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## Leading inflation indicators in Finland: pairwise analysis of Granger-causality and cointegration

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# BANK OF FINLAND DISCUSSION PAPERS

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24/95

**Antti Ripatti**

Monetary Policy Department  
17.8.1995

## Leading Inflation Indicators in Finland: Pairwise Analysis of Granger-Causality and Cointegration

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# Leading Inflation Indicators in Finland: Pairwise Analysis of Granger-Causality and Cointegration

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Monetary Policy Department

## Abstract

We analyse a set of macroeconomic variables in order to evaluate their ability to (linearly) predict inflation. A series of tests is conducted in which the consumer price index is paired with a single macroeconomic variable, such as monetary or credit aggregate, an interest rate, an asset price, a survey variable and or some other nominal or real variables. Using bivariate autoregressive models, hypotheses concerning cointegration and causality between price level and the particular macroeconomic variable are tested. Only in a few cases is cointegration found. We conclude that in general yield indices and cost variables cointegrate and predict inflation over a one-year horizon. Variables concerning economic activity, broad monetary aggregates and certain interest rates predict inflation about one year ahead. However, most of the variables of our dataset perform poorly as leading indicators of inflation.

## Tiivistelmä

Tutkimuksessa analysoidaan eri makrotaloudellisten aikasarjojen kykyä ennustaa inflaatiota. Näitä makrotaloudellisia aikasarjoja ovat esimerkiksi raha- ja luottoaggregaatit, korot, vaateiden hinnat, barometrimuuttujat ja eräät muut nimelliset ja reaaliset suureet. Kaksiulotteista autoregressiivistä mallia käytetään testaamaan yhteisintegroituvuutta ja Granger kausaalisuutta hintatason ja kunkin makrotaloudellisen suureen välillä. Yhteisintegroituvuutta löytyy vain vähän. Ainoastaan tuottoindeksit ja eräät kustannusmuuttujat yhteisintegroituvat kuluttajahintojen kanssa ja ennakoivat inflaatiota yli vuoden aikahorisontilla. Talouden aktiviteettia kuvaavat muuttujat, laveat raha-aggregaatit ja korot ennakoivat myös inflaatiota yli vuoden aikahorisontilla. Vain harvat tarkastelluista suureista kelpaavat inflaatiota ennakoivaksi indikaattoriksi.



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# 1 Introduction

In February 1993 the Bank of Finland's Board of Management formalized an explicit target for the inflation rate. In relying on an inflation target, instead of an intermediate target, such as a monetary aggregate, Finland followed the earlier examples of New Zealand, Canada, the United Kingdom and Sweden. To increase the transparency of the inflation target, the Bank of Finland announced a list of indicators that it monitors in an effort to anticipate forthcoming inflation. A further step to greater transparency was taken in June 1994 when the quarterly report "Economic Developments, Inflation and Monetary Policy" was published.

Articulation of the stance of monetary policy and of the measures applied is based on the evaluation of inflation prospects by means of a number of macroeconomic variables. When the first active measure to tighten monetary policy was taken in December 1994, which was an increase in the tender rate, the rationale was based on recent developments in certain inflation indicators.

An ideal direct approach to controlling the inflation rate would be based on a detailed macroeconometric model with special emphasis on the instruments and transmission mechanism of monetary policy. However, this has not been done in any country for several reasons. First, large scale, detailed models are not very transparent — neither for the public nor even for the economists involved. Second, according to the Lucas critique the estimated equations in such models could break down when subjected to a change in monetary policy. Third, a specification error or structural break in one segment of the model might disturb the forecasting ability of the model as a whole. The central bank must of course, incorporate all available information, i.e. there is reason to use several models or approaches.

In response to the above concerns, a simple indicator approach is suggested. The aim of this study is to analyze systematically — and, unfortunately, mechanically — the causal relations between consumer prices and a set of economic variables and therefore to evaluate the ability of the latter to serve as indicators of future inflation.

The indicator approach also has its drawbacks: the Lucas critique concerns causal issues too. Forecasts based on indicators are probably not very accurate. Control of an indicator might lead to a collapse of the causality relationship. However, the simplicity of the indicator approach adds much to the credibility of monetary policy, which also depends on the performance of the indicators.

The paper is organized as follows. In the section 2 we introduce the econometric approach to causality and cointegration. Section 3 contains the estimation results, and concluding remarks follow in the final section. The data are described in the appendix.

## 2 Econometric Setup

We analyse the temporal correlation of consumer prices and different macroeconomic variables in both the frequency and time domains.

The analysis in the time domain relies on the bivariate VAR (vector autoregression) model. The vector of variables,  $z_t$ , contains the explanatory variable (here, a macroeconomic variable),  $y_t$ , and the consumer price index,  $x_t$ , i.e.  $z_t = [y_t \ x_t]'$ . The process  $z_t$  can be described by the following VAR( $k$ ) process in levels:

$$z_t = \sum_{i=1}^k A_i z_{t-i} + \mu + \Psi D_t + \varepsilon_t, \quad t = 1, \dots, T, \quad (1)$$

where  $\varepsilon_t \sim NID(0, \Sigma)$  and covariance matrix  $\Sigma$  is not necessarily diagonal. Deterministic variables, such as seasonal dummies and a tax index<sup>1</sup> are included in the vector  $D_t$ .

First we need to determine the lag length  $k$ . In order to avoid problems concerning degrees of freedom, we choose the shortest possible lag length, when there is no residual autocorrelation and the Hannan–Quinn information criterion is minimized.

The VAR model can be utilized to describe the temporal cross-correlation of the variables. If we, for example, estimate the model (1) with different choices of  $k$  ( $k = 1, \dots, K$ ), the last coefficient matrix,  $A_k$ ,  $k = 1, \dots, K$ , is then called the *estimated partial cross-correlation* matrix. With the help of the sequence of such matrices, the temporal correlation (given the shorter lags) can be illustrated.

The lag polynomial  $A(B)$  can be partitioned like  $z_t$  and the model (1) can be described as follows

$$\begin{bmatrix} y_t \\ x_t \end{bmatrix} = \sum_{i=1}^k \begin{bmatrix} A_{yyi} & A_{yxi} \\ A_{xyi} & A_{xxi} \end{bmatrix} \begin{bmatrix} y_{t-i} \\ x_{t-i} \end{bmatrix} + \mu + \Psi D_t + \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{xt} \end{bmatrix}, \quad t = 1, \dots, T. \quad (2)$$

In this framework we can write the hypothesis that  $y_t$  does not Granger cause  $x_t$  as

$$H_0 : A_{xyi} = 0, \quad i = 1, \dots, k. \quad (3)$$

The non-causality hypothesis can easily be tested using the Wald test.

---

<sup>1</sup>The Statistics Finland publishes an index of indirect taxes and subsidies. Instead of using a huge number of dummies to capture the effects of changes in government tariffs, we use only this index, which models the exogenous, government driven, cost push. Due to the use of the index, the conclusions of the paper might also be applicable to the indicator of underlying inflation.

Since most of the economic time series are trending<sup>2</sup>, we are faced with the issue of cointegration. Full information maximum likelihood estimation of cointegration vectors (see Johansen 1988 and 1991) also relies on the VAR framework. The model (1) can be written in difference form as

$$\Delta z_t = \Pi z_{t-1} + \Gamma_1 \Delta z_{t-1} + \dots + \Gamma_{t-k+1} + \mu + \varepsilon_t, \quad t = 1, \dots, T \quad (4)$$

and  $\varepsilon_t \sim NID(0, \Sigma)$ , where  $\Gamma_i = -\left(\sum_{j=i+1}^{k-1} A_j\right)$  and matrix  $\Pi = -I + \sum_{i=1}^k A_i$  has a reduced rank in the case of cointegration, i.e.  $0 \leq \text{rank}(\Pi) \leq 2$ . Any reduced rank matrix can be partitioned into two sub-matrices. Here we partition matrix  $\Pi$  as  $\alpha$  and  $\beta'$ . Matrix  $\beta$  is called the cointegration matrix, and in cointegration  $\alpha$  is called the matrix of loadings of the equilibrium errors of linear combinations defined by  $\beta'$ .

The rank of the matrix  $\Pi$  determines the number of cointegration vectors. Two special cases can occur. When all  $p$  components of  $z_t$  are stationary, matrix  $\Pi$  has the full rank  $p$ . When no cointegration exists between the variables in  $z_t$ , the matrix  $\Pi$  has zero rank. Then all variables are integrated order 1, but there is no cointegration between them. In such a case, the simple VAR model in difference form is the proper framework for empirical analysis.

Johansen (1988 and 1991) has shown that the ML estimators of  $\alpha$  and  $\beta'$  can be obtained by solving the following eigenvalue problem

$$|\lambda S_{11} - S_{10} S_{00}^{-1} S_{01}| = 0$$

where  $S_{11}$  represents the residual moment matrix from the least squares regression of levels of variables on lagged differences and the deterministic variables (i.e. levels corrected by the short-run dynamics),  $S_{00}$  is the residual moment matrix from the least squares regression of the differences of the variables on the lagged differences and the deterministic variables (i.e. differences corrected by the short-run dynamics) and  $S_{01}$  is the cross-product moment matrix of the residuals from the regressions mentioned above.

The solution of the above eigenvalue problem generates eigenvalues  $\hat{\lambda}_1 > \dots > \hat{\lambda}_p$  and the eigenvectors  $\hat{V} = [\hat{v}_1 \dots \hat{v}_p]$ , which are usually normalized as  $\hat{V}' S_{11} \hat{V} = I_p$ . The estimators of the cointegration vectors  $\hat{\beta}$  are  $\hat{\beta} = [\hat{v}_1 \dots \hat{v}_r]$ , the eigenvectors corresponding to the  $r$  largest eigenvalues. Johansen (1988, pp. 233–236 and 1991) shows that the ML estimator of the space spanned by  $\beta$  is the space spanned by  $r$  canonical variates reflecting the  $r$  largest squared canonical correlations between the stationary and non-stationary parts of the system.

It is important to note that we can estimate only the space spanned by  $\beta$ . We can give an economic interpretation to the cointegration vectors only after identification. Before that they are a statistical property of the data.

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<sup>2</sup>A trending variable refers to a stochastic process which is non-stationary and which becomes stationary after differencing a suitable number of times.

Johansen (1988) derives two tests for the number of cointegration vectors. The null hypothesis can be formulated as

$$H_0 : \text{rank}(\Pi) \leq r.$$

The likelihood ratio test for the above hypothesis is

$$-2 \log(Q) = -T \sum_{i=r+1}^p \log(1 - \hat{\lambda}_i^2),$$

where  $\hat{\lambda}_{r+1}^2, \dots, \hat{\lambda}_p^2$  are the  $p - r$  smallest squared canonical correlations — eigenvalues. The alternative hypothesis is now that the number of cointegration vectors is larger than  $r$ . This test is called the *trace test*.

For the estimated cointegration vector,  $\hat{\beta}'$ , the process can be presented in the form

$$\Delta z_t = \sum_{i=1}^{k-1} \Gamma_i \Delta z_{t-i} + \alpha \hat{\beta}' z_{t-1} + \mu + \Psi D_t + \varepsilon_t, \quad t = 1, \dots, T$$

where  $\varepsilon_t \sim NID(0, \Sigma)$ . To be able to test Granger non-causality in the presence of cointegration, we have to consider the possible cointegration relations and the way they enter the equations. In the following we use the estimated cointegration space,  $\hat{\beta}$ . The super-consistency of  $\hat{\beta}$  makes it possible to handle  $\hat{e}_{t-1} = \hat{\beta}' z_{t-1}$  as any other stationary regressor in deriving asymptotic results. In order to illustrate problem, we write model (2) in the form

$$\begin{bmatrix} \Delta y_t \\ \Delta x_t \end{bmatrix} = \sum_{i=1}^{k-1} \begin{bmatrix} \Gamma_{yyi} & \Gamma_{yxi} \\ \Gamma_{xyi} & \Gamma_{xxi} \end{bmatrix} \begin{bmatrix} \Delta y_{t-i} \\ \Delta x_{t-i} \end{bmatrix} + \begin{bmatrix} \alpha_y \\ \alpha_x \end{bmatrix} \hat{e}_{t-1} + \mu + \Psi D_t + \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{xt} \end{bmatrix}, \quad (5)$$

where  $\hat{e}_t = \hat{\beta}' z_t$ . We can now test the hypothesis that  $y_t$  does not Granger cause<sup>3</sup>  $x_t$ , i.e.

$$H_0 : \Gamma_{xyi} = 0 \text{ and } \alpha_x = 0, \quad i = 1, \dots, k-1.$$

The hypothesis can be tested using, e.g., the Wald test. In the case of no cointegration, we drop  $\alpha_x$  from the hypothesis and obtain the traditional Granger non-causality test, which is described above.

We do not utilize the frequency domain approach as extensively as the time domain approach. However, analysis of the frequency domain makes the cyclical features of inflation very illustrative. In the set of figures we utilize the *coherence, gain and phase* of the level of the consumer prices and an economic variable. Coherence tells us how strongly the time series are correlated in different frequencies. Phase tells us how long time lag is needed to obtain the highest correlation.

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<sup>3</sup>In this particular bivariate case, the hypothesis is identical to the hypothesis of strong exogeneity (for definition, see Engle *et al.* 1983).

### 3 Estimation Results

In the following we analyze a wide set of economic variables. The pairwise analysis is summarized by means of graphs of the inter-relationships and tables<sup>4</sup> of the tested features. The period analyzed depends on the indicator variable. The longest period starts from the 1960. We also utilize the maximum frequency of the data. Many indicators are available with monthly frequency, but in some cases (e.g. stumpage prices) the longer data period is available only with lower frequencies. In these cases we use the longer data period.

In the Figures, the upper left panel presents the logarithmic level of the indicator variable and the consumer price index. The upper right graph shows the same variables after seasonal differencing, which is more illustrative in the case of trending variables with strong seasonal patterns. The lower left graph shows the computed partial cross-correlations, i.e. the coefficients of the lagged differences of the indicator variable when we have considered the influence of the shorter lags. Finally, the lower right corner of the graphs shows the co-spectral analysis of the logarithmic difference of the consumer price index and the indicator variable.

Often quite long VAR( $k$ ) processes are needed to describe the variations in the data. For monthly data, lag length 13 is a common choice. The determination of the lag length is based on the minimization of the Hannan–Quinn Information Criterion. Tests are done for residual autocorrelation and normality. However, normality is usually rejected by the Bera–Jarque normality test due to the large number of outliers, which shows up as excessive kurtosis. Institutional factors like changes in taxation are behind the large number of outliers. Thus, the statistical models include the index of indirect taxes and subsidies. We also test for cointegration and finally for Granger non-causality, taking the cointegration restriction into account.

#### 3.1 Nominal Indicators

This section analyzes a set of nominal macroeconomic variables. Included are a number of producer price indices (PPI and WPI), foreign trade prices (PEXP, PIMP and TOT), asset prices (HOUSEP and PSTUMP) and cost variables (RAWP, RAWPNO, WAGES, CONTRACT and CONSC). A summary of the causality analysis is presented in table 1. Price variables are usually released monthly and are rarely subject to major revision.

**Producer prices.** The first important group of indicators is the producer price variables. We investigate here the producer price index (PPI) and whole-

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<sup>4</sup>I thank Paolo Paruolo for providing me his Gauss-program CIA (Cointegration Analysis), which I have used in computing some of the test statistics. Some of the calculations has been done by PcFiml 8.0.

Table 1: Summary of Causality Tests, Nominal Indicators

Name	Starting period	Lag length	CI-rank	Res. corr.	Granger non-causality, $p$ values	Prediction period
PPI	1960M1	6	1	0.26	<0.0001	1-5
WPI	1960M1	7	0	0.28	<0.0001	1-6
PEXP	1975M1	9	0	0.08	0.0418	1-2,(6-7)
PIMP	1975M1	9	0	0.04	0.5803	(1)
TOT	1975M1	7	0	-0.02	0.1959	-
PHOUSE	1978M1	6	1	0.00	0.0021	?
PSTUMP	1964S1	3	1	0.40	0.0025	1-2
PRAW	1974M1	7	0	0.07	0.1800	(5)
PRAWNO	1974M1	7	0	-0.03	0.4226	(5)
WAGES	1960Q1	5	0	0.39	0.0491	4
CONTRACT	1960Q1	5	0	0.37	0.8511	(4-5)
CONSC	1973M1	7	1	0.23	<0.0001	(1-4)

Note: Variables in logarithmic form.

sale price index WPI. As figures (1 and 2) and the test statistics show, producer and wholesale price indices are good forecasters of consumer prices in the short run — within a quarter of a year. The rather clear residual correlation (0.26 and 0.28) suggests also contemporaneous co-movement.

A surprising finding is that according to our preferred model, consumer prices (CPI) and wholesale prices (WPI) are not cointegrated. This implies that the retail sales margin is not stationary, i.e. shocks to the margin tend to be permanent. However, producer prices (PPI) and consumer prices (CPI) are cointegrated with cointegration vector  $[1, -1]$ , i.e. the difference between producer and the consumer prices is stationary.

**Foreign trade prices.** For an small open economy, like Finland, foreign trade prices are an important determinant of the domestic price level. According to the test statistics, import prices (PIMP) are a poor predictor of consumer prices. The reason is exaggerated in the upper left panel of figure 3, where one can see the consequences of the drop oil prices in 1986 and the significant depreciation of Finnish markka. The decline in inflation in the presence of rising import prices in the early 1990s probably ruins the causal relation (in this particular model!).

Movements in export prices (PEXP) follow a similar pattern, but these prices predict consumer prices better than do import prices. Export prices predict

Figure 1: Producer Price Index (PPI)

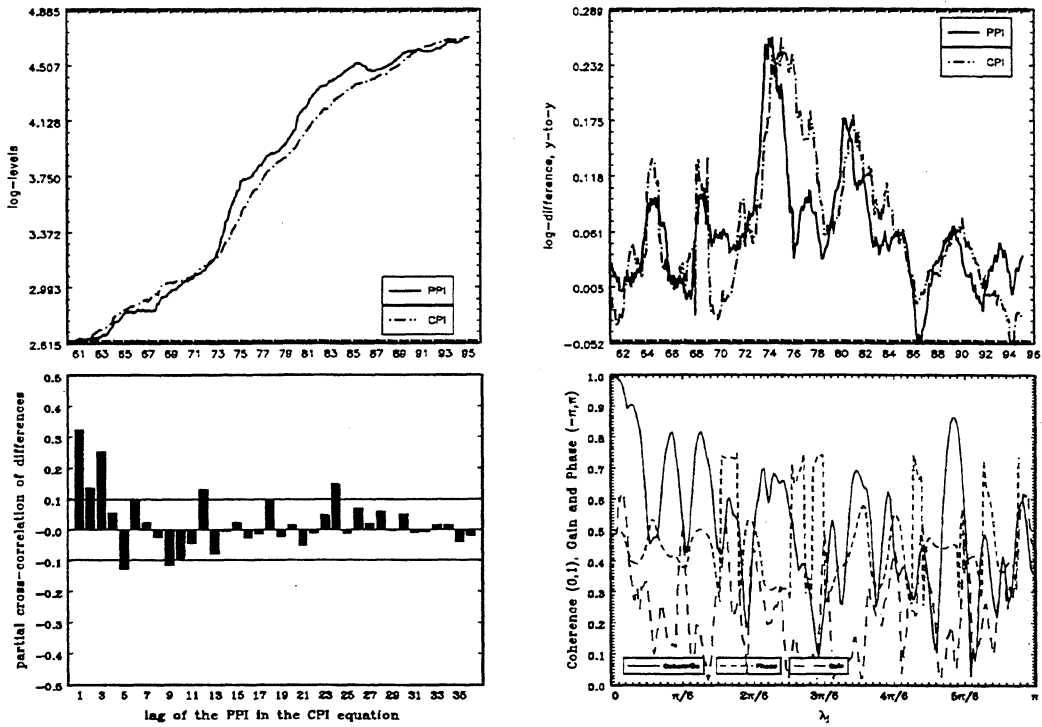
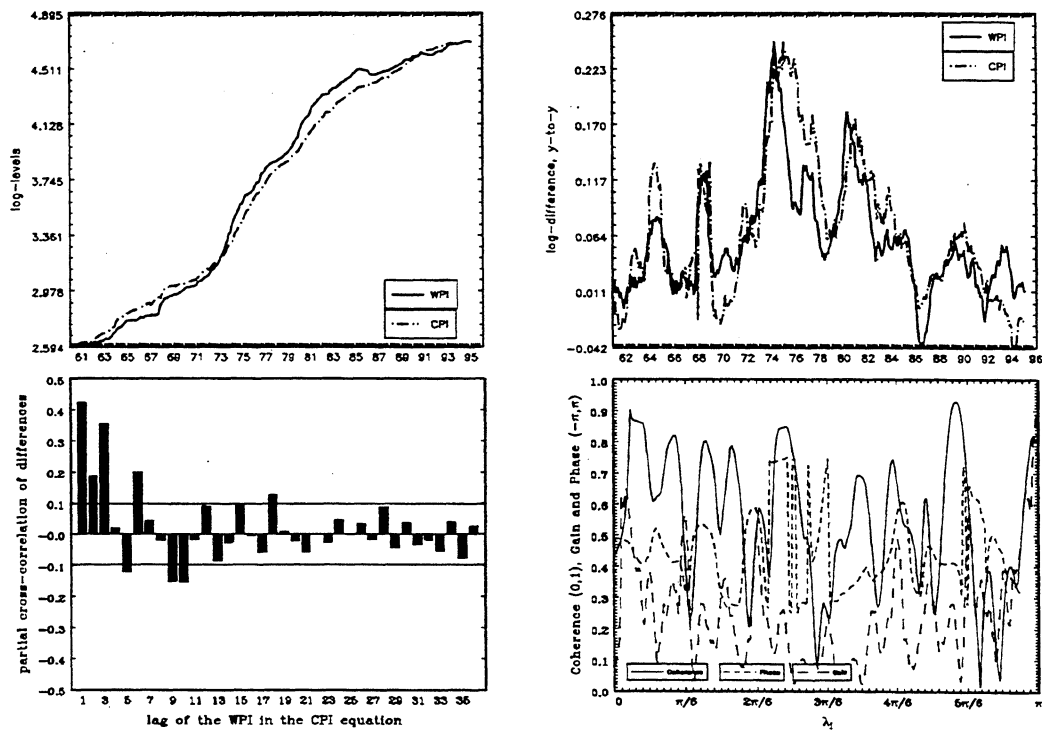


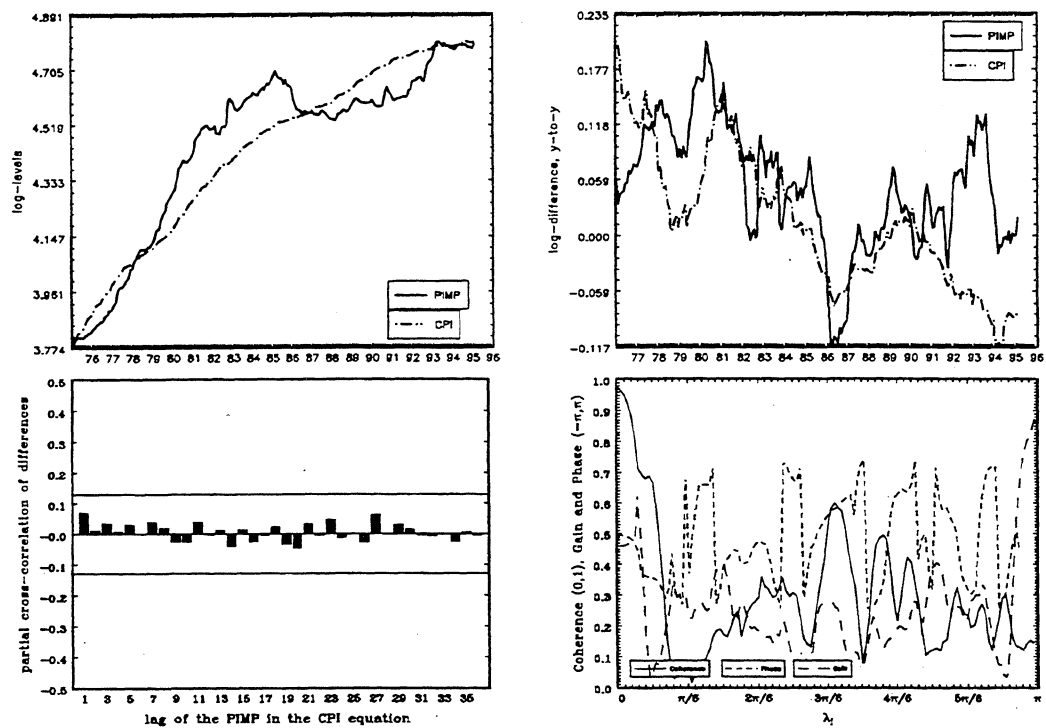
Figure 2: Wholesale Prices Index (WPI)





consumer prices about three quarters ahead. The terms of trade (figure 5),  $TOT = 100 * PEXP / PIMP$ , neither predict nor cointegrate with the consumer price level.

Figure 3: Import Prices (PIMP)



**Asset prices.** Financial assets, such as stocks, bonds, CDs and money, are analyzed in section 3.3. Here we analyse house prices (PHOUSE) and stumpage prices (PSTUMP). Our results do not differ from the results of Spolander (1994), according to which stumpage price is the best asset price for predicting consumer prices. House prices might cointegrate with consumer prices, albeit not in the beginning of the period. The cointegration relation indicates that in order to achieve stationarity one must multiply the consumer price level by four. That is, house prices have risen four times faster than consumer prices. If we accept cointegrating house and the consumer prices, we also find causality from house prices to consumer prices.

Stumpage price (PSTUMP) measures the value of a forest. Roundwood is also the most important raw material for the forest industry. The forests are also a significant part of households' wealth. Stumpage price predicts consumer prices about one and half years ahead and is cointegrated with consumer prices, so that the real stumpage price is stationary. The present level of stumpage prices is well below the historical average and, according to the error correction part of the statistical model, stumpage prices will rise in the near future.

Figure 4: Export Prices (PEXP)

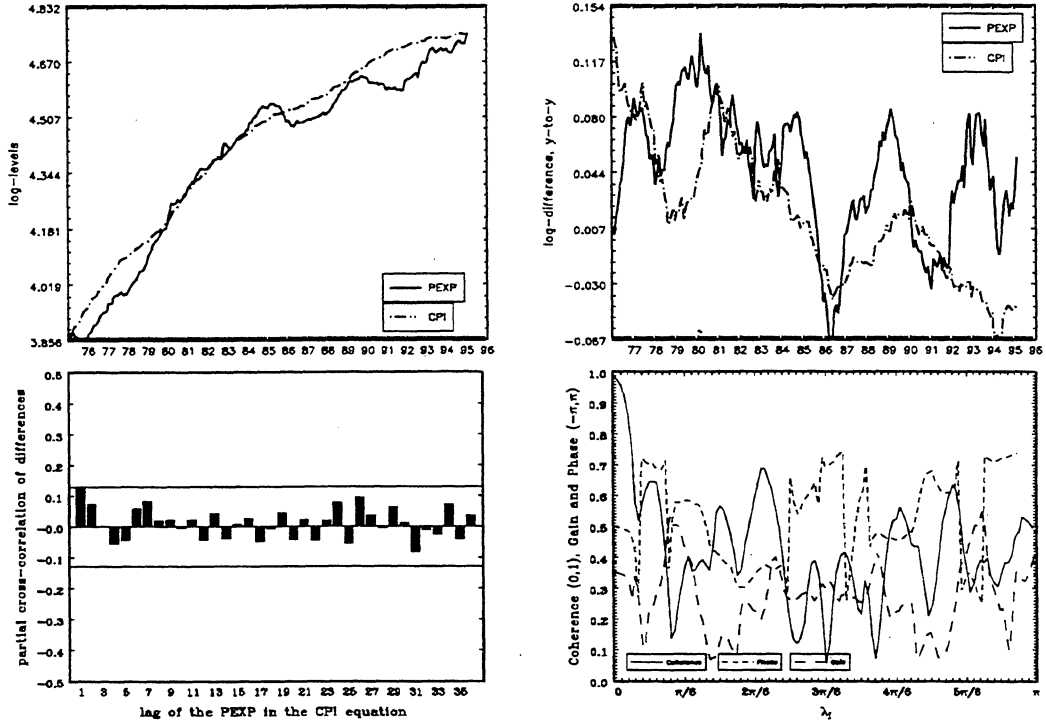
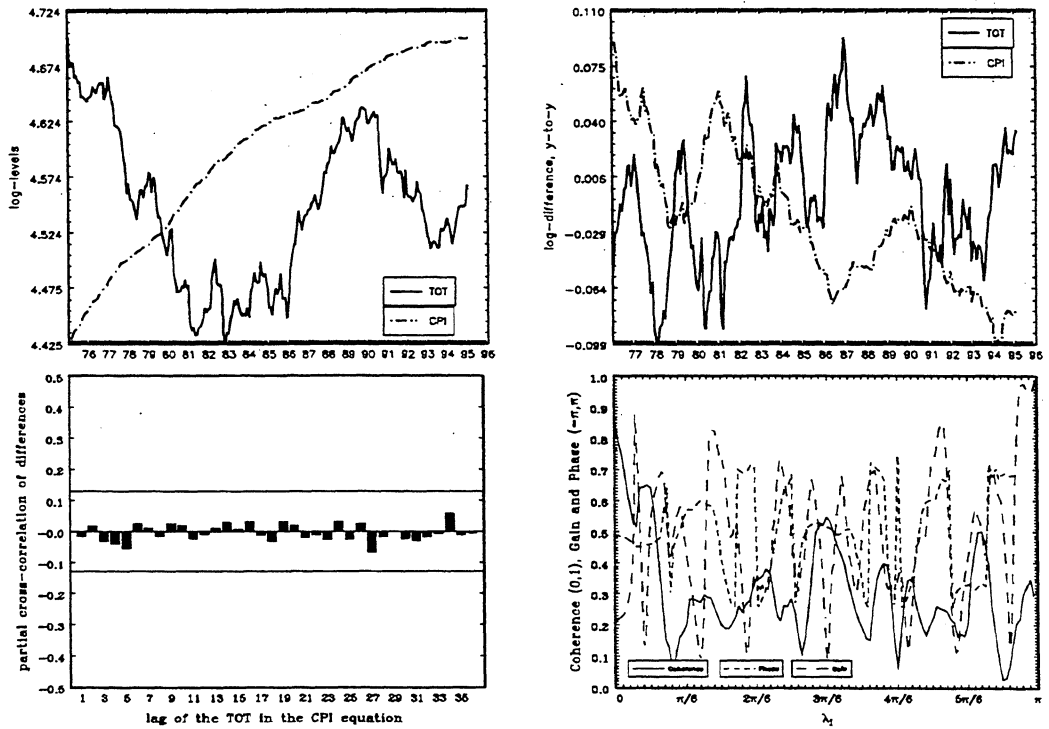
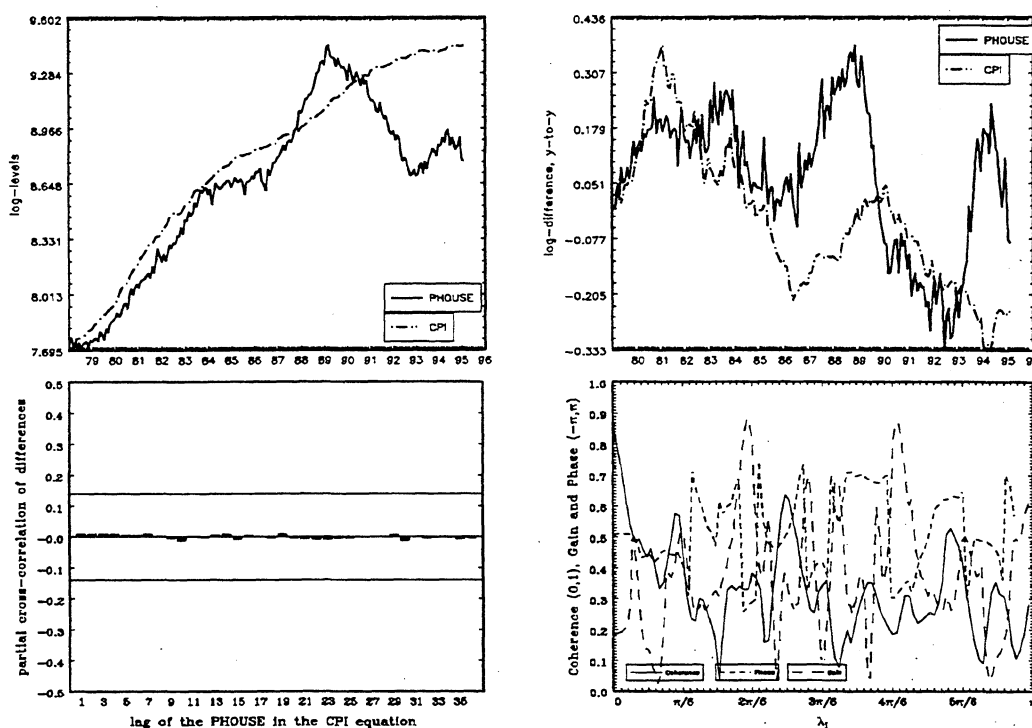


Figure 5: Terms of Trade (TOT)



The adjusting (endogenous) part of the system is the stumpage price. Due to the low sampling frequency of the data, there is a significant amount of contemporaneous correlation between stumpage and house prices.

Figure 6: House Prices (PHOUSE)



**Cost factors.** The cost variables, with which we are concerned here are price indices of raw materials, including (PRAW) and excluding (PRAWNO) energy. Wages (WAGES) and wage contracts (CONTRACT) are also modelled. Finally, the relation between construction costs (CONSC) and consumer prices is modelled.

Price indices for raw materials are not good predictors of consumer prices. The change in the HWWA index (measured in Finnish markkaa; PRAW) do not predict inflation at all, even though it appears that some peaks and troughs lead inflation. The level figure (upper left panel of figure 8) shows that there is a significant difference between the indices during the period of high oil prices. When the price of energy is excluded (PRAWNO), the predictor is even worse.

Wages (WAGES) and consumer prices move largely hand in hand, but contract wages (CONTRACT) do not predict consumer prices. Neither of them cointegrate with consumer prices. They also have instant (within a quarter) influence on the consumer prices and they still predict prices after one year.

Construction costs (CONSC) predict inflation in the very short run — within a quarter — and cointegrate with consumer prices. They also have a contemporaneous relationship with consumer prices.

Figure 7: Stumpage Prices (PSTUMP)

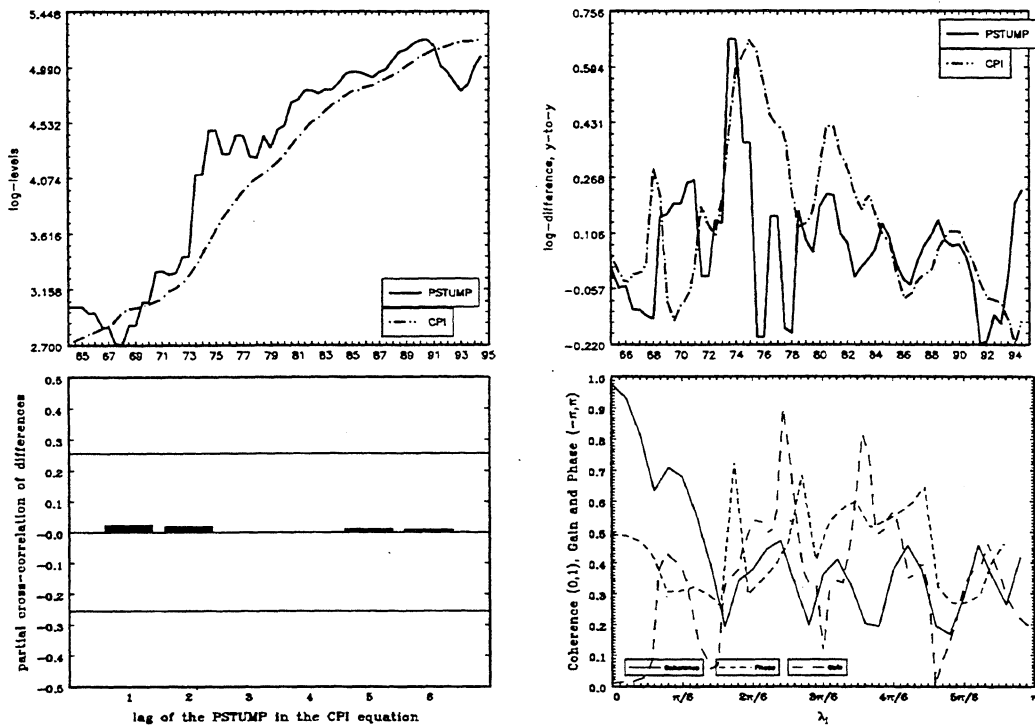


Figure 8: Prices of Raw Materials (PRAW)

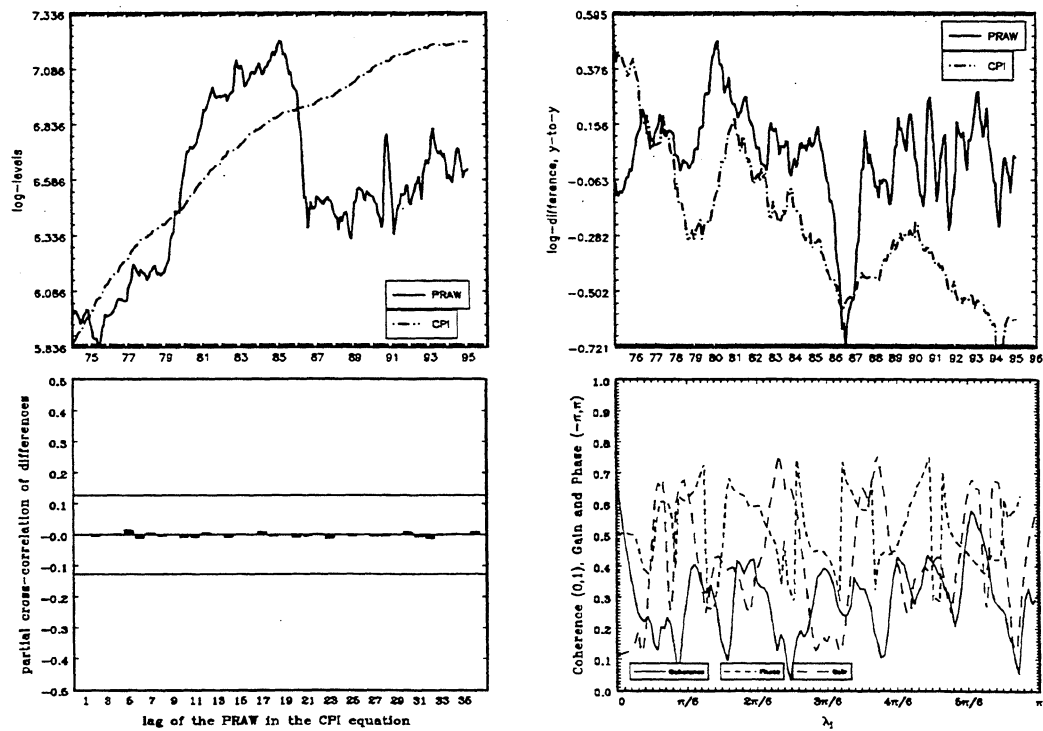


Figure 9: Prices of Raw Material excl. Energy (PRAWNO)

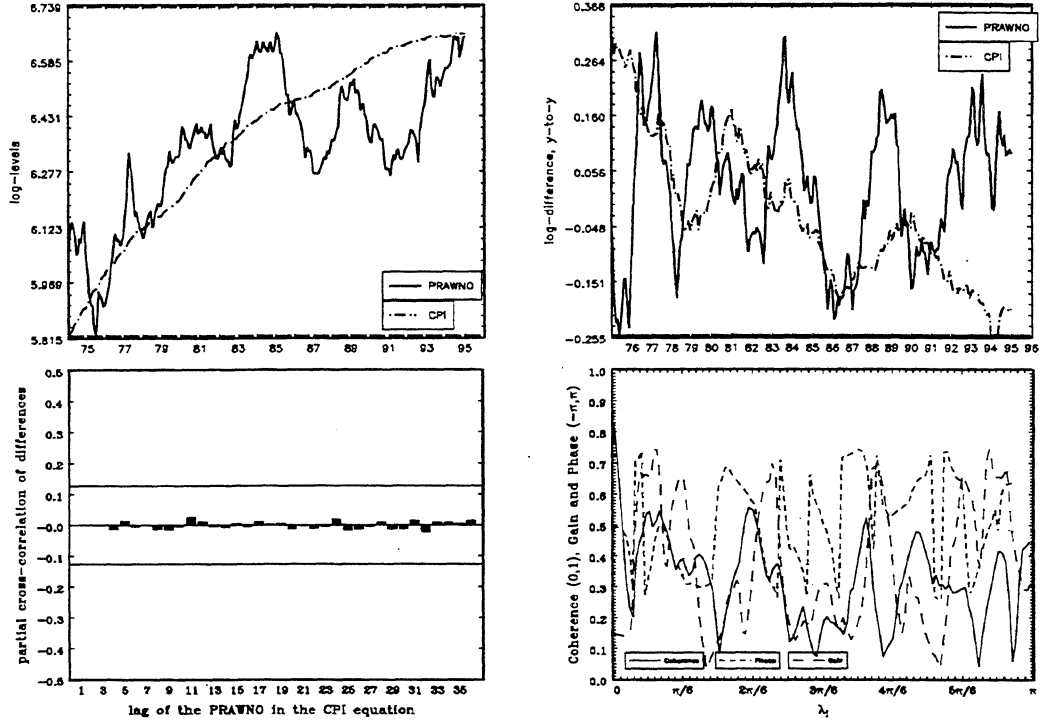


Figure 10: Earnings Index (WAGES)

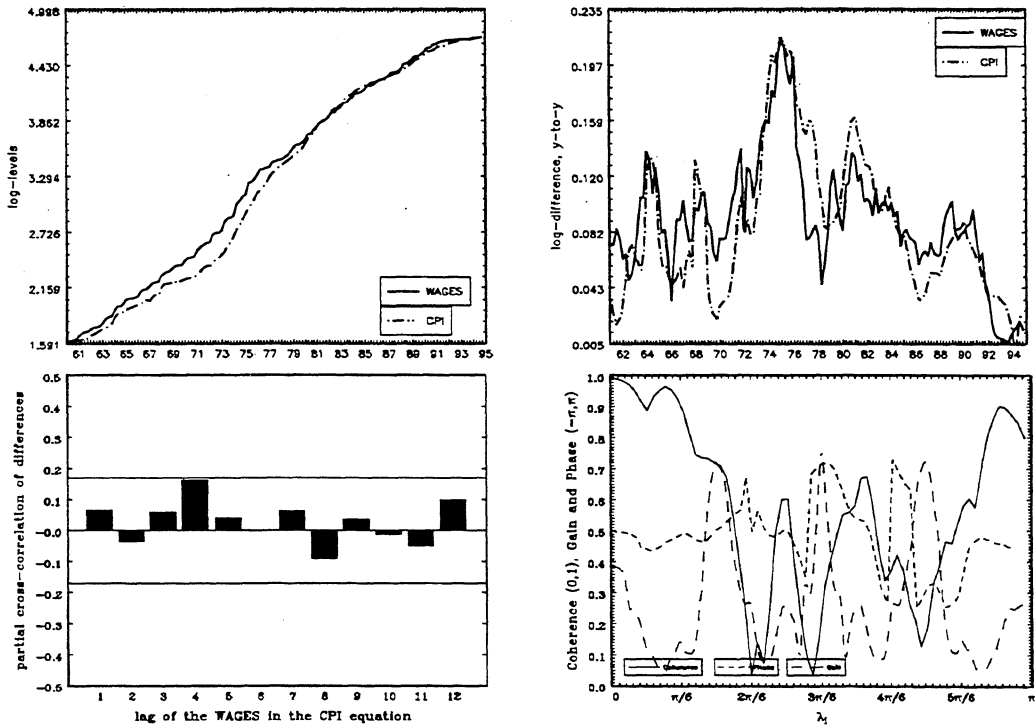


Figure 11: Contract Wages (CONTRACT)

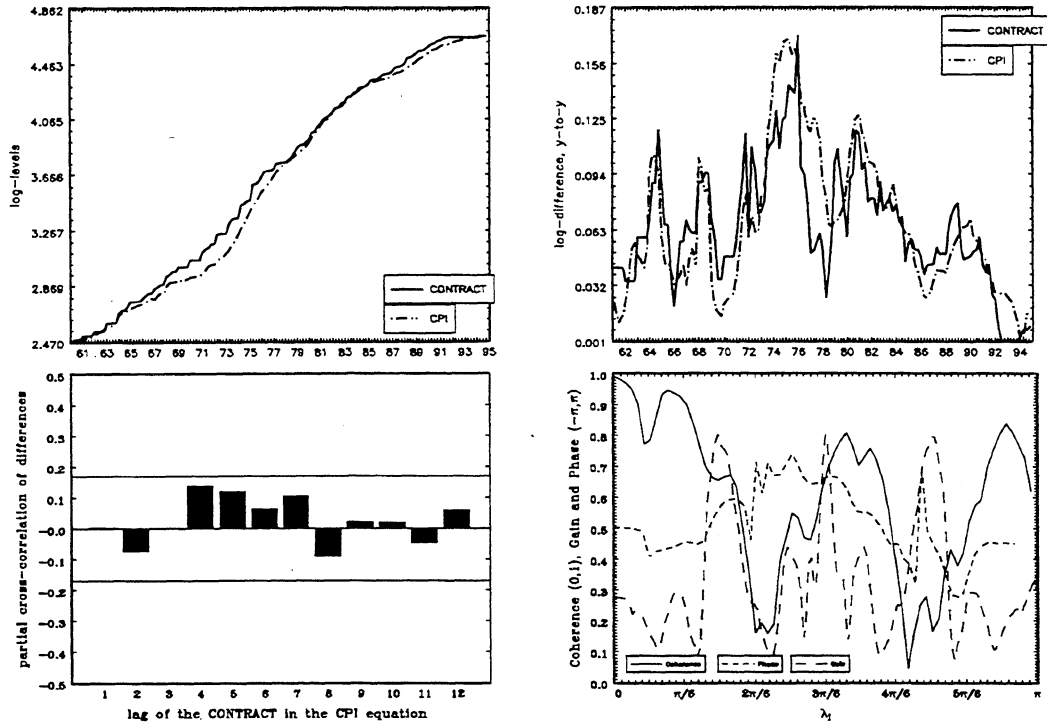
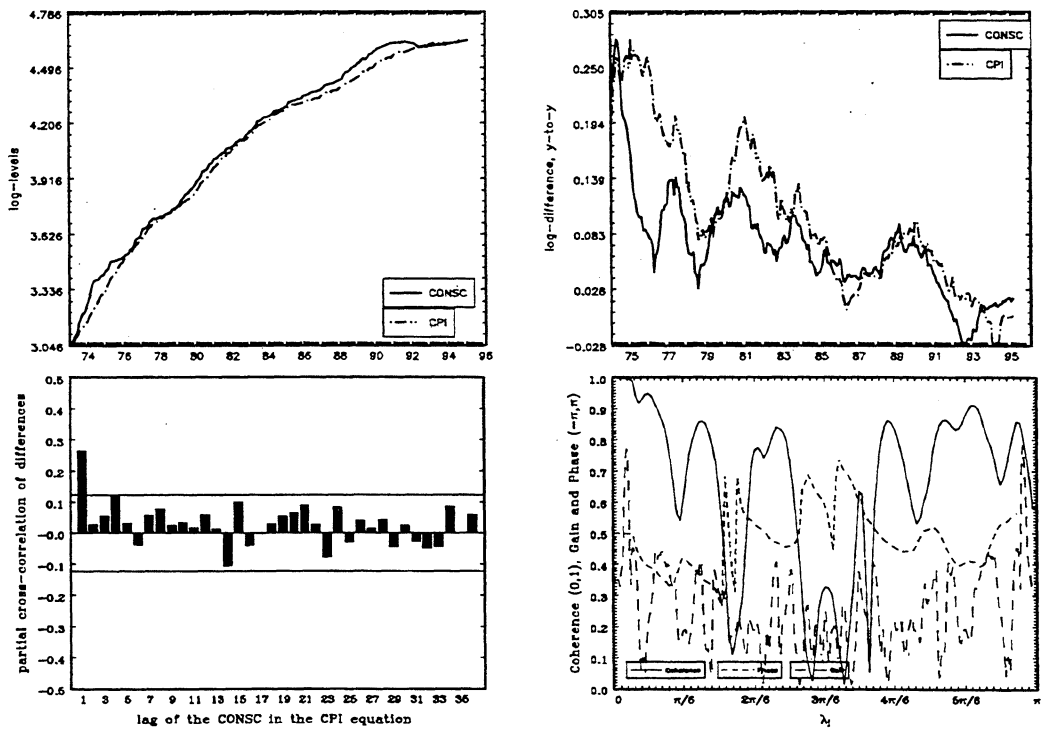


Figure 12: Construction Costs (CONSC)



### 3.2 Real Variables and Survey Indicators

In this section we analyze how well the economic activity variables predict consumer prices. These are variables which are expressed in quantity terms. We also study certain survey variables.

Table 2: Summary of Causality Tests, Real Variables and Survey Indicators

Name	Starting period	Lag length	CI-rank	Res. corr.	Granger non-causality, $p$ values	Prediction periods
GDPM	1970M1	13	1	-0.09	0.0002	6-13
INDPROD	1960M1	13	0	-0.03	0.6831	-
ELECT	1960M1	12	0	0.05	0.0414	12
UNEMP	1960M1	7	0	0.04	0.2669	-
CARS	1960M1	13	0	-0.17	0.0190	9-13
WVOL	1969M1	7	0	-0.04	0.2281	(1-5)
RVOL	1969M1	13	0	-0.20	0.0627	(9-13)
CAPACITY	1976Q1	5	-	-0.09	0.0386	1-4
ORDERS	1976Q1	4	-	0.15	0.0001	1-4
PRODPRED	1976Q1	4	-	0.06	0.0689	1-4

Note: Variables are in logarithmic form, except **CAPACITY**, **ORDERS** and **PRODPRED**, which are in levels with 12-month log-change of consumer prices.

**Production indicators.** Surprisingly, the monthly GDP indicator (GDPM) cointegrates with consumer prices (table 2). The cointegration vector shows positive interdependence between the GDP indicator and consumer prices, i.e. their difference is stationary. Growth of the GDP indicator predicts inflation more than a half-year ahead. The main element of the GDP indicator — industrial production INDPROD — is a poor forecaster of the consumer price level. Electricity output (ELECT) does not cointegrate with consumer prices, but its growth rate might predict inflation within a one-year period.

Unemployment (UNEMP) and consumer prices (in levels or differences) are not cointegrated. This can be interpreted as evidence of the non-existence of the long-run Phillips curve. Unemployment is also an inadequate forecaster of prices in the short run.

**Consumption indicators.** The consumption indicators (CARS, WVOL and RVOL) are not very good predictors of inflation. The number of registered

Figure 13: GDP Indicator (GDPM)

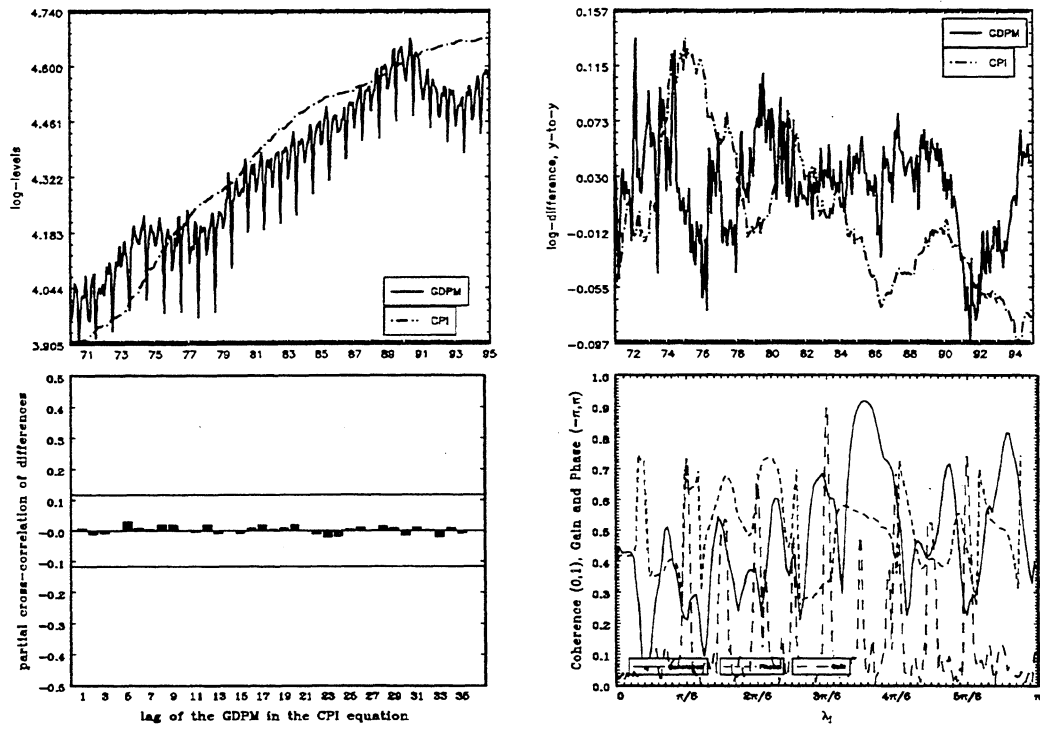


Figure 14: Industrial Output (INDPROD)

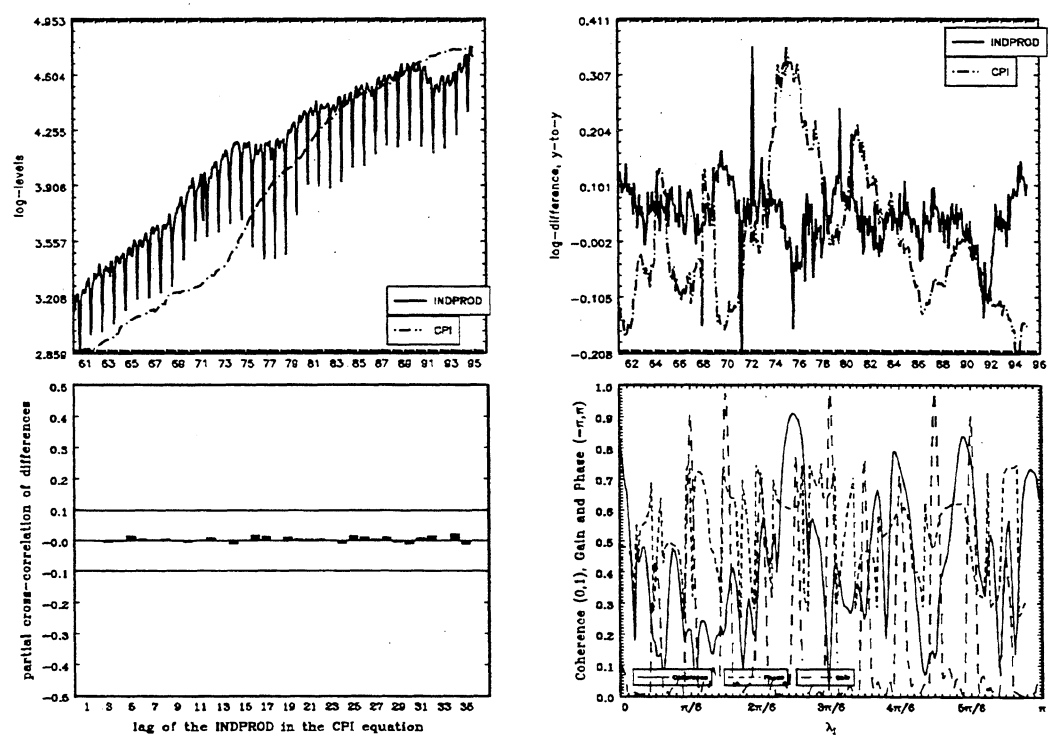




Figure 15: Electricity Output (ELECT)

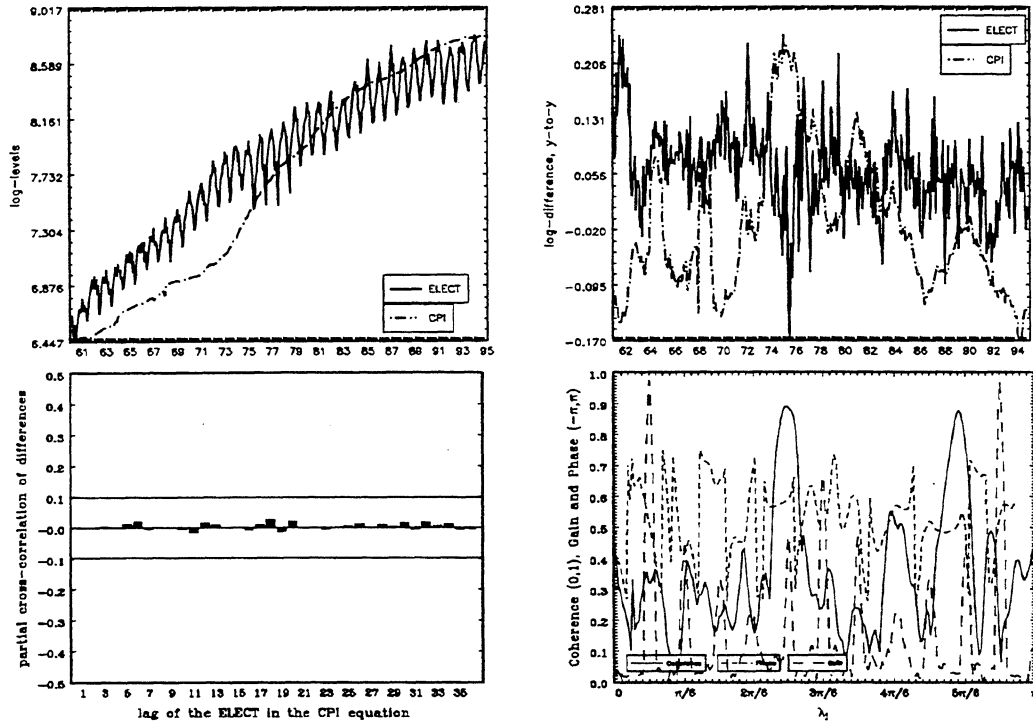
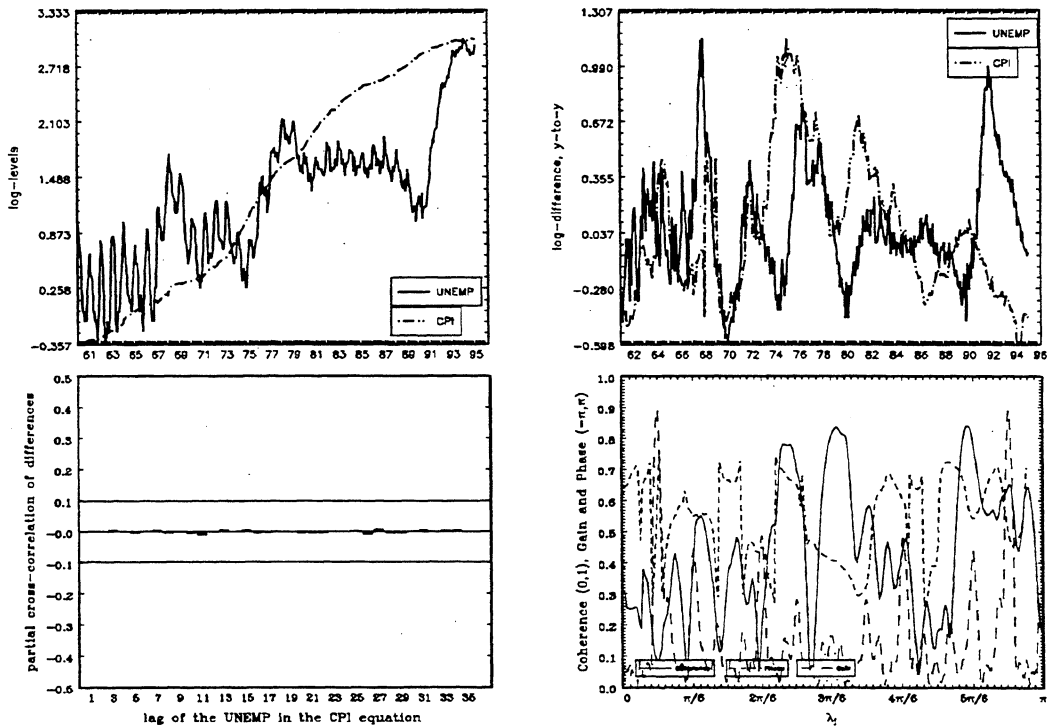
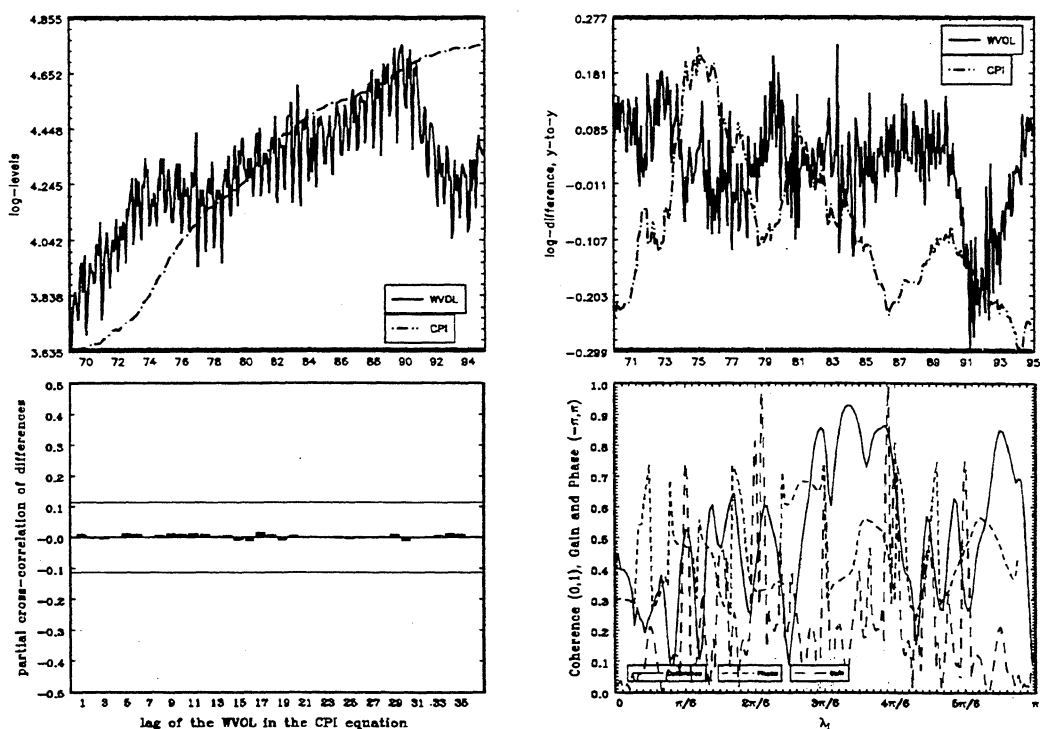


Figure 16: Unemployment (UNEMP)



cars (CARS) seems to predict inflation three quarters ahead on average. Neither wholesale (WVOL) nor retail sales (RVOL) cointegrate with consumer prices. However, the growth of the retail sales might predict inflation.

Figure 17: Volume of Wholesale Sales (WVOL)



**Survey indicators** The survey indicators (CAPACITY, ORDERS and PRODPRED) as forward looking indicators, contain information on the future development of consumer prices. It is important to remember that they really contain extra information on inflation since we have included lagged inflation in our statistical model. All of the survey indicators predict inflation within a year. The share of firms in manufacturing that do *not* have unused capacity (CAPACITY) is one of the few capacity utilization measures available in Finland and the only one used here. The level of orders compared to the normal level (ORDERS) describes the state of demand. Its prediction ability is even clearer than that of CAPACITY. The expected production in the following quarter (PRODPRED) is not as good predictor as the former two ones.

Figure 18: Volume of Retail Sales (RVOL)

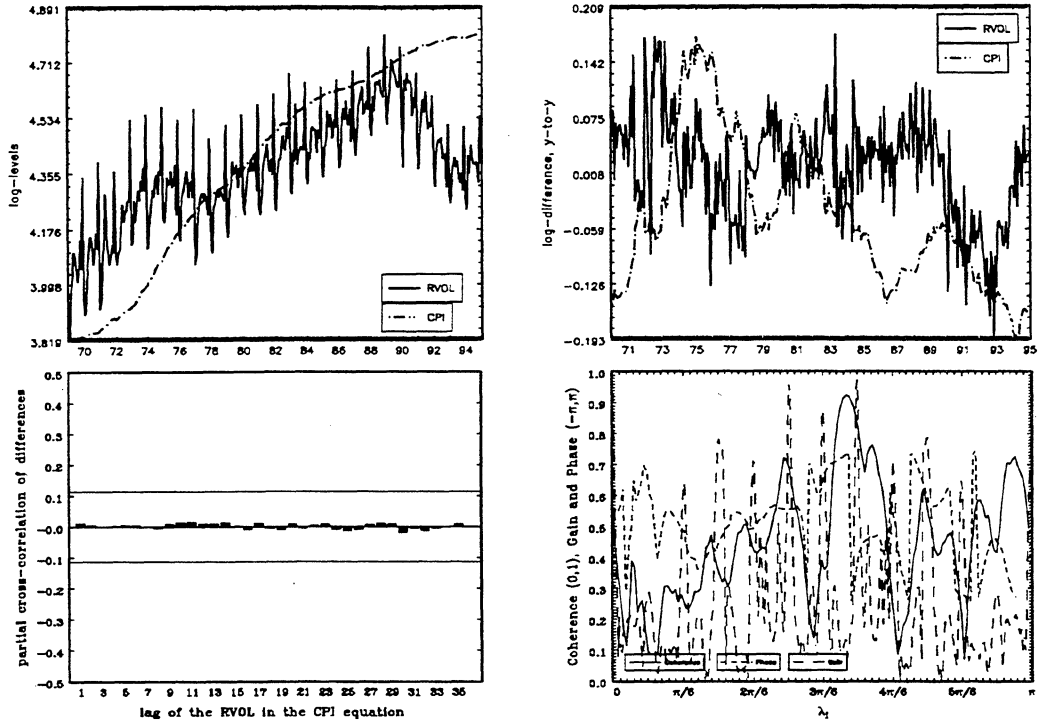


Figure 19: Cars Registered (CARS)

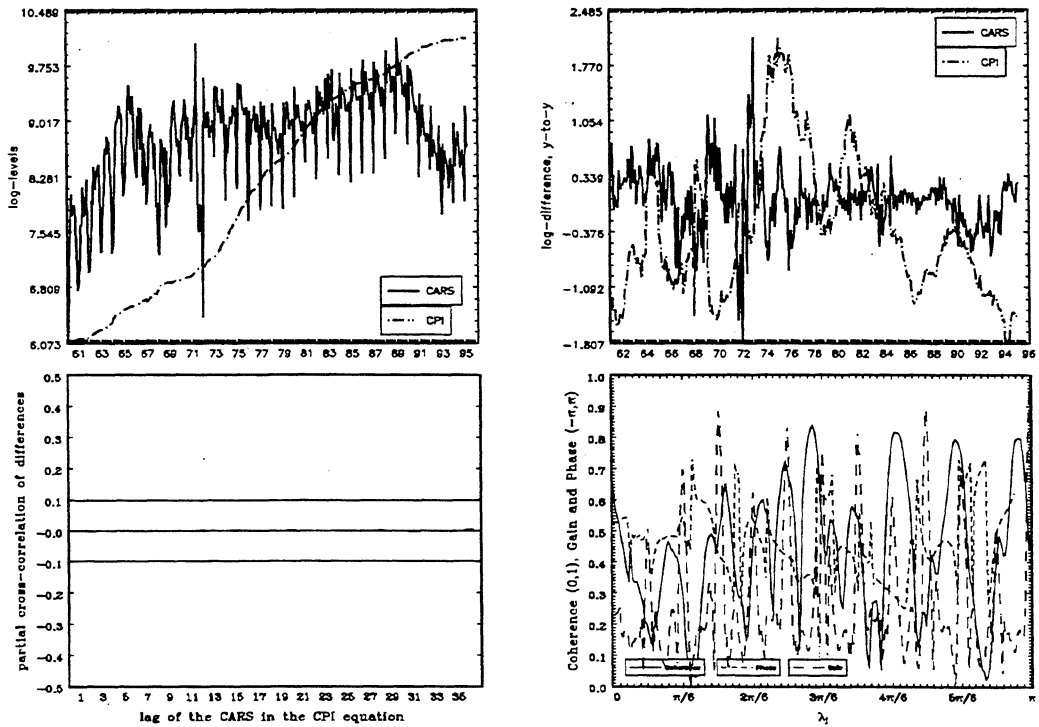


Figure 20: Share of Manufacturing Firms Not Having Unused Capacity (CAPACITY) Note: Inflation is measured as 12-month log-difference multiplied by one-hundred. Upper left and right graphs are the same.

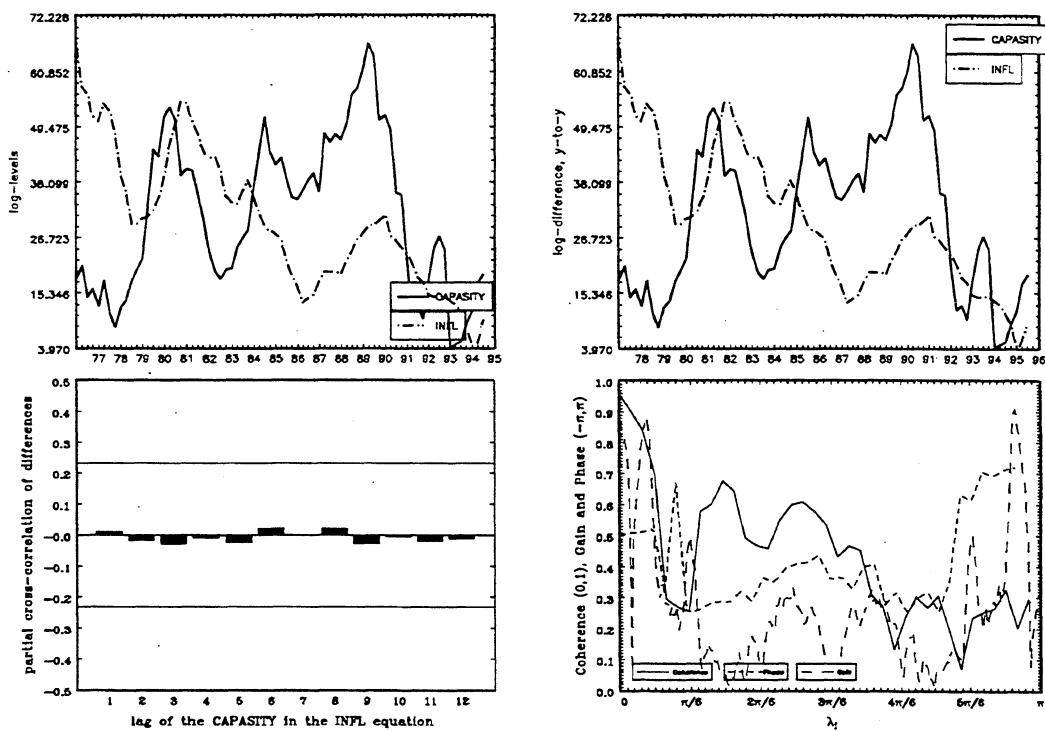


Figure 21: Level of Orders (of Manufacturing Firms) Compared to Normal (ORDERS) Note: Inflation is measured as 12-month log-difference multiplied by one-hundred. Upper left and right graphs are the same

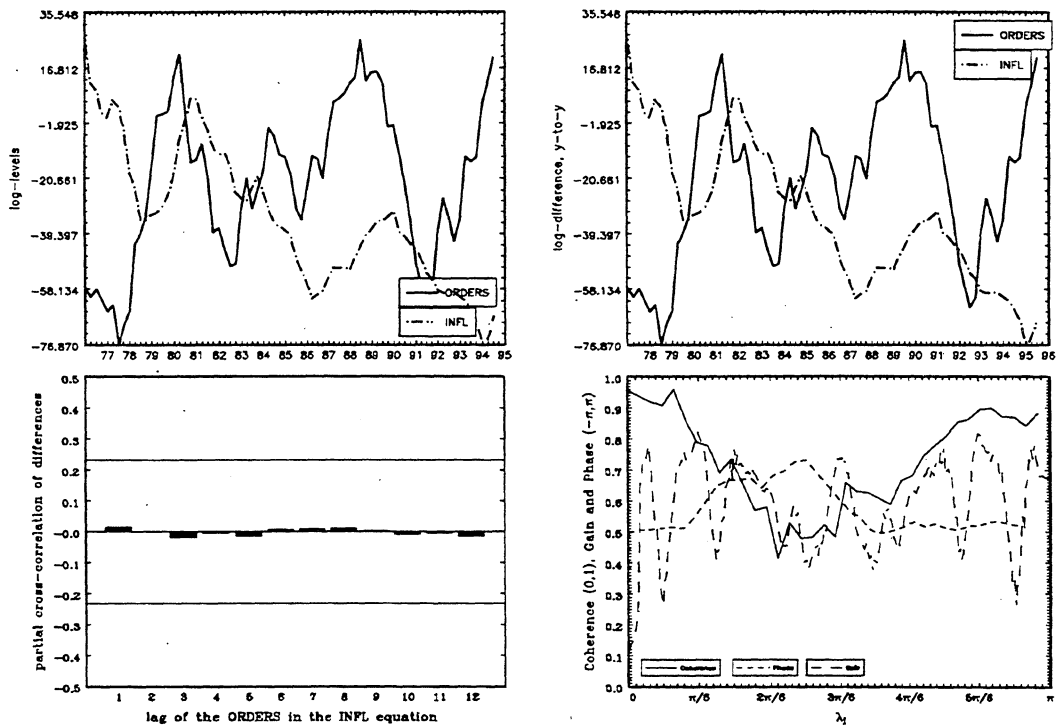
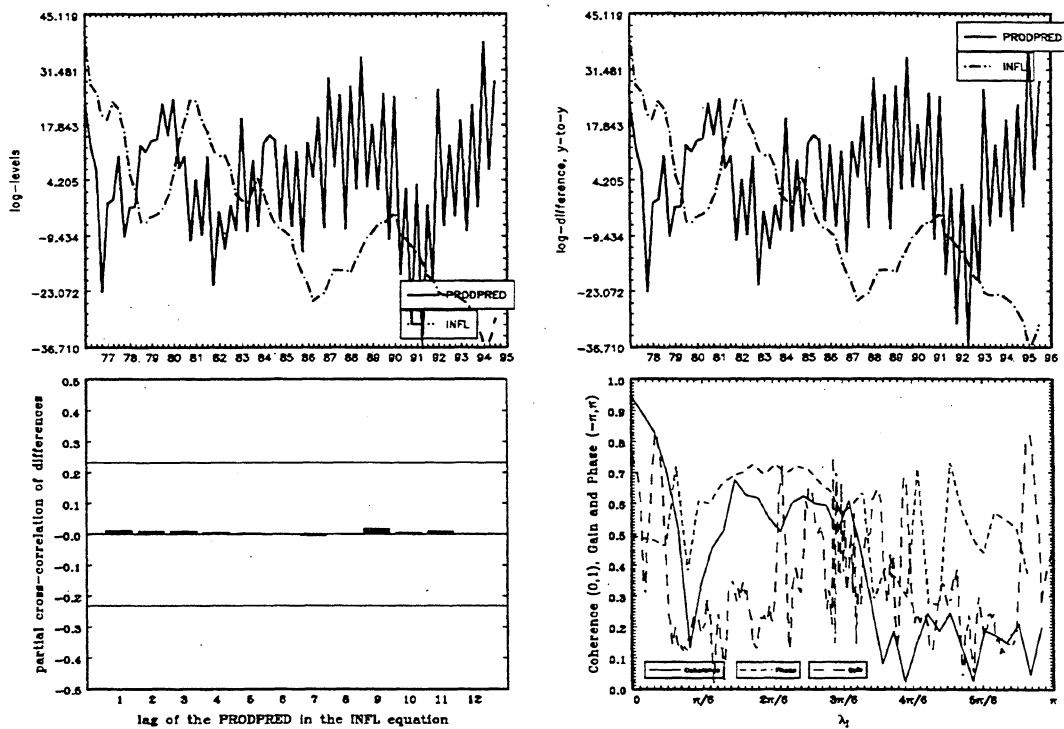


Figure 22: Expected Output (in Manufacturing) (PRODPRED) Note: Inflation is measured as 12-month log-difference multiplied by one-hundred. Upper left and right graphs are the same



### 3.3 Financial Indicators

Financial variables are very commonly used as inflation indicators (see e.g. McNees, 1989). The reason is that financial assets are traded continually and the data can be updated quickly. Also, financial data is usually very accurate<sup>5</sup>. In contrast, the publication of the non-financial data is delayed and often revised<sup>6</sup>. Another argument in favour of financial variables is that financial markets are supposed to be more future-oriented or forward-looking than real sector markets. However, as McNees (1989, p. 32) points out, "employment, output, and future investment decisions are also oriented toward the future".

In this section, we analyze the (pairwise) causality between consumer price index and monetary aggregates (M1, M2 and M3), exchange rates (EX and REX), bank lending (LEND), markka lending (FIMLEND), public debt (PDEBT), short (SHORTRAT) and long (LONGRATE) interest rates and yield indices computed from short (MMYIELDI) and long (BYIELDI) term interest rates. A summary of the statistical tests, base on monthly data, is presented in table 3.

**Monetary aggregates.** As expected, the growth of the broad monetary aggregates predicts inflation better than the narrow aggregates. Interestingly, narrow money (M1) does not predict consumer prices at all. The upper left panel of figure 23 illustrate the problem: the growth of narrow money is disturbed by several institutional shocks, which are not modelled. For example, the trough of 1991 was caused by the introduction of the interest withholding tax, which led to the portfolio shift from M1 to M2 accounts.

The growth of the broad monetary aggregates (M2 and M3) predicts inflation reasonably well<sup>7</sup> within one quarter. According to figures 24 and 25, the broad monetary aggregates might predict prices more than a year ahead. However, for longer lags the Granger non-causality test cannot reject the non-causality hypothesis.

The outcome differs somewhat from the demand for money results of Ripatti (1994), where narrow and broad money (M1 and M2) cointegrate with prices, GDP and interest rates. In that context, the unit long-run price elasticity could not be rejected. However, in demand for money studies the information set is broader, which influences the results. Causality analysis itself does not show that a given aggregate could serve as a monetary target, since it does not indicate which of the aggregates is most readily controllable by the central bank. Further the more structural modelling (e.g. the P-star approach) would yield quite different results. When we divide monetary aggregates by GDP vol-

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<sup>5</sup>In the Finnish case, monetary aggregates are usually revised only once after the first publication.

<sup>6</sup>The GDP volume indicator, GDPM, is sometimes revised more than 15 times!

<sup>7</sup>One should keep in mind that we test for Granger *non*-causality, i.e. the null-hypothesis is non-causality.

Table 3: Summary of Causality Tests, Financial Indicators

Name	Starting period	Lag length	CI-rank	Res. corr.	Granger non-causality, <i>p</i> values	Prediction periods
M1	1980M1	13	0	-0.02	0.9121	(1)
M2	1960M1	7	0	0.06	0.5375	1-3,(13-14)
M3	1960M1	13	0	0.02	0.3139	1-3,(13-14)
EX	1960M1	6	0	-0.02	<0.0001	3
REX	1960M1	6	0	-0.33	<0.0001	1-3
LEND	1975M1	7	0	0.06	0.1721	1-4
FIMLEND	1975M1	7	0	0.05	0.0002	1-4,(13-14)
SHORTTRAT	1972M1	13	-	-0.06	0.0519	1-13
LONGRATE	1971M5	13	-	0.10	0.3579	1
BYIELDI	1971M5	9	1	0.00	0.0001	1,(16-20)
MMYIELDI	1972M1	10	1	0.02	0.0003	1-4,(16,21,36)
YCURVE	1972M1	13	-	0.11	0.1479	?
HEX	1966M1	7	0	-0.08	0.5930	-
PDEBT	1966M1	7	1	-0.02	0.0005	(1-3)

Note: Variables were in logarithmic form, except **SHORTTRAT** and **LONGRATE**, which were in the form  $\log(1 + \frac{\%}{100})$ . The 12-month difference of  $\log(\text{CPI})$  is used in the models with **SHORTTRAT**, **LONGRATE** and **YCURVE**. Under the assumption of stationarity, no cointegration exists.



Figure 23: Narrow Money (M1)

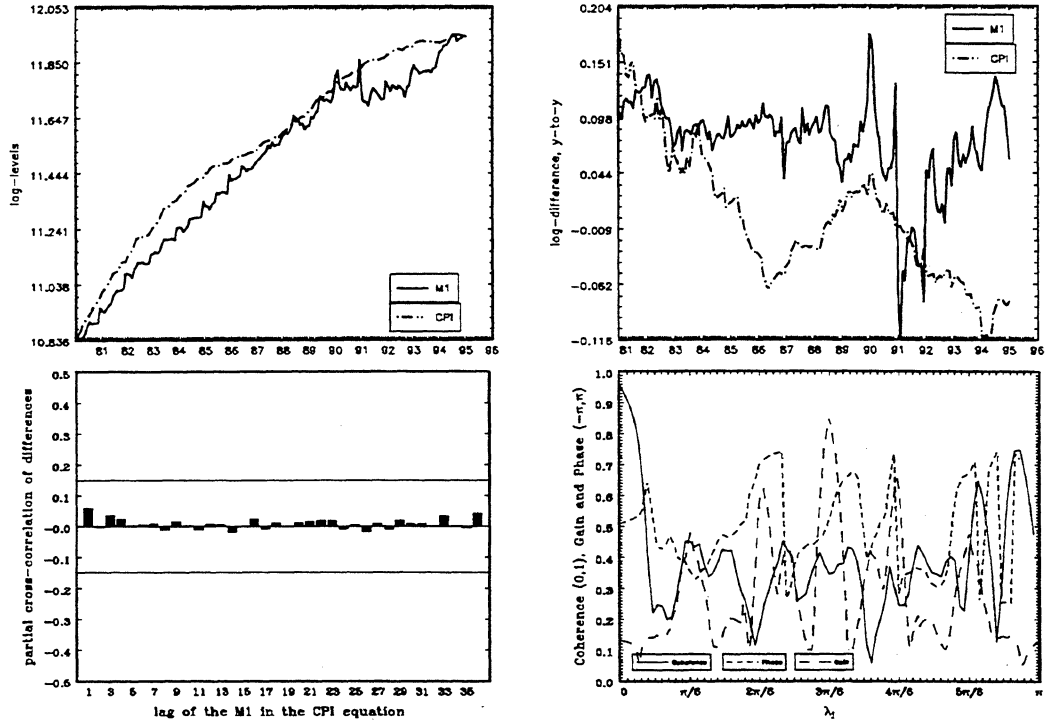


Figure 24: Broad Money (M2)

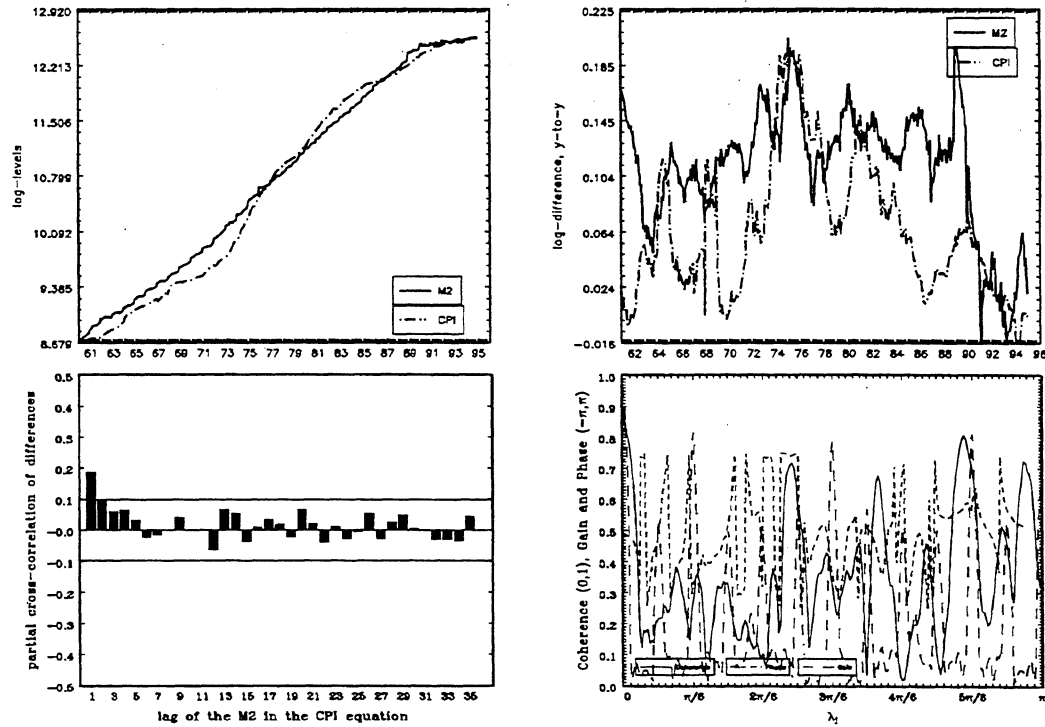
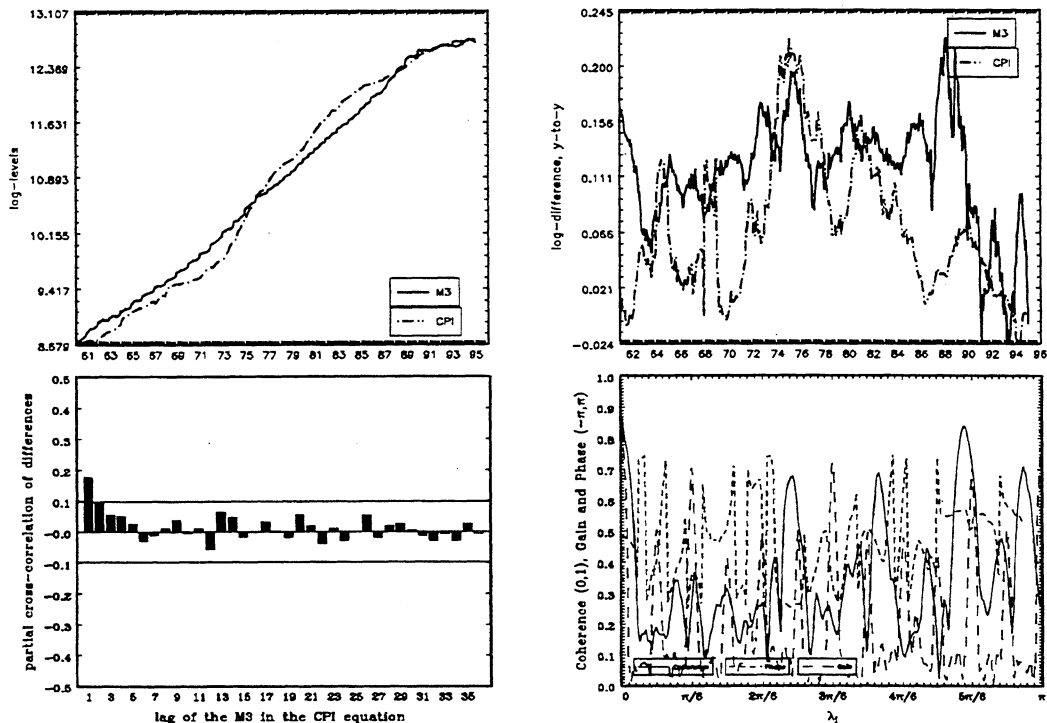


Figure 25: Broadest Monetary Aggregate (M3)



ume, cointegration is found most clearly with M2. In that case, non-causality is clearly rejected.

**Exchange rates.** The change in the trade-weighted (8 currencies) exchange rate index (EX) predicts inflation. For technical reasons, exchange rate changes forecast inflation most accurately three months ahead. However, the prediction ability is not very convincing. According to test statistics, the exchange rate does not cointegrate with consumer prices. However, the candidate for the cointegration relation has mean reverting features, although they are not very strong. The real exchange rate (REX) behaves in a similar manner.

**Credit aggregates.** We have separated banks' markka lending (FIMLEND) from total lending (LEND). Recent developments in total lending are dominated by changes in foreign exchange rates: First, the large devaluations in November 1991 and September 1992 increased the credit stock, since a significant part of bank lending was foreign currency-dominated and we measure it in FIM. Second, the recent appreciation of the markka has resulted in a decrease in the credit stock and a slowdown in conversions from foreign currency-dominated credit to markka credit. According to the non-causality tests, both lending indicators are good predictors of prices. However, markka lending is a better predictor than total lending. This can be seen from figures 29 and 28. For

Figure 26: Exchange Rate Index (EX)

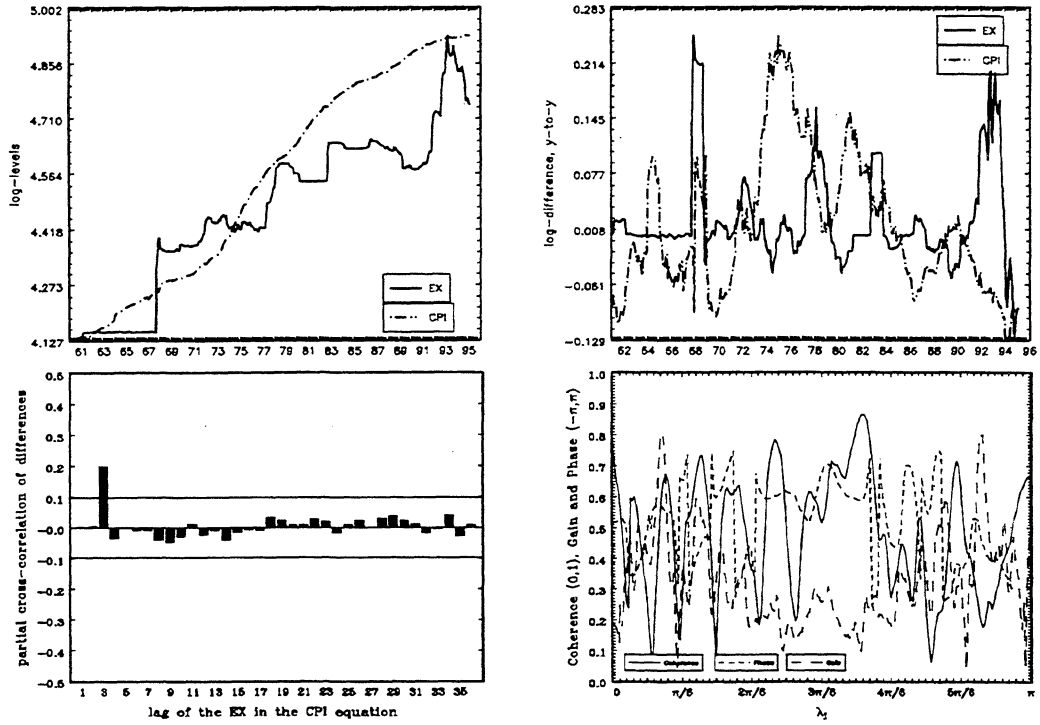
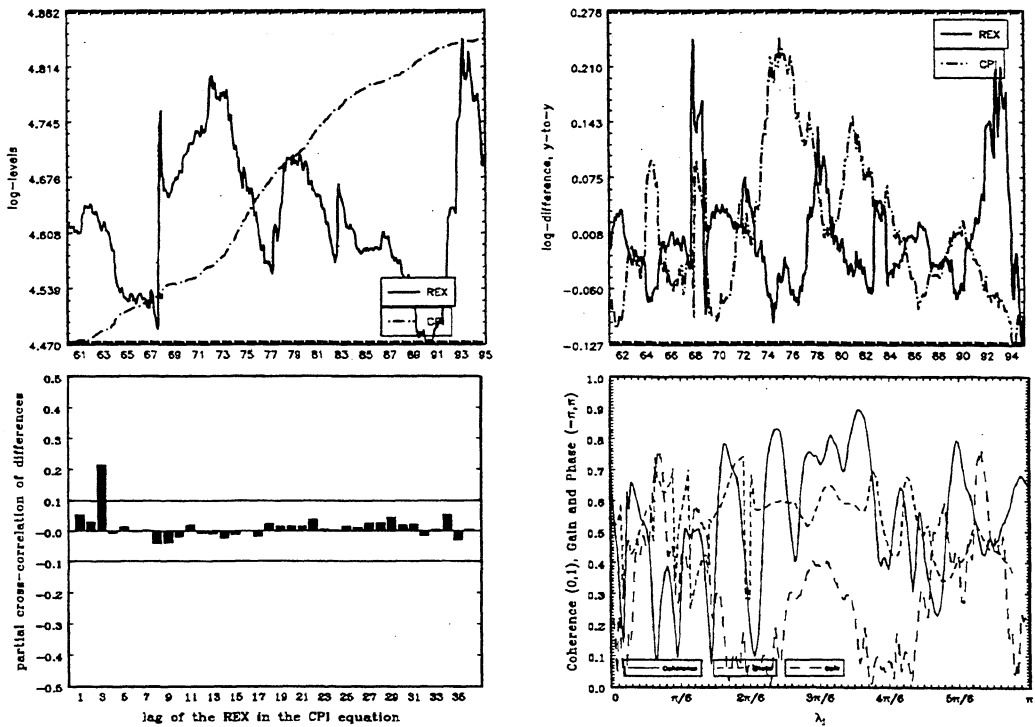
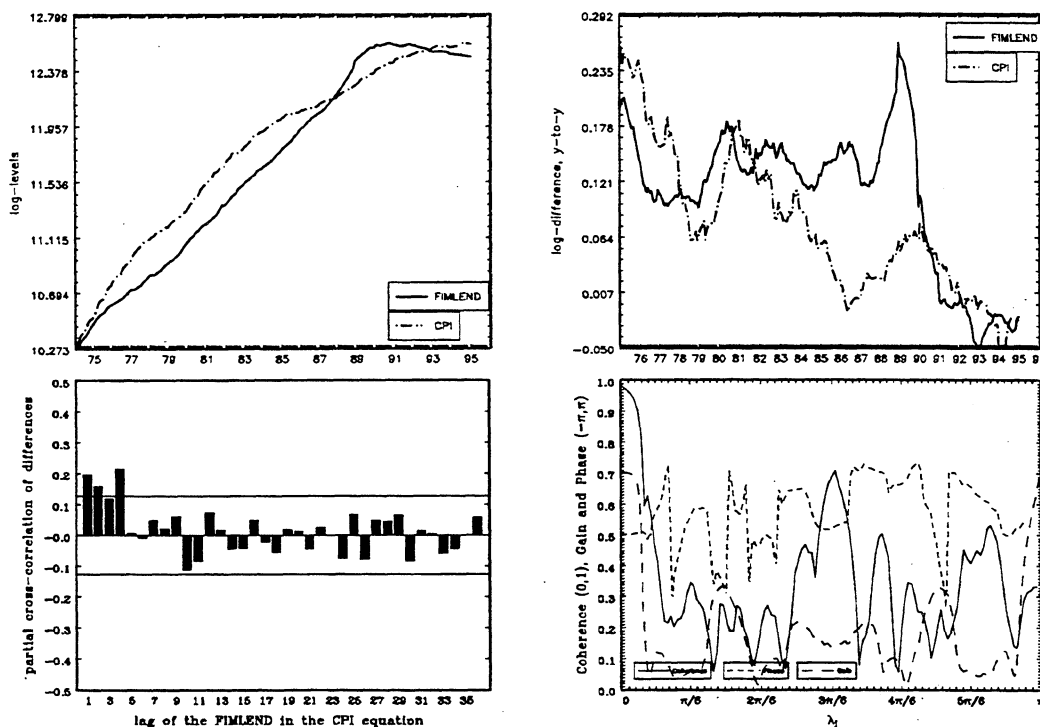


Figure 27: Real Exchange Rate (REX)



further analysis of credits see Saarenheimo (1995) who analyses the supply of credit and investment.

Figure 28: Banks' Markka Lending (FIMLEND)

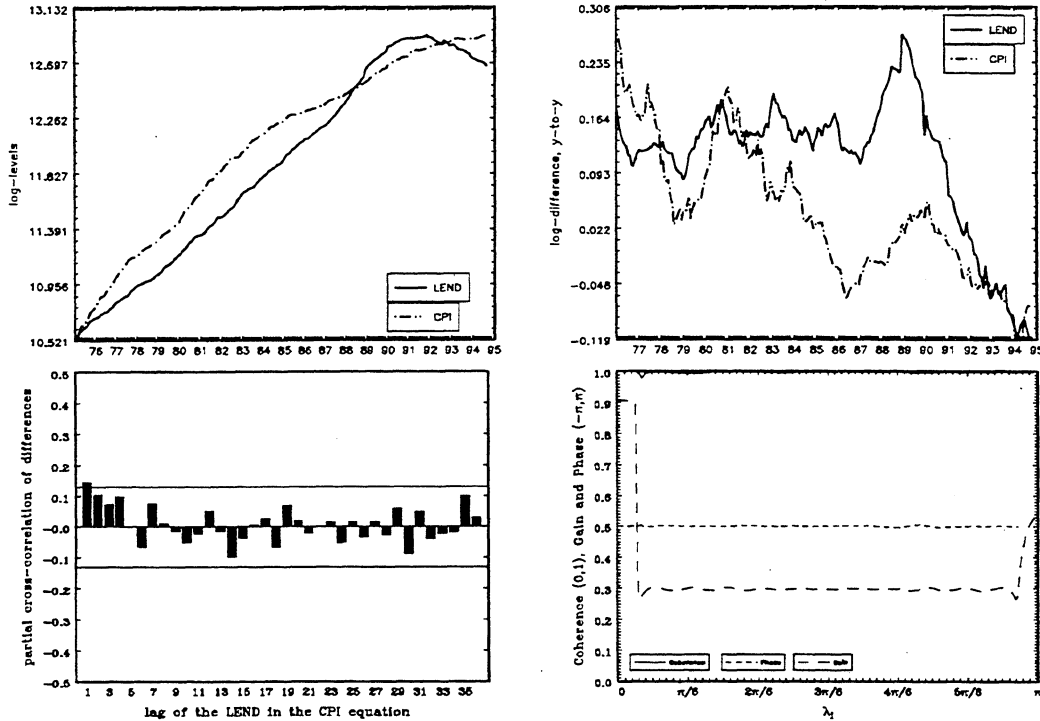


**Interest rates and the yield curve.** Interest rates are tested in the two different forms: First, the interest rates (SHORTRAT and LONGRATE) and inflation (12-month log-change of CPI) were modelled. They were considered stationary, which simplifies the causality testing. Second, the yield indices for interest rates (MMYIELDI and BYIELDI) are computed and cointegration between the yield indices and the CPI is tested.

The 3 month money market rate (SHORTRAT) predicts inflation (CPI) within a year surprisingly well. The 5-year bond rate (LONGRATE) is not much worse as a predictor. An increase in an interest rate has a negative impact on inflation, even in the short run. The prediction capability is magnified when we use the analogous yield indices. The money market yield index (MMYIELDI) seems to be an excellent predictor of price level — although it does not cointegrate with price level. The bond yield index (BYIELDI) is also very good, but not as good as the money market index. The slope of the yield curve (YCURVE) is not as good a predictor as the interest rates themselves.

One should remember that interest rates were not market determined before the mid-1980s. Short-term interest rates had a role already in early 1980s when forward exchange markets were not controlled by the Bank of Finland.

Figure 29: Bank Lending (LEND)



For the tax reasons, bonds were not in the range of households' investments during the 1970s and 1980s. The superiority of short rates (either in the form of interest rates or the yield index) has its roots in the fixed exchange rates. The short rates mainly reflect the (short-run) devaluation risk of the markka. The devaluation risk is primarily a consequence of rising inflation. A realized devaluation increases prices, as import prices rise, which gives the impression of long run predictability of inflation by the short rates.

**Stock prices and public debt.** According to the standard causality tests, the stock price index (HEX) is not a good predictor of consumer prices. It fluctuates much more and so gives false signals for future movements in consumer prices. However, one must remember that we are using linear models and that certain non-linear predictors could perform well. Such models are beyond the scope of this study. Public debt (PDEPT) contains some information about the future price level. However, the upper right panel of the figure 36 indicates that the direction of causality is the reverse.

Figure 30: Short-Term Money Market Rate (SHORTTRAT) Note: Inflation is measured as 12-month log-difference multiplied by one-hundred. Upper left and right graphs are the same.

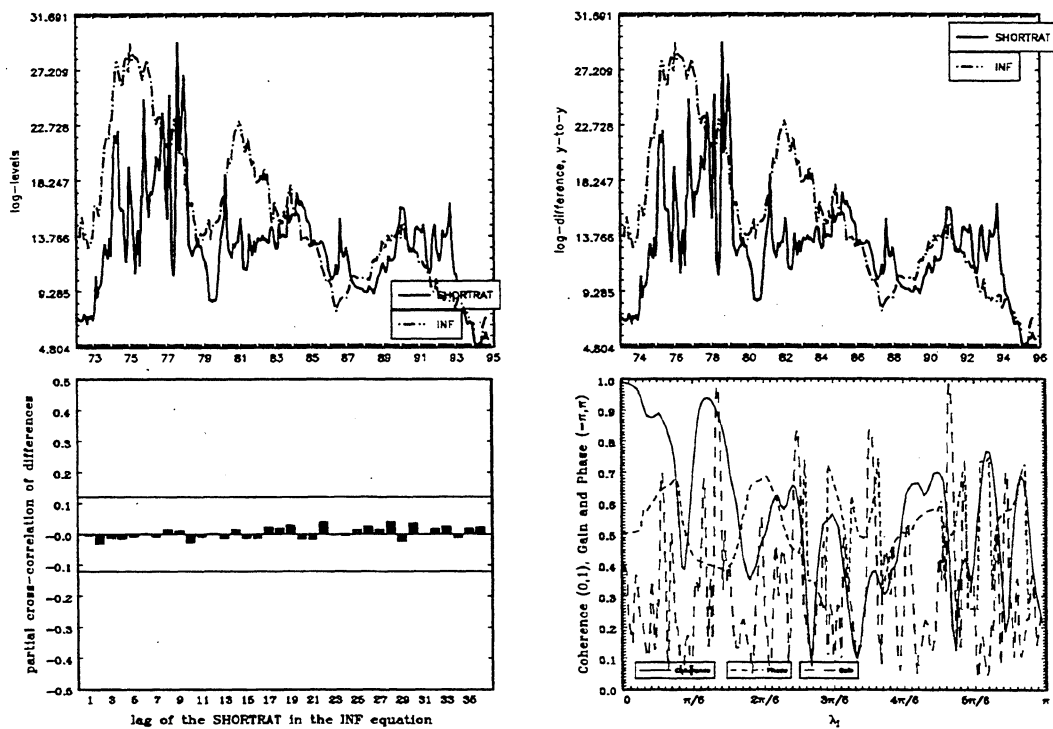


Figure 31: Bond Rate (3-6 years) (LONGRATE) Note: Inflation is measured as 12-month log-difference multiplied by one-hundred. Upper left and right graphs are the same.

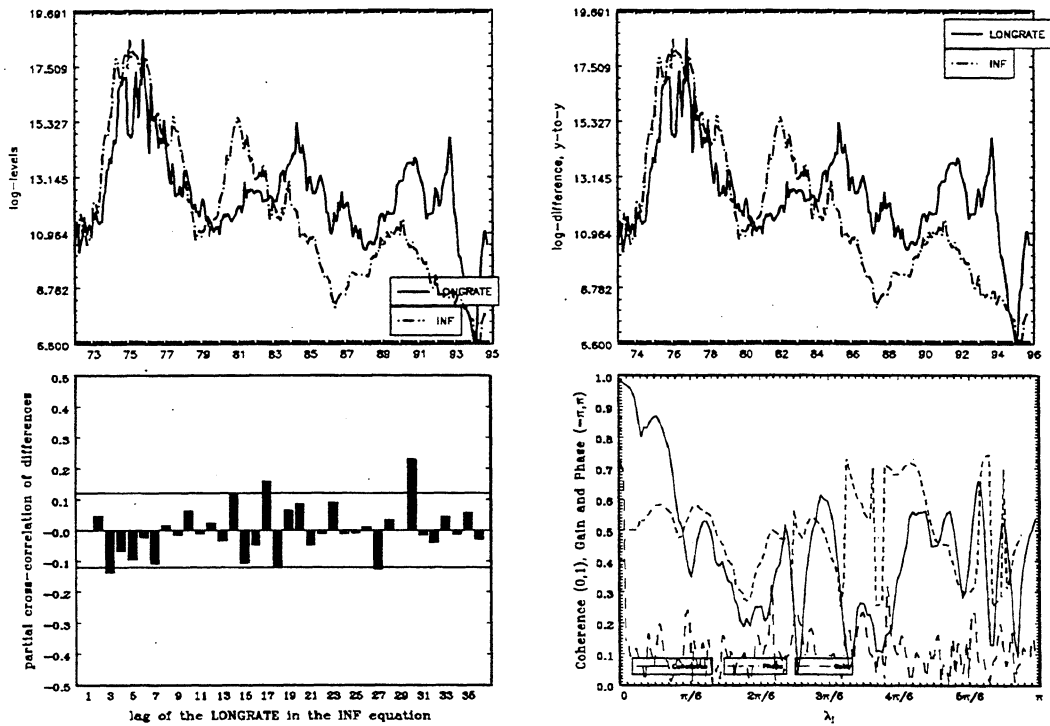


Figure 32: Money Market Yield Index (MMYIELDI)

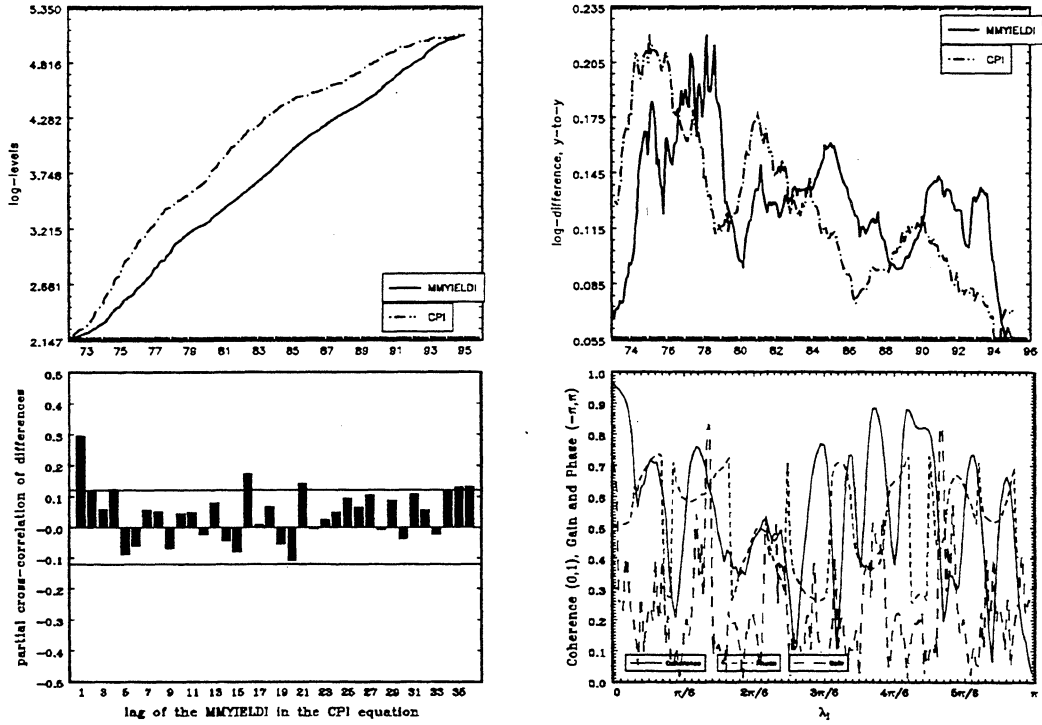


Figure 33: Bond Yield Index (BYIELDI)

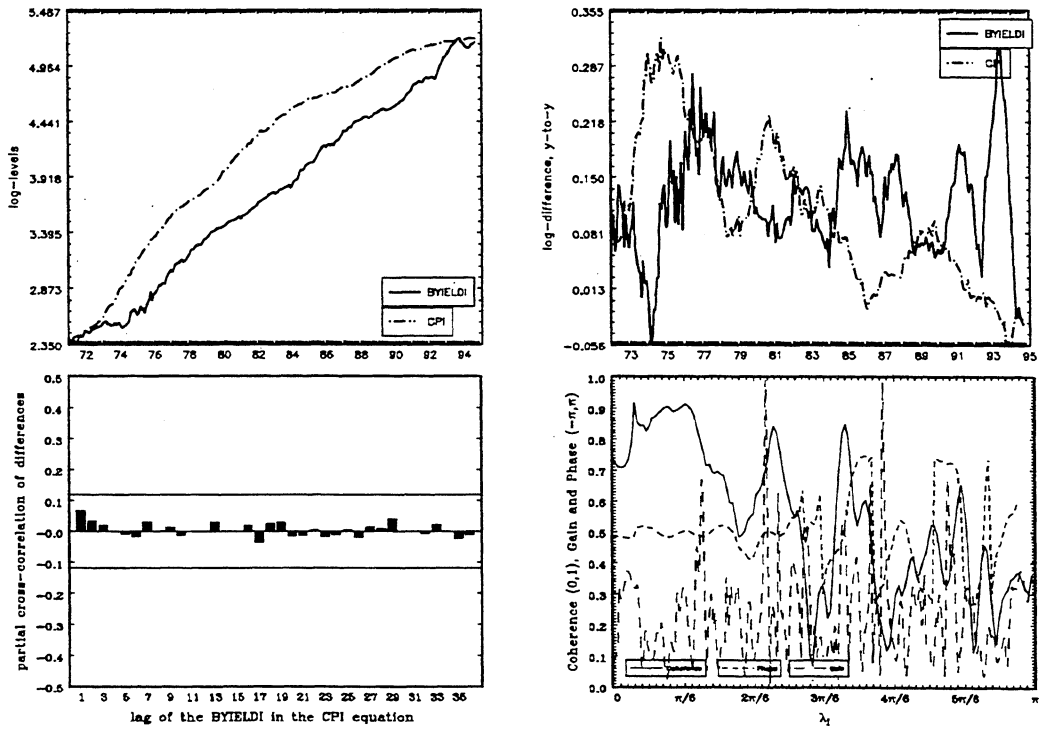




Figure 34: Slope of the Yield Curve (YCURVE) Note: Inflation is measured as 12-month log-difference multiplied by one-hundred. Upper left and right graphs are the same.

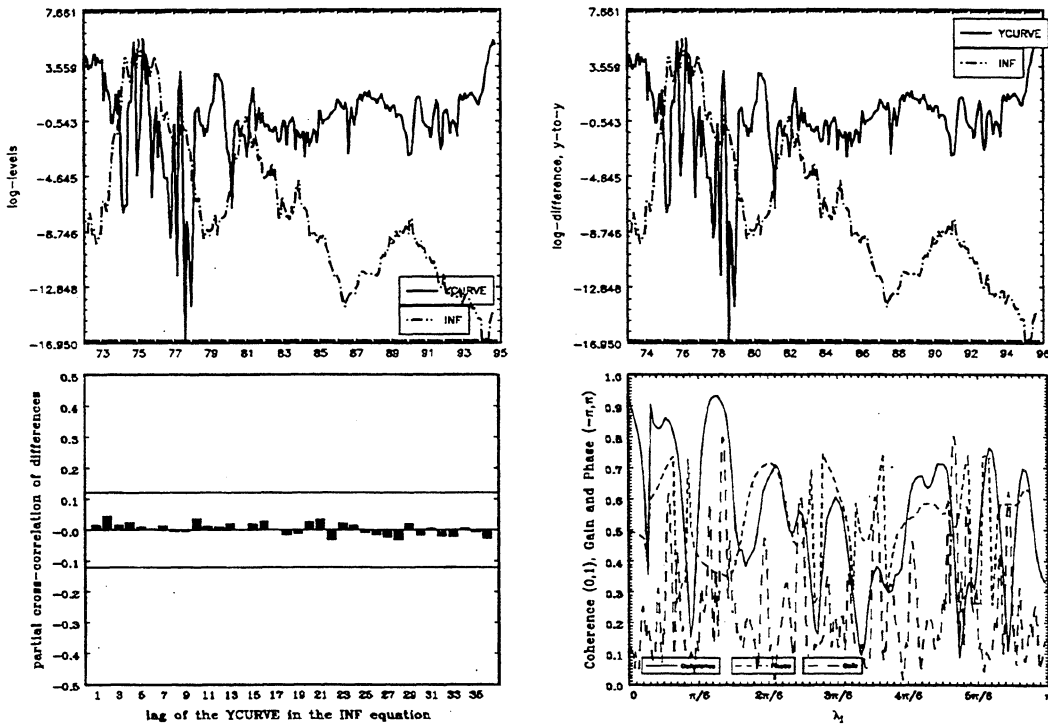


Figure 35: Stock Price Index (HEX)

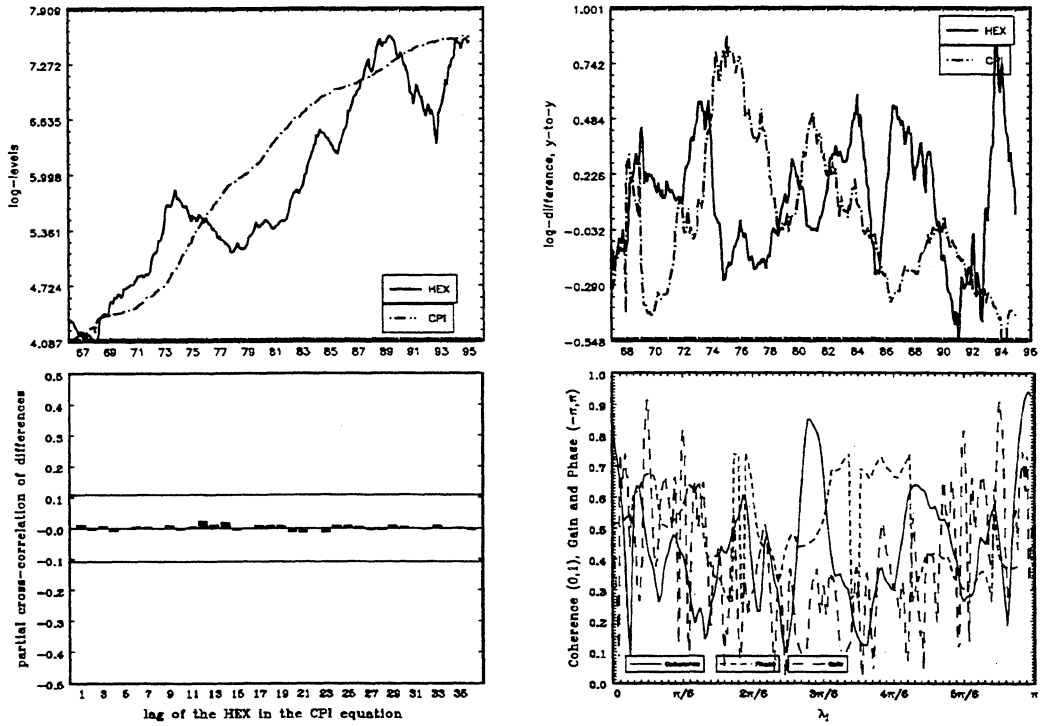
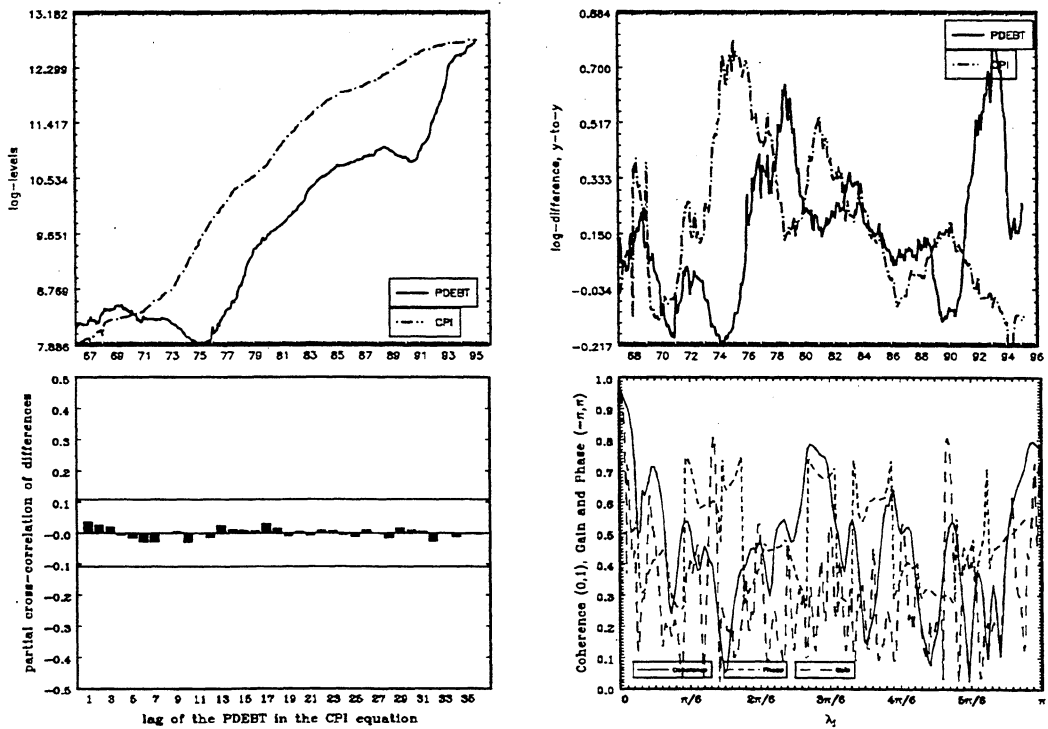


Figure 36: Public Debt (PDEBT)



## 4 Concluding Remarks

We have analysed a large set of economic variables in order to evaluate their ability to predict consumer price inflation. The overall result is that bivariate modelling is not very fruitful since we rarely can incorporate economic structure into the models. The lack of structure is replaced by a — usually long — autoregressive part of the model. Hence the results that follow are often not very robust to the choice of the lag length or cointegration rank. We have not analyzed possible structural changes caused by financial deregulation or the floating exchange rate regime. Thus, the implicit assumption has been that the causal relationships have been stable over the sample period.

As stated in the introduction, the strength of the indicator approach does not rely on the accuracy of the predictions generated by these simple models but by the transparency the formulation of the predictions. In fact, these causal relationships are temporal correlations and are thus easy for the public to understand.

For the purposes of monetary policy, it is important that the indicator be reliable in the sense that it is not revised very much after its initial publication. Further, the publication lag should not be too long since the lag from the monetary policy action to inflation is considered to be 1–2 years. Due to the long lag, it is important that the indicator predict inflation in the long run rather than only in the short run. The long run co-movement, i.e. cointegration, is the most fortunate outcome of the analysis. In the following table the macroeconomic variables are ranked by their usefulness as inflation indicators from the viewpoint of monetary policy (table 4).

The first and most highly ranked group contains yield indices and some cost variables. Bond and money market yield indices are influenced by expected changes in monetary policy. Due to this factor the yields are somewhat problematic as medium-term targets, but then they do indicate very well the stance of monetary policy.

Possibly the raw material property of stumpage prices dominates its role in the inflation process. It is the raw material and the most important cost factor in Finland's major export industry. The GDP indicator also fulfils the main features of an inflation indicator. Construction costs contain much information on forthcoming inflation but as an inflation indicator they are weak, because construction price increases are part of the inflation process itself.

The second group lacks cointegration but is still able to predict inflation in the long run. The survey indicators belong to this group as do several real economic activity indicators. All of them can probably predict inflation a year ahead with some accuracy. Many financial indicators also belong to this group. The broad monetary aggregates (M2 and M3) are on the borderline, according to the non-causality tests, but we include them here. Interestingly, interest rates, as levels and yield indices, also forecast inflation at a longer

Table 4: Usefulness as an inflation indicator

Name	Explanation	longest lag length (years)
Predicts over $\frac{1}{2}$ year ahead and cointegrates		
BYIELDI	Bond yield index, 1990=100	1 $\frac{1}{2}$
MMYIELDI	Money market yield index, 1990=100	1 $\frac{1}{2}$
PSTUMP	Stumpage prices, 1985=100	1
CONSC	Construction cost index, 1990=100	1-4
GDPM	GDP volume indicator at factor prices, 1990=100	$\frac{3}{4}$
Predicts over $\frac{1}{2}$ year ahead		
WAGES	Level of earnings index	1
ELECT	Consumption of electricity, 1000 GWh	1
CARS	Cars registered, number	1
CAPACITY	Share of the firms without capacity in manufacturing, %	1
ORDERS	Orders in manufacturing, compared to the normal level, %	1
PRODPRED	Expected production in the following quarter compared to the present quarter, %	1
M2	Monetary aggregate M2, M1+time deposits, mill. FIM	1
M3	Monetary aggregate M3, M2+CDs, mill. FIM	1
FIMLEND	Banks' markka lending, mill. FIM	1
SHORTRATE	3 month money market rate, %	1
PEXP	Export price index, 1990=100	$\frac{1}{4}$
Predicts less than $\frac{1}{2}$ year ahead		
LEND	Bank lending, mill. FIM	$\frac{1}{4}$
YCURVE	LONGRATE - SHORTRATE	$\frac{1}{4}$
WPI	Wholesale price index, 1990=100	$\frac{1}{4}$
PPI	Producer price index, Manufacturing, 1990=100	$\frac{1}{4}$
EX	Exchange rate index, 1982=100	$\frac{1}{4}$
REX	Real exchange rate index, 1982=100	$\frac{1}{4}$
Cointegrates but no short-run causality		
PHOUSE	Average price of old two room flats in Helsinki area, FIM	?
PDEBT	Public debt, mill. FIM	-
Does not predict inflation		
PIMP	Import price index, 1990=100	-
TOT	Terms of trade, 1990=100	-
CONTRACT	Index of contract wages	1
RAWP	Prices of raw materials, HWWA index	-
RAWPNO	Prices of raw materials excluding energy, HWWA index	-
INDPROD	Industrial output, 1990=100	-
UNEMP	Unemployment rate, %	-
WVOL	Wholesale volume, 1990=100	-
RVOL	Retail sale volume, 1990=100	-
M1	Monetary aggregate M1, cash+checkable and transactions accounts, mill. FIM	-
LONGRATE	5 year bond rate, %	-
HEX	Stock prices, 1990=100	-

time horizon, but the slope of the yield curve does not.

Price indices are typically good short-run predictors of inflation. Bank lending is more contemporaneous with prices than anticipatory of prices.

Many of the variables that are usually considered to be good candidates as predictors do not really predict inflation. The reasons may vary: first, our definition of non-causality is limited to linear processes<sup>8</sup>, whereas the causal relationship might have much more complex pattern. Second, our assumption of no structural breaks might in some cases be very restrictive and could easily lead to the erroneous acceptance of non-causality. Finally, bivariate analysis is not very fruitful. The actual causality between two variables could exist in a wider framework. For example, the cointegration of money and prices are accepted in the demand for money studies (see e.g. Ripatti 1994). Ripatti and Vilmunen (1994) relax the assumption concerning the weights of consumer prices and analyze cointegration and common trends for consumer price subgroups and macroeconomic variables.

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<sup>8</sup>Note that under the normality assumption the conditional expectation is linear in variables.

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## **A Data**

Table 5: Description of the data

Name	Explanation	Frequency
CPI	Consumer price index, 1990=100	monthly
Nominal Indicators		
WPI	Wholesale price Index, 1990=100	monthly
PPI	Producer price index, Manufacturing industry, 1990=100	monthly
PEXP	Export price index, 1990=100	monthly
PIMP	Import price index, 1990=100	monthly
TOT	Terms of trade, 1990=100	monthly
PHOUSE	Average price of old two room flats in Helsinki area, FIM	monthly
PSTUMP	Stumpage prices, 1985=100	semiannual
RAWP	Prices of raw materials, HWWA index	monthly
RAWPNO	Prices of raw materials excluding energy, HWWA index	monthly
CONSC	Construction cost index, 1990=100	monthly
WAGES	Level of earnings index	quarterly
CONTRACT	Index of contract wages	quarterly
Real Variables and Survey Indicators		
GDPM	GDP volume indicator at factor prices, 1990=100	monthly
INDPROD	Industrial production, 1990=100	monthly
ELECT	Consumption of electricity, 1000 GWh	monthly
UNEMP	Unemployment rate, %	monthly
CARS	Cars registered, number	monthly
WVOL	Wholesale volume, 1990=100	monthly
RVOL	Retail sale volume, 1990=100	monthly
CAPACITY	Share of manufacturing firms without unused capacity, %*	quarterly
ORDERS	Manufacturing orders compared to the normal level, %*	quarterly
PRODPRED	Expected output in the following quarter compared to the present quarter, %*	quarterly
Financial Indicators		
M1	Monetary aggregate M1, cash+checkable and transactions accounts, mill. FIM	monthly
M2	Monetary aggregate M2, M1+time deposits, mill. FIM	monthly
M3	Monetary aggregate M3, M2+CDs, mill. FIM	monthly
EX	Exchange rates, trade weighted (8 currencies), 1982=100	monthly
REX	Real exchange rate, trade-weighted (8 currencies, consumer prices), 1982=100	monthly
SHORTRATE	3-month money market rate, %	monthly
LONGRATE	5-year bond rate, %	monthly
BYIELDI	Bond yield index, 1990=100	monthly
MMYIELDI	Money market yield index, 1990=100	monthly
HEX	Stock prices, 1990=100	monthly
LEND	Banks' lending, mill. FIM	monthly
FIMLEND	Banks' markka lending, mill. FIM	monthly
YCURVE	LONGRATE - SHORTRATE	monthly
PDEBT	Public debt, mill. FIM	monthly

Source: Bank of Finland Database (originally various sources)

\* According to surveys by Confederation of Finnish Industry and Employers (TT). The percentage figure is based on difference between percentage share of the answers "greater" and "smaller".



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