The Relationship between the Markup and Inflation in the G7 plus One Economies

Anindya Banerjee†                   Bill Russell

Abstract

An I(2) analysis of inflation and the markup is undertaken for the G7 economies and Australia. We find that the levels of prices and costs are best described as I(2) processes and that except in each case cointegrates with inflation and that higher inflation is associated with a lower markup in the long-run.

Keywords: Inflation, Wages, Prices, Markup, I(2), Polynomial Cointegration.

JEL Classification: C22, C32, C52, E24, E31

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1 INTRODUCTION

The proposition examined in this paper is that there exists a long-run relationship in the sense proposed by Engle and Granger (1987) where the markup decreases as inflation increases and vice versa.

This paper estimates this relationship using data from the G7 economies and Australia. A central feature of our analysis is that the level of prices and costs may be taken to be integrated of order 2 (I(2)) and that the markup is of order 1 (I(1)).

Bénabou (1992) argues within a price-taking model that higher inflation leads to greater competition and therefore a lower markup. In contrast, Russell, Evans and Preston (1997), Chen and Russell (1998) and others interpret higher inflation in terms of the costs of overcoming the missing information with higher inflation. Importantly, Bénabou and Russell (1992) argue that the price-taking model and the price-setters model are equivalent in steady state.

The logarithm of the markup, $\mu$, is defined as

$$\mu_t = \ln(p_t / \prod_{i} c_{it})$$

where $p_t$ and the $c_{it}$'s are the logarithms of prices and the costs of production respectively, and $\prod_{i} c_{it} = 1$. If the latter condition is not satisfied then the relationship between prices and costs cannot be termed the markup.

The steady state is defined as all nominal variables growing at the same constant rate.
Banerjee, Cockerell and Russell (1998) investigate the proposition using Australian inflation data and find strong empirical support of the proposition. An important question is whether the findings in Banerjee et al. are in some way peculiar to the Australian data. The 'peculiarity' of the data may be due to the nature of the shocks encountered over the sample examined, the behaviour of relative prices, or the persistence of inflation when inflation is non-stationary. To this end we proceed to examine the proposition for the G7 economies and Australia.

The empirical investigation proceeds in two stages. First we estimate an I(2) system for each economy of the core variables of interest, namely prices and costs. Except for Japan, we find that a polynomially cointegrating relationship is present between the level of the markup and the changes in the core variables.

Having obtained an estimate from the I(2) analysis of the long-run relationship between the markup and general inflation of the core variables, we proceed to estimate an I(1) system. The I(1) system is a particular and full reduction of the I(2) system and corroborates the findings in the I(2) system.

While differences emerge between the economies, the finding of polynomial cointegration for the G7 economies and Australia is remarkably robust. The only exception is Japan where the levels of prices and costs... it cannot be interpreted as the markup. Therefore, it appears that except for Japan the proposition holds elsewhere.

3 Polynomial cointegration occurs when the cointegrated levels of the data cointegrate with the differences in the levels. In our case the I(2) levels of prices and costs cointegrate to the markup which is I(1) and the markup then cointegrates with inflation which is also I(1). For a detailed discussion concerning polynomial cointegration see Johansen (1995b).

Estimation and estimation of the elasticities in the I(2) system.

2 AN IMPERFECT COMPETITION MARKUP MODEL OF PRICES

We propose estimating an imperfect competition markup equation in the Layard / Nickell tradition for the eight economies. It is assumed that in the long-run firms desire a constant markup, \( q \), of prices, \( p \), on unit costs net of the cost of inflation. Short-run deviations in the markup are due to the business cycle and non-modelled shocks. For an open economy the main inputs are labour and imports and we can write the inflation cost long-run markupequation as:

\[
\Delta p - q = \lambda \Delta \gamma - \delta \Delta \gamma - b = \Delta \ln (\gamma - l) - \Delta \ln \gamma - d = \mu
\]

where \( \Delta \gamma \) and \( \Delta \ln \gamma \) are unit labour costs and unit import prices respectively and \( \delta \) and \( \lambda \) are positive parameters. Lower case variables are in logarithms and \( \Delta \) represents the change in the variable.

When the inflation cost coefficient, \( \lambda \), is zero, inflation imposes no costs on the firm in the long-run and the long-run markup equation collapses to the standard Layard / Nickell model.

For a detailed discussion of empirical models relating the markup with inflation see Cockerell and Russell (1995) and Banerjee et al. (1998)).
In the more general case when $0 > \lambda$ inflation imposes costs on the firm in terms of a lower markup net of the cost of inflation. This is given by $p q - \lambda = \lambda$.

The coefficients $\delta$ and $\delta - 1$ in (1) are the long-run price elasticities with respect to unit labour costs and import prices respectively. Linear homogeneity is imposed as the coefficients sum to one so that $q$ represents the markup of prices on costs. Linear homogeneity suggests that all else equal an increase in costs is fully reflected in higher prices in the long-run leaving the markup unchanged.

### 2.1 The I(2) System

The I(2) system analysis is an extension of the now standard I(1) system analysis. For a detailed theoretical outline of the model estimated here see Banerjee et al. (1998). Other empirical applications of the I(2) theory can be found in Engsted and Haldrup (1998) and Juselius (1998).

For illustration, suppose the long-run price equation can be written as a second order vector autoregression of the core variables, $t x$, of dimension $1 \times n$:

$$t = \Phi t + \Pi t + \mu + \varepsilon_{\mu}$$

where $\mu$ is a vector of unrestricted constant terms and $t D$ is a vector of predetermined variables that are assumed not to enter the cointegration space and on which the empirical analysis is conditioned. The lower case variables are in logs and in our case $3 = n$ and the core variables, $t x$, are the price level, unit labour costs and import prices. It is assumed that

$$\varepsilon_{\mu}$$

is a $-n$ dimensional Gaussian vector of errors. The I(2) analysis provides us with the orthogonal decomposition into the I(0), I(1) and I(2) relationships of the data with dimensions $r$, $s$ and $s - r - n$, respectively. Furthermore, the number of polynomially cointegrating vectors is equal to the number of I(2) trends, $n - r - s$.

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### 2.2 The Data

The data are quarterly, seasonally adjusted and taken from the June 1997 OECD Data Compendium. The length of the data sample for each economy is the maximum possible from the source given the series involved. West German data is used for Germany to avoid data problems associated with the reunification with East Germany to avoid data problems associated with the reunification with East Germany.

Except for the United States the price index is the private consumption implicit price deflator at 'factor cost'. Unit labour costs are calculated as total labour compensation divided by an 'average' cost,. Unit labour costs are calculated as total labour compensation divided by an 'average' cost. Import prices is the implicit price deflator for the imports of goods and services.

### The I(2) System

In the above equation each entry in $\varepsilon_{\mu}$ is a Gaussian distributed with mean equal to zero and variance equal to one.

$$\varepsilon_{\mu} \sim N(0, 1)$$

For illustration, suppose the long-run price equation can be written as a second order vector

$$x = \Phi x + \Pi x + \mu + \varepsilon_{\mu}$$

where $\mu$ is a vector of unrestricted constant terms and $x D$ is a vector of predetermined variables.

In the long-run, leaving the markup unchanged, the coefficients $b$, $\mu$ in (1) represent the markup of prices on costs. Larger long-run costs and import price responses reflect lower long-run costs and import price deflation with respect to unit wage levels. This is given by $b = \mu$.

In the more general case when $0 > \lambda$ inflation imposes costs on the firm in terms of a lower markup net of the cost of inflation.
The consumption deflator at factor cost was initially used for the United States but gave conflicting results. While the I(2) analysis indicated that the level of prices and costs were best described as I(2) ... markup' result is not useful in investigating the proposition, the GDP implicit price deflator at factor cost was used.

The predetermined variables are the log change in the unemployment rate and a number of spike intervention dummies to capture the sometimes erratic short-run wage and price behaviour of firms and labour. This is especially the case during the OPEC oil price shocks and large shifts in exchange rates and tax regimes. A step dummy is introduced for the period leading up to March 1968 ... competitive environment in these economies. Further details of the pre-determined variables are available in Appendix B.

The log change in the unemployment rate represents the business cycle in the model. An alternative specification of the empirical model would be to include the level of unemployment in the cointegrating space ... that of an indicator of the business cycle. It was therefore decided to allow for the effects of the business cycle by conditioning on a stationary pre-determined variable given by the log change in the unemployment rate and its lags. The data appendix describes in more detail the data and its sources.

The integration properties of the data were investigated using PT and DF-GLS univariate unit root tests from Elliot, Rothenberg and Stock (1996).

Prices are clearly I(2) except for Japan and West Germany which are marginally I(2). Similarly unit labour costs are mostly I(2) or marginally I(2). One ... clear acceptance of the hypothesis that they are I(1) which can only occur if all the core variables are I(2). Consequently we proceed under the assumption that the core variables are I(2). This assumption is supported by the rejection of the null of a unit root in all the core variables. The hypothesis of the correct number of lags is rejected for many of the economies. However, numerical tests of the Phillips-Perron version of the test confirm that the core variables are I(2). One exception is Australia where it appears that unit roots may be present in some of the variables.

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The I(2) System Results

Table 1 shows the results of the joint trace tests for determining \( r \) and \( s \) for the eight economies. In the case of the United States, Japan, Germany, France and the United Kingdom the hypothesis of \( r = s = 0 \) is accepted and our findings are corroborated by looking at the data.

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at the roots of the companion matrix (see Appendix B). The results therefore show that the levels of prices and costs in each of these economies contain an I(2) trend. Moreover, since there is only one cointegrating vector and hence it is of the polynomially cointegrating type.

For the remaining economies, Italy, Canada and Australia, there is a marginal rejection of \( 1 = r \), \( 1 = -s - r n \). However, we choose to accept this null hypothesis since the critical values on which inference is based are asymptotic and have been computed under the assumption that there are no pre-determined variables, including dummies, in the system. Not only would taking account of pre-determined variables raise the critical values (thereby leading to acceptance of the maintained hypothesis), the evidence from the roots of the companion matrix for these economies are unambiguously in favour of our hypothesis.

The subsequent I(1) system analysis in the next section confirms these results. Imposing \( 1 = r \) and \( 1 = -s - r n \) on each system imposes a polynomial cointegrating vector on the analysis in each case. Table 2 reports the normalised cointegrating vectors with linear homogeneity imposed for each economy. Except for Japan the hypothesis of linear homogeneity is accepted and, therefore, the levels of prices and costs cointegrate to the markup in the polynomially cointegrating vector.

For Japan, Germany, France and Canada import prices enter the markup with an insignificant coefficient. The analysis is therefore re-estimated excluding import prices and the results of the joint trace tests for the two variable systems are reported in Table 1 and again support the hypothesis that \( 1 = r \) and \( 1 = -s - r n \). Reported in Table 2 are the normalised cointegrating vectors. The results now hold as before for Germany, France and Canada but the estimated coefficients for Japan are not interpretable as the markup since the test for linear homogeneity continues to be rejected strongly.

Since the steady state is defined by the condition \( \Delta p_m = \Delta u = \Delta c = \Delta p \), we see in Table 2 that for the economies where the markup is defined, the sum of the coefficients on the difference terms is negative. This implies that there is a negative relationship between general inflation and the markup in the long-run.

ESTIMATING THE I(1) SYSTEM

The I(2) analysis provides estimates of polynomial cointegration between a linear combination of the markup and the differences in the core variables. In an economic sense it is necessary for \( \Delta p_m = \Delta u = \Delta c = \Delta p \) in the very long-run. However, the method of estimating the polynomial relationship between the markup and the differences in the core variables is a two step approach. The [1] approach provides estimates of polynomial cointegration between the

### Table 2: Normalised Cointegrating Vectors

<table>
<thead>
<tr>
<th>Country</th>
<th>Normalised Cointegrating Vector</th>
<th>Linear Homogeneity Assumed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The moduli of the first four roots are 1.0, 1.0, 1.0, 0.7144 for Italy, 1.0, 1.0, 0.9881, 0.8161 for Canada and 1.0, 1.0, 0.9417, 0.6533 for Australia under the assumption of \( 1 = r \). A finding of \( 1 = -s - r n \) would therefore not be consistent with the third root of close to unity for these economies if \( 1 = r \) is maintained.
Having established polynomial cointegration in the I(2) analysis, a particular reduction to I(1) space helps us establish the relationship of primary concern to us, namely; between price inflation and the markup. In this reduction we make use of the result that the decomposition into the I(0), I(1) and I(2) directions is an orthogonal one.

In particular, the vectors $\beta'$ and $2 \beta'$ lie in the space orthogonal to $3 \beta'$. Thus if

$$ b \equiv \beta' $$

then a basis for the space orthogonal to $3 \beta'$ is given by the matrix

$$
\begin{pmatrix}
-1 & 0 & 1 & 0 \\
0 & 1 & 1 & 0 \\
0 & 0 & 0 & 1
\end{pmatrix}
$$

Therefore

$$
\Delta_t = \begin{pmatrix}
0 & \Delta_t & \Delta_t & \Delta_t
\end{pmatrix}
$$

is a valid full reduction and under linear homogeneity

$$ f $$. Furthermore we can retrieve the implicit markup of prices on unit costs from this companion matrix strongly support the finding of 1 cointegrating vector.

Table 3 reports the adjustment coefficients and the error correction terms for each economy. We see that the ECM appears strongly in each of the 'markup' equations and, except for Italy, is insignificant in the equation for price inflation. The estimated inflation cost coefficients, $\lambda$, from the I(1) and I(2) analyses are given in Table 4 of Appendix C. From there it appears that the ECs are significant and that the inflation costs are strongly related to the markup.

Table 4 reports the implicit long-run price elasticities with respect to costs from the I(1) analysis and the equivalent estimates from the I(2) analysis. Also shown are the estimated inflation cost coefficients, $\lambda$, from the I(1) and I(2) analyses. The long-run impact of a one percentage point increase in annual steady state inflation on the markup is shown in the final column and range between 3.0 percent for the United States and 2 percent for Italy. It appears likely, therefore, that the long-run relationship between inflation and the markup is important in economic sense.

CONCLUSION

One explanation of the negative long-run relationship is that the 1970s were a period when supply shocks from the energy and labour markets were very prevalent. The low markup, therefore, simply reflects the lags in price adjustment following the shocks. The supply shocks also affected the terms of trade and therefore the prices of goods and services. The low markup is consistent with the view that prices of goods and services were not fully passed through to the final goods market. This suggests that when these shocks occurred they were not reflected in the price inflation, but rather in the cost inflation. The inflation cost coefficients, $\lambda$, are also reported in Table 4 of Appendix C. We see that the ECs are significant and that the inflation costs are strongly related to the markup.

In particular, the vectors $\phi$ and $2 \phi$ lie in the space orthogonal to $3 \phi$. Thus if

$$ (q', \phi') = (q', \phi') $$

the decomposition into the I(0) and I(2) directions is orthogonal. The unobserved components of the I(1) equations are orthogonal to the estimated inflation cost coefficients, $\lambda$, from the I(1) and I(2) analyses. The I(2) equations, therefore, provide the basis for further exploration of the economic significance of the estimated inflation cost coefficients, $\lambda$.
adjustment appears to be very slow for economies with little or no price controls. In most cases the relatively low markups persist for around 10 years following the shocks and the markup does not fully recover until the economy again experiences low inflation.

Graph 1 presents the long-run relationship, $L_R$, for the United States and the United Kingdom from the I(1) analysis along with the realisations of the markup and inflation for five distinct inflationary periods indicated by different symbols.

If the 'supply shocks' argument is correct then different mean levels of inflation would not affect the behaviour of the markup. Consequently, if inflation were to change and had nothing to do with demand shocks then the markup and inflation would follow the same curve. However, this is not observed. If the data are subdivided by inflation, then different inflation periods would be distributed along the entire curve in Graph 1. This however is not the case. The observations remain consistent with the general level of markup for the period following the early 1990s recession.

The observations remain consistent with the general level of markup for the period following the early 1990s recession. We can follow the relationship through the entire period until the mid-1970s. An analysis of the data shows that the regression for the period following the mid-1970s does not show a consistent pattern. The line of regression does not show a consistent pattern. However, this is not the case for the United States and the United Kingdom. The line of regression for the period following the early 1990s recession shows a consistent pattern.

If the actual observations are divided into periods of inflation with different means, the associated mean levels of the markups are different. For example, for both the United States and the United Kingdom, the early 1990s recession shows a consistent pattern. However, this is not the case for the United States and the United Kingdom. The line of regression for the period following the early 1990s recession shows a consistent pattern.

13 Similar graphs can be constructed for the other economies but for brevity only the United States and the United Kingdom is shown here. Appendix D reports scatter graphs of inflation and the estimated markup for each economy along with the long-run relationship, $L_R$, for each economy.
REFERENCES


Simon, J. (1999). Markups and Inflation, Department of Economics, Mimeo, MIT.


Tests of linear homogeneity and zero weight on coefficient are likelihood ratio tests distributed as $\chi^2$ in the I(1) analysis. Critical $r = Q(r)$ is the likelihood ratio statistic for determining $Q(s, r)$ conditional on predetermined variables on which the analysis is conditioned.

Notes: Statistics are computed with 4 lags of the core variables. See Appendix B for details of the procedure.

<table>
<thead>
<tr>
<th>Country</th>
<th>Sample Periods</th>
<th>Sample</th>
<th>(Q(s, r))</th>
<th>(Q(s))</th>
<th>(Q(r))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>67:1-97:1</td>
<td>1</td>
<td>13.33</td>
<td>11.73</td>
<td>1.60</td>
</tr>
<tr>
<td>France</td>
<td>71:4-97:2</td>
<td>2</td>
<td>13.32</td>
<td>11.07</td>
<td>2.25</td>
</tr>
<tr>
<td>Italy</td>
<td>62:1-94:4</td>
<td>3</td>
<td>16.98</td>
<td>14.75</td>
<td>2.23</td>
</tr>
<tr>
<td>Germany</td>
<td>71:1-94:4</td>
<td>4</td>
<td>17.04</td>
<td>14.75</td>
<td>2.29</td>
</tr>
</tbody>
</table>

Table 2: Cointegrating Vectors of the I(2) System Analysis

Table 1: The 'Joint Procedure' for Estimating $r$ and $s$
Table 3: I(1) System Adjustment Coefficients and Error Correction Terms

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Markup</th>
<th>Real Exchange Rate</th>
<th>Inflation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mulc</td>
<td>-0.298 (-5.7)</td>
<td>-0.182 (-1.2)</td>
<td>-0.061 (-2.0)</td>
</tr>
<tr>
<td>Germany</td>
<td>-0.116 (-4.7)</td>
<td>-0.017 (-1.4)</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>-0.194 (-4.9)</td>
<td>-0.092 (-3.7)</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>-0.039 (-2.7)</td>
<td>-0.079 (-2.3)</td>
<td>-0.030 (-5.1)</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>-0.278 (-6.4)</td>
<td>0.009 (0.1)</td>
<td>-0.080 (-3.2)</td>
</tr>
<tr>
<td>Canada</td>
<td>-0.085 (-3.0)</td>
<td>-0.068 (-4.6)</td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>-0.189 (-4.0)</td>
<td>0.125 (1.5)</td>
<td>-0.041 (-2.0)</td>
</tr>
</tbody>
</table>

Notes: Reported in brackets are t-statistics.

Table 4: I(1) and I(2) Estimates of the Markup and the Inflation Cost Coefficient

<table>
<thead>
<tr>
<th></th>
<th>λ Long-run Effect on the Markup of a 1 Percentage Point Increase in ( \Delta p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Markup Coefficient</td>
<td>λ Long-run Effect on the Markup of a 1 Percentage Point Increase in ( \Delta p )</td>
</tr>
<tr>
<td>United States I(1)</td>
<td>1 - 0.944 - 0.056 - 1.851 0.5</td>
</tr>
<tr>
<td>I(2)</td>
<td>1 - 0.937 - 0.063 - 1.390 0.3</td>
</tr>
<tr>
<td>Germany I(1)</td>
<td>1 - 1 - 4.748 1.2</td>
</tr>
<tr>
<td>I(2)</td>
<td>1 - 1 - 3.678 0.9</td>
</tr>
<tr>
<td>France I(1)</td>
<td>1 - 1 - 2.672 0.7</td>
</tr>
<tr>
<td>I(2)</td>
<td>1 - 1 - 2.756 0.7</td>
</tr>
<tr>
<td>Italy I(1)</td>
<td>1 - 0.685 - 0.315 - 8.174 2.0</td>
</tr>
<tr>
<td>I(2)</td>
<td>1 - 0.717 - 0.283 - 8.043 2.0</td>
</tr>
<tr>
<td>United Kingdom I(1)</td>
<td>1 - 0.878 - 0.122 - 2.523 0.6</td>
</tr>
<tr>
<td>I(2)</td>
<td>1 - 0.877 - 0.123 - 2.263 0.6</td>
</tr>
<tr>
<td>Canada I(1)</td>
<td>1 - 1 - 4.318 1.1</td>
</tr>
<tr>
<td>I(2)</td>
<td>1 - 1 - 4.538 1.1</td>
</tr>
<tr>
<td>Australia I(1)</td>
<td>1 - 0.858 - 0.142 - 5.383 1.3</td>
</tr>
<tr>
<td>I(2)</td>
<td>1 - 0.785 - 0.215 - 5.427 1.4</td>
</tr>
</tbody>
</table>

* A percentage point increase in annual inflation is equivalent to an increase in \( \Delta p \) of 0.25 per quarter.
The data are quarterly and drawn from the June 1997 OECD Statistical Compendium. The table below reports the identification codes of the series used in the estimation of the models.

**Data Codes for the OECD Statistical Compendium**

Series: United States, Japan, Germany, France

- **Current Price GDP**: 421008SC, 461008SC, 131008SC, 141008SC
- **Constant Price GDP**: 421108SR, 461108SR, 131108SR, 141108SR
- **Indirect Taxes less Subsidies**: 421304SC, 461304OC*, 131304OC*, 141304SC
- **Private Consumption Deflator**: 421201SK, 461201SP...
- **Total Labour Compensation**: 161301SM, 261301SC, 141301SC, 541301SC
- **Standardised Unemployment Rate**: 4242889J, 464286A3, 134280A2, 144286A3

Series: Italy, United Kingdom, Canada, Australia

- **Current Price GDP**: 29(5)261008SC, 441008SC, 541008SC
- **Constant Price GDP**: 29(5)261108SL, 441108SL, 541108S1
- **Indirect Taxes less Subsidies**: 28(5)261304SC, 441304SC, 541304SC
- **Private Consumption Deflator**: 161201SP, 261201SP, 141201SP, 541201S2
- **Total Labour Compensation**: 161301SM, 261301SC, 141301SC, 541301SC
- **Standardised Unemployment Rate**: 164286A3, UKOCSUN%E, 544286A3(4)
- **Imports of Goods and Services Deflator**: 161205SP, 261205SP, 141205SP, 541205S2

Notes:

- **(a)** Unit labour costs = total labour compensation divided by constant price gross domestic product (GDP).
- **(b)** The private consumption implicit price deflator at 'factor cost' is calculated as:
  \[
  \text{P} = \frac{M + a}{1 + a}
  \]
  where \(M\) is the consumption implicit price deflator at market prices and \(a\) is the proportion of indirect tax less subsidies in current price GDP.
- **(c)** Total labour compensation and indirect taxes less subsidies for Japan and Germany were seasonally adjusted by exponential smoothing using ESMOOTH in RATS.

* Not seasonally adjusted.

(1) Derived from 131006SC and 131106SR (current price and constant price imports of goods and services respectively).

(2) Prior to March 1982 use 144295A3.

(3) Prior to March 1975 use UKOCUNE%E plus 0.954839.


(5) Italian data from www.bbs.istat and Conti economici nazionali trimestrali 70.1-97.4 (03/98). Constant price data from C3VAGKD, current price data from C3VAGLD.
APPENDIX B: ESTIMATING THE I(2) SYSTEM

B.1 The Predetermined Variables


Japan: For \( n = 3 \) and \( n = 2 \). 3 lags of the first difference of the log of the unemployment rate and dummies for: March 1974, March 1975, June 1975.


France: For \( n = 3 \) and \( n = 2 \). 2 lags of the first difference of the log of the unemployment rate, a step dummy up to and including March 1975 and not restricted in the cointegrating space and dummies for: March 1974, December 1977, and September 1982.


Canada: For \( n = 3 \) and \( n = 2 \). 3 lags of the first difference of the log of the unemployment rate, a step dummy up to and including March 1970 not restricted in the cointegrating space and dummies for: September 1974, December 1976, December 1990, December 1991.


### B.2 Roots of the Companion Matrix

<table>
<thead>
<tr>
<th>Country</th>
<th>Modulus of Roots of the Companion Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>1.0000 1.0000 0.9006 0.7704 0.6092</td>
</tr>
<tr>
<td>Japan</td>
<td>1.0000 1.0000 0.9833 0.6800 0.6800</td>
</tr>
<tr>
<td>Germany</td>
<td>1.0538 1.0000 1.0000 0.7864 0.7864</td>
</tr>
<tr>
<td>France</td>
<td>1.0000 1.0000 0.9936 0.6797 0.6797</td>
</tr>
<tr>
<td>Italy</td>
<td>1.0071 1.0000 1.0000 0.7144 0.7144</td>
</tr>
<tr>
<td>United Kingdom</td>
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<td>Australia</td>
<td>1.0000 1.0000 0.9417 0.6533 0.4837</td>
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</tbody>
</table>
APPENDIX C:  RESULTS OF THE I(1) ANALYSIS

Table C1: Testing for the Number of Cointegrating Vectors

<table>
<thead>
<tr>
<th></th>
<th>United States</th>
<th>United Kingdom</th>
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<tr>
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</tr>
<tr>
<td></td>
<td>Eigenvalues</td>
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<tr>
<td></td>
<td>Q(r)</td>
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<td>Notes: Statistics are computed with 4 lags of the core variables. Q(r) is the likelihood ratio statistic for determining r in the I(1) analysis. 90 percent critical values shown in curly brackets { } are from Table 15.3 of Johansen (1995b).</td>
<td></td>
<td></td>
</tr>
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Table C2: Modulus of the Roots of the Companion Matrix

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<tr>
<th></th>
<th>United States</th>
<th>Germany</th>
<th>France</th>
<th>Italy</th>
<th>United Kingdom</th>
<th>Canada</th>
<th>Australia</th>
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<tbody>
<tr>
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<td>0.9690</td>
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<td>0.9690</td>
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<tr>
<td>Notes: Number of observations: 144. Lags in the core variables = 4. Reported in brackets are t-statistics. The ECM is calculated: ( \Delta \text{markup} + \Delta \text{real exchange rate} + \Delta \text{inflation} = \text{ECM} ). Implicit markup: ( \Delta \text{markup} - \text{ECM} \times \text{ECM} ). Predetermined variables are 1 lag of log unemployment, a step dummy up to June 1968 not in the cointegrating space and dummies for: June 1972, March 1974, June 1978, March 1982, and March 1991.</td>
<td></td>
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</tbody>
</table>

Table C3: I(1) System Analysis:  The United States

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Equation</th>
<th>Equation</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Markup'</td>
<td>Δmulc</td>
<td>Δmulc</td>
<td>Δmulc</td>
</tr>
<tr>
<td>'Real Exchange Rate'</td>
<td>Δrer</td>
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</tr>
<tr>
<td>'Inflation'</td>
<td>Δp</td>
<td>Δp</td>
<td>Δp</td>
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</tbody>
</table>

Loading Matrix

<table>
<thead>
<tr>
<th></th>
<th>α</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error Correction Term - 0.298 (- 5.7)</td>
<td></td>
</tr>
<tr>
<td>Error Correction Term - 0.182 (- 1.2)</td>
<td></td>
</tr>
<tr>
<td>Error Correction Term - 0.061 (- 2.2)</td>
<td></td>
</tr>
<tr>
<td>Constant - 1.553 (- 5.7)</td>
<td></td>
</tr>
<tr>
<td>- 0.948 (- 1.2)</td>
<td></td>
</tr>
<tr>
<td>- 0.316 (- 2.2)</td>
<td></td>
</tr>
</tbody>
</table>

\( R^2 = 0.39 \) \( 0.64 \) \( 0.52 \)

Notes: Number of observations: 144. Lags in the core variables = 4. Reported in brackets are t-statistics. The ECM is calculated: \( \Delta \text{markup} + \Delta \text{real exchange rate} + \Delta \text{inflation} = \text{ECM} \). Implicit markup: \( \Delta \text{markup} - \text{ECM} \times \text{ECM} \). Predetermined variables are 1 lag of log unemployment, a step dummy up to June 1968 not in the cointegrating space and dummies for: June 1972, March 1974, June 1978, March 1982, and March 1991. |

Tests for Serial Correlation

<table>
<thead>
<tr>
<th>LM(1)2</th>
<th>LM(4)2</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \chi^2(9) = 12.59 )</td>
<td>prob-value = 0.18</td>
</tr>
<tr>
<td>( \chi^2(9) = 4.52 )</td>
<td>prob-value = 0.87</td>
</tr>
</tbody>
</table>

Test for Normality

Doornik-Hansen Test for normality: \( \chi^2(6) = 10.15 \) | prob-value = 0.12 |
### Table C3: I(1) System Analysis: Germany

**September 1970 – December 1994**

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Equation</th>
<th>Loading Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Markup'</td>
<td>( \Delta )</td>
<td>( \alpha )</td>
</tr>
<tr>
<td>'Inflation'</td>
<td>( \Delta )</td>
<td>( \alpha )</td>
</tr>
</tbody>
</table>

#### Error Correction Term

- **Constant**: \( -0.116 \) (-4.7) \( -0.017 \) (-1.4)
- **\( R^2 \)**: 0.49 0.41

**Notes:** Number of observations: 98. Lags in the core variables = 4. Reported in brackets are \( t \)-statistics. The ECM is calculated:

\[ t_t \Delta \text{markup} + t_t \Delta \text{inflation} = \sum \text{ECM} \]

- **Predetermined variables**:
  - 1 lag of log unemployment

#### Tests for Serial Correlation

- **LM(1)**: \( \chi^2(4) = 1.65 \), prob-value = 0.80
- **LM(4)**: \( \chi^2(4) = 7.70 \), prob-value = 0.10

#### Test for Normality - Doornik-Hansen Test

- \( \chi^2(4) = 6.99 \), prob-value = 0.14

---

### Table C3: I(1) System Analysis: France

**December 1971 – March 1997**

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Equation</th>
<th>Loading Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Markup'</td>
<td>( \Delta )</td>
<td>( \alpha )</td>
</tr>
<tr>
<td>'Inflation'</td>
<td>( \Delta )</td>
<td>( \alpha )</td>
</tr>
</tbody>
</table>

#### Error Correction Term

- **Constant**: \( -0.194 \) (-4.9) \( -0.092 \) (-3.7)
- **\( R^2 \)**: 0.49 0.71

**Notes:** Number of observations: 102. Lags in the core variables = 4. Reported in brackets are \( t \)-statistics. The ECM is calculated:

\[ t_t \Delta \text{markup} + t_t \Delta \text{inflation} = \sum \text{ECM} \]

- **Predetermined variables**:
  - 2 lags of log unemployment
  - Step dummy up to June 1975

#### Tests for Serial Correlation

- **LM(1)**: \( \chi^2(4) = 0.93 \), prob-value = 0.92
- **LM(4)**: \( \chi^2(4) = 5.76 \), prob-value = 0.22

#### Test for Normality - Doornik-Hansen Test

- \( \chi^2(4) = 1.24 \), prob-value = 0.87

---

### Table C3: I(1) System Analysis: Italy

**March 1972 – March 1997**

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Equation</th>
<th>Loading Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Markup'</td>
<td>( \Delta )</td>
<td>( \alpha )</td>
</tr>
<tr>
<td>'Real Exchange Rate'</td>
<td>( \Delta )</td>
<td>( \alpha )</td>
</tr>
<tr>
<td>'Inflation'</td>
<td>( \Delta )</td>
<td>( \alpha )</td>
</tr>
</tbody>
</table>

#### Error Correction Term

- **Constant**: \( -0.039 \) (-2.7) \( -0.079 \) (-2.3) \( -0.030 \) (-5.1)
- **\( R^2 \)**: 0.40 0.56 0.60

**Notes:** Number of observations: 101. Lags in the core variables = 4. Reported in brackets are \( t \)-statistics. The ECM is calculated:

\[ t_t \Delta \text{markup} + t_t \Delta \text{real exchange rate} + t_t \Delta \text{inflation} = \sum \text{ECM} \]

- **Predetermined variables**:
  - 3 lags of log unemployment

#### Tests for Serial Correlation

- **LM(1)**: \( \chi^2(9) = 5.53 \), prob-value = 0.79
- **LM(4)**: \( \chi^2(9) = 12.08 \), prob-value = 0.21

#### Test for Normality - Doornik-Hansen Test

- \( \chi^2(6) = 1.56 \), prob-value = 0.96

---

### Table C3: I(1) System Analysis: The United Kingdom

**December 1961 – March 1997**

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Equation</th>
<th>Loading Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Markup'</td>
<td>( \Delta )</td>
<td>( \alpha )</td>
</tr>
<tr>
<td>'Real Exchange Rate'</td>
<td>( \Delta )</td>
<td>( \alpha )</td>
</tr>
<tr>
<td>'Inflation'</td>
<td>( \Delta )</td>
<td>( \alpha )</td>
</tr>
</tbody>
</table>

#### Error Correction Term

- **Constant**: \( -0.278 \) (-6.4) \( 0.009 \) (0.1) \( -0.080 \) (-3.2)
- **\( R^2 \)**: 0.39 0.37 0.70

**Notes:** Number of observations: 142. Lags in the core variables = 4. Reported in brackets are \( t \)-statistics. The ECM is calculated:

\[ t_t \Delta \text{markup} + t_t \Delta \text{real exchange rate} + t_t \Delta \text{inflation} = \sum \text{ECM} \]

- **Predetermined variables**:
  - 2 lags of log unemployment

#### Tests for Serial Correlation

- **LM(1)**: \( \chi^2(9) = 14.66 \), prob-value = 0.10
- **LM(4)**: \( \chi^2(9) = 9.80 \), prob-value = 0.37

#### Test for Normality - Doornik-Hansen Test

- \( \chi^2(6) = 8.92 \), prob-value = 0.18
Table C3: I(1) System Analysis: Canada
March 1962 – March 1997

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Equation</th>
<th>Loading Matrix</th>
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</thead>
<tbody>
<tr>
<td>Markup</td>
<td>( \Delta \text{mulc} )</td>
<td>[ (\alpha_{\Delta \text{mulc}} = -0.085, \text{t-stat} = -3.0) ]</td>
</tr>
<tr>
<td>Inflation</td>
<td>( \Delta \text{p} )</td>
<td>[ (\alpha_{\Delta \text{p}} = -0.068, \text{t-stat} = -4.6) ]</td>
</tr>
</tbody>
</table>

**Loading Matrix**

- \( \alpha_{\Delta \text{mulc}} = -0.085, \text{t-stat} = -3.0 \)
- \( \alpha_{\Delta \text{p}} = -0.068, \text{t-stat} = -4.6 \)
- Error Correction Term: -0.426, \(-3.0\)
- Error Correction Term: -0.342, \(-4.6\)

\[ R^2 = 0.35, 0.57 \]

**Notes:** Number of observations: 141. Lags in the core variables = 4. Reported in brackets are t-statistics. The ECM is calculated:

\[ \Delta \text{mulc} + \Delta \text{p} + \text{ECM} = 0 \]

Tests for Serial Correlation

- \( LM(1) \chi^2(9) = 2.78, \text{prob-value} = 0.60 \)
- \( LM(4) \chi^2(9) = 2.00, \text{prob-value} = 0.74 \)

Tests for Normality

- Doornik-Hansen Test for normality: \( \chi^2(6) = 12.74, \text{prob-value} = 0.01 \)

Table C3: I(1) System Analysis: Australia
March 1967 – March 1997

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Equation</th>
<th>Loading Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Markup</td>
<td>( \Delta \text{mulc} )</td>
<td>[ (\alpha_{\Delta \text{mulc}} = -0.189, \text{t-stat} = -4.0) ]</td>
</tr>
<tr>
<td>Real Exchange Rate</td>
<td>( \Delta \text{rer} )</td>
<td>[ (\alpha_{\Delta \text{rer}} = 0.125, \text{t-stat} = 1.5) ]</td>
</tr>
<tr>
<td>Inflation</td>
<td>( \Delta \text{p} )</td>
<td>[ (\alpha_{\Delta \text{p}} = -0.041, \text{t-stat} = -2.0) ]</td>
</tr>
</tbody>
</table>

**Loading Matrix**

- \( \alpha_{\Delta \text{mulc}} = -0.189, \text{t-stat} = -4.0 \)
- \( \alpha_{\Delta \text{rer}} = 0.125, \text{t-stat} = 1.5 \)
- \( \alpha_{\Delta \text{p}} = -0.041, \text{t-stat} = -2.0 \)
- Error Correction Term: -1.001, \(-4.0\)
- Error Correction Term: 0.665, \(1.5\)
- Error Correction Term: -0.215, \(-2.0\)

\[ R^2 = 0.40, 0.40, 0.52 \]

**Notes:** Number of observations: 121. Lags in the core variables = 4. Reported in brackets are t-statistics. The ECM is calculated:

\[ \Delta \text{mulc} + \Delta \text{rer} + \text{ECM} = 0 \]

Tests for Serial Correlation

- \( LM(1) \chi^2(9) = 15.63, \text{prob-value} = 0.08 \)
- \( LM(4) \chi^2(9) = 7.47, \text{prob-value} = 0.59 \)

Tests for Normality

- Doornik-Hansen Test for normality: \( \chi^2(6) = 9.75, \text{prob-value} = 0.14 \)

APPENDIX D: I(1) ANALYSIS OF THE MARKUP AND INFLATION
UNITED STATES
September 1961 - June 1997

The solid line shows the estimated cointegrating relationship from the I(1) analysis between the markup and price inflation assuming the change in unemployment, spike dummies and the differences of the core variables and their differences. The crosses indicate the observations that correspond to the spike dummies.