IMF WORKING PAPER

WP/95/115

INTERNATIONAL MONETARY FUND

European I Department

Monetary Policy and Inflation Indicators for Finland

Prepared by Martin Mühleisen 1/

Authorized for distribution by Liam Ebrill

November 1995

Abstract

This paper is assessing various leading indicators of inflation in Finland and their practical role in a framework for Finnish monetary policy under a floating exchange rate. Following Friedman (1990) who argued for the explicit inclusion of a broad set of economic indicators in the monetary decision process, absent a practical intermediate target, this paper tests a large number of indicators for their relevance in determining future inflationary pressure and guiding monetary policy. The robustness of the indicators is examined under different models, guided by alternative views of the monetary transmission process. The results indicate that a monetary conditions index, stumpage prices, and real and nominal effective exchange rates are among the strongest indicators, affecting inflation with a lag of between 4 and 11 quarters.

JEL Classification Numbers:

C113, 011, 055

1/ The author would like to thank Burkhard Drees, Liam Ebrill, Juha Kähkönen, Antti Ripatti, and Sunil Sharma for their comments. He is also grateful to Mark Griffiths and İnci Ötker for sharing their experience at an early stage of this project, and to Ilkka Lyytikäinen from the Bank of Finland who kindly provided the data. Research assistance from Sepideh Khazai and David Maxwell is also gratefully acknowledged.

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Summary

Mainly owing to the lack of a stable money demand function, the inflation target adopted by the Bank of Finland is not linked to any intermediate target. Rather, the Bank's policy can be described by what has been termed an "information variable approach." This term is used to define a policy that is guided by a central bank's internal inflation forecasts in the absence of a feasible rules-based policy. The approach has two key elements: (1) it incorporates a broad set of information variables into the policymaking process, reaching beyond the usual indicator set of financial variables and aiming at high-quality inflation forecasts; and (2) it updates the set of information variables by frequently reassessing the forecasting properties of each variable involved.

This paper is intended to provide background to the process of establishing a framework for Finnish monetary policy under an information variable approach. It argues that indicators should be mainly used to augment the information content of traditional inflation models. The evidence obtained from purely statistical tests tends to be unreliable for forecasting, in particular in periods of structural change, and offers little insight into the nature of the inflation process. If, however, indicators were used to increase the forecasting power of standard models, a better understanding of inflationary developments might be gained.

In this study, a large number of indicators are tested for their relevance in determining future inflationary pressure and guiding monetary policy. The robustness of the indicators is examined under different models, guided by alternative views of the monetary transmission process. The results indicate that a monetary conditions index, stumpage prices, and real and nominal effective exchange rates are among the strongest indicators, affecting inflation with a lag of between 4 and 11 quarters.

The results appear to be robust against changes in the underlying economic assumptions. By applying different ranking criteria, based on predicted values for both the immediate past and over the full sample period, the study has tried to address the problem of structural breaks in the data. This problem is particularly relevant for the Finnish economy; in particular, the liberalization of financial markets in the mid-1980s and its consequences pose considerable econometric difficulties. However, it turns out that the strongest indicators are not affected by the choice of the ranking method.

Monetary Policy and Inflation Indicators for Finland

This paper is intended to provide background to the process of establishing a monetary policy framework under a floating exchange rate in Finland. Following Friedman (1990) who argued for the inclusion of a broad set of economic variables in the monetary decision process, absent a practical intermediate target, the study tests indicator variables for their relevance in determining future inflationary pressure. Using the indicator results, recent work on the formulation of inflation models is applied to obtain a set of inflation equations for Finland. The paper shows that a monetary conditions index, the stumpage price index 1/, and real and nominal effective exchange rates are among the strongest indicators, affecting inflation with different lags, ranging from 4 to 11 quarters. Based on this finding, and on the assumption of unchanged policies, this paper forecasts an increase of CPI inflation to an annualized 4 percent by the end of 1996, though this result must be interpreted cautiously.

The paper is divided into four parts. The introduction outlines the current setting of monetary policy in Finland and discusses a strategy for identifying suitable strong indicators within the context of inflation models. Section 2 outlines the econometrics and analyzes the available data. Section 3 discusses the results of the evaluation and gives an inflation outlook for 1995-96; Section 4 concludes.

1. Introduction

a. Current monetary policy in Finland

The current institutional setting for monetary policy in Finland is relatively new. Since September 8, 1992, monetary policy has been conducted under a floating exchange rate system after the Bank of Finland (BoF) was forced to abandon the markka's link to the ECU, following a period of economic contraction and financial instability. Although the markka depreciated strongly immediately after the float, real interest rates remained at high levels and continued to hamper economic growth. Against this background, the BoF committed itself, on February 2, 1993, to stabilize inflation permanently at around 2 percent by 1995 (Åkerholm and Brunila [1994]).

1/ The stumpage price is the price for uncut timber (see below).

By announcing an inflation target, defined in terms of an underlying inflation index 1/, the BoF sought to increase the transparency of its monetary policy, thereby enhancing its credibility and creating room for the lowering of interest rates (Pikkarainen and Tyrväinen [1993]). Although CPI inflation fell from 4.1 percent in 1991 to 1.1 percent in 1994, the initial success of targeting was limited; it was apparently met with wide skepticism, and began only slowly to gain some respect (Åkerholm and Brunila [1994]). 2/ The start of the economic recovery in 1993 was marked by increased inflation expectations and a rise in long-term interest rates. Since then, the latter have fallen below 8 percent in July 1995 and the recovery has gotten well under way. The BoF tightened monetary policy in late 1994 but, after a moderate round of wage negotiations in the fall of 1995, the tender rate was again lowered in October 1995. 3/

b. The information variable approach to monetary policy

Mainly due to the lack of a stable money demand function, the inflation target of the BoF is not linked to any intermediate target. Rather, the Bank's policy can be described by what Friedman (1990, 1993) has termed an "information variable approach". This term is used to define a policy that is guided by a central bank's internal inflation forecasts in the absence of a feasible rules-based policy. The approach has two key elements: (1) it incorporates a broad set of information variables into the policy-making process, reaching beyond the usual indicator set of financial variables and aiming at high-quality inflation forecasts; and (2) it updates the set of information variables by frequently re-assessing the forecasting properties of each variable involved. This approach is advocated in a situation where "conditions that would favor the use of money as an intermediate target do not exist". 4/

The BoF has argued that the Finnish economy is indeed in such a situation. When adopting the inflation target, the bank decided against a

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1/ The indicator of underlying inflation (IUI) is derived from the consumer price index (CPI) by excluding housing prices (depreciation), mortgage payments, and the price effects of indirect taxes and subsidies (Spolander [1994a]). The IUI has been chosen in order to eliminate distortions created by policy measures, both of fiscal and monetary nature (Åkerholm and Brunila [1994]).

2/ In announcing an inflation target, Finland has followed the example of a number of other countries, including Canada, New Zealand, Sweden, and the U.K. (see Lane et al. [1995] for a description). Although some success has been achieved in these countries in bringing down inflation, it is still too early for an evaluation of their experience with an inflation target.

3/ Nevertheless, the Bank is aware that it faces the task of building credibility by establishing a track record that "can only be set by maintaining low inflation throughout [the current] economic upswing" (Åkerholm and Brunila [1994]).

4/ Friedman (1993), p. 128.

single intermediate target because it did not expect a strong relationship between money or credit aggregates and inflation in the future. Three concerns have been cited. First, the banking crisis in the early 1990s created difficulties in interpreting standard money and credit aggregates; second, a large portion of debt has been denominated in foreign currency, leading to balance sheet adjustments in line with exchange rate movements; and third, money velocity had been unstable prior to the time of the decision (Aaltonen et al. [1994]).

With no obvious intermediate target available, the BoF has announced that it follows a number of monetary policy indicators to determine the stance of its monetary policy (Aaltonen et al. [1994]). The indicators comprise money and credit aggregates, in particular M1, short-term interest rates, the structure of interest rates (measured by the yield curve), and exchange rates. Further, the BoF continues to monitor developments in all sectors of the economy, using its macro-econometric BOF4 model to generate forecasts for key variables, including inflation, on a regular basis. However, although the structure of the BOF4 model is publicly known, the Bank has only recently begun to publish inflation forecasts, albeit not on a regular basis. This is in contrast to other countries where details of the framework are known in greater detail (see Schoefisch [1993] for New Zealand and Duguay and Poloz [1994] for Canada).

The adoption of an information variable approach offers several advantages in a situation where an intermediate target cannot be employed. First, indicators can be used to justify policy actions to the public, similar to an intermediate target (Pikkarainen and Ripatti [1995]). Second, variables that have high forecasting power but are not useable as intermediate targets (e.g., expectations-related variables) retain a role in the decision process. Third, erratic movements of an indicator do not necessarily trigger a change in policy because the central bank's actions are no longer bound as if the variable was an intermediate target. Fourth, the new policy is flexible because monetary indicators that are no longer deemed valuable can be replaced by others that might have gained importance. It can thus be easily adjusted to a changing economic environment.

On the other hand, the new policy also poses two key challenges to the central bank. First, the set of monetary policy indicators has to be constantly verified and updated in order to produce reliable inflation forecasts. Second, the central bank's room for discretion makes the information variable approach less transparent--and hence credible--to the public if compared to an intermediate target approach. Unless details of the decision-making process are largely revealed, there is no other way for the public to evaluate the performance of the central bank than by comparing actual and targeted inflation rates. Therefore, owing to the long lags involved in the monetary transmission process, 1/ the public is merely able to judge past rather than current behavior of the central bank. Consequently, it is harder for the bank to maintain credibility than under an intermediate target.

c. Monetary indicators and the inflation process

This paper argues that indicators should be mainly used to augment the information content of traditional inflation models. Attempts have been made to identify inflation indicators by applying purely statistical criteria, such as correlation measures or Granger-causality tests (e.g., Bikker [1988] and Ripatti [1995]). However, the evidence obtained from such tests tends to be rather unreliable for forecasting, in particular in periods of structural change, and offers little insight into the nature of the inflation process (e.g., Woodford [1994]). If, however, indicators were used to increase the forecasting power of standard models, a better understanding of inflationary developments might be gained.

The identification and estimation of an inflation process is of central importance to the conduct of monetary policy under the information variable approach. However, no consensus has yet emerged on how this problem should be addressed empirically. Several suggestions have recently appeared in the literature, recommending different ways of how the traditional notion of a transmission process that works mainly via changes in the money supply could be replaced.

This study will employ three recent approaches that have already been empirically implemented. First, Duguay (1994) has focussed on the role of interest rates and exchange rate movements and their effects on domestic demand and supply. Having established a firm empirical link between real GDP growth and changes in real short-term interest rates and the real effective exchange rate (REER), he has estimated a Phillips curve-type model in which inflation is linked to the output gap, changes in taxation, and import prices. The combined impact of interest and exchange rates on output is measured by a monetary conditions index (MCI) that plays a significant role in the decision making process of the Bank of Canada (Freedman [1994a,b]). 2/ The BoF has also recently conducted studies on the MCI (e.g., Pikkarainen [1993]).

Second, a strand of the literature originating from Hallman et al. (1989, 1991) has employed the quantity equation to derive a long-run equilibrium price level (denoted P^*) that corresponds to potential output

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1/ It is common to find estimates for lags that amount to up to three years. For Finland, the transmission process is reckoned to take 1-2 years (Pikkarainen and Ripatti [1995]).

2/ The MCI will be described in more detail in the next section.

and the long-run equilibrium money velocity. Inflation is modeled as a function of the deviation of the actual price level from P^*, which results in an error-correction mechanism that can be estimated.

Third, Ford and Krueger (1995) have estimated a model for Italy that decomposes price increases into wage and import price components. By estimating separate equations for the two components, they have been able to analyze the impact of foreign export prices, import-price pass-through effects, the output gap, and unit labor costs in a structural manner.

These models provide a good starting point for the analysis of Finnish inflation. However, referring back to Friedman's (1993) notion of a monetary policy that is guided by information variables, they are not exhaustive from an information point of view. All of the approaches employ an error-correction mechanism (ECM) and, in their final specifications, include a variety of variables, ranging from exchange rates to tax indicators. However, since most specifications are derived from partial equilibrium analyses, they exclude variables that seem to bear no causal relationship with inflation but might be useful for forecasting.

It is relatively straightforward to address this shortcoming by including appropriate indicator variables in the respective models. To this end, the models will first be estimated in a standard way and, secondly, be augmented with a set of economic variables that are not necessarily related to the models on theoretical grounds. Since the addition of a good indicator will lead to a significant improvement of the forecast quality of a model, the variables can easily be ranked according to their relative contribution to inflation forecasts. 1/ Moreover, the use of more than one model for the transmission process makes it possible to check the ranking of the variables for robustness under different model assumptions.

2. Methodology and data

a. The econometric strategy

The identification of strong indicators is based on different models of the inflation process. These models' inflation equations are first estimated in a standard ("basic") form before being separately augmented by a number of indicator variables and subjected to a series of forecast ranking tests. Finally, the most successful indicators are jointly added to each basic equation to yield a preferred inflation equation that can be used for forecasting.

1/ A similar method was applied by McCallum (1990) for growth indicators, and Evans et al. (1992).

Three models have been used to derive basic equations. 1/ First, in order to set a benchmark, a P^* model has been estimated that includes all variables in first differences, irrespective of their order of integration. Velocity and output gaps are computed with a Hodrick-Prescott filter. Second, in order to pursue a more traditional approach, a standard VAR model has been derived from the quantity equation. Third, following Ford and Krueger (1995), inflation was modelled in the real sector, with import prices and wages as components of an inflation equation. This approach, denoted the wage-inflation model, yields an equation for CPI inflation whereas the first two models require modeling the GDP deflator (both series are depicted in Chart 1). Details of the econometric specification are discussed in Appendix I.

In the following, a sequence of steps is repeated for each of the three basic equations (see also Appendix II for a more detailed description):

- First, a set of indicator candidates is created, consisting of macro variables thought to be relevant for the determination of the price level but not contained in the model. Each of the variables in this set is used individually in turn, with a large number of lags, to augment the basic equation. For each indicator candidate, the Schwarz model selection criterion is applied to determine the lag structure that yields the best fit to the data.

- Second, having obtained one equation for each indicator candidate, two sets of forecasts are generated: (1) dynamic within-sample forecasts for 1993-94; and (2) one-step forecasts from rolling regressions over the whole sample period. The indicator candidates are then ranked according to the performance of their inflation forecasts. The accuracy of the forecasts is measured by the root mean squared error (RSME) criterion and by encompassing tests (Chong and Hendry [1986]).

- Third, the basic equation is combined with the most successful indicators to arrive at a preferred equation. This equation is used to analyze the inflation process in the recent past and to forecast inflation for 1995-96.

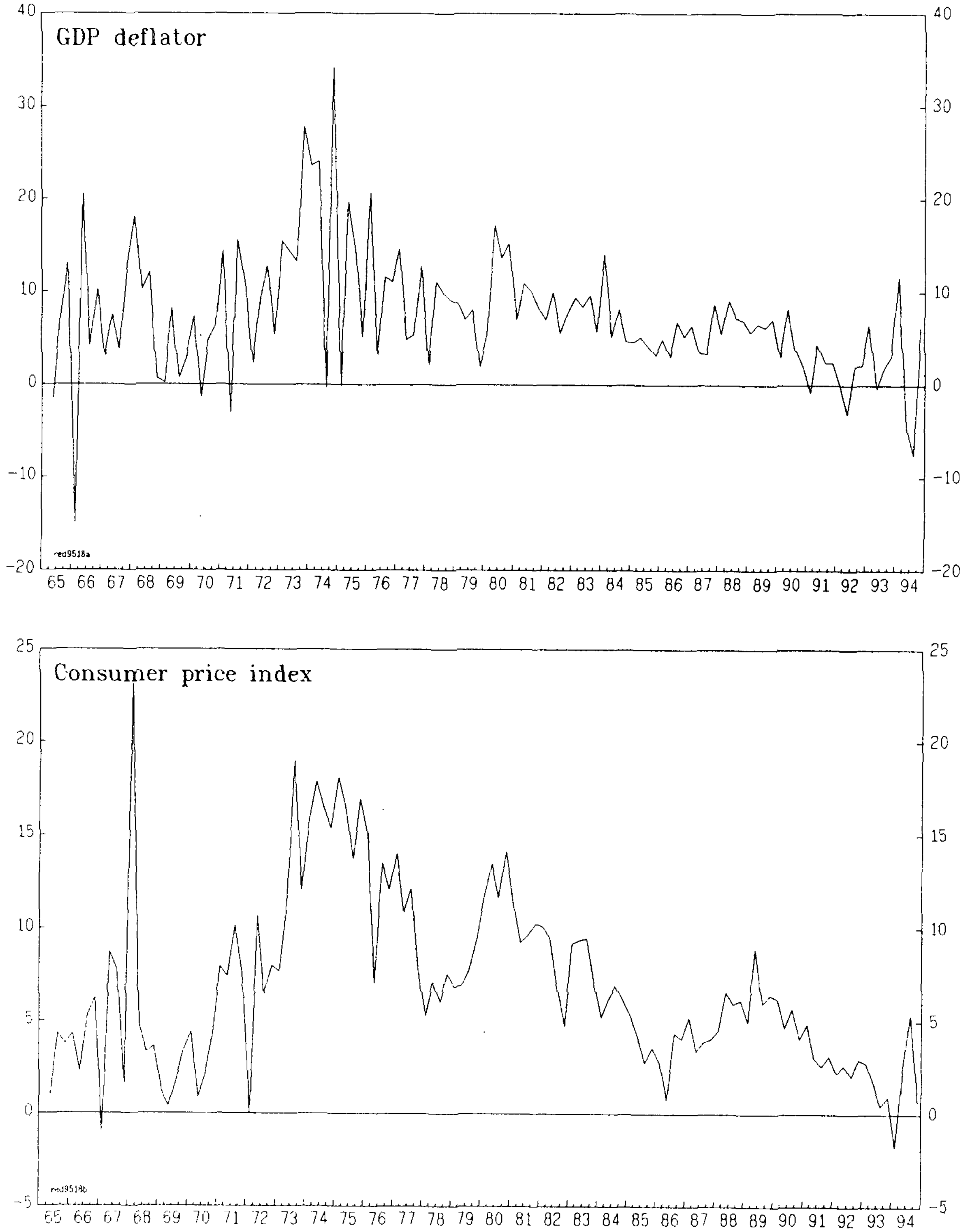
This approach takes account of two practical considerations. First, by incorporating the strongest indicators, the preferred equations address the problem faced by central banks of how to combine possibly conflicting signals from various sources. The regression coefficients provide a system of weights for the indicators that is superior to implicitly constructing weights by, e.g., averaging over indicators.

1/ Depending on the assumed order of integration, the equations are estimated in the first or second difference of the price level.

CHART 1

GDP DEFLATOR AND CPI INFLATION RATES, 1965-94 1/

(In percent)



Source: Bank of Finland.

1/ Series are on an annualized basis.

Second, Schoefisch (1993) and Duguay (1994) have reported that in the respective cases of New Zealand and Canada the central banks' multi-sectoral models failed to produce inflation forecasts that were as accurate as the ones produced by the small models of the authors. It remains to be seen, however, whether this also applies to the BOF4 model (BoF [1990]).

b. Data and frequency

The construction of a data set for this paper required a decision with respect to the frequency of the employed variables. 1/ Since the implementation of monetary policy requires a timely analysis of inflationary trends, inflation indicators necessarily have to be updated on a daily, monthly or, at least, quarterly basis. Therefore, an evaluation of the performance of inflation indicators should also be based on high frequency data, matching the decision process of the central bank. However, a number of reasons favor the decision to use a quarterly data set.

The BoF's monthly data set begins in the early 1980s, providing some 10-15 years of information, depending on the variables required. Whereas this turns out to be sufficient for studies that do not involve long lags, it appears too short for an evaluation of monetary indicators for two reasons. First, due to the delayed effect of monetary policy on inflation, some three years of data are needed for the construction of lagged variable. This leaves the monthly data set with information covering only 7-12 years. In contrast, most of the series in the quarterly data set reach back into the 1960s or early 1970s. 2/

Second, the early years covered by the monthly data set coincide with a number of significant changes in the Finnish economy. A series of liberalizations that started in the mid-1980s, the Nordic banking crisis, and the eventual floating of the markka in 1992 have transformed both the financial sector and the environment within which monetary policy is being conducted. Consequently, it becomes difficult to judge from the monthly data set whether any estimated relationship is stable enough to serve as a basis for inflation forecasts. On the other hand, the quarterly data includes a period of relative stability during the 1970s and allows tests for structural breaks in the forecasts.

In addition, technical considerations also favor a quarterly approach. Given the highly dynamic nature of monetary relationships, it is necessary to determine the statistical order of integration of the involved series. However, testing for integration is more difficult when the data are subject to seasonal fluctuations (Hylleberg et al. [1990]); and the recent discussion suggests that a solution to this problem has not yet been found (Harvey and Scott [1994]). Quarterly data appear to be less prone to the

1/ The variables contained in the data set are described in Appendix III.
2/ However, for some variables, the quarterly frequency prior to 1975 is artificial because the seasonal figure has been imposed at a later stage.

problem of misidentifying the order of integration. Moreover, from a modeling point of view, the inclusion of up to 36 monthly lags causes problems in separating seasonal and trend components. These problems are most easily solved by aggregating (e.g., calculating average inflation over previous periods) which is already implicitly done in quarterly models.

On the other hand, the use of monthly data has advantages, too. Since today's central financial variables (like the Helibor interest rates) have only been introduced during the liberalizations in the financial sector, interest rates became fully market-determined for the first time in Finland during the mid-1980s. Therefore, interest rates contained in the quarterly data set are no longer as relevant today as in the past, and they were also determined by fiat for a very long time. Consequently, one could argue that data from the 1960s and 1970s should not be used for forecasting future inflation. If the data were to be limited to the years from 1985 onwards, however, the quarterly data set would become to small, and only the monthly data set would provide a technically sufficient number of observations. Therefore, monthly information should be used to verify results obtained with quarterly data. 1/

c. Integration tests

An overview of the augmented Dickey-Fuller (ADF) tests for variable integration is contained in Table 1. The tests use quarterly data up to the end of 1994, with the starting period varying between 1964 and 1978, depending on data availability. The procedure is mainly based on Perron (1988) who suggested to determine the appropriate lag order by consecutively reducing the number of lags until the coefficient of the longest lag becomes significant. To check the results, the lag order was also determined by the Schwarz model selection criterion. Where applicable, different results of the second procedure have been noted.

The results clearly distinguish, except for import-related variables, between nominal and real series. In the event, all domestic nominal series (GDP, money supply, prices, and wages) are integrated of order two, that is, only the difference of their growth rates is stationary. If the series are reduced to their real values, however, they are found to be integrated of order one. Surprisingly, import-related prices (denominated in Finnish markka) are integrated of order one, which seems to be linked to the stationarity of the nominal effective exchange rate (NEER). This finding contradicts the generally held view that, because import prices constitute an important determinant of the domestic price level, they should also be related to it in the long-term. However, since the results are consistent for all import price series, they have been retained for most of the further analysis. On the other hand, the power of ADF tests is relatively weak, and the analysis should not be subject to purely technical considerations;

1/ See, e.g, Ripatti (1994, 1995) for recent studies with monthly data.

Table 1. Results of Integration Tests

Stationary Variables (Order of Integration 0)	Difference-Stationary Variables (Order of Integration 1)	Variables Stationary in 2nd Difference (Order of Integration 2)
	Dwelling price index	CPI
	Import price index	GDP deflator
	Export price index	Producer price index 1/
	Foreign export price index	Stumpage price index 1/
	HWWA raw materials price index	Raw materials import price index 1/
	Fuel import price index	
	Real GDP	GDP
	Industrial production index	
	Manufacturing output	
Output gap	Capacity utilization	
	Capacity utilization (manufacturing)	
	Wholesale sales index	
	Real wage index	Wage index
Labor Productivity	Social security contributions	Unit labor costs 1/
Vacancy Rate 1/	Unemployment rate	
NEER 1/	REER	
	Terms of trade	
Real M1	Real M2, Real M3	M1, M2 1/, M3 1/
	M1 Velocity	M3 Velocity 1/
	M2 Velocity	
	Monetary Conditions Index	
Market yield on debentures 1/	Bank lending rate	Money market rate 1/
Bond yield index 1/	Market yield on tax-free bonds	Money market yield index
	Interest rate spread 2/	Bank lending
Central government fiscal balance		

Source: Staff calculations (see Appendix III for a description of the variables).
1/ ADF-Tests using Schwarz criterion suggest order of integration 1.
2/ ADF-Tests using Schwarz criterion suggest order of integration 2.

therefore, this study will also take account of the possibility that the order of integration of some variables has not been properly identified.

d. Indicator candidates

In searching for suitable indicators, this study draws on earlier work by Griffiths (1994) who investigated the directions of Granger-causality between inflation and a large number of Finnish time series. The variables he identified as being potentially useful for forecasting inflation have been kept for this study:

- Industrial production
- Capacity utilization
- Unemployment
- M3
- Import prices
- Manufacturing output
- Wholesale sales
- Vacancies
- House prices
- Raw material prices

In addition, Griffiths (1994) also constructed a monetary conditions index (MCI) that measures the impact of monetary policy on the output gap by weighing nominal exchange rate and interest rate developments. In order to compute the MCI, Griffiths followed Duguay (1994) by running regressions for the output gap on the bank lending rate (BLR), terms of trade, and NEER, using quarterly data from 1975-93. In his analysis, an increase of 1 percent in the bank lending rate had an effect on the output gap that was some 5.5 times larger than a 1 percent change in the exchange rate. 1/ Using this relation, the MCI is defined as:

$$MCI = (BLR - BLR_{88:1}) + (NEER - NEER_{88:1}) / 5.5$$

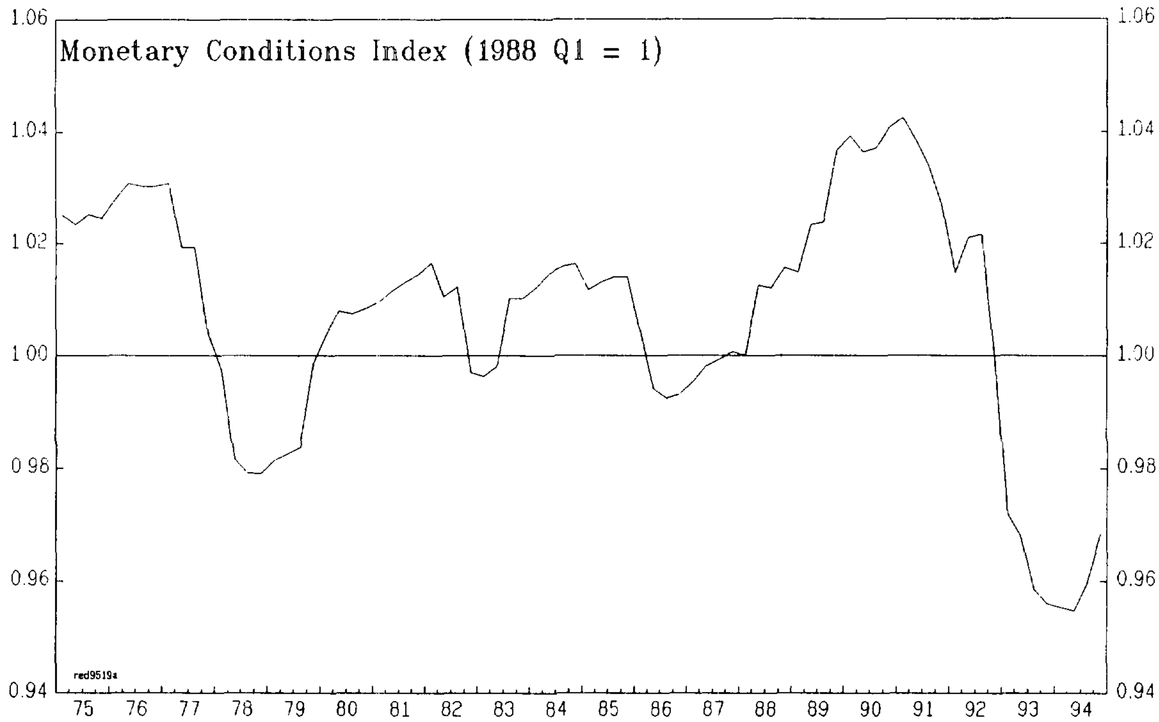
with the quarter 1988:1 serving as base period. The MCI (in logarithms) and its components are depicted in Chart 2. An increase in the MCI indicates a tightening in monetary conditions, consistent with an exchange rate appreciation or an increase in bank lending rates.

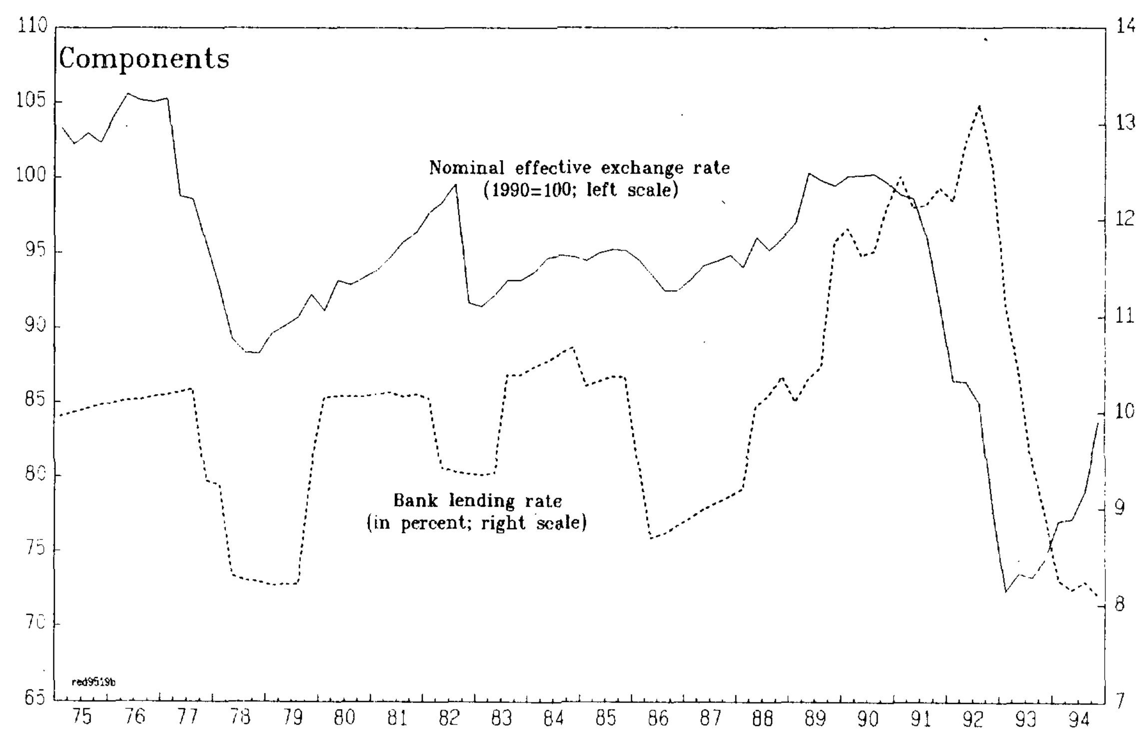
In addition, stumpage prices are a particularly important variable for Finnish inflation, caused by the strong role of the wood and paper and pulp sectors in Finland (Chart 3). Stumpage prices are an asset price as well as a cost indicator for the wood industry. Increases in stumpage prices, indicating growing production in the wood industry, quickly translate into higher income for the large number of Finnish forest owners as well as higher wage demands in the forest sector. As a result of strong wage-wage links, stumpage prices have in the past been closely related to economy-wide earnings (Spolander [1994b]). Ripatti (1995) offers some evidence that they are also related to the inflation rate.

1/ The trade-off of this relation is within the 3 1/2 - 11 range of estimates by Pikkarainen (1993).

CHART 2

THE MONETARY CONDITIONS INDEX AND ITS COMPONENTS, 1975-94

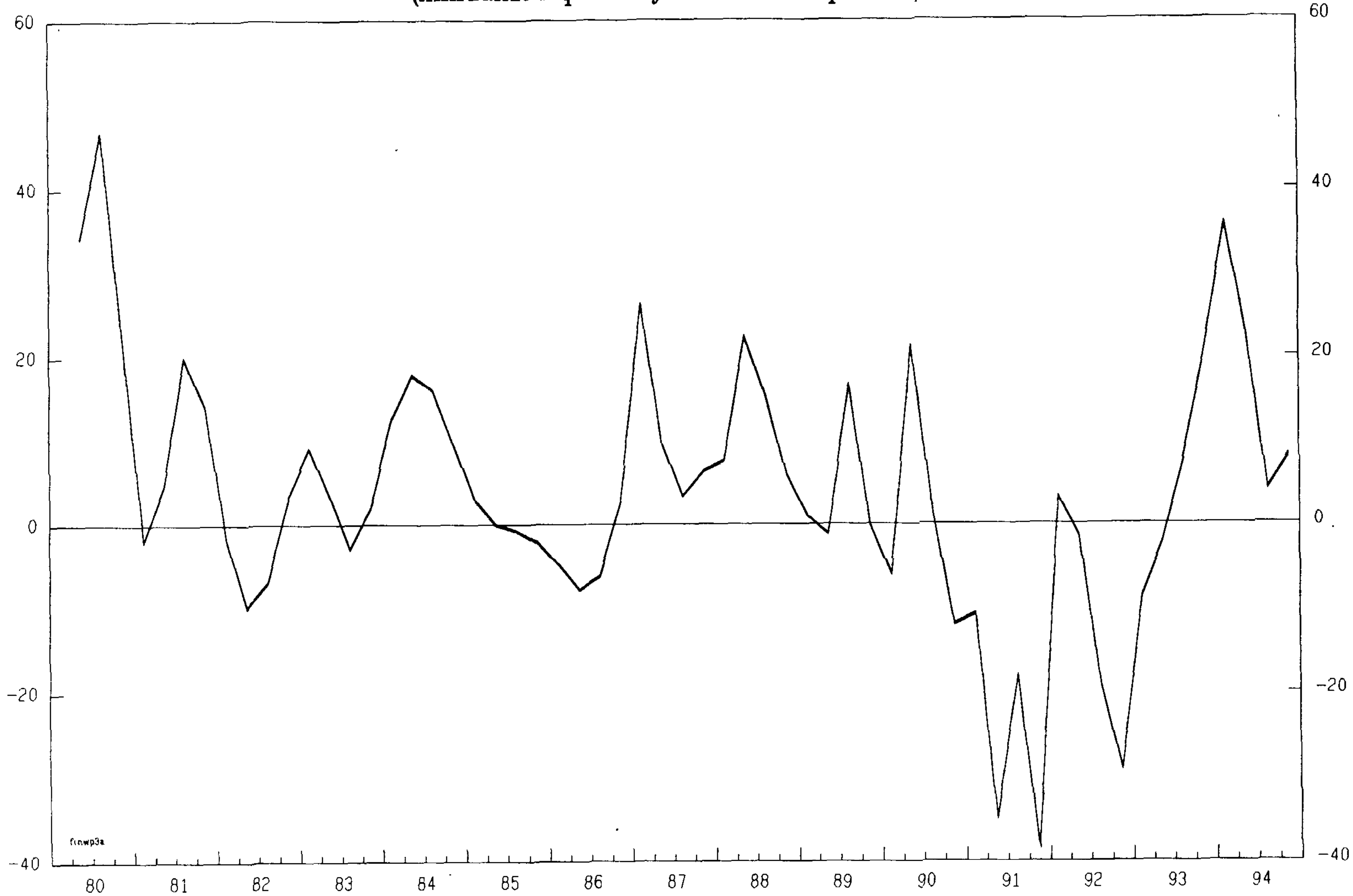




Sources: Bank of Finland; and staff calculations.

CHART 3

STUMPAGE PRICE INDEX, 1980-94
(Annualized quarterly increases in percent)



Source: Bank of Finland.

Furthermore, this study enlarges the search by including additional variables that are frequently used in the discussion of inflationary pressures. These comprise both nominal and real effective exchange rates, producer prices and unit labor costs, as well as a number of interest rates and their spread.

3. Results of the indicator evaluation

This section discusses the results of the indicator selection process for each of the basic models. First, the rankings obtained from the individual forecast contributions are presented. After having identified the best-performing indicators, the results from the preferred equations are summarized, followed by a discussion of the robustness of the findings. The section concludes with an inflation forecast for the years 1995-96.

a. Indicator tests

The best performing indicators and the applied ranking criteria are depicted in Tables 2-4 (see box below for how to interpret the tables). Four main observations can be made:

- Most of the strongest indicators are linked to the exchange rate and to monetary policy. There are only three indicators that are in the top group across all models, namely the nominal effective exchange rate (NEER), the stumpage price index, and the monetary conditions index (MCI). They are followed by a range of import-related indices, such as the import price index and the foreign export price index. Interest rates are less important on their own (only the bank lending rate appears in the VAR model), but they are of course related to the MCI.

- The full pass-through of exchange rate and monetary policy changes appears to take some 6-12 quarters. The MCI has a strong impact with a lag of 6 and 10 quarters; the NEER acts with a lag of between 4 and 12 quarters. The effect of import price changes is less clearly determined, but it appears that changes in foreign export prices are not immediately fed

Table 2. Indicator Performance for the P* Model

Δ	Indicator	Lags	RMSE * 1000 Dyn.	RMSE * 1000 Rec.	Encompassing Sup.	Encompassing Ind.	Encompassing Inf.	Rank
..	(Basic Model)	..	16.98	9.98	2	8	16	21
Δ	Industrial Production	5	17.37	9.61	7	5	14	16
..	Output gap	..	..	..	..	..	..	..
Δ	Capacity Utilization	5	17.28	10.00	2	8	16	22
Δ	Producer Price Index	2,8	16.83	9.23	10	5	11	12
Δ	Stumpage price index	4,5,9,10	14.25	5.64	25	1	--	1
Δ	Unit labor costs	2	15.75	7.60	14	7	5	8
Δ	Nominal effective exchange rate (ULC)	6,12	13.82	7.24	16	7	3	6
Δ	Real effective exchange rate (ULC)	6,10	15.32	7.72	14	7	5	7
Δ	Export price index	3,8	16.65	9.51	8	7	11	14
Δ	Import Price Index	8	17.58	9.86	4	8	14	17
Δ	Foreign export price index	9	15.50	7.35	18	5	3	4
Δ	Raw materials import price index	9,10	17.10	9.84	4	7	15	18
Δ	HWWA index (raw materials excl. energy)	11	15.87	8.19	9	7	10	13
Δ	Fuels and lubricants import price index	2	17.22	9.86	3	9	14	19
Δ	Terms of trade	6	16.33	10.19	2	4	20	23
Δ	M1	5,9	17.49	9.03	12	13	1	11
..	M3	..	..	..	..	..	..	..
Δ	Bank lending	5,8,12	14.33	6.68	20	5	1	3
Δ	Money market rate	3	16.83	10.28	2	9	15	20
Δ	Bank lending rate	3,4	17.57	9.63	7	12	7	15
Δ	Market yield on debentures	8	14.83	10.46	--	2	24	26
Δ	Interest rate spread	9,10	16.82	8.46	13	4	9	10
Δ	Bond yield index	8	15.43	10.07	1	5	20	24
Δ	Money market yield index	10,12	16.51	7.19	17	5	4	5
Δ	Monetary conditions index (MCI)	6	13.04	7.45	14	7	5	9
Δ	Central government fiscal balance	1,2,3,9	17.20	8.24	21	4	1	2
..	(Preferred model)	..	10.93	6.57	--	25	1	25

Source: Staff calculations.

NOTE: RMSE is the Root Mean Square Error, reported for both dynamic and recursive forecasts. A "Δ" in the first column indicates that the series has been used in first difference. A lag "i" indicates that the quarterly variable x_{t-i} has been contained in the equation. The "Sup" column counts the number of other indicators that are encompassed by an indicator, "Ind" counts the number of draws, and "Inf" counts the number of other indicators that encompass the indicator. The rank within the indicator set has been obtained by sorting all indicators by "Sup" and "Ind". A lower number indicates a higher rank (see text box for details).

Table 3. Indicator Performance for the VAR Model

Δ	Indicator	Lags	RMSE * 1000 Dyn.	Rec.	Encompassing Sup.	Ind.	Inf.	Rank
..	(Basic Model)	..	18.23	7.08	1	10	15	24
Δ	Industrial Production	5	17.35	6.84	2	14	10	16
--	Output gap	10	17.84	6.83	2	14	10	17
Δ	Capacity Utilization	9	18.10	6.75	5	12	9	12
Δ^2	Producer Price Index	12	17.72	6.94	2	13	11	20
Δ^2	Stumpage price index	2,5	19.62	5.63	21	5	--	2
Δ^2	Unit labor costs	10	18.33	6.92	2	13	11	19
--	Nominal effective exchange rate (ULC)	4,6,7	14.30	6.30	10	9	7	11
Δ	Real effective exchange rate (ULC)	5,6,10,12	16.72	6.48	17	7	2	6
Δ	Export price index	6,7,9	18.55	6.88	4	11	11	14
Δ	Import Price Index	5,6	16.78	6.17	19	5	2	3
Δ	Foreign export price index	11	18.94	6.96	1	16	9	21
Δ	Raw materials import price index	5	17.78	6.91	3	13	10	15
Δ	HWWA index (raw materials excl. energy)	10	18.21	7.27	--	1	25	26
Δ	Fuels and lubricants import price index	1,5,6	17.47	6.45	12	13	1	10
Δ	Terms of trade	4,6,12	16.61	6.28	18	8	--	4
Δ^2	M1	9,10,12	14.80	6.30	17	8	1	5
..	M3	..	..	..	..	..	..	..
Δ^2	Bank lending	8	18.16	6.82	14	4	8	9
Δ^2	Money market rate	9,10	22.65	7.09	1	5	20	25
Δ	Bank lending rate	2,12	15.26	6.51	17	6	3	7
..	Market yield on debentures	..	..	..	..	..	..	..
Δ	Interest rate spread	3	17.68	7.03	1	12	13	23
--	Bond yield index	6	18.44	6.88	2	13	11	18
Δ^2	Money market yield index	2	18.76	6.83	4	12	10	13
Δ	Monetary conditions index (MCI)	6	16.10	6.94	1	13	12	22
--	Central government fiscal balance	4,8,9,11,12	18.88	6.29	16	7	3	8
..	(Preferred model)	..	13.84	5.61	22	4	--	1

Source: Staff calculations.

NOTE: RMSE is the Root Mean Square Error, reported for both dynamic and recursive forecasts. A "Δ" or "Δ^2" in the first column indicates that the series has been used in first or second difference, respectively. A lag "i" indicates that the quarterly variable x_{t-i} has been contained in the equation. The "Sup" column counts the number of other indicators that are encompassed by an indicator, "Ind" counts the number of draws, and "Inf" counts the number of other indicators that encompass the indicator. The rank within the indicator set has been obtained by sorting all indicators by "Sup" and "Ind". A lower number indicates a higher rank (see text box for details).

Table 4. Indicator Performance for the Wage-Inflation Model

Δ	Indicator	Lags	RMSE * 1000		Encompassing			
			Dyn.	Rec.	Sup.	Ind.	Inf.	Rank
..	(Basic Model)	..	6.85	6.37	1	6	20	26
Δ	Industrial production	4,10,12	7.39	4.60	7	6	14	17
--	Output gap	4	6.68	6.61	--	3	24	27
Δ	Capacity utilization	9	6.61	6.38	1	6	20	25
Δ^2	Producer price index	5	6.86	6.23	3	3	21	23
Δ^2	Stumpage price index	8	5.66	3.57	24	2	1	2
Δ^2	Unit labor costs	1,3,7	7.33	5.68	3	10	14	20
--	Nominal effective exchange rate (ULC)	6,7	6.18	3.84	19	5	3	6
Δ	Real effective exchange rate (ULC)	10	6.54	3.90	19	3	5	7
Δ	Export price index	1,2	7.98	5.61	7	10	10	16
..	Import price index	..	..	..	..	..	..	..
Δ	Foreign export price index	5,11	6.18	3.62	24	1	2	3
Δ	Raw materials import price index	1,12	5.57	5.79	6	7	14	18
Δ	HWWA index (raw materials excl. energy)	1,5,6	7.08	4.19	15	5	7	9
Δ	Fuels and lubricants import price index	1,8	6.90	6.01	4	5	18	19
Δ	Terms of trade	2,5	7.25	6.11	1	10	16	24
Δ^2	M_1	12	6.19	5.35	10	6	11	15
Δ^2	M_3	4	6.90	4.97	11	4	12	12
Δ^2	Bank lending	9,10	6.31	3.70	21	3	3	5
Δ^2	Money market rate	12	6.69	5.01	12	7	8	11
Δ	Bank lending rate	6	6.58	6.06	3	6	18	22
--	Market yield on debentures	4,5	6.62	4.63	3	10	14	21
Δ	Interest rate spread	6	6.69	4.44	11	3	13	13
--	Bond yield index	4,5	6.53	4.42	10	7	10	14
Δ^2	Money market yield index	5	6.65	4.21	14	5	8	10
Δ	Monetary conditions index (MCI)	6,10	5.57	3.70	21	4	2	4
--	Central government fiscal balance	11	6.80	3.92	18	3	6	8
..	(Preferred model)	..	4.61	3.16	26	1	--	1

Source: Staff calculations.

NOTE: RMSE is the Root Mean Square Error, reported for both dynamic and recursive forecasts. A "Δ" or "Δ^2" in the first column indicates that the series has been used in first or second difference, respectively. A lag "i" indicates that the quarterly variable x_{t-i} has been contained in the equation. The "Sup" column counts the number of other indicators that are encompassed by an indicator, "Ind" counts the number of draws, and "Inf" counts the number of other indicators that encompass the indicator. The rank within the indicator set has been obtained by sorting all indicators by "Sup" and "Ind". A lower number indicates a higher rank (see text box for details).

How to read the result tables?

This box explains the contents of Tables 2-4, using the P^* model as an example (Table 2).

- The root mean squared errors (RMSEs) of the basic model are listed in the first row, both for the dynamic forecasts covering the period 1993:1 to 1994:4, and for the recursive one-step forecasts based on the whole sample period. The RMSEs of the dynamic forecasts are larger because the forecasts cover eight quarters rather than one, and use forecasts of the endogenous variable for later periods.

- The remaining columns show the outcome of the encompassing tests, noting the number of other indicators that are encompassed ("Sup."), the number of indecisive tests ("Ind."), and the number of indicators that encompass the model ("Inf."). The rank indicates the position among all indicator candidates, such that the lower the rank number, the more other indicators are encompassed.

- It is noted whether an indicator was differenced to achieve stationarity, and which lags turned out significant. For example, industrial production was tested in first difference, affecting inflation most strongly with a delay of 5 quarters. In the last row, the preferred equation is also listed.

- In order to simplify the interpretation of the tables, Chart 4 contains a cross-plot of the RMSEs from both dynamic and recursive forecasts, showing all indicator candidates that were tested. In the lower left corner of the graph, the preferred equation is clearly singled out as the best performer, indicating that a combination of indicators is more powerful than a single indicator alone.

through into import prices. 1/ Foreign export prices are generally found to act with an 11 quarter lag, whereas the delay for Finnish import price changes is only around 5 quarters.

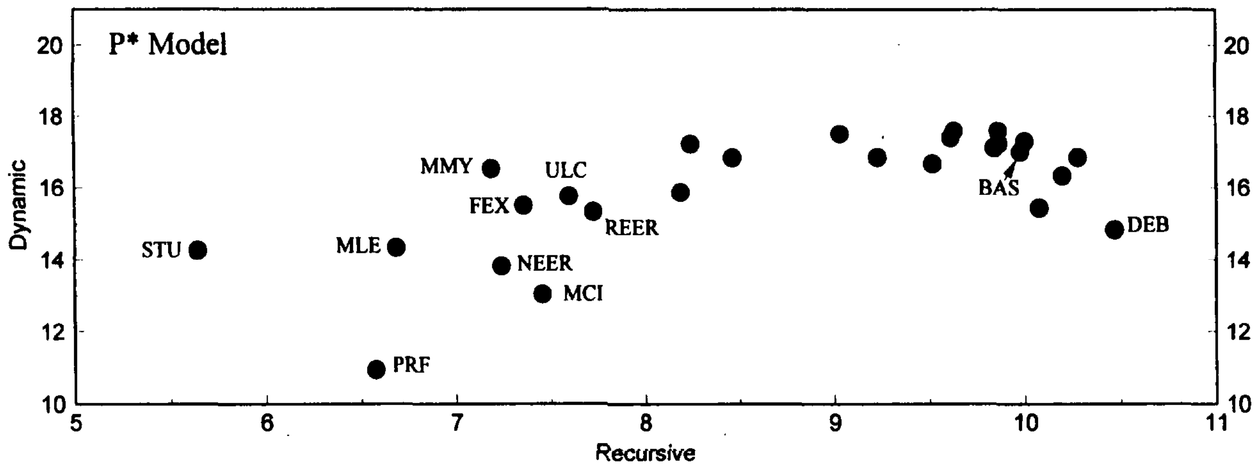
- Most indicators from the real sector, i.e., GDP growth, productivity, and variables measuring capacity, perform poorly and are not in the top group in any of the models. However, this does not come completely as a surprise because either GDP or productivity is already included in the basic models. Therefore, one could indeed expect that, as indicators, they do not add much new information to the basic equations.

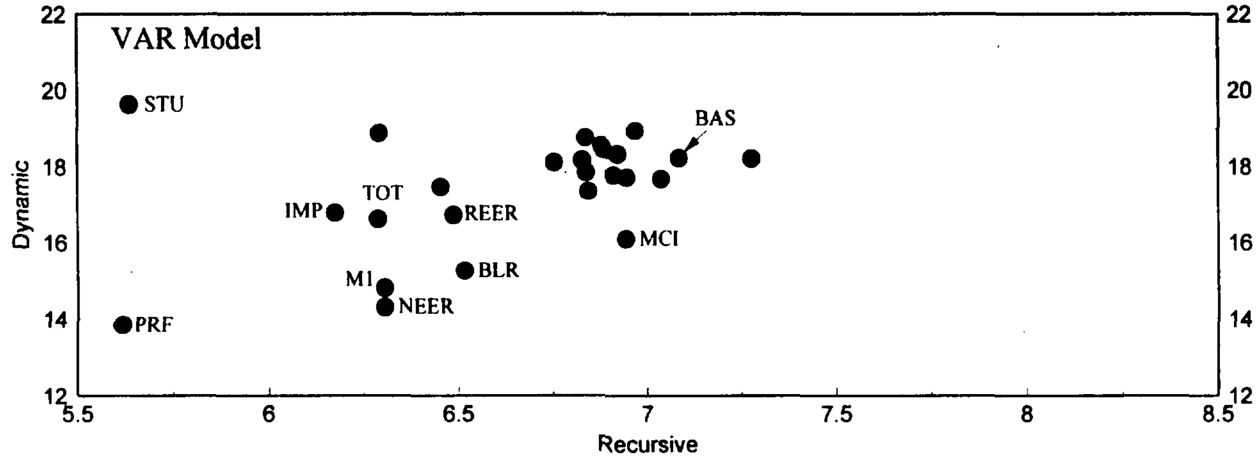
- In Chart 3, the RMSEs do not lie close to a diagonal line as would ideally be the case. Whereas some indicators are in the top group for both types of forecasts, other indicators perform well only in one type of forecast. Stumpage prices, for example, perform extremely well in the recursive forecasts but not in the VAR model's dynamic forecast. The MCI, on the other hand, does much better in dynamic forecasts but rarely encompasses other indicators. This varying performance is an indication for structural change.

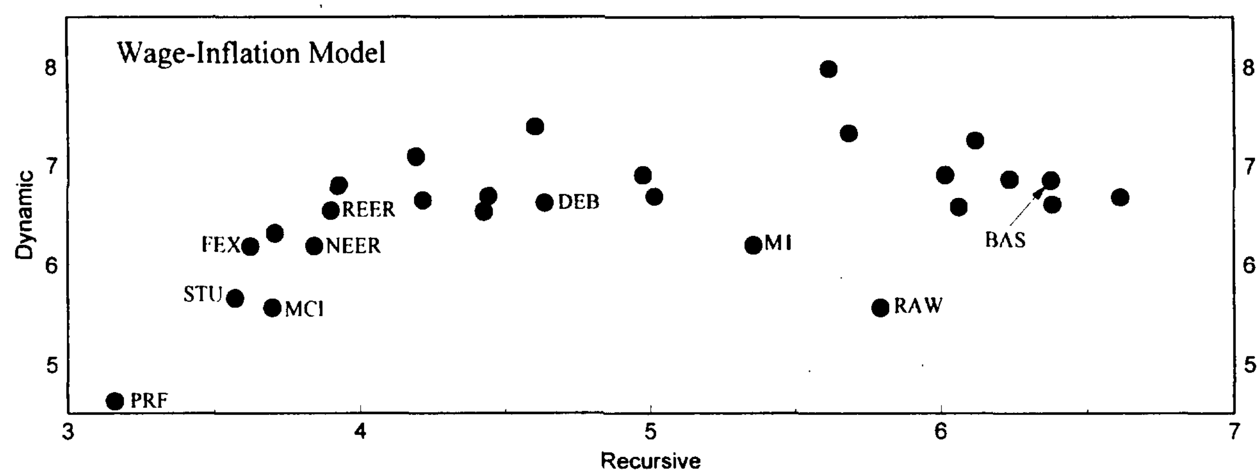
1/ Good indicators should also be identifiable by a consistent lag structure across models. The stronger the impact of an indicator, the more reliable becomes the determination of its strongest lags.

CHART 4

ROOT MEAN SQUARED ERRORS -- DYNAMIC VS. RECURSIVE FORECASTS
(In 1/1000 of percentage points)







Source: Staff calculations.

Note: BAS = basic equation;
BLR = bank lending rate;
DEB = market yield on debentures;
FEX = foreign export price index;
IMP = import price index;
MLE = bank markka lending;
MMY = money market yield index;
PRF = preferred equation;
RAW = raw materials import price index;
STU = stumpage price index;
TOT = terms of trade;
ULC = unit labor costs.

Summing up, it was shown that exchange rate and monetary policy changes have the strongest forecast performance within a large set of possible indicator candidates. They lead to the smallest forecast errors, the estimated lags are broadly similar across different specifications, and they encompass most other indicators. The results point to a structural change in the economy because dynamic forecasts--which cover a more recent period--would generally recommend a different set of indicators than recursive forecasts. However, even if some indicators may no longer be relevant, there are other indicators (the MCI and the nominal exchange rate) that have performed well both in the recent past and over the long run. This gives hope that these rather robust indicators might also live through any possibly ongoing and future structural changes.

b. The preferred equations

For each basic model, a preferred equation has been found by adding the most important indicators to the basic equation at once, and subsequently eliminating the insignificant lags. A summary of the resulting regressions is contained in Table 5. Further, Chart 5 compares actual inflation with dynamic simulations. Chart 6 shows Chow-tests that identify breaks in the one-step forecasts. Finally, Chart 7 contains within-sample forecasts for inflation in 1993-94.

Among the three models, the P^* equation gives the least satisfactory results. Judging from the diagnostic statistics, the fit of the regression is reasonably good, but some coefficients have a sign that is hard to interpret from an economic point of view. First, the output gap enters with a negative sign, implying lower inflation in boom times. Second, the real effective exchange rate (REER) enters positively, apparently leading to higher inflation if the exchange rate appreciates; and third, the MCI also has a positive sign, thereby indicating that tighter monetary policy would lead to higher inflation rates. On the other hand, the velocity gap and changes in M1 turn out to have the expected signs, whereas increases in labor productivity appear to have an upward impact in the long run. 1/

Some more general findings also point out the weakness of the P^* model. Although one should take care when comparing models estimated over different time periods, the strong improvement of the model diagnostics from the basic to the preferred model indicates that the basic model itself constitutes a very weak starting point. This might be caused by the approximation used in measuring the output and velocity gaps, but also by the fact that the integration properties of the time series are not taken account of. Furthermore, the dynamic forecast also performs rather poorly, anticipating

---

1/ It turned out that, despite the good test performance, stumpage prices added little explanatory power to all of the preferred equations. Moreover, their inclusion would have caused a severe shortening of the estimation period because they have only been available since 1980. They were therefore not included in the final specifications.

Table 5. Estimation Results for the Preferred Equations

	Lag	P* Model Δ(GDP Deflator)		VAR Model Δ^2(GDP Deflator)		Wage Inflation Δ^2(CPI)	
Dependent variable	1	0.1060	(1.07)	-0.7632	(7.29)	-0.2289	(2.17)
Dependent variable	2	0.5068	(5.23)	-0.5260	(4.15)		
Dependent variable	3			-0.4883	(3.64)		
Dependent variable	4			-0.2479	(2.29)		
Dependent variable	6			-0.1672	(2.50)		
Output gap (y - y*)	3	-0.1088	(2.53)				
Δ Labor productivity	6	0.2598	(3.63)				
Δ Labor productivity	7	0.1777	(2.65)				
Δ Labor productivity	12	-0.1379	(2.17)				
Δ REER	6	0.0743	(3.15)				
Δ NEER	4			-0.0862	(3.33)		
Δ NEER	6			0.2163	(3.85)		
Δ NEER	7			-0.1303	(2.97)		
Δ Foreign export prices	11					0.0260	(2.26)
Δ^2 Raw mat. import prices	1					0.0206	(2.70)
Δ HWWA index	10			-0.0441	(2.42)	-0.0180	(1.99)
Δ M1	5	0.1302	(3.62)				
Velocity gap (v* - v)	1	0.0919	(2.09)				
Δ MCI	6	0.3372	(1.95)			-0.1476	(2.29)
Δ MCI	10					-0.2178	(2.74)
EI	3			-0.3541	(2.37)		
EI	8			-0.4360	(2.54)		
CI_p	1					-0.4719	(2.00)
CI_w	1					-0.3662	(2.11)
Estimation period		76:4 - 94:4		76:4 - 94:4		78:1 - 94:4	
N 1/		73		73		68	
R^2		0.8608		0.6505		0.4135	
Correlation Actual-Fitted		0.7776		0.8065		0.6415	
Autoregressive errors test 2/		0.4486 [.81]		1.3891 [.24]		1.6038 [.18]	
Normality test		3.5986 [.17]		4.8297 [.09]		0.6652 [.72]	
ARCH test		0.4707 [.76]		0.6060 [.66]		0.7631 [.55]	

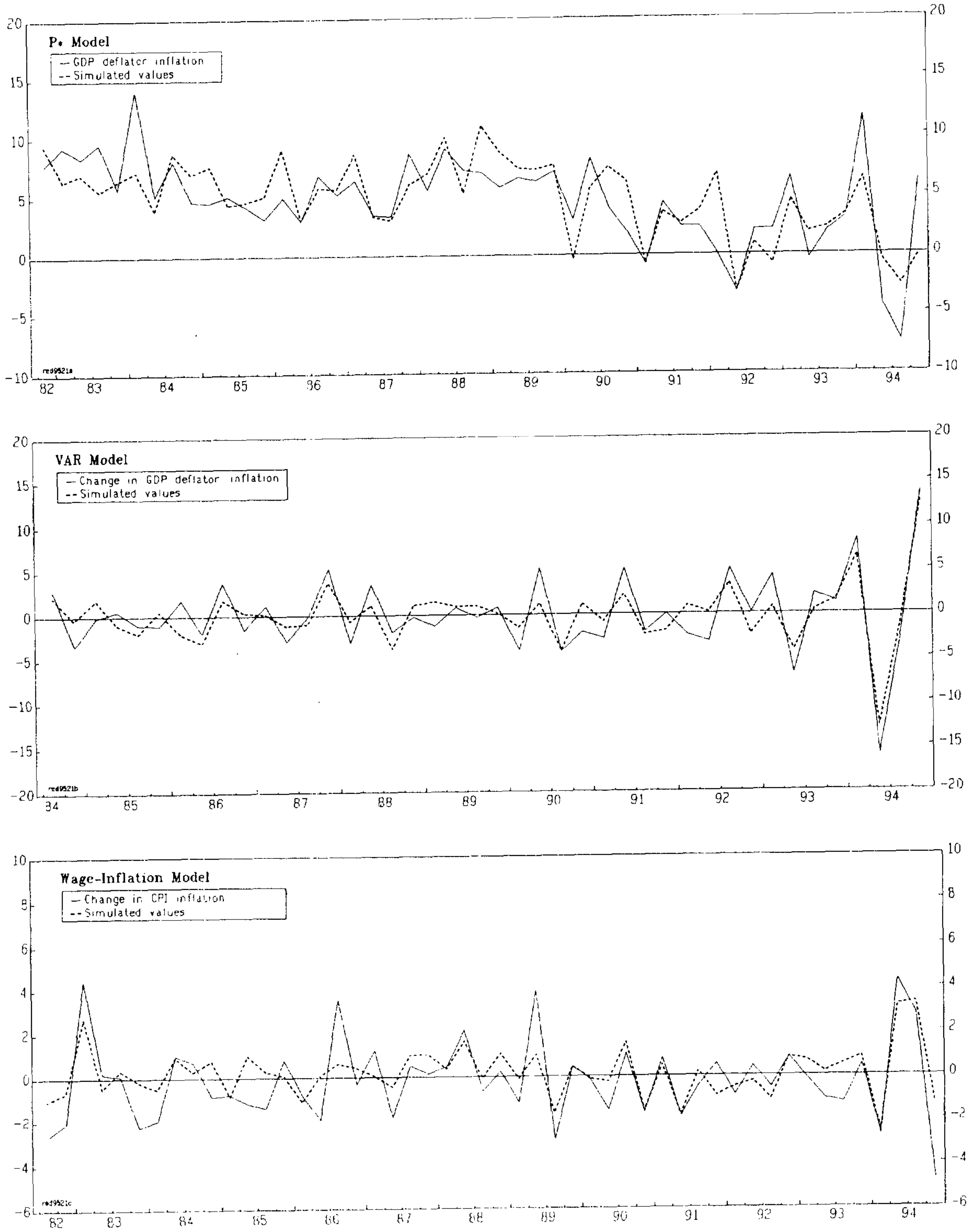
Source: Staff calculations.

1/ N is the number of observations.
2/ Test statistics are reported with p-values in brackets.

CHART 5

DYNAMIC SIMULATION OF INFLATION, 1982-94 1/

(In percent)

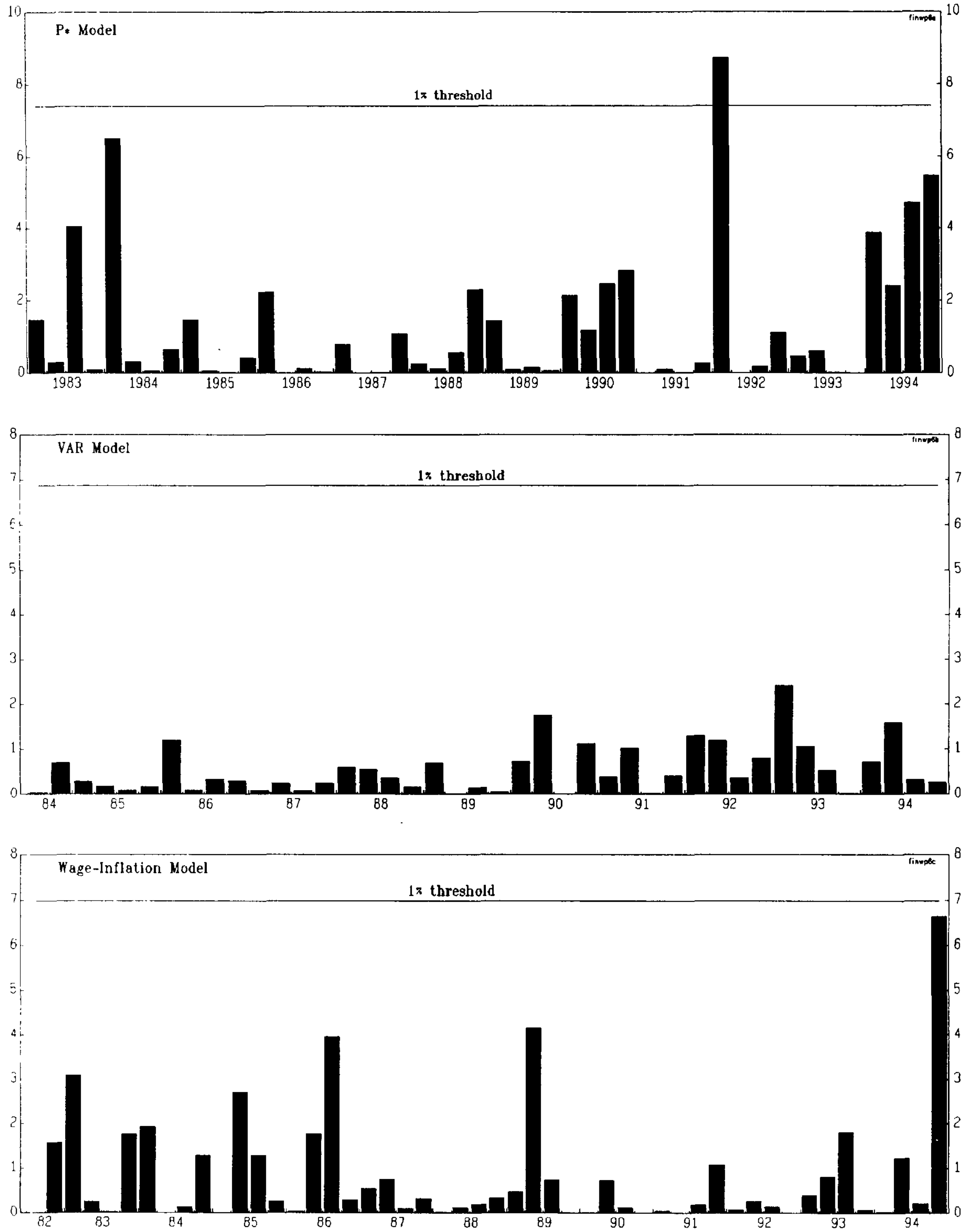


Sources: Bank of Finland; and staff calculations.

1/ Series are on an annualized basis.

CHART 6

CHOW-TESTS FOR FORECAST BREAKS, 1982-94

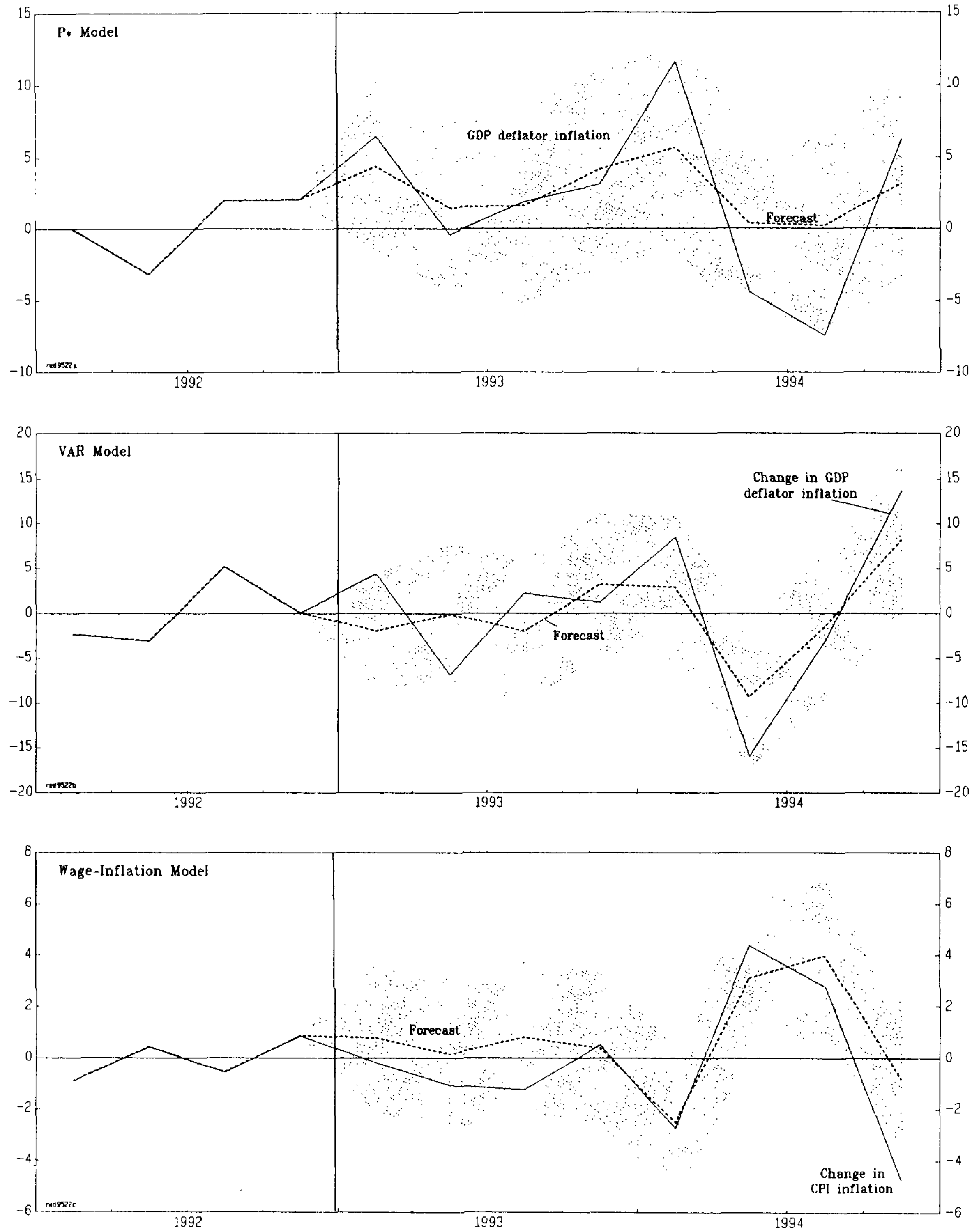


Source: Staff calculations.

CHART 7

DYNAMIC INFLATION FORECASTS, 1992-94 1/

(In percent)



Sources: Bank of Finland; and staff calculations.

1/ Series are on an annualized basis. Shadowed area marks range of double standard error.

mainly the frequency but not the magnitude of inflation. The Chow tests further indicate a declining forecast performance during the 1990s.

In contrast, the equation derived from the VAR model appears to be somewhat more in line with economic expectations. The overall fit is worse compared to the P^* model but the diagnostic statistics indicate a well-specified regression. The preferred equation has not changed much compared to the basic equation. As for additional variables, the nominal exchange rate has a negative impact in the long run, as could be expected, while the raw material price index (excluding energy) has a negative sign that appears difficult to explain.

Comparing the dynamic simulations for the VAR model with the P^* model (both use the GDP deflator as price variable), it appears that the former is closer to the actual series although it has the disadvantage of modeling the price level in second differences. The VAR model does not always predict the full amplitude of changes in the GDP deflator inflation, but it moves consistently close to it and even follows the large swings during the VAT introduction in 1994.

Finally, the CPI inflation equation derived from the wage-inflation model is mostly in line with economic theory. Again, the error correction mechanism from the basic model still holds, and both ECM terms are significant. Foreign export prices appear to pass through with a lag of 11 quarters, whereas changes in raw material prices seem to translate into increases of the inflation rate more quickly.

The fit of this model has greatly improved for the years after 1988, following large differences between actual and simulated inflation for most observations of the 1980's. This may indicate that the CPI relation has changed during the last years. In the dynamic forecast, there is an over-estimation of inflation increases during 1993, but the strong movements in 1994 are again well covered. The Chow tests indicate that the forecasts were comparatively close to actual values well in the 1990s, except for late 1994 when the VAT increase prompted strong fluctuations in quarterly inflation rates.

The GDP deflator and CPI inflation series appear to exhibit significantly different short-term behavior, as evidenced by the strong but opposite influence of major indicators. In particular, the GDP deflator models pose problems as the signs of a number of coefficients in the preferred equations are hard to explain with economic theory. However, a number of factors lead to the conclusion that the distinctive behavior of both equations is related to the different nature of the GDP deflator and the CPI: first, the basic models yield economically sound relationships; second, the significance of the indicators is about the same in all of the preferred equations; and third, the forecasts in general yield satisfactory results. One possible explanation for this phenomenon might be that, since export prices are part of the GDP deflator, a depreciation of the currency first leads to a fall in the deflator before import price increases feed through the economy.

c. Inflation forecasts for 1995-96

This section discusses GDP deflator and CPI inflation forecasts based on the VAR model and the wage-inflation model, respectively. The results should be interpreted with care, as they obviously suffer from a number of potential biases. The forecasts are computed for a period before which significant changes in the Finnish financial sector took place, with tests indicating a structural break at the end of the estimation period; they also include, for reasons of data availability, variables that are no longer of central importance in the Finnish economy. Further, it remains to be shown that they perform better than forecasts derived from a multi-equation system that takes explicit account of simultaneity among the variables.

The assumptions for the exogenous variables are detailed in Table 6. With an appreciating markka in 1995 (6 percent), import prices are assumed to grow by 1.2 percent, less than inflation rates in the major industrial countries. Real GDP is assumed to grow by 5 and 4.5 percent in 1995 and 1996, respectively. Monetary conditions are assumed to tighten modestly in 1995, leading to an increase in the MCI of 1.3 percent. One should note that, owing to the lag structure of the models, the assumptions made for many indicators have no impact on the inflation rate before late 1996.

The forecasts are depicted in Chart 8. Both models imply an increase in inflation between 1995 and 1996, although they differ in the magnitude of the increase. On the one hand, the GDP deflator estimates are relatively low, implying an average 1995-96 inflation rate of 0.8 percent for the basic model, and -0.5 percent for the preferred model. The lower estimates of the preferred model are mainly caused by the increasing NEER during 1993-94, as shown in the tabulation below.

On the other hand, projected CPI inflation is relatively high for both years in the preferred wage-inflation model, a consequence of the inflation process operating with lags of up to 12 quarters. However, taking into account the conceptional difficulties by which this forecast is burdened, it must be doubted that this outlook gives a fully realistic picture, particularly when looking at the projected decline of inflation towards end-1996. On the contrary, it is likely that, as a consequence of over-capacity in the domestic sector, monetary shocks are currently transmitted less strongly through the economy than during normal times. If depressed demand conditions in the wake of high unemployment prevent a strong pass-through of the devaluation, the preferred model probably over-predicts inflation.

The outcome of the wage-inflation model can nevertheless be used to assess the potential for future CPI inflation. First, the inflation path predicted by the basic model sets a lower boundary, being mainly the result

Table 6. Inflation Forecast: Assumptions and Results

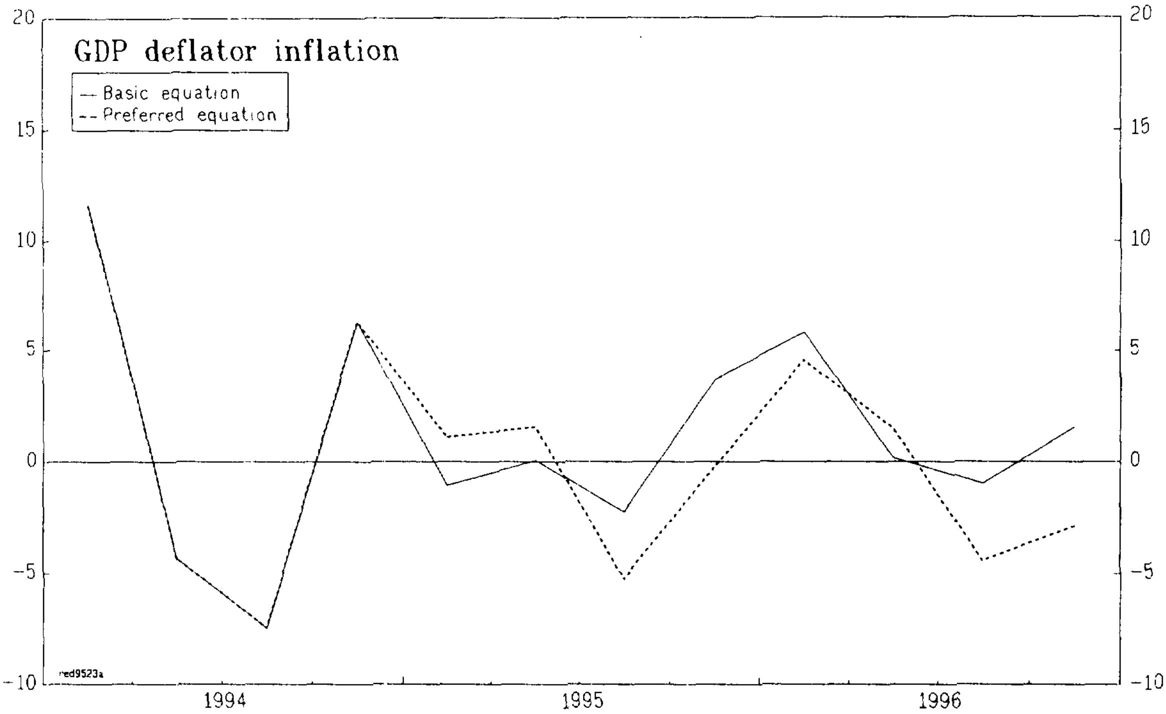
	VAR Model		Wage-Inflation Model	
	1995	1996	1995	1996
	(Annual change in percent)			
Assumptions				
Real GDP	5.0	4.5		
Labor productivity			2.3	...
Social Security Contributions 1/			--	--
Vacancy Rate 1/			0.4	0.2
NEER	6.0	...		
Import Price Index			1.2	1.2
Raw materials import prices 2/			--	--
HWWA import price index	1.2	...	1.2	...
M3	7.0	6.5		
Market yield on debentures	-1.0	1.2		
Monetary Conditions Index			1.3	...
Results				
GDP deflator (basic model)	0.1	1.6		
GDP deflator (pref. model)	-0.7	-0.3		
Wages (basic model)			4.6	5.3
Wages (pref. model)			5.4	7.5
CPI (basic model)			2.4	3.8
CPI (pref. model)			4.5	4.6

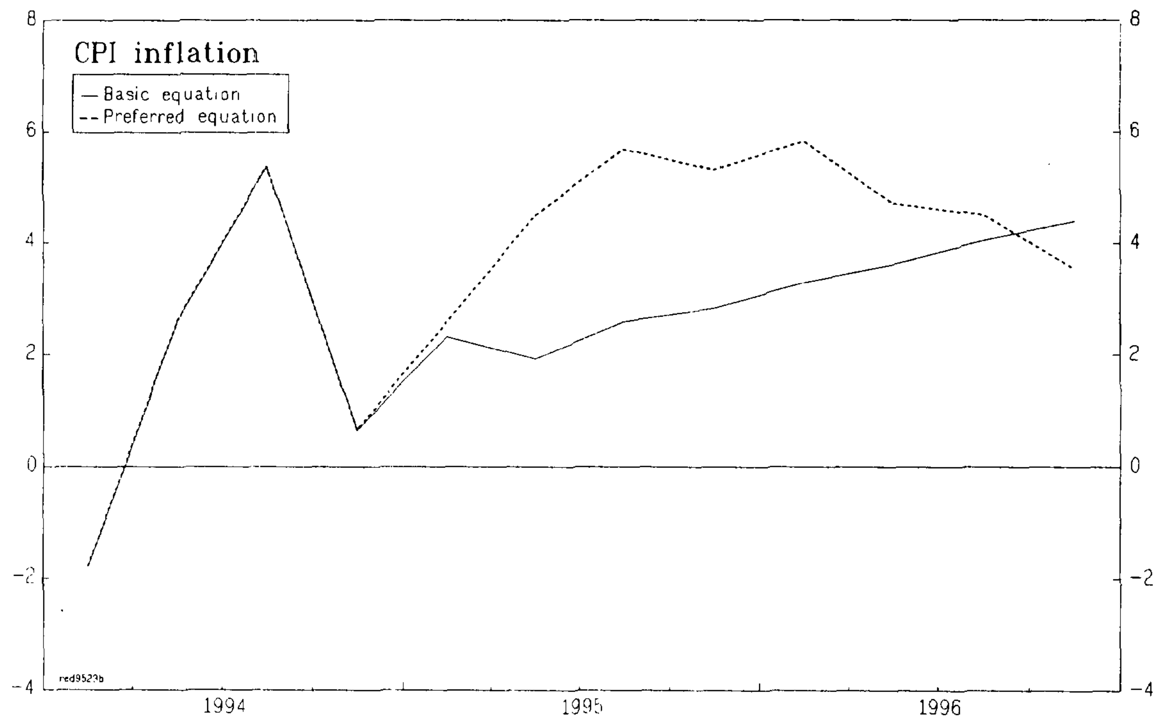
Source: Staff calculations.

1/ Change in percent of GDP or labor force, respectively.
2/ Change of second order, in percent.

CHART 8

INFLATION FORECASTS, 1994-96 1/
(In percent)





Sources: Bank of Finland; and staff calculations.

1/ Series are on an annualized basis.

of increasing wages, following a growing number of vacancies. Second, monetary conditions remained expansionary during the complete first half 1994, before an appreciating markka and a monetary tightening by the BoF led to an increase in the MCI. Therefore, taking into account that the MCI acts with a lag of some 6 and 10 quarters, it can be expected that pressures from the demand side will persist at least until end-1996, adding to the effect

Contribution to Price Increases 1995-96

	VAR model		Wage-inflation model	
	Basic	Pref.	Basic	Pref.
	(In percent of total price increase)			
Lagged inflation	99.5	14.9	12.5	6.8
Error correction terms	0.5	-33.2	72.4	-49.3
NEER	...	72.3	...	...
Import prices	...	45.9	15.1	-24.7
Monetary Conditions Index	...	...	...	167.2
Total	100.0	100.0	100.0	100.0

of import prices and wages. Consequently, a realistic assessment of the results could lead to the conclusion that inflation would increase more slowly than forecasted by the preferred model, but would continue to grow to reach an annualized rate of some 4 percent at the end of 1996.

4. Conclusions

This paper has identified a number of indicators that help to predict Finnish inflation. The most successful indicators are the nominal effective exchange rate (NEER), the stumpage price index, and the monetary conditions index (MCI). They are followed by a range of import-related indices, such as the import price index and the foreign export price index. Interest rates have been found less important on their own, but they are related to the MCI. The results are based on a comprehensive set of forecasting tests under different economic assumptions.

The models have produced further insight into the nature of the inflation process. On the one hand, real conditions appear to affect the price level rather quickly. Although the output gap and capacity measures are rarely significant in the models, wages react strongly to vacancies; and since the adjustment process in the estimated wage-inflation model is relatively strong, prices also appear to move closely in line with wages. On the other hand, the full pass-through of exchange-rate and monetary policy changes appears to last 4-12 quarters. The MCI is consistently found to be most effective with a lag of 6 and 10 quarters, and the NEER acts with a lag of 4-7 quarters. The lag of import price changes is less clearly determined, but it appears that changes in foreign export prices are not immediately fed through to import prices.

The results appear to be robust against changes in the underlying economic assumptions. By applying different ranking criteria, based on predicted values for both the immediate past and over the full sample period, the study has tried to address the problem of structural breaks in the data. This problem is particularly relevant for the Finnish economy; in particular, the liberalization of financial markets in the mid-1980s and its consequences pose considerable econometric difficulties. Again, however, it turns out that the strongest indicators are not affected by the choice of the ranking method.

Among the three models used, it appears that the approaches that model the inflation rate in changes rather than in levels have led to a superior outcome. Strikingly, however, the VAR and wage-inflation models (that analyze GDP deflator and CPI, respectively) exhibit significantly different short-term behavior as evidenced by opposite signs of several coefficients. Although this seems to be caused by the inclusion of export prices in the GDP deflator, further analysis is needed to explore why strong indicators, such as the MCI, appear with opposite signs in the preferred equations without affecting the overall quality of the forecasts.

Appendix I. Estimation of Three Basic Models

a. The P^* model

Following Hallman et al. (1991), the equilibrium price level p^* is defined as the price level consistent with the current money stock and equilibrium in an economy's goods and financial markets: 1/

$$p^* = m3 + v^* - y^* \tag{1}$$

with m3 denoting money supply, v^* trend M3 velocity and y^* capacity output. Subtracting the quantity equation, and assuming that the inflation rate depends on the deviation from its equilibrium level (the price gap) and previous inflation, one can write

$$\Delta p = \alpha_1 (v^* - v)_{-1} + \alpha_2 (y - y^*)_{-1} + \beta_0 + \Sigma_i \beta_i \Delta p_{t-i}. \tag{2}$$

where further lags of velocity and output gaps can also be included. Both output and velocity gaps have been obtained using a Hodrick-Prescott filter to calculate the trend values. The following specification yielded the best fit, resulting in the first of the three basic inflation equations of this section: 2/

$$\Delta p = \underset{(3.44)}{0.1818} (v^* - v)_{-1} + \underset{(4.67)}{0.3348} (y - y^*)_{-1} - \underset{(3.52)}{0.2484} (y - y^*)_{-3}$$

$$\underset{(0.41)}{-0.0340} \Delta p_{t-1} + \underset{(8.59)}{0.5964} \Delta p_{t-2} + \underset{(4.82)}{0.3964} \Delta p_{t-3} \tag{3}$$

N = 100 (70:1-94:4)	Correlation Actual-Fitted	0.7198	Normality Test	16.0080 [.00]
R^2 = 0.7878	Autoregressive Errors	1.5826 [.17]	ARCH Test	2.6361 [.04]

Both velocity and output gaps have the correct signs, with inflationary pressure resulting from output exceeding potential and velocity falling beneath trend velocity.

1/ All variables are seasonally adjusted where required, the lower case denoting logarithms.

2/ t-values are reported in brackets.

b. The VAR model

Contrary to the previous approach, the following model will take account of the statistical properties of the variables. In particular, the basic inflation equation has to be formulated in the second difference of the GDP deflator. Assuming that M3 velocity is positively dependent on interest rates, the following co-integration relationship is obtained:

$$y \; - \; (m3 - p) \; = \; 14.48 \; MYD \; + \; CI_m \qquad (4)$$

where MYD is the market yield on government debentures and CI_m a stationary residual. 1/

The VAR model matched the data best with only one lag. As could therefore be expected, the error-correction model (ECM) contains only one lag of the co-integration residual (the "error-correction term"). The only additional term is a dummy variable ($d_{88:4}$) that accounts for a large increase in money supply due to the anticipation of a capital gains tax tightening in early 1989. The estimation results were as follows:

$$\begin{aligned}
\Delta y &= \underset{(3.90)}{-0.0588} + \underset{(4.23)}{0.0277}\, CI_{m,-1} + EY \\
\Delta(m_3 - p) &= \underset{(2.17)}{-0.0490} + \underset{(2.65)}{0.0260}\, CI_{m,-1} + \underset{(3.75)}{0.0739}\, d_{88:4} + EM \qquad (5) \\
\Delta MYD &= \underset{(2.57)}{-0.0218} + \underset{(2.49)}{0.0092}\, CI_{m,-1} + EI.
\end{aligned}$$

with EY, EM, and EI denoting stationary residuals.

In order to arrive at a basic equation, the model contained in (5) had to be incorporated in a model for the second difference of the price level ($\Delta^2 p$). To that end, (m3-p) is interpreted as a residual of the co-integration relationship between m3 and p. 2/ Consequently, $\Delta^2 p$ is related to Δ(m3-p) and $\Delta^2 m3$ in an error-correction relationship. This relationship is augmented by remaining VAR variables (Δy, ΔMYD) and the residuals EY, EM, and EI so as to take account of the ECM estimated in (5). The final equation became:

1/ The debenture yield was tested stationary but is one of the few borderline cases. The co-integration relationship for y and (m_3-p) did not hold without MYD being included.

2/ Both m3 and p are integrated of order two whereas (m3-p) is a linear combination that is only integrated of order one.

$$\Delta^2 p = -0.5751\, \Delta^2 p_{-1} - 0.3911\, \Delta^2 p_{-2} - 0.2443\, \Delta^2 p_{-3} - 0.1854\, \Delta^2 p_{-6}$$
$$(5.09) \qquad (3.04) \qquad (2.23) \qquad (2.93)$$

$$-0.3776\, EI_{-3} - 0.5090\, EI_{-8} + 0.1790\, EM_{-1}. \qquad (6)$$
$$(2.32) \qquad (2.83) \qquad (2.43)$$

N = 74 (76:3-94:4)	Correlation Actual-Fitted 0.7532	Normality Test	3.8732 [.14]
R^2 = 0.5618	Autoregressive Errors 1.2863 [.28]	ARCH Test	0.3443 [.85]

As it turns out, growth in real money demand in excess of its equilibrium level tends to increase inflation with a one-quarter lag, whereas interest rate increases above equilibrium tend to lower inflation with a lag of between 3 to 8 quarters.

c. <u>The wage inflation model</u>

The last of the basic models formulates an equation for the growth rate of CPI inflation. Following Ford and Krueger (1995), it is assumed that the CPI is related directly to import prices and nominal wages. In turn, import prices and wages are dependent on a number of factors, including the exchange rate, domestic demand conditions, and the price level itself. Applied to Finland, three separate co-integration relationships emerge:

Import prices:

$$p_{im} = 0.6097\, p_{fx} + 0.3778\, p_{oil} + CI_{im} \qquad (7)$$

Real wage:

$$\Delta(w - p) = 0.3766\, VAC - 0.2192\, SOC + CI_w \qquad (8)$$

Mark-up:

$$\Delta p = 0.7564\, \Delta w + 0.0040\, p_{im} + CI_p \qquad (9)$$

where p_{im} and w represent import prices and wages, p_{fx} and p_{oil} are foreign export and oil import prices, VCR and SOC are the vacancy rate and social security contribution of employers (covering excess labor demand and non-wage labor costs), and CI_{im}, CI_w and CI_p are stationary residuals.

Similarly to the VAR model, the basic equation has to be modeled in second differences, i.e. for $\Delta^2 p$. This is done by formulating an ECM for the mark-up equation and adding the co-integration residuals CI_{im} and CI_w from (7) and (8), thereby incorporating deviations from the import price and wage equations equilibria. Again, insignificant lags and variables have been deleted to yield the following relation:

$$\Delta^2 p = \underset{(4.68)}{-0.3432}\ \Delta^2 p_{-1} - \underset{(5.28)}{1.2087}\ CI_{p,-1} - \underset{(5.43)}{0.9016}\ CI_{w,-1} + \underset{(6.42)}{0.1209}\ \Delta p_{im,-1}. \tag{10}$$

N = 117 (65:4-94:4)	Correlation Actual-Fitted	0.7016	Normality Test	4.7295 [.09]
R^2 = 0.4922	Autoregressive Errors	1.9422 [.09]	ARCH Test	3.5343 [.01]

It follows that import price increases as well as deviations from equilibrium distortions have an immediate impact on inflation. Whereas the coefficient of CI_p has the correct sign, one would expect that excessive real wage increases (indicated by a positive value for CI_w) would push inflation upwards. On the other hand, CI_p and CI_w both contain prices and wages and, owing to the larger size of the CI_p coefficient, their combined effect appears to be in the right direction.

Appendix II. Indicator Selection

Writing the basic equation for a model as

$$p = f(x_1, \ldots, x_s) \tag{11}$$

where $x_1, \ldots, x_s$ are variables contained in the respective model, and f is a function for the inflation process (in first or second difference). The following steps are then repeated for every equation:

(1) At the outset, a set of n indicator candidates $Z = \{z_1, \ldots z_n\}$ is set up, consisting of variables z which are expected to help forecast future inflation. Each of the z is used to set up the following equation:

$$p = f(x_1, \ldots, x_s) + \sum_{t=1}^{T} \beta_t z_{-t}. \tag{12}$$

i.e., a fixed number of lags 1/ of the series z are added to the basic model.

Subsequently, equation (12) is re-estimated T times, eliminating at each step the lag z_{-t} with the least significant coefficient. After having eliminated all but one lag, the Schwarz sample selection criterion is employed to identify the lag structure that leads to the best fit. This results in a model that comprises k lags of z, yielding a set $I = \{i_1, \ldots, i_k\}$. 2/ The estimation with the best fit can therefore be written as

$$p = f(x_1, \ldots, x_s) + \sum_{j \in I} \beta_j z_{-j}. \tag{13}$$

This procedure is repeated for all indicator candidates in Z, resulting in one equation for each of the candidates.

(2) For further analysis, three different approaches have been taken (following Coelli and Fahrer [1992]) in order to evaluate the forecast performance of the indicator candidates:

- First, the equation obtained for each candidate is used to generate a dynamic inflation forecast for the two years prior to the end of the sample. 3/ The word "dynamics" implies that predicted values are used for lags of the price level, rather than

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1/ For this paper, $T = 15$ was chosen.

2/ Note that these are not the first k lags $z_{-1}, \ldots, z_{-k}$ but the lags that have remained after the elimination of T-k less significant lags.

3/ The current sample covers the time frame from 1960 to 1994 with quarterly data, therefore the dynamic forecast period is 1993:1 to 1994:4.

actual values. The quality of the forecasts can then be measured by the Root Mean Squared Error (RMSE) criterion.

- Second, each equation is estimated by a series of recursive regressions, starting with the smallest number of observations possible and adding one observation at a time. At every step, a one-period ahead forecast is made for the dependent variable. Again, the forecasts can be evaluated by the RMSE.

- Third, the quality of the forecasts from the recursive regressions can be evaluated by encompassing tests, as proposed by Chong and Hendry (1986). These tests involve forecast errors from two equations, say, e^i and e^j. The following regressions are carried out:

$$e^i = \beta_i (e^j - e^i) \quad \text{and} \quad e^j = \beta_j (e^i - e^j). \tag{14}$$

  If β_j is significantly different from zero, but β_i is not, then model i is encompassing model j in the sense that model i contains information that helps forecasting e^j but the reverse is not true. Running these tests on the forecast errors for each possible pair of indicator candidates, a ranking is obtained by counting for each indicator (a) the number of other indicators which are encompassed by it, and (b) the number of draws, i.e., the events in which it neither encompasses another indicator nor is encompassed itself.

(3) Finally, the basic equation is augmented by the most successful indicator candidates. This yields

$$p = f(x_1, \ldots, x_s) + \sum_{q \in Q} \sum_{i \in I_q} \beta_{qi} z_{q,-i}. \tag{15}$$

where $Q \in Z$ is a set containing the strongest indicator candidates. This equation is then reduced to a preferred inflation equation by eliminating any insignificant variables.

Appendix III. List of Variables.

Variable name	Source 1/	Description
CPI	CPI.W	Consumer price index, 1985=100.
GDP deflator	PGDP.W	Value added deflator in purchasers' values, 1985=100.
Producer price index	P1850.M	Producer price index, manuf. prod. [rebased: 1985=100].
Stumpage price index	[BoF]	1985=100 2/
Dwelling price index	PHM.W	Dwelling price index, all, whole country, 1985=100.
Export price index	XP.M	Export price index [rebased: 1985=100].
Import price index	MP.M	Import price index [rebased: 1985=100].
Foreign export price index	[Staff]	Average of partners' export prices, 1985=100. 3/
Raw materials import price index	PMR.W	Import prices of raw materials (in FIM), 1985=100.
HWWA raw materials price index	F219.M	(HWWA) Raw material prices, excl. energy, 1985=100. 4/
Fuel import price index	PMFL.W	Import prices of fuels and lubricants (in FIM), 1985=100.
GDP	GDPV.W	GDP in purchasers' values, FIM million
Real GDP	GDP.W	GDP in purchasers' values, millions of 1985 FIM.
Output gap	[Staff]	Real GDP / Hodrick-Prescott filtered real GDP.
Industrial production index	Q070.K	Industrial production volume index [rebased: 1985=100].
Manufacturing output	GDP4.W	Production at factor cost, manufacturing, mill. 1985 FIM.
Capacity utilization	ZRCU	Capacity utilization (GDP/KF)
Capacity utilization (manuf.)	ZRCU4	Capacity utilization (GDP4/KF4), manufacturing.
Wholesale sales index	C110.KP	Wholesale sales index.
Wage index	WR.W	Wage rate, total, 1985=100.
Real wage index	[Staff]	Wage index / CPI.
Labor Productivity	Q.W	Labour productivity, 1985=100.
Unit labor costs	[IMF]	Normalized unit labor costs in manufact. (CIS:LNULCM).
Social security contributions	SOCC.W	Employers' social security contributions, total (/ GDP).
Unemployment rate	UR.W	Unemployment rate, per cent.
Vacancy Rate	L090.K	L090.K:Vacancies / L030.K:Labor Force.
NEER	[IMF]	Nominal effective exchange rate (ULC based, IFS).
REER	[IMF]	Real effective exchange rate (ULC based, IFS).
Terms of trade	[IMF]	Export unit values / Import unit values.
M1	MON1.W	Monetary aggregate M1, FIM million.
M2	MON2.W	Monetary aggregate M2, FIM million.
M3	MON3.W	Monetary aggregate M3, FIM million.
Bank markka lending	[BoF]	FIM million.
Real M1 (M2, M3)	[Staff]	M1 (M2, M3) / GDP deflator.
M1 (M2, M3) Velocity	[Staff]	Real GDP * GDP deflator / M1 (M2, M3).
Monetary Conditions Index	[Staff]	(Weighted average of bank lending rate and NEER). 5/
Bank lending rate	RLB.W	Bank lending rate, per cent.
Money market rate	RS.W	Money market rate, per cent.
Market yield on tax-free bonds	RB.W	Market yield on tax-free bonds, per cent.
Market yield on debentures	RDEB.W	Market yield on debentures, per cent.
Bond yield index	[BoF]	1990=100
Money market yield index	[BoF]	1990=100
Interest rate spread	[Staff]	Debentures Yield - money market rate.
Central government fiscal balance	ZR10B	General government fiscal balance (/ GDP).

Source: Bank of Finland, and staff calculations.

Note: The variables have been seasonally adjusted using the X-11 method of the Fund's AREMOS program, and are used in logarithmic form.

1/ If a series is contained in the Bank of Finland's BOF4 model, the BOF4 code and description are given.
2/ Stumpage prices have been recorded semi-annually up to 1987, the quarterly figure of prior years is imposed.
3/ The export price indices of the 12 most important import countries have been added, weighted with their respective share in Finnish imports, and divided by the nominal effective exchange rate.
4/ The original index is in US dollars, but has been converted into Finnish markka.
5/ See text for details.

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