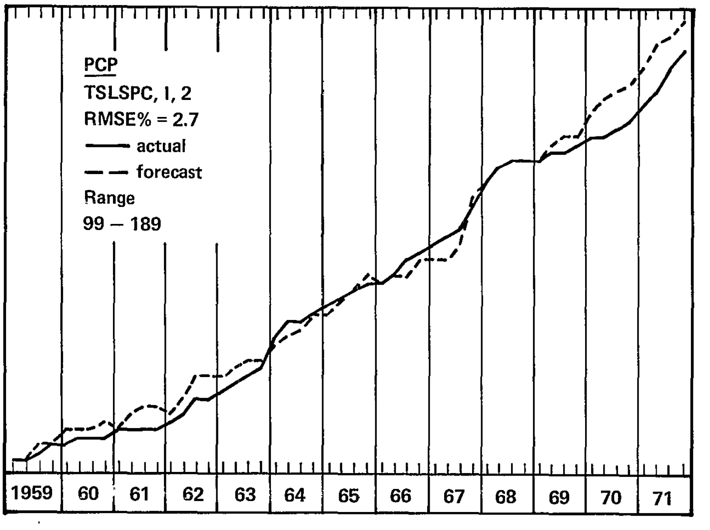

M
TSLSPC, II, 1
RMSE% = 5.2
actual
forecast
Range
679 – 2111
1959
60
61
62
63
64
65
66
67
68
69
70
71

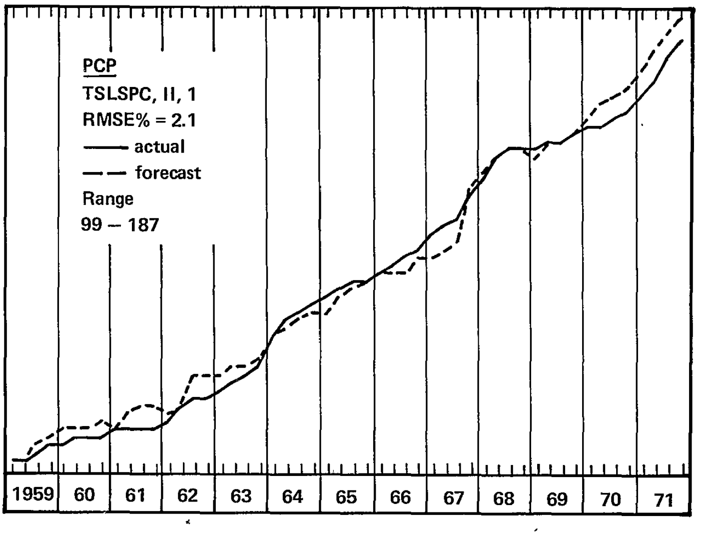

GNP
OLS
RMSE% = 8.9
actual
forecast
Range
3383 – 7660
1959
60
61
62
63
64
65
66
67
68
69
70
71

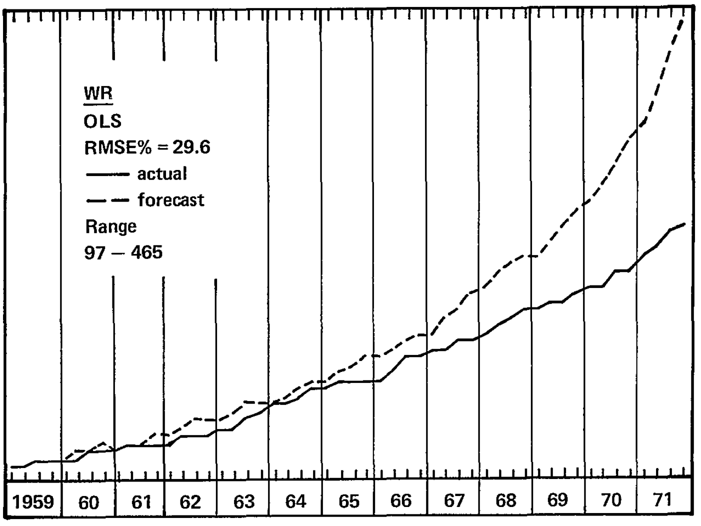

GNP
TSLSPC, I, 2
RMSE% = 1.9
actual
forecast
Range
3383 – 6630
1959
60
61
62
63
64
65
66
67
68
69
70
71

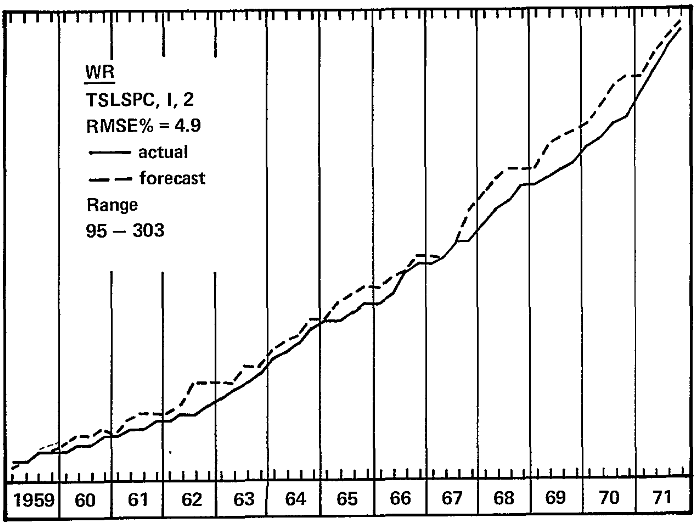

GNP
TSLSPC, II, 1
RMSE% = 2.2
actual
forecast
Range
3383 – 6601
1959
60
61
62
63
64
65
66
67
68
69
70
71

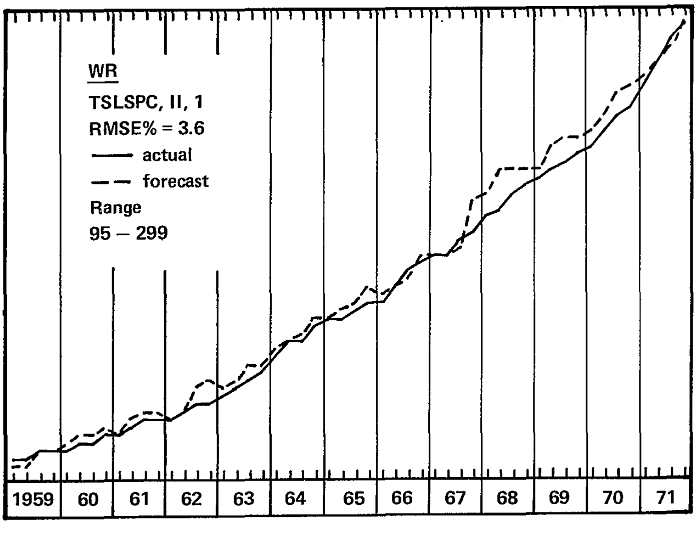

PCP
OLS
RMSE% = 10.6
actual
forecast
Range
99 – 229
1959
60
61
62
63
64
65
66
67
68
69
70
71

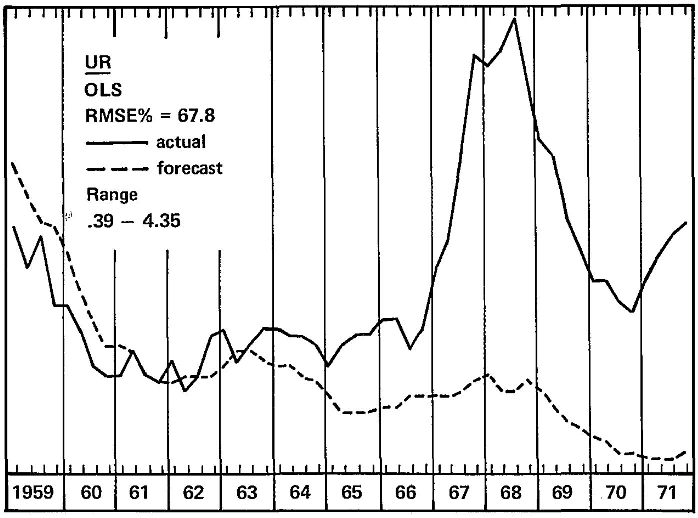

PCP
TSLSPC, I, 2
RMSE% = 2.7
actual
forecast
Range
99 – 189
1959
60
61
62
63
64
65
66
67
68
69
70
71

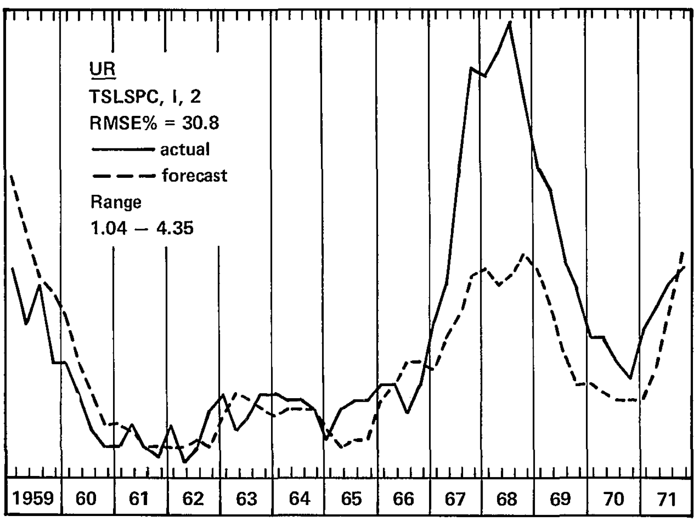

PCP
TSLSPC, II, 1
RMSE% = 2.1
actual
forecast
Range
99 – 187
1959
60
61
62
63
64
65
66
67
68
69
70
71

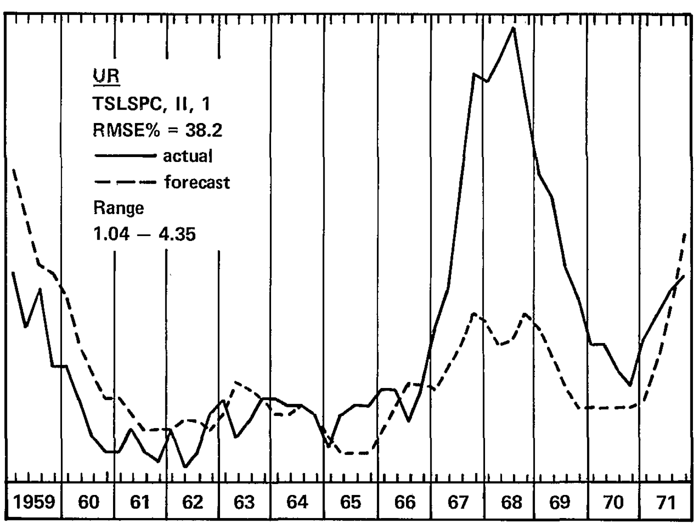

WR
OLS
RMSE% = 29.6
actual
forecast
Range
97 – 465
1959
60
61
62
63
64
65
66
67
68
69
70
71

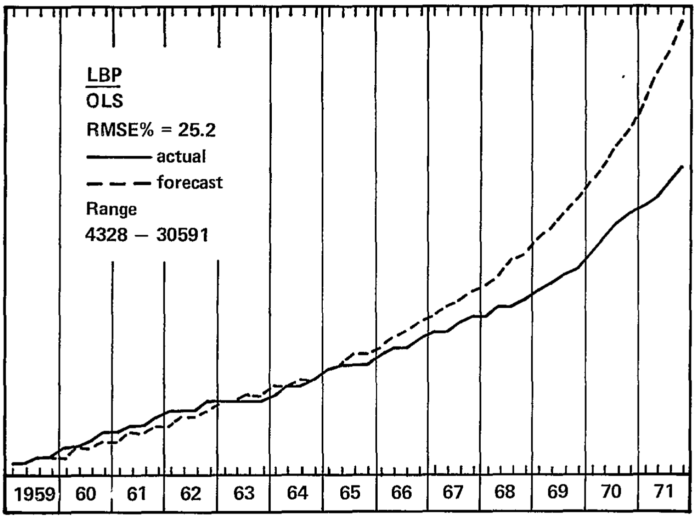

WR
TSLSPC, I, 2
RMSE% = 4.9
actual
forecast
Range
95 – 303
1959
60
61
62
63
64
65
66
67
68
69
70
71

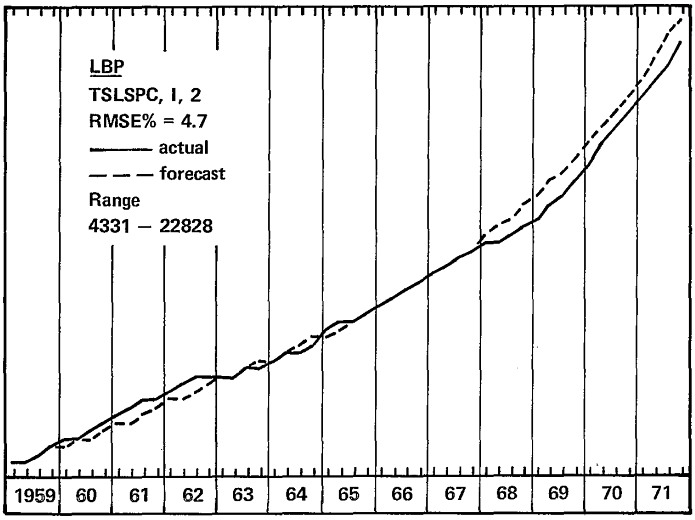

WR
TSLSPC, II, 1
RMSE% = 3.6
actual
forecast
Range
95 – 299
1959
60
61
62
63
64
65
66
67
68
69
70
71

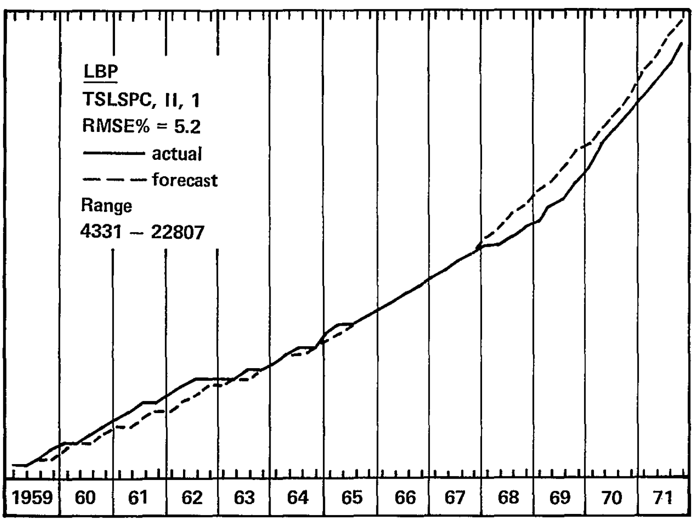

UR
OLS
RMSE% = 67.8
actual
forecast
Range
.39 – 4.35
1959 60 61 62 63 64 65 66 67 68 69 70 71

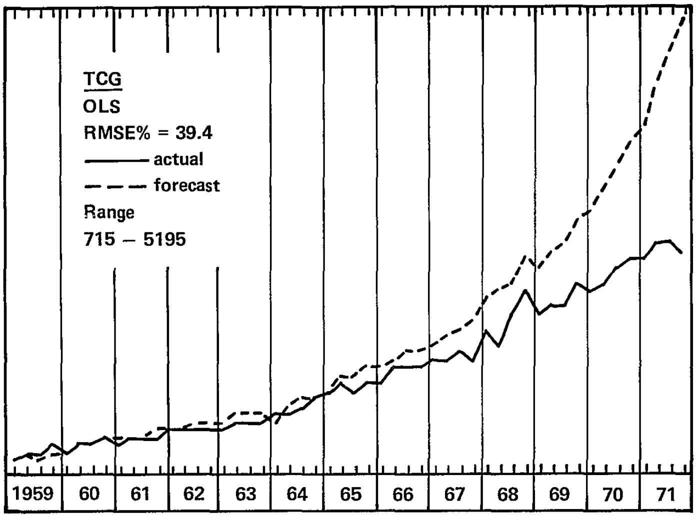

UR
TSLSPC, I, 2
RMSE% = 30.8
actual
forecast
Range
1.04 – 4.35
1959 60 61 62 63 64 65 66 67 68 69 70 71

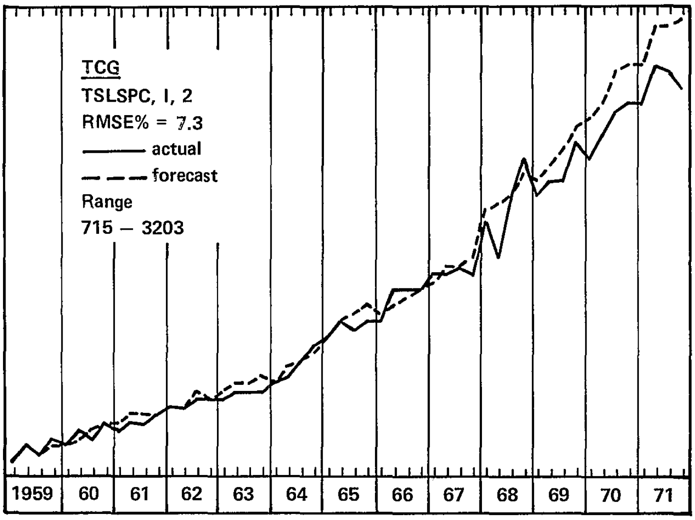

UR
TSLSPC, II, 1
RMSE% = 38.2
actual
forecast
Range
1.04 – 4.35
1959 60 61 62 63 64 65 66 67 68 69 70 71

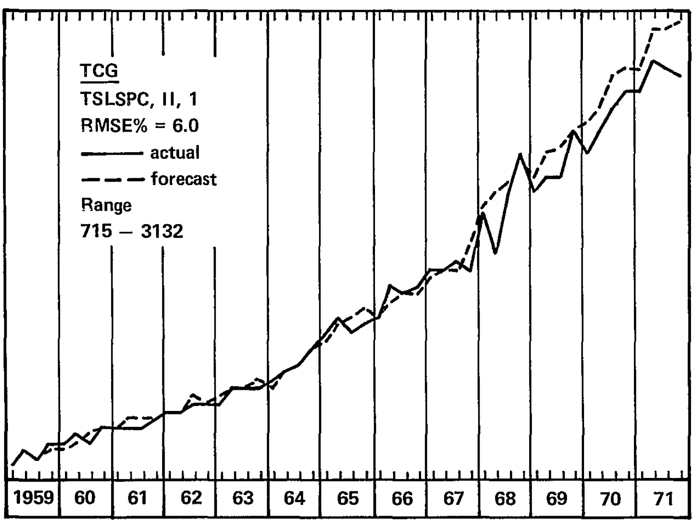

LBP
OLS
RMSE% = 25.2
actual
forecast
Range
4328 – 30591
1959
60
61
62
63
64
65
66
67
68
69
70
71


LBP
TSLSPC, I, 2
RMSE% = 4.7
actual
forecast
Range
4331 – 22828
1959
60
61
62
63
64
65
66
67
68
69
70
71


LBP
TSLSPC, II, 1
RMSE% = 5.2
actual
forecast
Range
4331 – 22807
1959
60
61
62
63
64
65
66
67
68
69
70
71


TCG
OLS
RMSE% = 39.4
actual
forecast
Range
715 – 5195
1959
60
61
62
63
64
65
66
67
68
69
70
71


TCG
TSLSPC, I, 2
RMSE% = 7.3
actual
forecast
Range
715 – 3203
1959
60
61
62
63
64
65
66
67
68
69
70
71


TCG
TSLSPC, II, 1
RMSE% = 6.0
actual
forecast
Range
715 – 3132
1959
60
61
62
63
64
65
66
67
68
69
70
71

Appendix II

LIST OF EQUATIONS

Each equation contains three sets of parameter estimates. The first is that obtained with OLS, the second with TSLSPC,I,2 and the third with TSLSPC,II,1. The figures in parentheses are the absolute values of the t-statistics. $\bar{R}^2$ is the coefficient of determination adjusted for degrees of freedom and DW is the Durbin-Watson statistic. The equations are presented in the form in which they were estimated.

1. CONSUMPTION

Consumer expenditure, durables (except cars) and non-durables, volume

1.1. $$\ln CDND = \underset{(112.5)}{5.144} + \underset{(54.3)}{.169} \sum_{0}^{3} \ln (YD/PCP)_{-v} + \underset{(2.9)}{.221} \sum_{0}^{3} \ln (DT_{-v}/DT_{-v-1}) - \underset{(2.1)}{.013} \ln UR + \underset{(3.7)}{.036}\, DST64 \qquad \bar{R}^2 = .982 \qquad DW = 1.37$$

const.	YD/PCP	DT	UR	DST64	$\bar{R}^2$	DW
5.144 (112.5)	.169 (54.3)	.221 (2.9)	- .013 (2.1)	+ .036 (3.7)	.982	1.37
5.145 (110.9)	.169 (54.0)	.213 (2.5)	- .011 (1.7)	+ .035 (3.7)	.982	1.37
5.158 (108.9)	.169 (53.3)	.145 (1.6)	- .016 (2.3)	+ .036 (3.7	.982	1.34

Consumer expenditure, tobacco, value

1.2. $$\ln CTV = - \underset{(9.6)}{1.967} + \underset{(10.6)}{.295} \sum_{0}^{3} \ln (YD/PCP)_{-v} + \underset{(7.8)}{.555} \ln PT \qquad \bar{R}^2 = .952 \qquad DW = 1.94$$

const.	YD/PCP	PT	$\bar{R}^2$	DW
- 1.967 (9.6)	.295 (10.6)	.555 (7.8)	.952	1.94
- 1.948 (9.4)	.289 (10.2)	.568 (7.9)	.952	1.94
- 1.941 (9.4)	.287 (10.1)	.573 (7.9)	.952	1.94

Consumer expenditure, services, volume

1.3. $$\ln CS = \underset{(48.0)}{3.689} + \underset{(25.1)}{.214} \sum_{0}^{3} \ln (YD/PCP)_{-v} - \underset{(5.7)}{.181} \sum_{0}^{3} \ln ((YSE1 + YSE3)/YW)$$

const.	YD/PCP	(YSE1 + YSE3)/YW	$\bar{R}^2$	DW
3.689 (48.0)	.214 (25.1)	- .181 (5.7)	.989	.86
3.816 (41.4)	.197 (18.4)	- .254 (6.2)	.987	1.11
3.815 (38.9)	.197 (17.0)	- .255 (5.7)	.987	1.11

Consumer expenditure, motor cars, volume

1.4. $$\ln CA = - \underset{(4.1)}{2.099} + \underset{(12.2)}{.475} \sum_{0}^{3} \ln (YD/PCP)_{-v} - \underset{(7.4)}{2.470} \ln (PA/PCP) - \underset{(2.6)}{.173} \ln UR_{-1} - \underset{(3.0)}{.921}\, DCA67$$

const.	YD/PCP	PA/PCP	UR_{-1}	DCA67	$\bar{R}^2$	DW
- 2.099 (4.1)	.475 (12.2)	- 2.470 (7.4)	- .173 (2.6)	- .921 (3.0)	.894	1.24
- 2.287 (4.3)	.490 (12.2)	- 2.332 (6.4)	- .180 (2.6)	- .918 (3.C)	.893	1.22
- 2.352 (4.4)	.495 (12.1)	- 2.346 (6.1)	- .180 (2.6)	- .924 (3.0)	.893	1.22

Consumer expenditure, fuel for motor cars, volume

1.5. $\ln CFA = - \underset{(5.7)}{3.055} + \underset{(16.5)}{.649} \sum_{0}^{3} \ln (YD/PCP)_{-v}$ $\quad \bar{R}^2 = .831 \quad DW = .35$

$- \underset{(5.7)}{3.071} \quad \underset{(16.4)}{.650} \quad .831 \quad .35$

$- \underset{(5.6)}{3.027} \quad \underset{(16.3)}{.647} \quad .831 \quad .35$

Total private consumption, volume and value

1.6. C = CDND + CA + CS

1.7. CV = .01 x PCP x C

Total consumption, volume and value

1.8. CTOT = C + CG

1.9. CTOTV = .01 x PCG x CG + CV

Propensity to consume

1.10. GAMMA = CV/YD

2. INVESTMENT

Investment and stock of capital, machinery, equipment and non-residential construction, volume

2.1. $IFEQCON = \underset{(10.3)}{334.4} + \sum_{0}^{9} w_v^{(1)} GNPFC4_{-v} + \sum_{1}^{14} w_v^{(2)} PII_{-v}$ $\quad \bar{R}^2 = .837 \quad DW = 1.29$

$\underset{(10.3)}{334.0} \quad .837 \quad 1.29$

$\underset{(10.3)}{334.7} \quad .837 \quad 1.29$

$w_v^{(1)}$ and $w_v^{(2)}$ are the coefficients of the 1st and 2nd degree Almon polynomials:

$w_0^{(1)}, \ldots, w_9^{(1)}$ = .083, .075, .067, .058, .050, .042, .033, .025, .017, .008

t-statistics for all coefficients = 16.9

TSLSPC estimates are equal to corresponding OLS estimates

$w_1^{(2)}, \ldots, w_{14}^{(2)}$ =

-4.191, (3.0)	-4.215, (3.9)	-4.189, (5.0)	-4.113, (6.1)	-3.988, (6.7)	-3.813, (6.5)	-3.588, (5.9)
-4.196, (3.0)	-4.220, (3.9)	-4.194, (5.0)	-4.118, (6.1)	-3.992, (6.7)	-3.817, (6.5)	-3.592, (5.9)
-4.185, (3.0)	-4.209, (3.9)	-4.183, (5.0)	-4.108, (6.1)	-3.983, (6.7)	-3.809, (6.5)	-3.585, (5.8)
-3.314, (5.2)	-2.990, (4.6)	-2.616, (4.1)	-2.192, (3.7)	-1.719, (3.4)	-1.196, (3.2)	-.623 (3.0)
-3.317, (5.2)	-2.992, (4.6)	-2.618, (4.1)	-2.194, (3.7)	-1.720, (3.4)	-1.197, (3.2)	-.623 (3.0)
-3.311, (5.2)	-2.987, (4.6)	-2.613, (4.1)	-2.190, (3.7)	-1.717, (3.4)	-1.194, (3.2)	-.622 (3.0)

2.2. $KFEQCON - IFEQCON = \underset{(7123.2)}{.996} KFEQCON_{-1}$ $\bar{R}^2 = .9999$ DW = .28

TSLSPC estimators are identical with OLS estimators

2.3. $IFEQ = \underset{(11.6)}{284.1} + \sum_{0}^{9} w_v^{(1)} GNPFC4_{-v} + \sum_{1}^{14} w_v^{(2)} PII_{-v}$ $\bar{R}^2 = .837$ DW = 1.34

$\underset{(11.5)}{283.7}$ .837 1.34

TSLSPC,II results are equal to OLS results

$w_v^{(1)}$ and $w_v^{(2)}$ are the coefficients of the 1st and 2nd degree Almon polynomials:

$w_0^{(1)}, \ldots, w_9^{(1)}$ = .062, .056, .050, .044, .037, .031, .025, .019, .012, .006

t-statistic for all coefficients = 16.7

TSLSPC,I estimates are equal to corresponding OLS estimates

$w_1^{(2)}, \ldots, w_{14}^{(2)}$ =

-2.869, (2.7)	-3.132, (3.8)	-3.322, (5.2)	-3.441, (6.7)	-3.488, (7.7)	-3.462, (7.8)	-3.365, (7.3)
-2.875, (2.7)	-3.137, (3.8)	-3.328, (5.2)	-3.446, (6.7)	-3.492, (7.7)	-3.467, (7.8)	-3.369, (7.3)
-3.196, (6.6)	-2.955, (6.0)	-2.643, (5.5)	-2.258, (5.1)	-1.801, (4.8)	-1.273, (4.5)	-.672 (4.3)
-3.200, (6.6)	-2.958, (6.0)	-2.645, (5.5)	-2.260, (5.1)	-1.803, (4.8)	-1.274, (4.5)	-.673 (4.3)

2.4. $KFEQ - IFEQ = \underset{(6153.0)}{.995} KFEQ_{-1}$ $\bar{R}^2 = .9999$ DW = .25

TSLSPC estimators are identical with OLS estimators

Residential construction, volume

2.5. $IH = -\underset{(4.0)}{46.8} + \underset{(30.6)}{2.828} \sum_{0}^{3} (YD/PCP)_{-v} + \sum_{1}^{14} w_v^{(2)} PII_{-v} + \underset{(4.4)}{118.2} DTR62 + \underset{(4.2)}{127.2} DTR66$

$-\underset{(4.0)}{47.5}$ $\underset{(30.6)}{2.834}$ $\underset{(4.4)}{118.3}$ $\underset{(4.2)}{127.3}$

$-\underset{(3.9)}{46.5}$ $\underset{(30.4)}{2.824}$ $\underset{(4.4)}{118.1}$ $\underset{(4.2)}{127.2}$

$w_1^{(2)}, \ldots, w_{14}^{(2)}$ = the coefficients of the 2nd degree Almon polynomial:

-.713, (1.7)	-.790, (2.4)	-.848, (3.4)	-.885, (4.5)	-.903, (5.3)	-.902, (5.5)	-.880, (5.2)
-.721, (1.7)	-.797, (2.5)	-.853, (3.4)	-.890, (4.5)	-.908, (5.3)	-.906, (5.5)	-.883, (5.2)
-.709, (1.7)	-.787, (2.4)	-.844, (3.4)	-.883, (4.5)	-.901, (5.3)	-.900, (5.5)	-.879, (5.2)
-.839, (4.7)	-.779, (4.3)	-.698, (3.9)	-.598, (3.6)	-.478, (3.4)	-.338, (3.2)	-.179 (3.1)
-.842, (4.7)	-.780, (4.3)	-.699, (3.9)	-.599, (3.6)	-.479, (3.4)	-.339, (3.2)	-.179 (3.1)
-.838, (4.7)	-.777, (4.3)	-.697, (3.9)	-.597, (3.6)	-.478, (3.4)	-.338 (3.2)	-.179 (3.1)

$\bar{R}^2$ = .949 DW = 1.80

.949 1.80

.949 1.80

Change in and stock of, business inventories, volume

2.6. $II = -\underset{(5.2)}{1865.8} + \underset{(4.5)}{.599}\, GNPFC_{-2} + \underset{(4.0)}{.881}\,(GNPFC_{-1} - GNPFC_{-2}) - \underset{(2.6)}{19.10}\, TIME + \underset{(1.6)}{95.9}\, DSTI64$

TSLSPC estimators are identical with OLS estimators

$\bar{R}^2 = .834 \qquad DV = 1.67$

2.7. $KI = II + KI_{-1}$

Total fixed investment, volume and value

2.8. ITOT = IFEQCON + ICONG + IH + ILW

2.9. ITOTV = .01 x PIF x ITOT

Change in business inventories, value

2.10. IIV = GNPV + MV - CTOTV - ITOTV - XV

3. FOREIGN TRADE

Imports of raw materials, volume

3.1. $\ln MR = -\underset{(1.0)}{.189} + \underset{(32.4)}{.920} \ln GNPFC4_{-1} - \underset{(3.1)}{.361} \ln (PMR/P4)_{-1} + \underset{(4.9)}{.530} \ln (GNPFC4/GNPFC4_{-4})$

$\qquad -\underset{(1.0)}{.189} \quad \underset{(32.4)}{.920} \quad -\underset{(3.1)}{.361} \quad \underset{(4.6)}{.527}$

$\qquad -\underset{(1.0)}{.187} \quad \underset{(32.4)}{.920} \quad -\underset{(3.1)}{.358} \quad \underset{(4.6)}{.549}$

$\bar{R}^2 = .979 \qquad DW = 1.57$

.979 1.57

.979 1.57

Imports of fuels and lubricants, volume

3.2. $\ln MFL = -\underset{(9.9)}{4.769} + \underset{(20.1)}{1.395} \ln GNPFC4 + \underset{(1.1)}{.195} \ln (KIF/KIF_{-1}) \qquad \bar{R}^2 = .880 \qquad DW = 1.18$

$\qquad -\underset{(9.9)}{4.785} \quad \underset{(20.1)}{1.397} \quad \underset{(1.1)}{.195} \qquad .880 \qquad 1.18$

$\qquad -\underset{(9.9)}{4.795} \quad \underset{(20.1)}{1.399} \quad \underset{(1.1)}{.195} \qquad .880 \qquad 1.18$

Imports of consumer goods, volume

3.3. $\ln MC = -\underset{(11.8)}{2.376} + \underset{(36.8)}{2.201} \ln (YD/PCP) - \underset{(4.8)}{.872} \ln (PMC/P4) - \underset{(.5)}{.015}\, DMCP$

- 2.425 (11.1)	2.215 (34.1)	- .870 (3.9)	- .015 (.6)
- 2.351 (10.4)	2.192 (32.6)	- .976 (4.1)	- .017 (.6)

$\bar{R}^2$	DW
.976	1.58
.976	1.59
.975	1.55

Imports of investment goods, volume

3.4. $\ln MI = -\underset{(6.7)}{2.133} + \underset{(18.9)}{1.094} \ln IFEQ + \underset{(5.1)}{.172} \ln XME - \underset{(2.5)}{.495} \ln (PMI/P4)$

- 2.496 (7.1)	1.169 (18.3)	.154 (4.3)	- .527 (2.4)
- 2.664 (7.2)	1.199 (17.6)	.152 (4.2)	- .590 (2.6)

$\bar{R}^2$	DW
.935	1.08
.933	1.16
.931	1.16

Imports of motor cars, volume

3.5. $\ln MA = -\underset{(1.4)}{.377} + \underset{(14.7)}{.872} \ln CA \qquad \bar{R}^2 = .797 \qquad DW = 1.60$

		$\bar{R}^2$	DW
- .500 (1.8)	.900 (14.4)	.796	1.61
- .515 (1.8)	.903 (14.3)	.796	1.61

Imports of goods, by category, value

3.6. MRV = .01 x PMR x MR

3.7. MFLV = .01 x PMFL x MFL

3.8. MCV = .01 x PMC x MC

3.9. MIV = .01 x PMI x MI

3.10. MAV = .01 x PMI x MA

Imports of goods, total, volume and value

3.11. MG = MR + MFL + MC + MI + MA

3.12. MGV = .01 x PM x MG

Imports of goods and services, volume and value

3.13. M = MG + MS

3.14. MV = MGV + MSV

Trade balance

3.15. BPTV = XGV - MGV

4. PRODUCTION

Production at factor cost, by sector (1 = Agriculture, 2 = Non-competitive industries, 3 = Forestry, 4 = Competitive industries), volume

4.1. GNPFC1/GNP =

CTOT/GNP	ITOT/GNP	X/GNP	M/GNP	II/GNP
.135 (8.4)	+ .104 (1.8)	+ .129 (3.0)	- .184 (2.5)	+ .178 (4.6)
.132 (4.3)	- .026 (.1)	.125 (2.2)	- .025 (.1)	.067 (.6)
.175 (3.7)	.001 (.0)	.112 (1.8)	.169 (.5)	.242 (1.2)

TIME	$\bar{R}^2$	DW
- .00097 (8.9)	.942	1.71
- .00106 (3.4)	.929	1.80
- .00113 (3.6)	.927	1.43

4.2. GNPFC2/GNP =

CTOT/GNP	ITOT/GNP	X/GNP	M/GNP	II/GNP
.623 (27.6)	+ .319 (3.9)	+ .324 (5.3)	- .515 (5.0)	+ .241 (4.5)
.641 (13.2)	- .052 (.2)	.336 (3.8)	- .151 (.4)	.073 (.4)
.614 (8.3)	.066 (.2)	.331 (3.5)	- .214 (.4)	- .002 (.0)

TIME	$\bar{R}^2$	DW
.00093 (6.0)	.686	1.22
.00047 (1.0)	.525	1.89
.00081 (1.6)	.522	1.91

4.3. GNPFC3/GNP =

CTOT/GNP	ITOT/GNP	X/GNP	M/GNP	II/GNP
.041 (3.5)	+ .160 (3.7)	+ .195 (6.1)	- .169 (3.1)	+ .195 (7.0)
.038 (1.8)	.245 (1.8)	.206 (5.2)	- .270 (1.7)	.253 (3.4)
.036 (1.1)	.228 (1.5)	.199 (4.8)	- .237 (1.1)	.239 (1.7)

TIME	$\bar{R}^2$	DW
- .00075 (9.4)	.886	1.50
- .00068 (3.1)	.872	1.74
- .00071 (3.3)	.876	1.69

4.4. GNPFC4/GNP = .101 CTOT/GNP + .333 ITOT/GNP + .360 X/GNP − .243 M/GNP + .236 II/GNP

.101 (6.5)	.333 (6.0)	.360 (8.6)	.243 (3.4)	.236 (6.4)
.049 (1.1)	.862 (3.0)	.430 (5.2)	− .764 (2.3)	.414 (2.6)
.076 (.7)	1.177 (2.4)	.463 (3.5)	−1.239 (1.8)	.724 (1.6)

.00090 TIME (8.6)	$\bar{R}^2$ = .966	DW = .83
.00154 (3.3)	.903	1.81
.00182 (2.6)	.777	2.06

Indirect taxes minus subsidies, volume

4.5. TIN/GNP = .100 CTOT/GNP + .087 ITOT/GNP − .008 X/GNP + .110 M/GNP + .150 II/GNP

.100 (4.3)	.087 (1.0)	− .008 (.1)	.110 (1.0)	.150 (2.7)
.140 (3.2)	− .029 (.1)	− .097 (1.2)	.209 (.7)	.193 (1.3)
.099 (1.1)	− .472 (1.1)	− .106 (.9)	.859 (1.4)	− .202 (.5)

− .00010 TIME (.6)	$\bar{R}^2$ = .506	DW = .41
− .00026 (.6)	.435	.72
− .00079 (1.3)	*)	1.29

*) Nonsensible because of rounding errors

Gross domestic product at factor cost, volume and value

4.6. GNPFC = GNPFC1 + GNPFC2 + GNPFC3 + GNPFC4

4.7. GNPFCV = YW + YNW + SOCC

Gross domestic product at market prices, volume and value

4.8. GNP = GNPFC + TIN

4.9. GNPV = GNPFCV + TINV

5. PRICES

Public consumption prices

5.1. PCG = − 48.9 + 1.471 PCGIOE $\bar{R}^2$ = .997   DW = .59
(32.1) (131.2)

TSLSPC results are equal to OLS results

Private consumption prices

5.2. $$PCP = \underset{(1.8)}{2.2} + \underset{(105.9)}{.987}\ PCPIOE \qquad \bar{R}^2 = .995 \qquad DW = .30$$

TSLSPC results are equal to OLS results

Fixed investment prices

5.3. $$PIF = -\underset{(5.5)}{10.5} + \underset{(76.9)}{1.087}\ PIFIOE \qquad \bar{R}^2 = .991 \qquad DW = .14$$

TSLSPC results are equal to OLS results

Prices in sectors 2 (Non-competitive industries) and 4 (Competitive industries)

5.4. $$P2 = \underset{(6.8)}{12.8} + \underset{(38.3)}{.856}\ P2IOE + \underset{(6.5)}{.261}\ TIME \qquad \bar{R}^2 = .999 \qquad DW = .68$$

$$\underset{(6.4)}{12.4} \quad \underset{(37.5)}{.860} \quad \underset{(6.2)}{.253} \qquad .999 \qquad .68$$

TSLSPC,II results are equal to OLS results

5.5. $$P4 = \underset{(3.4)}{27.29}\ (YW4 + SOCC4)/GNPFC4 + \underset{(9.0)}{.315}\ (.293\ PMFG + .707\ PXFG) + \underset{(8.1)}{.132} \sum_{1}^{4} P4_{-v}$$

$$\underset{(3.2)}{27.08} \qquad \underset{(9.0)}{.315} \qquad \underset{(7.9)}{.132}$$

$$\underset{(3.1)}{26.77} \qquad \underset{(9.0)}{.315} \qquad \underset{(7.8)}{.133}$$

$$\bar{R}^2 = .992 \qquad DW = .80$$

$$.992 \qquad .80$$

$$.992 \qquad .80$$

Input - output estimates of price indices

5.6. $PCGIOE = .0072\ P1 + .8860\ P2 + .0205\ P3 + .0493\ P4 + .0370\ PMC$

5.7. $PCPIOE = .0549\ P1 + .7298\ P2 + .0011\ P3 + .1188\ P4 + .0954\ PMC$

5.8. $PIFIOE = .6667\ P2 + .0126\ P3 + .1472\ P4 + .1735\ PMI$

5.9. $P2IOE = .1027\ P1 + .0113\ P3 + .1291\ P4 + .0489\ PMR2$

$+ 70.79\ (YW2 + YNW2 + SOCC2)/GNPFC2$

Price index of gross domestic product

5.10. $PGNPFC = 100\ GNPFCV/GNPFC$

NON-WAGE INCOMES

Incomes from unincorporated enterprises in sectors 1 (Agriculture), 3 (Forestry), and 2 and 4 (Non-competitive and Competitive industries)

6.1.	YSE1 =	- 335.2 (6.4)	+ 3.117 P1 (25.4)	+ .795 GNPFC1 (6.0)	$\bar{R}^2$ = .935	DW = 1.41
		- 132.4 (1.3)	3.229 (21.9)	.259 (1.0)	.915	1.65
		- 83.9 (.7)	3.256 (20.5)	.131 (.4)	.904	1.67

6.2.	YSE3 =	- 277.5 (11.1)	+ 1.613 P3 (11.4)	+ .924 GNPFC3 (7.0)	$\bar{R}^2$ = .931	DW = .74
		- 332.2 (9.7)	1.335 (7.1)	1.259 (6.5)	.923	.99
		- 340.3 (8.9)	1.294 (6.3)	1.309 (6.0)	.920	1.02

6.3.	YSE24 =	38.9 (18.3)	+ .0396 GNPFCV (119.0)	$\bar{R}^2$ = .996	DW = .98

TSLSPC results are equal to OLS results

Non-wage incomes by sector

6.4.	YNW1 =	96.8 (3.0)	+ .594 YNW1IOE (5.7)	+ 3.747 TIME (5.4)	$\bar{R}^2$ = .962	DW = 1.02
		117.0 (1.9)	.528 (2.7)	4.163 (3.3)	.962	1.05
		100.7 (1.9)	.581 (3.3)	3.827 (3.4)	.962	1.02

6.5.	YNW2/(YNW2 + YW2 + SOCC2) =	.454 (165.3)	- .00555 UR (4.9)	- .00140 TIME (22.5)	$\bar{R}^2$ = .919	DW = .50
		.456 (161.8)	- .00621 (5.2)	- .00139 (22.3)	.919	.50
		.455 (158.8)	- .00605 (4.9)	- .00140 (22.3)	.919	.50

6.6.	YNW3 =	1.206 YNW3IOE (59.4)	$\bar{R}^2$ = .854	DW = .80
		1.217 (59.3)	.854	.81
		1.221 (59.1)	.853	.82

6.7.	YNW4 =	1.049 YNW4IOE (98.1)	$\bar{R}^2$ = .974	DW = 1.50
		1.053 (98.1)	.974	1.51
		1.053 (97.9)	.974	1.51

Dividends

6.8.
$$YDIV = \underset{(3.4)}{6.2} + \underset{(3.7)}{.015}\ YNW4 + \underset{(21.1)}{.875}\ YDIV_{-1} - \underset{(1.3)}{.086}\ TIME \qquad \bar{R}^2 = .979 \qquad DW = .32$$
$$\underset{(3.4)}{6.3} + \underset{(3.8)}{.016} \qquad \underset{(20.8)}{.870} \qquad - \underset{(1.4)}{.096} \qquad .979 \qquad .32$$
$$\underset{(3.4)}{6.3} + \underset{(3.5)}{.015} \qquad \underset{(20.8)}{.873} \qquad - \underset{(1.3)}{.090} \qquad .979 \qquad .32$$

Rent and interest income

6.9.
$$YRI = \underset{(5.0)}{63.7} + \underset{(47.1)}{.0947}\ GNPFCV \qquad \bar{R}^2 = .976 \qquad DW = .20$$
$$\underset{(5.0)}{63.5} \quad \underset{(47.1)}{.0947} \qquad .976 \qquad .20$$
$$\underset{(4.9)}{63.2} \quad \underset{(47.1)}{.0948} \qquad .976 \qquad .20$$

Input - output estimates of non-wage incomes in sectors 1, 3 and 4

6.10.
$$YNW1IOE = .01432\ (P1 \times GNPFC1) - .00267\ (P2 \times GNPFC1) - .00014\ (P3 \times GNPFC1) - .00106\ (P4 \times GNPFC1) - .00045\ (PMR1 \times GNPFC1) - YW1 - SOCC1$$

6.11.
$$YNW3IOE = .01062\ (P3 \times GNPFC3) - .00034\ (P1 \times GNPFC3) - .00013\ (P2 \times GNPFC3) - .00012\ (P4 \times GNPFC3) - .00003\ (PMR3 \times GNPFC3) - YW3 - SOCC3$$

6.12.
$$YNW4IOE = .01969\ (P4 \times GNPFC4) - .00006\ (P1 \times GNPFC4) - .00282\ (P2 \times GNPFC4) - .00282\ (P3 \times GNPFC4) - .00399\ (PMR4 \times GNPFC4) - YW4 - SOCC4$$

Incomes from unincorporated enterprises and non-wage incomes, total

6.13. $YSE = YSE1 + YSE3 + YSE24$

6.14. $YNW = YNW1 + YNW2 + YNW3 + YNW4$

7. WAGE INCOMES

Level of earnings, by sector (1 = Agriculture, 2 = Non-competitive industries, 3 = Forestry, 4 = Competitive industries)

7.1.
$$\ln (WR1/WR1_{-4}) = \underset{(20.2)}{1.133}\ (\ln (YW234/LW234) - \ln (YW234/LW234)_{-4})$$
$$\underset{(19.9)}{1.132}$$
$$\underset{(19.6)}{1.130}$$

$\bar{R}^2 = .526 \qquad DW = .71$

$.526 \qquad .71$

$.526 \qquad .71$

7.2. $$\ln(WR2/WR2_{-4}) = \underset{(4.3)}{.411}\ln(PCP/PCP_{-4}) + \underset{(7.9)}{.595}\left(\ln(YW4/LW4) - \ln(YW4/LW4)_{-4}\right)$$

$$\underset{(5.2)}{.589} \qquad\qquad \underset{(6.1)}{.519}$$

$$\underset{(4.9)}{.633} \qquad\qquad \underset{(5.5)}{.488}$$

$$+ \underset{(2.4)}{.086}\left(1/\sum_{1}^{4} UR_{-v}\right) \qquad \bar{R}^2 = .624 \qquad DW = .60$$

$$+ \underset{(1.8)}{.073} \qquad .619 \qquad .65$$

$$+ \underset{(1.8)}{.076} \qquad .606 \qquad .65$$

7.3. $$\ln(WR3/WR3_{-4}) = \underset{(3.1)}{.960}\ln(PCP/PCP_{-4}) + \underset{(4.9)}{.382}\left(\ln(GNPFC3/LW3) - \ln(GNPFC3/LW3)_{-4}\right)$$

$$\underset{(.8)}{.542} \qquad\qquad \underset{(2.1)}{.677}$$

$$\underset{(.1)}{.051} \qquad\qquad \underset{(2.4)}{.922}$$

$$+ \underset{(2.5)}{.272}\left(1/\sum_{1}^{4} UR_{-v}\right) \qquad \bar{R}^2 = .368 \qquad DW = 1.85$$

$$+ \underset{(2.1)}{.327} \qquad .192 \qquad 1.57$$

$$+ \underset{(2.4)}{.417} \qquad *) \qquad 1.50$$

*) Nonsensible because of rounding errors

7.4. $$\ln(WR4/WR4_{-4}) = \underset{(8.2)}{.769}\ln(PCP/PCP_{-4}) + \underset{(6.3)}{.538}\left(\ln(GNPFC4/LW4) - \ln(GNPFC4/LW4)_{-4}\right)$$

$$\underset{(7.1)}{.772} \qquad\qquad \underset{(6.1)}{.660}$$

$$\underset{(6.3)}{.778} \qquad\qquad \underset{(6.0)}{.676}$$

$$+ \underset{(3.2)}{.068}\left(1/\sum_{1}^{4} UR_{-v}\right) \qquad \bar{R}^2 = .351 \qquad DW = .61$$

$$+ \underset{(2.0)}{.048} \qquad .326 \qquad .74$$

$$+ \underset{(1.8)}{.045} \qquad .318 \qquad .75$$

Negotiated wage rate

7.5. $$\ln WNR = \underset{(148.3)}{.894}\ln PCP + \underset{(19.2)}{.512}\ln(GNPFC/LW) \qquad \bar{R}^2 = .996 \qquad DW = 1.48$$

$$\underset{(147.0)}{.893} \qquad \underset{(19.2)}{.516} \qquad .996 \qquad 1.48$$

$$\underset{(146.7)}{.893} \qquad \underset{(19.2)}{.517} \qquad .996 \qquad 1.48$$

Rate of employers' contributions to social security

7.6. $$SOCCR - SOCNPGR = \underset{(2.1)}{.009} + \underset{(12.1)}{.837}\,DSOCO + \underset{(8.9)}{.00038}\,TIME \qquad \bar{R}^2 = .971 \qquad DW = 1.04$$

TSLSPC estimators are identical with OLS estimators

Wages and salaries, in non-farm sectors and all sectors

7.7. $YW1 = .00667\ (WR1 \times LW1)$

7.8. $YW2 = .01189\ (WR2 \times LW2)$

7.9. $YW3 = .01170\ (WR3 \times LW3)$

7.10. $YW4 = .01162\ (WR4 \times LW4)$

7.11. $YW234 = YW2 + YW3 + YW4$

7.12. $YW = YW1 + YW234$

Employers' contributions to social security, by sector, and as a whole

7.13. $SOCC1 = SOCCR \times YW1$

7.14. $SOCC2 = SOCCR \times YW2$

7.15. $SOCC3 = SOCCR \times YW3$

7.16. $SOCC4 = SOCCR \times YW4$

7.17. $SOCC = SOCC1 + SOCC2 + SOCC3 + SOCC4$

Disposable income of households

7.18. $YD = YW + SOCC + YSE + YDIV + YRI - TRHGN$

Level of earnings, total

7.19. $WR = 86.12\ YW/LW$

Share of labour income in nominal gross domestic product

7.20. $ALFA = 100\ YW/GNPFCV$

8. EMPLOYMENT

Labour input by sector (1 = Agriculture, 2 = Non-competitive industries, 3 = Forestry, 4 = Competitive industries)

8.1.
$$\ln LW1 = \underset{(2.5)}{5.096} - \underset{(1.5)}{.387} \ln LW234 - \underset{(3.8)}{.480} \ln (WR1/P1) + \underset{(3.1)}{.386} \ln LW1_{-1}$$
$$\underset{(2.4)}{5.154} - \underset{(1.5)}{.406} \qquad - \underset{(3.2)}{.451} \qquad \underset{(3.2)}{.405}$$
$$\underset{(2.0)}{4.388} - \underset{(1.2)}{.328} \qquad - \underset{(2.9)}{.423} \qquad \underset{(3.5)}{.461}$$

$\bar{R}^2 = .923 \quad DW = 1.86$

$.923 \quad 1.90$

$.922 \quad 2.00$

8.2.

$$\begin{array}{lllll}
\ln LW2 = & .550\ + & .432 \ln GNPFC2\ - & .209 \ln (WR2/P2)\ + & .432 \ln LW2_{-1} \\
 & (1.7) & (6.6) & (3.6) & (5.1) \\
 & .695 & .410 & -\ .178 & .434 \\
 & (2.0) & (5.4) & (2.7) & (4.6) \\
 & .295 & .064 & -\ .020 & .885 \\
 & (.6) & (.5) & (.2) & (5.0)
\end{array}$$

$$\begin{array}{ll}
\bar{R}^2 = .994 & DW = 1.58 \\
.994 & 1.59 \\
.991 & 2.19
\end{array}$$

8.3.

$$\begin{array}{lllll}
\ln LW3 = & 3.256\ + & .219 \ln GNPFC3\ - & .478 \ln (WR3/P3)\ - & .089 \ln UR \\
 & (4.2) & (1.6) & (6.8) & (2.3) \\
 & 4.813\ - & .057 & -\ .368 & -\ .138 \\
 & (3.9) & (.3) & (3.7) & (2.5) \\
 & 7.282\ - & .495 & -\ .189 & -\ .215 \\
 & (3.6) & (1.4) & (1.2) & (2.7)
\end{array}$$

$$\begin{array}{ll}
\bar{R}^2 = .750 & DW = 1.24 \\
.730 & 1.38 \\
.618 & 1.43
\end{array}$$

8.4.

$$\begin{array}{llllll}
\ln LW4 = & 1.384\ + & .228 \ln GNPFC4\ - & .136 \ln (WR4/P4)\ - & .017 \ln UR\ + & .505 \ln LW4_{-1} \\
 & (5.1) & (8.6) & (5.4) & (4.2) & (7.4) \\
 & 1.374 & .239 & -\ .149 & -\ .018 & .495 \\
 & (4.6) & (8.2) & (5.5) & (4.1) & (6.5) \\
 & 1.843 & .294 & -\ .169 & -\ .026 & .351 \\
 & (2.7) & (4.2) & (5.1) & (2.4) & (1.8)
\end{array}$$

$$\begin{array}{ll}
\bar{R}^2 = .992 & DW = 1.80 \\
.992 & 1.79 \\
.991 & 1.52
\end{array}$$

Unemployment rate

8.5.

$$\begin{array}{llllll}
\ln UR = & 112.384\ + & \sum_{0}^{3} w_v^{(1)} \ln GNPFC_{-v}\ + & .177\ TIME & \bar{R}^2 = .844 & DW = .80 \\
 & (16.5) & & (17.0) & & \\
 & 122.891 & & .193 & .837 & .81 \\
 & (16.2) & & (16.6) & & \\
 & 121.917 & & .191 & .839 & .82 \\
 & (16.2) & & (16.6) & &
\end{array}$$

$w_0^{(1)}, \ldots, w_3^{(1)}$ = the coefficients of the 1st degree Almon polynomial:

$$\begin{array}{llll}
-5.611, & -4.208, & -2.805, & -1.403 \\
(16.4) & (16.4) & (16.4) & (16.4) \\
-6.137, & -4.603, & -3.069, & -1.534 \\
(16.1) & (16.1) & (16.1) & (16.1) \\
-6.088, & -4.566, & -3.044, & -1.522 \\
(16.1) & (16.1) & (16.1) & (16.1)
\end{array}$$

Labour input in non-farm sectors and total labour input

8.6. $LW234 = LW2 + LW3 + LW4$

8.7. $LW = LW1 + LW234$

9. MONEY MARKET

Bank credit to the non-bank private sector

9.1.

$$LBP - LBP_{-1} = \underset{(2.3)}{150.2} + \underset{(5.2)}{.369}\,(.01 \times PIF \times (IFEQCON + IH) + IIV) - \underset{(2.2)}{4.305}\ TIME$$

$$\underset{(1.4)}{126.7} \qquad \underset{(2.4)}{.258} \qquad\qquad - \underset{(1.1)}{2.795}$$

$$\underset{(1.0)}{108.8} \qquad \underset{(1.6)}{.245} \qquad\qquad - \underset{(.8)}{2.570}$$

$$- \underset{(2.8)}{.162}\,(FLMN + FSMN - (KSMBN - KSMBN_{-1})) - \underset{(.8)}{.090}\ IIV$$

$$- \underset{(.8)}{.066} \qquad\qquad \underset{(.6)}{.128}$$

$$- \underset{(.3)}{.042} \qquad\qquad \underset{(.5)}{.141}$$

$\bar{R}^2 = .806 \qquad DW = 1.95$

$.783 \qquad 2.08$

$.776 \qquad 2.09$

Foreign credits of the banks, net

9.2.

$$KSMBN = \underset{(11.5)}{.217} \sum_{1}^{4} KSMBN_{-v} + \underset{(3.1)}{6.200} \sum_{1}^{3} PII_{-v} - \underset{(1.4)}{60.195}\ RTBLON/RLB$$

TSLSPC estimators are identical with OLS estimators

$\bar{R}^2 = .800 \qquad DW = .84$

Demand deposits

9.3.

$$DD = \underset{(21.6)}{.325}\ YNW + \underset{(8.3)}{.314}\ KMBFN \qquad \bar{R}^2 = .979 \qquad DW = .64$$

$$\underset{(21.5)}{.324} \qquad \underset{(8.3)}{.315} \qquad .979 \qquad .64$$

$$\underset{(21.4)}{.325} \qquad \underset{(8.2)}{.312} \qquad .979 \qquad .64$$

Time deposits

9.4.

$$DT - DT_{-1} = - \underset{(2.1)}{107.0} + \underset{(11.6)}{.0618}\ YD + \underset{(2.3)}{363.2}\ YSE3/(YSE1 + YSE3) - \underset{(1.6)}{1450.8}\ (PCP - PCP_{-1})/PCP_{-1}$$

$$- \underset{(2.5)}{148.5} \qquad \underset{(10.9)}{.0606} \qquad \underset{(2.8)}{529.5} \qquad - \underset{(1.9)}{2224.7}$$

$$- \underset{(2.2)}{148.8} \qquad \underset{(9.9)}{.0618} \qquad \underset{(2.7)}{562.5} \qquad - \underset{(1.6)}{3566.1}$$

$$- \underset{(4.4)}{66.4}\ DDT62 + \underset{(5.9)}{156.3}\ DDT71 \qquad \bar{R}^2 = .833 \qquad DW = 2.04$$

$$- \underset{(4.3)}{66.4} \qquad \underset{(5.9)}{158.4} \qquad .827 \qquad 2.17$$

$$- \underset{(4.0)}{66.1} \qquad \underset{(5.6)}{159.1} \qquad .809 \qquad 2.21$$

Banks' "other assets", net

9.5. KBOA = LBFBN + KSMBN + DT + DD + KBOWN - LBP - LBCGN

Indicator of tightness of credit

9.6. PII = 100 LBFBN/LBP

10. PUBLIC FINANCES

State revenue from direct taxes on households and private non-profit institutions

10.1. $TYPCG = -\underset{(19.2)}{213.3} + \underset{(43.7)}{.1031}\,(YW + YRI + YDIV + YSE)$ $\bar{R}^2 = .972$ DW = .16

Constant	(YW + YRI + YDIV + YSE)	$\bar{R}^2$	DW
- 213.3 (19.2)	.1031 (43.7)	.972	.16
- 213.6 (19.2)	.1032 (43.7)	.972	.16
- 213.8 (19.3)	.1032 (43.7)	.972	.16

State cash revenue from income and property tax

10.2. $TYCG = \underset{(3.8)}{93.4} + \underset{(6.1)}{.861}\,TYPCG + \underset{(1.0)}{.054}\,(YNW - YRI - YDIV - YSE)$ $\bar{R}^2 = .953$ DW = 1.87

Constant	TYPCG	(YNW - YRI - YDIV - YSE)	$\bar{R}^2$	DW
93.4 (3.8)	.861 (6.1)	.054 (1.0)	.953	1.87
72.2 (2.6)	.763 (4.5)	.100 (1.7)	.952	1.89
67.3 (2.1)	.709 (3.8)	.110 (1.6)	.952	1.89

State revenue from excise taxes

10.3. $TECG = \underset{(1.5)}{15.4} + \underset{(3.1)}{.792}\,(TCTVR \times CTV) + \underset{(8.9)}{1.217}\,(TCFAR \times CFA)$ $\bar{R}^2 = .967$ DW = 2.39

Constant	(TCTVR x CTV)	(TCFAR x CFA)	$\bar{R}^2$	DW
15.4 (1.5)	.792 (3.1)	1.217 (8.9)	.967	2.39
24.1 (1.2)	.552 (1.1)	1.347 (4.9)	.966	2.38
19.2 (.8)	.676 (1.1)	1.284 (3.8)	.966	2.39

State revenue from sales tax

10.4. $\ln TSCG = -\underset{(24.8)}{9.025} + \underset{(3.2)}{.710}\ln TSR + \underset{(34.4)}{1.599}\ln CV + \underset{(3.9)}{.836}\ln DST5863 - \underset{(13.1)}{.140}\ln DST6263$

Constant	ln TSR	ln CV	ln DST5863	ln DST6263	$\bar{R}^2$	DW
- 9.025 (24.8)	.710 (3.2)	1.599 (34.4)	.836 (3.9)	- .140 (13.1)	.994	1.71
- 9.032 (24.8)	.659 (3.0)	1.614 (34.2)	.788 (3.6)	- .142 (13.2)	.993	1.72
- 9.032 (24.8)	.661 (3.0)	1.613 (33.5)	.789 (3.6)	- .142 (13.1)	.993	1.72

State revenue from tax on motor cars and motor cycles

10.5. $$\ln TAMCG = -\underset{(19.6)}{18.205} + \underset{(21.9)}{1.449} \ln MA + \underset{(16.6)}{3.378} \ln PA \qquad \bar{R}^2 = .952 \qquad DW = 1.59$$

$$-\underset{(19.0)}{18.088} \quad \underset{(20.7)}{1.560} \quad \underset{(15.4)}{3.271} \qquad .949 \qquad 1.72$$

$$-\underset{(19.0)}{18.095} \quad \underset{(20.5)}{1.553} \quad \underset{(15.5)}{3.278} \qquad .949 \qquad 1.72$$

State revenue from customs duties

10.6. $$\ln TCDCG = \underset{(2.7)}{1.338} + \underset{(6.9)}{.507} \ln MGV + \underset{(5.4)}{.589} \ln DKEN + \underset{(12.7)}{1.035} \ln VEFTA$$

$$\underset{(3.0)}{1.571} \quad \underset{(6.1)}{.472} \quad \underset{(4.9)}{.556} \quad \underset{(11.8)}{1.001}$$

$$\underset{(2.8)}{1.532} \quad \underset{(5.7)}{.478} \quad \underset{(4.8)}{.562} \quad \underset{(11.2)}{1.006}$$

$$\bar{R}^2 = .890 \qquad DW = 1.51$$

$$.889 \qquad 1.50$$

$$.889 \qquad 1.50$$

State revenue from child allowance contributions by employers

10.7. $$SOCCG = \underset{(107.1)}{1.052} (SOCCGR \times YW) \qquad \bar{R}^2 = .967 \qquad DW = 2.19$$

$$\underset{(107.0)}{1.053} \qquad .967 \qquad 2.19$$

$$\underset{(106.8)}{1.054} \qquad .967 \qquad 2.19$$

Revenue from social security contributions to the Social Insurance Institution, total

10.8. $$SOCNP = \underset{(47.8)}{1.051} (SOCNPR \times YW) \qquad \bar{R}^2 = .941 \qquad DW = 2.76$$

$$\underset{(47.7)}{1.052} \qquad .941 \qquad 2.76$$

$$\underset{(47.7)}{1.052} \qquad .941 \qquad 2.76$$

Indirect taxes minus subsidies, value

10.9. $$TINV = \underset{(6.4)}{46.8} + \underset{(103.0)}{.952} (TICG - SUBCG) \qquad \bar{R}^2 = .995 \qquad DW = .38$$

TSLSPC estimators are identical with OLS estimators

State revenue from indirect taxes, total

10.10. $$TICG = TECG + TSCG + TAMCG + TCDCG + TALCG + TIOCG$$

Total state revenue

10.11. $$TCG = TICG + TYCG + TYOCG + SOCCG + TOCG$$

Total state borrowing, net

10.12. $LCGN = GCG - TCG$

Net income transfers from households to public sector

10.13. $TRHGN = TYPCG + TYLG + SOCCG + SOCNP + TRHCG + TRHLG - TRCGH - TRLGH$

Indicator of EFTA tariff reductions

10.14. $VEFTA = .01 \times MEFSOV \times DEFTA - .01 \times MEFSOV + 1$

A p p e n d i x III

LIST OF VARIABLES

Explanations

- Symbols are in the standard LINK notation (cf. p. 25, footnote 1.)
- Endogenous variables are denoted by *
- Volume figures are expressed at 1959 prices, in millions of Finnmarks
- Value figures in millions of Finnmarks
- Prices, wages and levels of earnings are indices, 1959 = 100
- Labour input is expressed in thousands of man-quarters
- Sectoral disaggregation:

  Sector 1 = Agriculture

  Sector 2 = Non-competitive industries

  Sector 3 = Forestry

  Sector 4 = Competitive industries
- The dummies are also assigned values other than 0 and 1.

* ALFA	=	Share of labour income in nominal gross domestic product
* BPTV	=	Trade balance
* C	=	Total private consumption, volume
* CA	=	Consumer expenditure, motor cars, volume
* CDND	=	Consumer expenditure, durables (except cars) and non-durables, volume
* CFA	=	Consumer expenditure, fuel for motor cars, volume
CG	=	Total public consumption, volume
* CS	=	Consumer expenditure, services, volume
* CTOT	=	Total consumption, volume
* CTOTV	=	Total consumption, value
* CTV	=	Consumer expenditure, tobacco, value
* CV	=	Total private consumption, value
DCA67	=	Dummy variable for impact of devaluation on sales of motor cars in 1967
* DD	=	Demand deposits
DDT62	=	Dummy variable for the change in taxation of rent income in 1962 for impact for time deposits
DDT71	=	Dummy variable for Supplementary turnover tax on consumer durables in 1971
DEFTA	=	Dummy variable for EFTA tariff reductions
DKEN	=	Dummy variable for Kennedy-round tariff reductions
DMCP	=	Dummy variable for cash payment system for imports
DSOCO	=	Dummy variable for other social security payment rate
DST5863	=	Dummy variable for sales tax rate in 1958 - 1963
DST6263	=	Dummy variable for sales tax avoidance in 1962 - 1963
DSTC64	=	Dummy variable for sales tax reform in 1964 for impact on consumption

	DSTI64	= Dummy variable for sales tax reform in 1964 for impact on stock formation
*	DT	= Time deposits
	DTR62	= Dummy variable for the change in taxation of rent income (1962 effect) for impact on residential construction
	DTR66	= Dummy variable for the change in taxation of rent income (1966 effect)
	FLMN	= Long-term capital import, net
	FSMN	= Short-term capital import, net
*	GAMMA	= Propensity to consume
	GCG	= Total state expenditure
*	GNP	= Gross domestic product at market prices, volume
*	GNPFC	= Gross domestic product at factor cost, volume
*	GNPFCV	= Gross domestic product at factor cost, value
*	GNPFC1	= Production at factor cost in sector 1, volume
*	GNPFC2	= Production at factor cost in sector 2, volume
*	GNPFC3	= Production at factor cost in sector 3, volume
*	GNPFC4	= Production at factor cost in sector 4, volume
*	GNPV	= Gross domestic product at market prices, value
	ICONG	= Public investment in construction, volume
*	IFEQ	= Investment in machinery and equipment, volume
*	IFEQCON	= Investment in machinery, equipment and non-residential construction, volume
*	IH	= Residential construction, volume
*	II	= Change in business inventories, volume
*	IIV	= Change in business inventories, value
	ILW	= Investment in land and waterway construction, volume
*	ITOT	= Total fixed investment, volume
*	ITOTV	= Total fixed investment, value

* KBOA	=	Banks' "other assets", net
KBOWN	=	Banks' own capital
* KFEQ	=	Stock of fixed business capital, machinery and equipment, volume
* KFEQCON	=	Stock of fixed business capital, total, volume
* KI	=	Stock of business inventories, volume
KIF	=	Stock of fuels
KMBFN	=	Foreign assets of the Bank of Finland, net
* KSMBN	=	Foreign credits of the banks, net
LBCGN	=	Banks' credit to state, net
LBFBN	=	Credit from the Bank of Finland to the banks, net
* LBP	=	Bank credit to the non-bank private sector
* LCGN	=	Total state borrowing, net
* LW	=	Labour input, total
* LW1	=	Labour input in sector 1
* LW2	=	Labour input in sector 2
* LW3	=	Labour input in sector 3
* LW4	=	Labour input in sector 4
* LW234	=	Labour input in non-farm sectors
* M	=	Imports of goods and services, volume
* MA	=	Imports of motor cars, volume
* MAV	=	Imports of motor cars, value
* MC	=	Imports of consumer goods (other than cars), volume
* MCV	=	Imports of consumer goods, value
MEFSOV	=	Share of EFTA countries and USSR in Finnish imports
* MFL	=	Imports of fuels and lubricants, volume
* MFLV	=	Imports of fuels and lubricants, value
* MG	=	Imports of goods, total, volume

* MGV = Imports of goods, total, value
* MI = Imports of investment goods, volume
* MIV = Imports of investment goods, value
* MR = Imports of raw materials, volume
* MRV = Imports of raw materials, value

MS = Imports of services, volume

MSV = Imports of services, value

* MV = Imports of goods and services, value

PA = Price index for motor cars

* PCG = Public consumption prices
* PCGIOE = Public consumption prices, input-output estimate
* PCP = Private consumption prices (cost-of-living index)
* PCPIOE = Private consumption prices, input-output estimate
* PGNPFC = Price index of gross domestic product at factor cost
* PIF = Fixed investment prices
* PIFIOE = Fixed investment prices, input-output estimate
* PII = Indicator of tightness of credit

PM = Import prices, goods

PMC = Import prices, consumption goods

PMFG = Import prices, final goods

PMFL = Import prices, fuels and lubricants

PMI = Import prices, investment goods

PMR = Import prices, raw materials

PMR1 = Import prices, raw materials for sector 1

PMR2 = Import prices, raw materials for sector 2

PMR3 = Import prices, raw materials for sector 3

PMR4 = Import prices, raw materials for sector 4

PT = Price index for tobacco

PXFG = Export prices of manufactured goods

P1 = Prices in sector 1

* P2 = Prices in sector 2

* P2IOE = Prices in sector 2, input-output estimate

P3 = Prices in sector 3

* P4 = Prices in sector 4

RLB = Bank lending rate

RTBLON = Foreign interest rate (3-month Eurodollar deposit rate)

* SOCC = Employers' contributions to social security, total

* SOCC1 = Employers' contributions to social security in sector 1

* SOCC2 = Employers' contributions to social security in sector 2

* SOCC3 = Employers' contributions to social security in sector 3

* SOCC4 = Employers' contributions to social security in sector 4

* SOCCG = State revenue from child allowance contributions by employers

* SOCCGR = Rate of child allowance contributions by employers

* SOCCR = Rate of employers' contributions to social security

SOCNP = Revenue from social security contributions to the Social Insurance Institution, total

SOCNPGR = Rate of social security contributions by employers to the Social Insurance Institution and central government

SOCNPR = Rate of national pension and sickness insurance contributions by employers and employees

SUBCG = Subsidies

TALCG = State revenue from alcohol monopoly

* TAMCG = State revenue from tax on motor cars and motor cycles

* TCDCG = State revenue from customs duties

	TCFAR	= Excise tax rate on fuel for motor cars
*	TCG	= Total state revenue
	TCTVR	= Excise tax rate on tobacco
*	TECG	= State revenue from excise taxes
*	TICG	= State revenue from indirect taxes, total
	TIME	= Time trend, 1, 2, 3,..., 1958 Q1 = 1
*	TIN	= Indirect taxes minus subsidies, volume
*	TINV	= Indirect taxes minus subsidies, value
	TIOCG	= State revenue from other indirect taxes
	TOCG	= State revenue, "other"
	TRCGH	= Transfers from state to households and private non-profit institutions
	TRHCG	= Non-tax transfers from households and private non-profit institutions to state
*	TRHGN	= Net income transfers from households to public sector
	TRHLG	= Non-tax transfers from households and private non-profit institutions to local government
	TRLGH	= Transfers from local government to households and private non-profit institutions
*	TSCG	= State revenue from sales tax
	TSR	= Sales tax rate
*	TYCG	= State cash revenue from income and property tax
	TYLG	= Local government revenue from direct taxes
	TYOCG	= State revenue from other taxes on income and property
*	TYPCG	= State revenue from direct taxes on households and private non-profit institutions
*	UR	= Unemployment as percentage of total labour force
*	VEFTA	= Indicator of EFTA tariff reductions
*	WNR	= Negotiated wage rate
*	WR	= Level of earnings, total

*	WR1	= Level of earnings in sector 1
*	WR2	= Level of earnings in sector 2
*	WR3	= Level of earnings in sector 3
*	WR4	= Level of earnings in sector 4
	X	= Exports of goods and services, volume
	XGV	= Exports of goods, total, value
	XME	= Exports of metal and engineering industry products, volume
	XV	= Exports of goods and services, value
*	YD	= Disposable income of households
*	YDIV	= Dividends
*	YNW	= Total non-wage income
*	YNW1	= Non-wage income in sector 1
*	YNW1IOE	= Non-wage income in sector 1, input-output estimate
*	YNW2	= Non-wage income in sector 2
*	YNW3	= Non-wage income in sector 3
*	YNW3IOE	= Non-wage income in sector 3, input-output estimate
*	YNW4	= Non-wage income in sector 4
*	YNW4IOE	= Non-wage income in sector 4, input-output estimate
*	YRI	= Rent and interest income.
*	YSE	= Incomes from unincorporated enterprises, total
*	YSE1	= Income of unincorporated enterprises in sector 1
*	YSE3	= Income of unincorporated enterprises in sector 3
*	YSE24	= Income of unincorporated enterprises in sector 2 and 4
*	YW	= Wages and salaries, total
*	YW1	= Wages and salaries in sector 1
*	YW2	= Wages and salaries in sector 2
*	YW3	= Wages and salaries in sector 3
*	YW4	= Wages and salaries in sector 4
*	YW234	= Wages and salaries in non-farm sectors

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