PRICE INFLATION, UNEMPLOYMENT AND DEVALUATIONS: THE FINNISH EXPERIENCE OF THE 1990S

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Price Inflation, Unemployment and Devaluations: The Finnish Experience of the 1990s

Key words: Cointegration, inflation, monetary policy

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Price Inflation, Unemployment and Devaluations: The Finnish Experience of the 1990s

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Abstract

In this paper I provide some empirical answers to important questions such as the determinants of price inflation and the role of inflation polices. The results indicate that monetary policy is surprisingly impotent as a device for controlling inflation and there is little support that it influences the real variables. The low inflation after the Finnish devaluations in the beginning of 90s is foremost due to a previous imbalance in the labor markets and depressed aggregate demand.
1 Introduction

During the past decades, inflation has been seen as one of the most important economic variables. Much have been said about the virtues of price stability for promoting growth. This view was partly developed after the turbulent 60s and 70s when support for monetarist ideas were increasing. Since the 80s a significant efforts has been made to promoting price stability in most developed countries including Finland. Central to this view is the belief that inflation is a monetary phenomenon to be fought with monetary policy. This view was dominant in Finland during the 80s. For example, a fixed exchange-rate regime was rigorously deployed and it was generally believed that a devaluation of the Finnish Markka (FIM) would trigger off inflation. Capital deregulations during the last half of the 80s sent the economy booming with seemingly endless growth. In the beginning of the 90s, however, the Finnish economy basically collapsed and a deep recession followed. Finland was forced to abandon the fixed exchange-rate regime and devalued its currency by approximately 12%. Surprisingly, the devaluations did not have the anticipated adverse effects of inflation. Instead the country experienced an export based recovery (see Kiander and Vartia (1998) and Honkapohja and Koskela (1999)). This raises interesting questions such as: Is there a role for monetary policy? Why did the devaluations not increase the rate of inflation? What is the role of inflation for real growth? Which were the main determinants of inflation in this period?

The aim of this paper is to provide empirical answers to some of these questions in the framework of a cointegrated VAR model. Many potential sources of inflation have been suggested in the literature\footnote{The literature on price formation is vast. For a nice summary of the discussion in the monetary policy literature see McCallum (1999). For reviews of the labor markets and unemployment literature see Bean (1994), Nickell (1990) and Blanchard and Katz (1997).}. Surrey (1989) distinguishes between (1) pure monetary theories (2) internal theories, including both labor markets and excess demand, and (3) external theories. Surrey assumes that these are interrelated. A similar distinction is utilized in the present paper. The main differences are that pure monetary theories are included in the excess demand analysis and labor markets are treated separately. The central idea is to analyze the long-run properties of each sector separately and then utilize the results to estimate a model for the complete economy. Similar strategies of analyzing the determinants of inflation has previously been deployed by Juselius (1992) and Metin (1995) among others. Juselius (1992) investigates the long-run properties of inflation in the Danish economy by a similar division of the economic sectors as in this paper. Metin (1995) conducts this analysis on Turkish data with a somewhat different sector division than is followed here.

The main empirical findings in this paper are: (1) there is no role for monetary policy, i.e. neither short-run interest rates nor real money balances determines inflation
and inflation has only marginal effect on the real variables. (2) Inflation is primarily
driven by excess demand and labor market imbalances. (3) The devaluations in the
90s primarily corrected a disequilibrium in the real exchange rate induced by a fixed
exchange rate regime, and thus did not have a large inflation cost.

The paper is organized in the following manner. Section 2 provides a simple the-
oretical framework, that accounts for the potential sources of inflation and section 3
introduces the statistical model. Section 4 reports the empirical findings in four parts.
First, long-run relations describing the demand side, the labor market, and the external
sector are examined. Conditional on these relations, section 4.4 provides a full analysis
of the economy. The results are extensively discussed in section 5 and section 6 finally
concludes.

2 Theoretical framework

This section summarizes known results which are useful for interpreting the empirical
analyses. The aim is to present a framework of the determinants for inflation that takes
into account the demand side, the labor market and the external sector.

In the demand side of the economy inflation can be the result of excess demand,
either from monetary expansions or increased public spending. In equilibrium where
money demand equals supply, individuals want to hold real money balances in propor-
tion to income. Also, higher interest rates or higher inflation rates increases transaction
costs and decrease the demand for money held. This can be expressed as,

\[ m_t - p_t = \lambda_0 + \lambda_1(y_t - p_t) - \lambda_2i_t + \lambda_3\Delta p_t + \nu_{1t} \]  

(1)

where \( m \) is the log of nominal money stock, \( y \) is the log of nominal income, \( i \) is the
short term interest rate, \( \nu_{1t} \) is i.i.d and \( \lambda_i \geq 0 \). An increase in nominal money can lead
to inflation if it is anticipated by the agents in the economy (i.e. equilibrium is restored
by inflation if the real variables do not change). Furthermore inflation might also result
from excess aggregate demand which, for example, can derive from increased public
spending. This can be expressed as,

\[ \Delta p_t = \lambda_4 + \lambda_5((y_t - p_t) - \bar{y}) + \nu_{2t} \]  

(2)

and interpreted as a standard Phillips-curve. \( \bar{y} \) denotes the full employment income. It
is also common in the literature to specify a monetary policy rule and an IS curve,

\[
i_t = \lambda_6 + \lambda_7(\Delta p_t - \Delta p^*) + \lambda_8(y_t - \bar{y}) + \nu_{3t}
\]

\[
y_t - p_t = \lambda_9 - \lambda_{10}i_t + \nu_{4t}
\]

which together with the Phillips curve (2) provides the setting for analyzing inflation
Inflation can also arise as a result of labor market imperfections in the economy. Workers supply their labor in proportion to the offered real wages. Concentrating on unemployment rather than employment (assuming \( n = 1 - u \), where \( n \) is employment) we have,

\[
w_t^s - p_t = \lambda_{11} - \lambda_{12} u_t + \lambda_{13} \Delta p_t + \nu_{6t}
\]

where \( w \) is nominal wages. Assuming that producers follow mark-up pricing and set wages proportionally to labor productivity we have,

\[
w_t^d - p_t = \lambda_{14} + \lambda_{15} a^L_t + \lambda_{16} \pi_t + \nu_{6t}
\]

where \( a^L \) is labor productivity and \( \pi \) is the profit mark-up (see Nickell (1990), Blanchard and Katz (1997) and Bean (1994)). This simple framework ignores many other relevant aspects of the labor markets such as unions and wage bargaining, but is sufficient for the present purpose.

Inflation can also be a result of disequilibrium in the external sector of the economy. For example, a domestic devaluation raises the price of imported raw materials which is passed on to consumer prices (inflation pass through). The standard assumption regarding the external sector is that PPP (purchasing power parity) holds, at least as a long run property. However it has been surprisingly hard to find empirical support for PPP (see Rogoff (1996) for a survey). PPP is expressed as,

\[
s_t = p_t - p^*_t
\]

where \( s \) is the log of nominal exchange rate and \( p^* \) is the log of external price level. Underlying this relation is the law of one price. Uncovered interest parity is assumed to hold as a market clearing mechanism in the capital market,

\[
i_t = i^*_t + \Delta s_t
\]

. It follows from the discussion above that inflation might potentially originate in all these sectors of the economy.

3 The statistical model

The baseline statistical model is the \( p \) dimensional cointegrated VAR-model with \( k \) lags

\[
\Delta X_t = \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-1} + \mu + \Psi D_t + \varepsilon_t
\]

where the vector process \( X_t \) is assumed to be \( I(1) \), \( \mu \) is a vector of constants, \( D_t \) consist of the other deterministic components and \( \varepsilon_t \sim N_n(0, \Sigma) \). If there exists cointegration
\( \Pi = \alpha \beta' \) and \( \mu = \alpha \beta_0 + \alpha_{-1} \gamma_0 \), etc. where \( \alpha \) and \( \beta \) are two \((p \times r)\) matrixes such that \( r < p \), then the moving average representation of the model is given by

\[
X_t = X_0 + C(\sum_{i=1}^{t} (\varepsilon_i + D_i) + \mu t) + C^* (L) (\varepsilon_t + D_t)
\]  

(8)

where \( X_0 \) are the initial values of the process and \( C = \beta_{-1} (\alpha'_{-1} (I - \Gamma_1) \beta_{-1})^{-1} \alpha_{-1} \), Johansen (1995). The main properties of the model are investigated in Johansen (1995) and will not be repeated here\(^2\). However, for the sake of clarity some of the most crucial results are reproduced.

### 3.1 Linear restrictions on the \( \beta \)-vectors

An important part of the analysis consist of testing linear restrictions on the \( \beta \)-vectors with the aim of identifying a structure of empirically relevant relations. The restrictions can either be applied to all the cointegrating relations simultaneously or to the individual vectors separately. Given \( \Pi = \alpha \beta' \) Johansen and Juselius (1990) show that the same restriction on all the vectors can be tested by formulating the alternative hypothesis

\[
\mathcal{H}_2 : \Pi = \alpha \varphi H'
\]

(9)

that is \( \beta = H \varphi \) where \( H \) is a \((p \times s)\) with \( r \leq s \leq p \) matrix defining linear restrictions on \( \beta \). Restrictions on the individual vectors are formulated as

\[
\mathcal{H}_3 : \Pi = \alpha \beta', \beta = \{ H_1 \varphi_1, ..., H_r \varphi_r \}
\]

(10)

where \( H_i \) is \( p \times s_i \), defining linear restrictions on the individual vectors. Johansen (1995) derives the LR-tests for testing the hypothesis in the form (9) and (10).

### 3.2 Linear restrictions on the \( \alpha \)-matrix and weak exogeneity

The \( \alpha \)-vectors can also be restricted in a similar fashion as in the last section. Of special interest is the case where one or several rows in \( \alpha \) consist of zeros. A variable with an zero row in \( \alpha \) is not affected by the long-run relationships and is hence treated as weakly exogenous. In this case one estimates

\[
\Delta X_{1,t} = A \Delta X_{2,t} + \sum_{i=1}^{k-1} \Gamma_i X_{t-i} + \tilde{\alpha} \beta' X_{t-1} + \mu + \psi D_t + \varepsilon_t
\]

(11)

where \( X_{1,t} \) consist of the endogenous variables while \( X_{2,t} \) consist of the weakly exogenous variables and \( X_t = \{ X_{1,t}, X_{2,t} \} \). The dimension is now \( p - h \), where \( h \) is the number of exogenous variables Henry and Juselius (2000).

\(^2\)see Henry and Juselius (1999, 2000) for a helpful overview.
Section 2 demonstrated many potential sources of inflation. Taking account of them all simultaneously would involve a large number of variables in the information set, making identification difficult. To cope with this problem a General to Specific approach used by Juselius (1992), Metin (1995) is followed. Henry (1995) provides a full account of General to Specific modeling and the relative merits of this approach is investigated in Hoover and Perez (1999, 2000).

The three informations sets used to describe the three sectors are $I_{1,t} = \{cp_t, m3_t, il_t, is_t, y_t\}$ for the demand sector, $I_{2,t} = \{cp_t, pp_t, w_t, al_t, u_t\}$ for the labor market and $I_{3,t} = \{cp_t, cp^*_t, s_t, il_t, il^*_t\}$ for the external sector. The definition of the variables is given in Appendix A. The analysis proceeds by first investigating cointegration in each sector. The short run structure of the entire economy will then be analyzed using the cointegration vectors.

All partial models were checked for misspecification based on the following tests: A multivariate version of the Shenton-Bowman test was used to test for normally distributed residuals. Autocorrelation was tested by a Ljung-Box test (L-B) and a LM type test. The long-run analysis of the three sectors was conducted in CATS in RATS, while the final analysis was conducted in PC-Fiml.

### 4.1 Long-run relationships of the demand side

Investigating the price mechanisms from the demand side of the economy (7) was estimated with $X_t = [cp_t, m3_t, il_t, is_t, y_t], k = 2$, and a linear trend included in the cointegration space (note the additional column in $H'$). Graphical inspection suggests that $\{cp, m3, y\} \sim I(2)$ while $\{il, is\} \sim I(1)$, and are hence assumed through the analysis. The existence of the $I(2)$ variables complicates the analysis considerably. However, cointegration might exist between them making the transformation either $I(1)$ or $I(0)$ (the latter is unlikely). Natural candidates would be $m3 - cp$ and $y - cp$, that is homogeneity between money, prices and GDP, i.e. real money and real GDP. Given $r = 2$, the homogeneity restriction was tested by (9) with

$$H' = \begin{pmatrix} 1 & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & -1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

that is, the same restriction on all cointegrating vectors. The likelihood ratio test statistic is $\chi^2(1)$ and the p-value was 0.03 i.e. a rejection of the hypothesis (against a 5% significance level). Nevertheless, assuming homogeneity at this stage has the
advantage of significantly simplifying the analysis but a small fraction of the $I(2)$ components is likely to remain in the data after the transformation. As a consequence of the transformation the difference of either $m_3$, $cp$ or $g$ had to be included Juselius (1999), the natural candidate being $\Delta cp$. Hence the system was re-estimated with $X_t = [\Delta cp_t, r m_3_t, il_t, is_t, ry_t]$ and all components of $X_t$ treated as $I(1)$ (Tests of stationarity where rejected for all variables). The trace test reported in Table 1 suggests that the rank is two. Testing for weak exogeneity for the long-run parameters indicated that $ry$ could be treated as weakly exogenous based on a LR-test value of 5.50 against the $\chi^2_{0.05}$ of 7.81. Four dummy variables were included to account for policy interventions. These were $D_{88}$, $D_{92a}$, $D_{94a}$ and $D_{94b}$. The first of these corresponds to the revaluation in 1988 while $D_{92a}$ corresponds to the devaluation in 1991.

The demand sector was finally estimated by equation (11) where $X_{1,t} = [\Delta cp_t, r m_3_t, il_t, is_t], X_{2,t} = ry_t$ and $X_t = \{X_{1,t}, X_{2,t}\} \sim I(1)$. Inspection of the $\alpha$-matrix and the roots of the companion matrix (the first two roots were 0.98 and 0.78) indicates that the choice of rank should be set equal to three and hence do not support the previous choice of $r = 2$. The results from testing for residual normality and autocorrelation are included in Table 1 and support the normality assumption of the model and indicate that the fit is fairly good. The three estimated cointegration relations and their corresponding weights are reported in Table 2. The estimated $\beta$-vectors span the cointegration space, $sp(\beta)$, within which linear restrictions can be tested.

<table>
<thead>
<tr>
<th>(r)</th>
<th>trace</th>
<th>trace$_{a10}$</th>
<th>test</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>106.8</td>
<td>83.68</td>
<td>L-B</td>
<td>0.13</td>
</tr>
<tr>
<td>1</td>
<td>60.45</td>
<td>58.96</td>
<td>LM(1)</td>
<td>0.64</td>
</tr>
<tr>
<td>2</td>
<td>37.56</td>
<td>39.09</td>
<td>LM(4)</td>
<td>0.79</td>
</tr>
<tr>
<td>3</td>
<td>16.80</td>
<td>22.95</td>
<td>$\chi^2$ for normality</td>
<td>0.63</td>
</tr>
</tbody>
</table>

Table 3 reports the test results of linear restrictions on the $\beta$-vectors, where the restrictions are of the form $\beta = \{H_1 \varphi, \psi_1, \psi_2\}$, corresponding to restricting one single vector. The first hypothesis, $H_{1,1}$, tests the stationarity of the real long-term interest-rate. The hypothesis is accepted with a $p$-value of 0.34. The second hypothesis is similar to the first one but with the short term interest-rates instead and is rejected. The third relation in $H_{1,3}$ can be interpreted as a Phillips curve. It is strongly accepted. $H_{1,4}$ tests the stationarity of the interest-rate spread and is rejected whereas $H_{1,5}$ tests whether the two interest rates are cointegrated. $H_{1,6}$ tests whether the interest-rates
Table 2: Estimated cointegrating vectors and weights

<table>
<thead>
<tr>
<th></th>
<th>$\hat{\beta}_1$</th>
<th>$\hat{\beta}_2$</th>
<th>$\hat{\beta}_3$</th>
<th>$\hat{\alpha}_1$</th>
<th>$\hat{\alpha}_2$</th>
<th>$\hat{\alpha}_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta cp$</td>
<td>0.362</td>
<td>-0.298</td>
<td>1.000</td>
<td>-0.85</td>
<td>0.100</td>
<td>-0.290</td>
</tr>
<tr>
<td>$r m3$</td>
<td>-0.002</td>
<td>0.012</td>
<td>0.003</td>
<td>-2.900</td>
<td>-0.060</td>
<td>-0.270</td>
</tr>
<tr>
<td>$i l$</td>
<td>1.000</td>
<td>0.418</td>
<td>-1.559</td>
<td>-0.170</td>
<td>-0.020</td>
<td>0.060</td>
</tr>
<tr>
<td>$i s$</td>
<td>-0.415</td>
<td>1.000</td>
<td>1.135</td>
<td>0.910</td>
<td>-0.320</td>
<td>-0.010</td>
</tr>
<tr>
<td>$y$</td>
<td>-0.016</td>
<td>-0.038</td>
<td>-0.027</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$t r e n d$</td>
<td>0.000</td>
<td>0.001</td>
<td>0.000</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 3: Structural hypothesis on the $\beta$-vectors

<table>
<thead>
<tr>
<th>hypothesis</th>
<th>$\Delta cp$</th>
<th>$r m3$</th>
<th>$i l$</th>
<th>$i s$</th>
<th>$y$</th>
<th>$t$</th>
<th>LR(df)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_{1,1}$</td>
<td>-1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3.32(3)</td>
<td>0.34</td>
</tr>
<tr>
<td>$H_{1,2}$</td>
<td>-1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>8.61(3)</td>
<td>0.03</td>
</tr>
<tr>
<td>$H_{1,3}$</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>$-a_3$</td>
<td>$b_3$</td>
<td>0.23(1)</td>
<td>0.63</td>
</tr>
<tr>
<td>$H_{1,4}$</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>-1</td>
<td>0</td>
<td>0</td>
<td>8.54(3)</td>
<td>0.04</td>
</tr>
<tr>
<td>$H_{1,5}$</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>$-a_5$</td>
<td>0</td>
<td>0</td>
<td>0.45(2)</td>
<td>0.80</td>
</tr>
<tr>
<td>$H_{1,6}$</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>-0.5</td>
<td>$-a_6$</td>
<td>$b_6$</td>
<td>0.24(1)</td>
<td>0.63</td>
</tr>
<tr>
<td>$H_{1,7}$</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>$a_7$</td>
<td>$-b_7$</td>
<td>0</td>
<td>15.88(1)</td>
<td>0.00</td>
</tr>
<tr>
<td>$H_{1,8}$</td>
<td>1</td>
<td>$a_8$</td>
<td>0</td>
<td>$-b_8$</td>
<td>0</td>
<td>0</td>
<td>0.02(1)</td>
<td>0.88</td>
</tr>
</tbody>
</table>

and real GDP are cointegrated. It is accepted and can be interpreted as an IS-curve type relation. $H_{1,7}$ tests a money demand relation and is rejected by the data. The last hypothesis $H_{1,8}$ tests whether inflation, real money and the short-run interest-rates are cointegrated. It is strongly accepted and can be interpreted as a central bank policy rule, i.e. when the inflation is expected to rise the central banker reacts by increasing the interest-rates and contracting the money supply.

Inspection of Table 3 reveals that there are five potential candidates for the three $\beta$-vectors. The preferred choice of the vectors should correspond to an interpretable $\alpha$-matrix and, to some proximity, be able to reproduce the original $\Pi$-matrix. Based on these criteria, the relations given in $H_{1,3}$, $H_{1,6}$ and $H_{1,8}$ were selected. This choice corresponds to common beliefs in the theoretical literature (McCallum (1999)). Testing the joint hypothesis, that these relations together span the cointegration space, produces a p-value of 0.80. The three selected cointegrating relations gives the following identified
system

\[ \begin{align*}
\hat{\beta}_1'X_t &= \Delta cp_t - 0.019ry_t + 0.0004t \\
\hat{\beta}_2'X_t &= il - 0.5is_t - 0.006ry_t + 0.0001t \\
\hat{\beta}_3'X_t &= is_t - 2.34cp_t - 0.02rm3
\end{align*} \] (12)

Figure 1 shows the three relations centered around their mean and labelled ECM1, ECM2 and ECM3 respectively\(^3\).

Finally, the identified relations are subjected to the recursive constance tests over the period from 1987:4 to 1998:1 described in Hansen and Johansen (????). The results are reported in Figure 2. The test indicate that the same \(\beta\)-vectors would have been accepted on any sub sample in the interval. The interpretation is that the long-run parameters of the vectors have been reasonably constant over the period.

\(^3\)ECM stands for Equilibrium error Correction Mechanism. This labeling is not strictly correct since an ECM is dependent on the short-run adjustment parameter, which should be negative.
4.2 The labor market

The analyses of the labor market and the external sector closely follows that of the demand side in section 4.1. The text will be kept as compact as possible since most of the comments carry over. For the analysis of the labor market (7) was estimated with

$$X_t = [cp_t, pp_t, w_t, al_t, u_t]$$

and a linear trend restricted in the cointegration space. Graphical inspection indicated that the assumptions \(\{cp, pp, w\} \sim I(2)\) and \(\{al, u\} \sim I(1)\) are appropriate. Testing for Price homogeneity between the nominal variables is a natural way of simplifying the analysis. This hypothesis was tested by (9) with

$$H' = \begin{pmatrix}
1 & -1 & 0 & 0 & 0 \\
0 & -1 & 1 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 1
\end{pmatrix}$$

The restrictions were accepted with likelihood ratio test value of 7.72 and a p-value of 0.05. The transformations \((w - pp)\), real producer wages and \((cp - pp)\), the wedge between consumer and producer prices (henceforth the price wedge, \(\pi\)) were included in the information set. The transformation implies only one restriction and hence that only one of \(\Delta cp, \Delta pp\) or \(\Delta w\) must be included in the analysis. The natural choice is \(\Delta cp\).

The model was re-estimated with, \(X_t = [\Delta cp_t, \pi_t, rw_t, al_t, u_t]\). The trace test is reported in Table 4 and suggests that the choice of rank should be three. Stationarity was rejected for all the variables and \(u\) was found to be weakly exogenous with \(\chi^2 = 5.92\) against \(\chi^2_{0.05} = 7.81\). Three dummy variables \(D82, D84\) and \(D91\) were included in the analysis. \(D82\) corresponds to the devaluation in at the end of 1982 while \(D84\) corresponds to a decision by the government, not to support temporary labor. Finally \(D91\) was included for the beginning of the crisis.

Finally, (11) was estimated with \(X_{1,t} = [\Delta cp_t, \pi_t, rw_t, al_t]\) and \(X_{2,t} = u_t\) and \(X_t \sim I(1)\). \(r\) was set at three based on the trace test, the \(\alpha\)-matrix and the roots of the companion matrix. The results of misspecification tests are given in Table 4 and indicate a good fit. The estimated \(\beta\)-vectors with corresponding weights are reported Table 5.

As previously, structural hypothesizes where tested given the estimated \(sp(\beta)\). The results are reported in table 6. \(H_{2,1}\) tests cointegration between inflation and unemployment and is rejected. This can be interpreted as a standard Phillips-curve. \(H_{2,2}\) tests cointegration between consumer inflation and the price wedge and rejected as well. In \(H_{2,3}\) cointegration between inflation, the price wedge and real wages is tested. This hypothesis is accepted by the data. A natural interpretation of this relation is a market pricing relation, i.e. that real wage increases lead to higher inflation and decreases in the price wedge leads to lower inflation. In \(H_{2,4}\) inflation in relation to real wages and productivity is tested and rejected. \(H_{2,5}\) tests cointegration between the
Table 4: Trace-test and tests for autocorrelation and normality

<table>
<thead>
<tr>
<th>r</th>
<th>trace</th>
<th>trace&lt;sub&gt;0.10&lt;/sub&gt;</th>
<th>likelihood ratio</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>149.42</td>
<td>82.68</td>
<td>L-B</td>
<td>0.11</td>
</tr>
<tr>
<td>1</td>
<td>76.71</td>
<td>58.96</td>
<td>LM(1)</td>
<td>0.18</td>
</tr>
<tr>
<td>2</td>
<td>41.50</td>
<td>39.08</td>
<td>LM(4)</td>
<td>0.74</td>
</tr>
<tr>
<td>3</td>
<td>16.01</td>
<td>22.95</td>
<td>$\chi^2$ for normality</td>
<td>0.98</td>
</tr>
</tbody>
</table>

Table 5: Estimated cointegrating vectors and weights

<table>
<thead>
<tr>
<th>$\Delta \text{cp}$</th>
<th>$\hat{\beta}_1$</th>
<th>$\hat{\beta}_2$</th>
<th>$\hat{\beta}_3$</th>
<th>$\hat{\alpha}_1$</th>
<th>$\hat{\alpha}_2$</th>
<th>$\hat{\alpha}_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi$</td>
<td>0.35</td>
<td>-1.34</td>
<td>-1.34</td>
<td>-0.52</td>
<td>-0.01</td>
<td>-0.09</td>
</tr>
<tr>
<td>$\text{rw}$</td>
<td>-0.11</td>
<td>-0.72</td>
<td>1</td>
<td>0.21</td>
<td>0.11</td>
<td>0.24</td>
</tr>
<tr>
<td>$\text{al}$</td>
<td>-0.13</td>
<td>1</td>
<td>0.55</td>
<td>3.93</td>
<td>-0.45</td>
<td>-0.40</td>
</tr>
<tr>
<td>$\text{u}$</td>
<td>-0.01</td>
<td>0.05</td>
<td>0.08</td>
<td>-0.11</td>
<td>-0.72</td>
<td>1</td>
</tr>
<tr>
<td>$\text{trend}$</td>
<td>0.002</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.01</td>
</tr>
</tbody>
</table>

Table 6: Structural hypothesis on the $\beta$-vectors

<table>
<thead>
<tr>
<th>hypothesis</th>
<th>$\Delta \text{cp}$</th>
<th>$\pi$</th>
<th>$\text{rw}$</th>
<th>$\text{al}$</th>
<th>$\text{u}$</th>
<th>$\text{t}$</th>
<th>LR(df)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mathcal{H}_{2,1}$</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>a</td>
<td></td>
<td>12.38(2)</td>
<td>0.00</td>
</tr>
<tr>
<td>$\mathcal{H}_{2,2}$</td>
<td>1</td>
<td>a</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td>11.23(1)</td>
<td>0.00</td>
</tr>
<tr>
<td>$\mathcal{H}_{2,3}$</td>
<td>a</td>
<td>0.5</td>
<td>-1</td>
<td>0</td>
<td>0</td>
<td></td>
<td>0.94(1)</td>
<td><strong>0.33</strong></td>
</tr>
<tr>
<td>$\mathcal{H}_{2,4}$</td>
<td>1</td>
<td>0</td>
<td>a</td>
<td>-b</td>
<td>0</td>
<td></td>
<td>9.14(1)</td>
<td>0.00</td>
</tr>
<tr>
<td>$\mathcal{H}_{2,5}$</td>
<td>0</td>
<td>1</td>
<td>a</td>
<td>-0.5</td>
<td>0</td>
<td></td>
<td>1.58(2)</td>
<td><strong>0.45</strong></td>
</tr>
<tr>
<td>$\mathcal{H}_{2,6}$</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>a</td>
<td></td>
<td>2.88(1)</td>
<td><strong>0.09</strong></td>
</tr>
</tbody>
</table>

price wedge, real producer wages and productivity. This hypothesis is accepted and can be interpreted as a labor demand relation. The last hypothesis tests cointegration between trend-adjusted real producer wages and unemployment. The relation in $\mathcal{H}_{2,5}$ is accepted and can be interpreted as labor supply.

The test whether the relations, given in $\mathcal{H}_{2,3}$, $\mathcal{H}_{2,5}$ and $\mathcal{H}_{2,6}$ spans the cointegration
space was accepted with a likelihood ratio of 3.23(4) and a p-value of 0.52. The three vectors reproduce the Π-matrix fairly well and are consistent with the α-matrix. The selected cointegration relations give the following identified system

\[
\begin{align*}
\hat{\beta}_1'X_t &= \Delta cp_t + 0.9\pi_t - 0.19rw_t + 0.002t \\
\hat{\beta}_2'X_t &= al_t - 2\pi_t - 0.71rw_t \\
\hat{\beta}_3'X_t &= rw_t + 0.05ut - 0.01t
\end{align*}
\] (13)

The three vectors are centered around their mean and presented as ECM4, ECM5 and ECM6 in Figure 3. The model was tested for constant long-run parameters. Recursive estimates of the betas over the period of 1986:01-1998:01 are presented in Figure 4.

![Figure 3: ECM 4, 5 and 6](image)

![Figure 4: A recursive test for constant β-parameters](image)

The results indicate that the β-vectors were constant parameters over the period.

### 4.3 The external sector

The external sector was analyzed by estimating (7) with, \(X_t = [cp_t, cp^*_t, s_t, il_t, il^*_t]\), the assumptions \(\{cp, cp^*, s\} \sim I(2)\) and \(\{il, il^*\} \sim I(1)\) and no trend present in the
cointegration space. A natural candidate for cointegration between the \(I(2)\) variables is the real exchange rate, \((cp - cp^* - s)\) denoted \(R\) in this paper.

This hypothesis was tested by (9), given \(r = 3\), and \(H'\) as a \((3 \times 5)\) matrix but the restriction was rejected. A more modest attempt was then made by restricting only one of the vectors. This was by (10) with \(H_1 = [1, -1, -1, 0, 0]\) and the other vectors unrestricted, which produced a \(p\)-value of 0.01. The restriction was used despite the weak support due to the rather large benefits of a simpler analysis. However, parts of the \(I(2)\) trend are likely to remain, weakening the results of this section. The transformation imply two restrictions, making it necessary to include difference of two of the series in the information set. For this purpose, \(\Delta cp\) and \(\Delta cp^*\) where chosen.

The system was re-estimated by (7). The trace-test is reported in Table 7 and indicated that \(r = 2\). Stationarity was rejected in all variables, while both the German and the domestic long-term interest-rates where found to be weakly exogenous (with \(\chi^2\)-values of 0.65 and 5.12 respectively compared with \(\chi^2_{0.05} = 5.99\)). Two dummy variables, \(D82\) and \(D92b\) were also included to account for the late devaluation in 1982 and the float in 1992.

The external sector was finally estimated by (11) where \(X_{1,t} = [\Delta cp_t, \Delta cp^*_t, R_t]\), \(X_{2,t} = [il_t, il^*_t]\) and \(X_t \sim I(1)\). The previous choice of rank was also supported by the \(\alpha\)-matrix and the roots of the companion matrix. Tests of residual normality and autocorrelation are reported in Table 7. The estimated \(\beta\)-vectors and the corresponding weights are reported in Table 8.

Table 7: Trace-test and tests for autocorrelation and normality

<table>
<thead>
<tr>
<th>(r)</th>
<th>trace</th>
<th>(\text{trace}_{0.10})</th>
<th>likelihood ratio</th>
<th>(p)-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>89.55</td>
<td>64.74</td>
<td>L-B</td>
<td>0.03</td>
</tr>
<tr>
<td>1</td>
<td>44.37</td>
<td>43.84</td>
<td>LM(1)</td>
<td>0.07</td>
</tr>
<tr>
<td>2</td>
<td>15.47</td>
<td>26.70</td>
<td>LM(4)</td>
<td>0.23</td>
</tr>
</tbody>
</table>

\(\chi^2\) for normality 0.37

Table 9 reports the results of testing linear hypotheses on \(\beta\). In \(\mathcal{H}_{3,1}\) cointegration between the real exchange rate and the spread between the two bond rates was tested. This relation can be interpreted as UIP when PPP does not hold in the short-run. The hypothesis was rejected. \(\mathcal{H}_{3,2}\) is similar to the first but the coefficients were allowed to vary but this did not change the results. \(\mathcal{H}_{3,3}\) tests a homogeneous relation between domestic inflation and the two bond rates but this was rejected. In \(\mathcal{H}_{3,4}\) the same relation is tested with German inflation. This is accepted but not very plausible. Inspection of the alpha matrix suggest that this vector has the most explanatory power.
Table 8: Estimated cointegrating vectors and weights

<table>
<thead>
<tr>
<th></th>
<th>$\hat{\beta}_1$</th>
<th>$\hat{\beta}_2$</th>
<th>$\hat{\alpha}_1$</th>
<th>$\hat{\alpha}_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta cp$</td>
<td>-22.46</td>
<td>-0.03</td>
<td>0.006</td>
<td>-0.17</td>
</tr>
<tr>
<td>$\Delta cp^*$</td>
<td>14.26</td>
<td>1</td>
<td>0.000</td>
<td>-0.83</td>
</tr>
<tr>
<td>$R$</td>
<td>1</td>
<td>-0.004</td>
<td>-0.09</td>
<td>0.56</td>
</tr>
<tr>
<td>$il$</td>
<td>-1.99</td>
<td>0.45</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>$il^*$</td>
<td>1.11</td>
<td>-1.65</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

Table 9: Structural hypothesis on the $\beta$-vectors

<table>
<thead>
<tr>
<th>hypothesis</th>
<th>$\Delta cp$</th>
<th>$\Delta cp^*$</th>
<th>$R$</th>
<th>$il$</th>
<th>$il^*$</th>
<th>LR(df)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_{3,1}$</td>
<td>0</td>
<td>0</td>
<td>a</td>
<td>-1</td>
<td>1</td>
<td>21.80(2)</td>
<td>0.00</td>
</tr>
<tr>
<td>$H_{3,2}$</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>-a</td>
<td>b</td>
<td>21.44(1)</td>
<td>0.00</td>
</tr>
<tr>
<td>$H_{3,3}$</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>a</td>
<td>-(1-a)</td>
<td>17.69(2)</td>
<td>0.00</td>
</tr>
<tr>
<td>$H_{3,4}$</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>a</td>
<td>-(1-a)</td>
<td>3.18(1)</td>
<td>0.20</td>
</tr>
<tr>
<td>$H_{3,5}$</td>
<td>0</td>
<td>-1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>7.84(3)</td>
<td>0.05</td>
</tr>
<tr>
<td>$H_{3,6}$</td>
<td>1</td>
<td>0</td>
<td>-a</td>
<td>-b</td>
<td>0</td>
<td>5.32(1)</td>
<td>0.02</td>
</tr>
</tbody>
</table>

in the equation for German inflation but it is doubtful that German inflation is in any way explained by Finnish bond rates. $H_{3,5}$ the German real long-term bond rate. This hypothesis is accepted. Finally in $H_{3,6}$ a market relation for the real exchange rate is tested and weakly accepted.

The relation in $H_{3,4}$ need some further examination. If the first three years are excluded from the data this hypothesis receives much weaker support, while the hypotheses $H_{3,5}$ and $H_{3,6}$ gains much stronger acceptance. It is likely that there is a structural brake in the external sector in the beginning of the 1980s and the unpalusible result is a residual effect of that. Hence, from an economic point of view the relations from $H_{3,5}$ and $H_{3,6}$ should be adopted.

Testing whether the two relations span the cointegration space, produces a p-value of 0.05. The selected cointegration vectors produce the following identified system

$$
\beta_1' X_t = il_t^* - \Delta cp_t^*
$$
$$
\beta_2' X_t = \Delta cp_t - 0.046R_t - 0.168il_t
$$

(14)

The two vectors are centered and presented in Figure 5 as $ECM7$ and $ECM8$ re-
spectively. Finally testing for constant parameters in the $\beta$-vectors over the period


-.02
-.01
0
.01
ECM7


-.01
0
.01
.02
.03
ECM8

Figure 5: ECM 7 and 8

1988:02-1998:01 produces Figure 6. Inspection of the figure reveals that there might

have been some instabilities at the end of the 1980s. This effect is likely to be a result

of residual $I(2)$ components left in the analysis and from the possibility of a break point

in the beginning of the sample.

4.4 Finnish inflation: the short-run structure of the combined analysis

Given the estimated long-run relationships from the previous sections the short-run

structure of the complete economy was estimated by

$$
\Delta X_{1,t} = A_1 \Delta X_{2,t} + A_2 \Delta X_{t-1} + \alpha_1 ECM_{t-1} + \mu + \Psi D_t + \varepsilon_t
$$

(15)

where $X_{1,t} = [\Delta cp_t, rm3_t, il_t, is_t, R_t, \pi_t, r w_2, al_t]$, $X_{2,t} = [\Delta cp^*_t, il^*_t, u_t, ry_t]$, $X_t = \{X_{1,t}, X_{2,t}\}$, $ECM_t$ is a column vector consisting of the eight long-run relationships and

$\alpha_1$ in a ($8 \times 8$) matrix. Note that $\Delta cp^*_t$ is included in $X_{2,t}$ as exogenous. This choice is

motivated on theoretical as well as statistical grounds$^4$. (15) corresponds to (11) with

$^4$It is highly unlikely that Finish economic variables have any explanatory power on German inflation.
\( p = 8, \ k = 2 \) and \( \beta'X_t \) given. The initial system was highly over-parameterized and reduced by applying zero restrictions in accordance with the principles of the general to specific approach. Since the focus was on explaining inflation, more caution was exerted when imposing zero-restrictions on variables with explanatory power over \( \Delta^2cp \). By this approach, the variables retained in the system after the reduction have explanatory power for the system as a whole (based on conventional F-tests) or for the \( \Delta^2cp \) equation alone (based on the t-tests in that equation).

Based on the F-tests, \( \Delta cp_{t-1}, \Delta is_{t-1}, \Delta rm3_{t-1}, \Delta il_{t-1}, \Delta R_{t-1}, \Delta rw_{t-1}, \Delta al_{t-1}, \Delta cp_t^*, \Delta cp_{t-1}^*, \Delta u_{t-1}, \Delta u_t, \Delta il_t^*, \Delta il_{t-1}^*, \Delta ry_{t-1}, ECM7_{t-1}, D88 \) and \( D92a \) could be left out of the equations (the F-tests gave p-values 0.25, 0.21, 0.83, 0.41, 0.69, 0.11, 0.41, 0.19, 0.58, 0.46, 0.39, 0.16, 0.46, 0.04, 0.46, 0.13 and 0.33 respectively). Consequently, the reduced system

\[
\Delta Y_{1,t} = A_3 \Delta Y_{2,t} + A_4 \Delta Y_{3,t-1} + \alpha_2 ECM_{t-1} + \cdots + \varepsilon_t \tag{16}
\]

was estimated where \( Y_{1,t} = [\Delta cp_t, is_t, rm3_t, il_t, R_t, \pi_t, rw_t, al_t] \), \( Y_{2,t} = [ry_t] \) and \( Y_{3,t-1} = [\pi_{t-1}] \) while \( A_3 \) and \( A_4 \) are (8 × 1) vectors, \( \alpha_2 \) is a (8 × 7) matrix and \( ECM_t \) is a vector of the seven remaining long-run relationships. The system was also tested for normality and autocorrelation of the residuals. The results are presented in Table (10) along with the correlations between the observed and estimated values of the equations.

Table 10: Test for normality and autocorrelation for the equations in model (16)

<table>
<thead>
<tr>
<th>Equ.</th>
<th>&quot;normality ( \chi^2 )</th>
<th>ARCH</th>
<th>AR 1-5</th>
<th>Correlation(obs/est)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Delta^2cp )</td>
<td>0.55</td>
<td>0.08</td>
<td>0.32</td>
<td>0.90</td>
</tr>
<tr>
<td>( \Delta is )</td>
<td>0.21</td>
<td>0.21</td>
<td>0.72</td>
<td>0.60</td>
</tr>
<tr>
<td>( \Delta rm3 )</td>
<td>0.33</td>
<td>0.08</td>
<td>0.46</td>
<td>0.72</td>
</tr>
<tr>
<td>( \Delta il )</td>
<td>0.63</td>
<td>0.08</td>
<td>\textbf{0.01}</td>
<td>0.83</td>
</tr>
<tr>
<td>( \Delta R )</td>
<td>0.96</td>
<td>0.43</td>
<td>0.70</td>
<td>0.89</td>
</tr>
<tr>
<td>( \Delta \pi )</td>
<td>0.95</td>
<td>0.43</td>
<td>0.61</td>
<td>0.83</td>
</tr>
<tr>
<td>( \Delta rw )</td>
<td>0.39</td>
<td>0.96</td>
<td>0.56</td>
<td>0.82</td>
</tr>
<tr>
<td>( \Delta al )</td>
<td>0.24</td>
<td>0.33</td>
<td>0.59</td>
<td>0.98</td>
</tr>
</tbody>
</table>

Finally, zero-restrictions on the individual equations were tested with a LR test of over-identifying restrictions against (16). The results are presented in Table (11). The restrictions on the individual equations are jointly accepted with a p-value of 0.42. Actual and fitted values are presented for the equations are presented in Figure 7 to 9.
Table 11: The final model

<table>
<thead>
<tr>
<th></th>
<th>Equ1</th>
<th>Equ2</th>
<th>Equ3</th>
<th>Equ4</th>
<th>Equ5</th>
<th>Equ6</th>
<th>Equ7</th>
<th>Equ8</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta \pi_{t-1}$</td>
<td>-0.13</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.52</td>
<td>-</td>
<td>0.68</td>
</tr>
<tr>
<td></td>
<td>(−2.48)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta r_t$</td>
<td>-</td>
<td>-</td>
<td>0.38</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.69</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(5.00)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECM1_{t-1}</td>
<td>-0.37</td>
<td>-</td>
<td>-3.58</td>
<td>-</td>
<td>-3.42</td>
<td>-</td>
<td>-</td>
<td>-1.43</td>
</tr>
<tr>
<td></td>
<td>(−3.32)</td>
<td></td>
<td>(−3.92)</td>
<td></td>
<td>(−3.61)</td>
<td></td>
<td></td>
<td>(−3.64)</td>
</tr>
<tr>
<td>ECM2_{t-1}</td>
<td>-0.66</td>
<td>-</td>
<td>-</td>
<td>-0.42</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(−3.56)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECM3_{t-1}</td>
<td>-</td>
<td>-0.07</td>
<td>-0.93</td>
<td>-</td>
<td>-1.14</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(−2.65)</td>
<td>(−2.59)</td>
<td></td>
<td>(−3.05)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECM4_{t-1}</td>
<td>-0.28</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.07</td>
<td>-0.58</td>
<td>-</td>
<td>1.69</td>
</tr>
<tr>
<td></td>
<td>(−2.73)</td>
<td></td>
<td></td>
<td></td>
<td>(2.57)</td>
<td>(−4.53)</td>
<td></td>
<td>(4.88)</td>
</tr>
<tr>
<td>ECM5_{t-1}</td>
<td>0.03</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-0.79</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(2.81)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(−8.15)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECM6_{t-1}</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-0.12</td>
<td>-0.76</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(−5.52)</td>
<td>(−5.39)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECM8_{t-1}</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.95</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(4.53)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$D82$</td>
<td>-0.01</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-0.11</td>
<td>-0.02</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$D84$</td>
<td>-</td>
<td>-</td>
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5 Price inflation, unemployment and devaluations in Finland

The estimated system of equations in table (11) reveals several interesting features of the Finnish economy during the time period. However, the interpretation of these
relationships is not straightforward as many of the links are indirect. In this section, an interpretation to some of the main features of the system is given. The aim is to find answers to the question posed in the beginning.
5.1 Price inflation and the role for monetary policy

The main determinants of the rate of change in inflation within this system can be seen by inspection of equation 1, table 11. This variable is directly negatively affected by the change in the price wedge. The intuition is that whenever the price wedge (crudely the profit mark-up) grows too large, forces such as competition will ensure that the change in inflation will decrease. The rate of change in inflation is also determined by imbalances in the long run relationships ECM1, ECM2, ECM4 and ECM5. The first two are demand side relationships while the remaining two are labor market relationships. ECM1 is error correcting in equation 1 and has the characteristics of a standard Phillips cure. If real GDP is high in relation to inflation ECM1 will be negative (under ceteris paribus and assuming initial equilibrium, see 12) and given its negative short run adjustment coefficient in equation 1 the effect on the rate of inflation will be positive. ECM2 was given the interpretation of an IS-curve. If the central bank has control over the short run interest-rates and decides to raise it, it would make ECM2 negative. Since the coefficient of ECM2 is negative in equation 1 the result would be accelerating inflation, i.e. the opposite of the conventional belief. The long-run interest rates on the other hand have the opposite effect on inflation but there is no reason to believe that the central bank can control this variable. ECM4 is also error correcting in equation 1. In that relation higher real wages makes ECM4 negative and thus results in increasing inflation (cost push effects). Similarly, a higher price wedge reduces the rate of inflation. ECM5 gives the additional effects on the rate of inflation from the labor demand schedule.

An interesting feature in system (11) is that the rate of change in inflation is not explained by neither the short-term interest rates nor real money. rm3 does not enter the inflation equation at all while is enters in ECM2 but is dominated by the long run interest-rate. In fact these variables only enter equations 2 and 3 that determines the changes in the two variables themselves. The only explanatory variable in equation 2 is ECM3 with the interpretation of a central bank policy rule. This result suggests that the central bank has some control over the short-run interest rates but the effects on inflation are marginal. The change in real money, equation 3, is explained by a direct demand effect from the change in real GDP and from long-run equilibrium corrections in ECM1 and ECM3. The sign for ECM1 suggest the interpretation that the central bank reacts to high inflation by restricting the supply of money but accommodates money demand otherwise.

Finally, the dummy variables D82, D92b and D94b are significant in equation 1. D92b probably correspond to some inflation pass-through from the second devaluation. This effect is marginal compared to the effects from the equilibrium variables.

5This result is expected to hold only under stable economic conditions. It is reasonable that the CB can create inflation by highly expansionary measures.
5.2 Wages, productivity and the price wedge

Equations 6, 7 and 8 in table (11) describe the labor market of the economy. In Equation 8, the rate of change in wages is directly and positively effected by changes in the price wedge indicating that some of the surplus is captured by the workers of the economy. The change in wages is also determined by the equilibrium adjustment from ECM1 and ECM4. ECM1 has negative sign indicating that a high activity level in the economy raises the wages. The other long run relation that determines wage inflation, ECM4, is error correcting in equation 8 and has the interpretation of a market pricing relation. By similar arguments as above it can be seen that higher inflation or larger profit mark-up leads to higher wage inflation. This is natural given the level of central bargaining and strong labor unions in Finland (Layard and Nickell (1999)).

However, strong unions and a high degree of central bargaining can also be an efficient barrier to adjustment when shocks occur (due to a low frequency of bargaining opportunities). If for example wages are sticky downwards other variables must adjust to restore equilibrium. Within the system in table (11), the variables that adapt are the change in labor productivity and the change in the price wedge (equations 6 and 7). This can be seen as follows. ECM6 is present in both these equations but absent from the change in real wages, equation 8. ECM6 represents an equilibrium relation between wages and unemployment (recall that unemployment is weakly exogenous in the system). If unemployment raises as a consequence of an adverse chock, then wages must come down to restore the equilibrium, but this does not happen directly since ECM6 does not enter equation 8. Hence, adjustment happens through equation 6 and 7. Note also that productivity is reacting to ECM5 while the price wedge reacts to ECM4.

5.3 External effects

Equation 5 describes the effects from the external sector in the system. Changes in the real exchange rate is explained by ECM1, ECM3, ECM4 and ECM8 and the real exchange rate only enters ECM8so this variable does not explain the other variables within the system. Equation 5 partly offers an explanation to the apparent lack of control over inflation by the central bank. If the central bank decides to raise the short-run interest rates it will affect the real exchange rate trough ECM3 but otherwise leaves the economy unaffected. This is likely to be a result of the capital market liberalizations in the 80s which has put some serious restriction on the role for monetary policy.
5.4 The devaluations in 1991 and 1992

The model also provides a tentative explanation to the low inflation rate after the devaluations in the early 90s. By inspecting ECM8 one can see a negative disequilibrium building up during the first six quarters. During this period, Finland had adopted a policy of a "strong" markka, by which was meant keeping a fixed exchange rate at almost any cost. This policy failed in the respect that the boom of the late 80s produced higher inflation than abroad, leaving the home currency over-valued. At the beginning of the economic crisis of the 90s, devaluation expectations raised the short-term interest-rates to extremely high levels. Eventually Finland was forced to abandon this policy and devalue the currency\textsuperscript{6}. The devaluations were in a sense only correcting the disequilibrium that can be seen in ECM8. Therefore the effects on inflation were moderate. The dummy variable $D_{92}$ captures some of the inflation pass through by the time of the second devaluation (a significant value of 0.007 in equation 1). Furthermore, the economy was already in a recession with high unemployment, when the devaluations were made.

6 Conclusions

In this paper Finnish price inflation was examined by employing a cointegrated VAR model. The long-run relationships from the demand side, the labor market, and the external sector were first investigated. These relationships were then used to estimate the short-run dynamics for the complete economy. The focus of the analysis was on inflation.

The central results were that the strongest determinants of the rate of change in inflation originated from imbalances in aggregate demand and in the labor market. It was also shown that neither the short-run interest rates nor real money have large impacts on inflation. The central bank has some control setting the short-run interest-rates and the money supply, but monetary policy is impotent as a device for controlling inflation. The devaluations in the beginning of the 90s corrected an imbalance in the real exchange rate induced by the policy of the "strong markka" and did not have a large inflation cost.

The model also provides some quite intuitive explanations for the events in the beginning of the 1990s. At the beginning of the recession, unemployment rose dramatically but due to the structure of the labor market the wages did not decrease sufficiently to counter the high unemployment. Thus, labor productivity begun increasing instead

\textsuperscript{6}In November 1991 Finland devalued by some 12%. This measure was not adequate to correct the disequilibrium and a renewed attack on the currency led to a float from December 1992 a few years onwards.
as firms demanded more from the remaining work force. This correction process was slow, leading to a long and persistent recession.

**References**


A Definitions of the variables

In this appendix the variables used in the empirical analysis are defined. The data-set span the period from 1980:1 to 1998:1, a total of 73 observations of quarterly data. All variables are given in logs unless specifically mentioned. Most of the data originate from OECD main economic indicators and OECD quarterly national account, but the $m3$ series is from the bank of Finland. The data is available from the author on request. The definitions of the dummy variables in the analysis are: D82 (1982:4 = 1), D84 (1984:4 = 1), D88 (1988:4 = 1), D91 (1991:1 = 1), D92a (1992:1 = 1), D92b (1992:4-1993:1 = 1), D94a (1994:2 = 1) and D94b (1994:3 = 1). The definitions of the
variables are:

\( cp = \) consumer price index (CPI)
\( pp = \) producer price index (PPI)
\( m3 = \) money base M3
\( cp* = \) german CPI
\( e = \) FIN/GER exchange rate
\( il = 0.0025 \times \text{yield on 10 year bonds} \)
\( is = 0.0025 \times \text{yield on 3 month interest rates} \)
\( y = \) GDP
\( u = \) unemployment rate
\( w = \) wage index of manufactures

\( rm3 = m3 - cp, \quad rw = w - pp \)
\( ry = y - cp, \quad al = y - pp - \log(\text{hours worked}) \)
\( \pi = cp - pp, \quad R = cp - s - cp \)