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The Long-Run Relationships among Relative Price Variability, Inflation and the Markup*

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Abstract

This paper links two existing but separate literatures. Measures of the markup, inflation and relative price variability (RPV) from annual and quarterly US and UK data are used to examine the relationships among the variables. The results show that two long-run relationships can be identified from the data: a negative relationship between inflation and the markup and a positive relationship between inflation and RPV. As RPV does not enter the inflation-markup long-run relationship we argue that explanations of this relationship based on RPV are poor even though they may help explain a short-run relationship between the variables.

Keywords: markup, inflation, relative price variability, cointegration.

JEL Classification: C32, E31.

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CONTENTS

1. INTRODUCTION

This paper draws together two existing but separate literatures on the relationship between inflation, the markup and relative price variability (RPV). Previous empirical work by Richards and Stevens (1987), Bénabou (1992), Franz and Gordon (1993), Cockerell and Russell (1995), de Brouwer and Ericsson (1998), Simon (1999) and Batini, Jackson, and Nickell (2000) has assumed that inflation and the markup are stationary and has led to the general view that there is a negative relationship between inflation and the markup. This relationship has been described as a short-run relationship by some authors while Banerjee, Cockerell, and Russell (2001) and Banerjee and Russell (2000, 2001a, 2001b) identify a *long-run* negative relationship.[1] Similarly, work by Mitchell (1915), Mills (1927), Okun (1971), Vining and Elwertowski (1976), Parks (1978), Fischer (1981), Mizon, Safford, and Thomas (1991), Parsley (1996), Debelle and Lamont (1997) establish the general view that there is a positive relationship between inflation and RPV but this view is not unanimous. For example, Hartman (1991), Reinsdorf (1994), Fielding and Mizen (2001) and Silver and Ioannidis (2001) provide some evidence that higher inflation may be associated with a lower RPV especially during recessions. While it has always been the case that the relationships between inflation and the markup and inflation and RPV have been estimated separately, this paper suggests that they ought to be considered in a system where all the interactions between the variables can be modelled.[2]

The primary purpose of this paper is to examine four questions concerning the inflation-markup-RPV system. First, can we confirm the general findings of the empirical literature that there is a negative relationship between inflation and the markup and a positive

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1 See Banerjee, Dolado, Galbraith, and Hendry (1993) and Johansen (1995) for a description of the long run in the econometric sense of Engle and Granger (1987). The long-run relationship between the markup and inflation is easily identified in the data of a number of economies and different levels of aggregation. The relationship is also found using unit cost and marginal cost measures of the markup. See Hall (1988).

2 The only paper of which we are aware that models inflation and RPV (but excludes the markup) in a systems framework is Mizon (1991) using quarterly United Kingdom data for the period 1965-1987. The focus of the paper, however, is to demonstrate the encompassing methodology. The main conclusions are that simple regression models overstate the relationship between inflation and RPV because they can be shown to be 'badly misspecified' when evaluated in the context of a wider information set.

relationship between inflation and RPV? Second, are these relationships found in the short run (between variables that are essentially stationary in the econometric sense) or the long run (where the relationships are rank-reducing cointegrating relationships)? Third, does the system have two separate relationships (i.e. between inflation and the markup and between inflation and RPV), or are there relationships among all three variables? Some of the empirical literature has motivated the inflation-markup relationship by implicitly arguing that inflation acts as a proxy for RPV. If this were so, could we replace inflation with RPV in the inflation-RPV relationship and still obtain a similar relationship? Finally, nearly all of the existing empirical analysis of the inflation-RPV relationship assumes that single-equation estimation is appropriate. We ask, is this assumption sustainable?

We proceed by estimating a cointegrated system comprising inflation, the markup and RPV. For comparability with the existing empirical literature we estimate the system with quarterly and annual data for the United States and the United Kingdom. The following results emerge from our analysis. First, in all four data sets, we re-establish the negative relationship between the markup and inflation and find a positive relationship between inflation and RPV. Second, these relationships are characterised as long-run relationships that are identified from rank-reducing cointegrating vectors. This is a central finding and, of course, has the implication that the data for inflation, markup and RPV are integrated of order one.[3] It enables us to rule out several possible explanations of the relationship between inflation and the markup and inflation and RPV, by distinguishing among models that explain the short-run behaviour of the variables versus those that describe possible long-run interactions. Third, we are able to accept the restriction that RPV does not appear in the first long-run relationship, and the markup does not appear in the second. From this it follows that inflation cannot be replaced with RPV in the long-run inflation-markup relationship. Therefore, the argument that inflation is a proxy for RPV cannot be supported. However, the argument may still help to explain the short-run dynamics between inflation and the markup. Finally, estimating within a systems framework, we are able to establish that single-equation estimation of the inflation-RPV relationship is justified for three of the four data sets.

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3 Banerjee, *et al.* (2001) and Banerjee and Russell (2001b) have argued at length the case in favour of regarding inflation and markup as I(1) variables. We re-establish this finding for all the data sets examined in this paper including the RPV series.

Therefore, the inflation-RPV relationship should be investigated within a system, since this facilitates the simultaneous consideration of exogeneity, integration of the variables and inter-linkages between the cointegrating relationships. Moreover, our analysis shows that for all four data sets, single-equation estimation of the relationship between inflation and the markup cannot be justified, since in no case can the hypothesis of weak-exogeneity of inflation be accepted.

In the next section we briefly consider the existing literature on the inflation-markup and inflation-RPV relationships, focusing mainly on whether these models may help to explain the long-run relationships identified among the variables. Section 3 looks at the data and estimates the models before the results are considered in Section 4. Section 5 concludes.

2. BROAD EXPLANATIONS OF THE RELATIONSHIPS

The literature on the inflation-markup relationship can be broadly separated into 'supply-side' and 'demand-side' explanations. The supply-side explanations include the following three sets of models.

The first is in the 'menu' cost tradition of Mankiw (1985) and Parkin (1986). Rotemberg (1983), Kuran (1986), Naish (1986), Danziger (1988), Konieczny (1990) and Bénabou and Konieczny (1994) model the price setting behaviour of firms and show that inflation has a negative impact on the average markup. These models are not designed to support a long-run inflation-markup relationship except by assuming that the probability of price-setting firms changing prices is constant and that the adjustment cost depends on the absolute change in prices. Both assumptions are unlikely to be supported empirically because the costs of not adjusting prices would increase (decrease) substantially with higher (lower) steady-state inflation. This would lead to a variation in the proportion of firms that change prices.[4] Non-menu costs of changing relative prices will ensure that the adjustment costs do not depend on the absolute change in prices alone.

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[4] See Ball, Mankiw, and Romer (1988), Sims (1988) and Dotsey, King, and Wolman (1999).

A long-run relationship therefore requires non-menu cost supply- or demand-side explanations for their justification. Athey, Bagwell, and Sanichiro (1998) provides the second supply-side explanation and argues that higher variability in input costs makes it harder for firms to collude when setting prices. Therefore, if RPV increases with inflation, there will be an increase in competition leading to a lower markup and this relationship may hold in the long run.

The third supply-side explanation focuses on the difficulties that firms face when coordinating price changes in an inflationary environment and includes papers by Russell (1998), Russell, Evans, and Preston (2002), and Chen and Russell (2002). The lower markup associated with higher inflation in these papers is interpreted as the cost to firms of overcoming missing information when adjusting prices.

Among the demand-side explanations, Bénabou (1988, 1992) and Diamond (1993) focus on the interaction of inflation with the demand for a firm's output. In these models higher inflation increases price dispersion and the degree of search behaviour by consumers leading to an increase in competition and a subsequent fall in the markup.[5] Of particular relevance to our empirical analysis are the explanations of the relationship between inflation and the markup provided by Bénabou, Diamond and Athey, *et al.* (1998). These explanations imply that the increase in RPV associated with higher inflation is the cause of the lower markup. We return to this issue in Section 4 when we discuss if inflation is a proxy for RPV.

Explanations of the relationship between inflation and RPV can also be separated into three broad sets. The first is again based on the Mankiw (1985) and Parkin (1986) 'menu' cost literature mentioned above. This model can generate a positive relationship between inflation and RPV if inflation leads to prices exceeding the upper threshold price (for example see Sheshinski and Weiss (1977)). However, when there is negative inflation breaching the lower threshold price there may no longer be a positive relationship. Furthermore, Rotemberg (1983) and Ball and Mankiw (1994) argue that price dispersion may fall with

5 A menu cost model generates the RPV that induces greater search in the Bénabou (1988, 1992) models and, following on from the arguments above, these models can thus only describe a short-run relationship between inflation and the markup. However, if variations in RPV occur for non-menu cost reasons, the search arguments in these models are valid and may describe a long-run relationship.

inflation if firms try to avoid the menu costs of continual adjustment or the costs of losing market share. Using arguments similar to those presented above, these menu-cost based models cannot explain a long-run relationship between inflation and RPV.

The second set of explanations is based on the 'islands model' of Lucas (1973). Hercowitz (1981), Lach and Tsiddon (1992) and Debelle and Lamont (1997) argue that higher inflation causes an increase in misperceptions that lead in turn to higher RPV. Reinsdorf (1994) is in the minority but argues the opposite by suggesting that unanticipated inflation increases the uncertainty among buyers in Lucas's model. The issue for buyers is whether they have been offered a price by a high-priced seller, or an average-priced seller in circumstances where the price has risen in line with inflation. Consequently, the reservation price of buyers will be too low relative to the 'true' reservation price and the increased search will decrease RPV.

The final set of explanations suggest that the relationship is simply an artefact of the aggregation of the data or the time period examined. Fischer (1981), Hartman (1991) and Driffill, Mizon, and Ulph (1990) argue that shocks to food and energy prices in the 1970s simultaneously increased inflation and measures of RPV and thereby created or overstated the positive relationship between inflation and RPV even though there was no underlying economic reason for the relationship. We return to this issue in Section 3.2.

3. ESTIMATING THE LONG-RUN RELATIONSHIPS

In this section we estimate the long-run or cointegrating relationships between inflation, the markup and relative price variability using standard I(1) techniques developed by Johansen (1988, 1995). These long-run relationships can be motivated by the non-menu cost literature discussed above.

3.1 The Long-Run Relationships

The first long-run relationship follows from Banerjee, *et al.* (2001) which can be written as:

$$mu = q - \lambda \Delta p \qquad (1)$$

where mu is the estimated markup of price on unit costs 'net' of the costs of inflation, q

is the ‘gross’ markup, and λ is a positive parameter and termed the ‘inflation cost’ coefficient.[6] Lower case variables are measured in natural logarithms and Δ represents the change in the variable. The markup, mu, for k inputs of the production process is defined as:

$$mu \equiv p - \sum_{i=1}^{k} \psi_i c_i \tag{2}$$

where the c_i's are the logarithms of the costs of production and $\sum_{i=1}^{k} \psi_i = 1$. If the latter condition is satisfied then the relationship between prices and costs can be termed the markup on unit costs.[7] The condition $\sum_{i=1}^{k} \psi_i = 1$ imposes linear homogeneity and implies that, *ceteris paribus*, a change in unit costs will be fully reflected in the price level in the long-run leaving the markup unchanged. In our case, *ceteris paribus* includes no change in the rate of inflation. In a ‘standard’ macroeconomic model $\lambda = 0$ and inflation has no effect on the markup in the long-run. In the general model estimated here, $\lambda > 0$ and the markup, net of the cost of inflation, is lower with higher inflation and *vice versa* in the long-run.

Before we turn to the empirical analysis we need to consider an issue relating to definitions. In the empirical analysis we use two measures of prices. The first measure of prices is the private consumption implicit price deflator, p_C, and the definition of the markup in this case is straightforward.[8] The inputs in the production process are capital, labour and imports and

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6 Banerjee, *et al.* (2001) and Banerjee and Russell (2001b) show that (1) can be interpreted as a particular I(1) reduction of the polynomially cointegrating relationship of an I(2) system. In this case the levels of prices and costs are I(2) and they cointegrate to the markup which is I(1). The markup in turn polynomially cointegrates with inflation.

7 The standard literature focuses on the relationship between inflation and the markup on marginal costs. If the short-run perturbations of marginal costs around some long-run level of costs are due to the business cycle and are, therefore, stationary then the use of the markup on unit costs is valid when estimating the long-run relationship between inflation and the markup.

8 Richards and Stevens (1987), Franz and Gordon (1993), Cockerell and Russell (1995) and de Brouwer and Ericsson (1998) define the markup in a similar fashion in their empirical markup models of inflation.

the relevant markup is price on the unit costs of labour and imports. Using (2), the long-run markup equation (1) with linear homogeneity imposed can then be written:

$$mu_1 = mu_L + \rho\, rer_M = q - \lambda \Delta p \qquad (3)$$

where $mu_L = p_C - ulc$, the 'real exchange rate' $rer_M = p_C - pm$ and ulc and pm are unit labour and unit import costs respectively. In terms of (2) the estimated markup from (3) is then:

$$mu_1 = p_C - \frac{1}{1+\rho} ulc - \left(1 - \frac{1}{1+\rho}\right) pm \qquad (4)$$

The second measure of prices used in the empirical analysis is based on the gross domestic product (GDP) implicit price deflator, p_{GDP}, and the estimated markup can be interpreted as that of the price of non-traded GDP on unit labour costs. If we estimate (3) using the GDP price deflator, the 'real exchange rate' is defined now as $rer_X = p_{GDP} - px$ where px is the exports implicit price deflator and the markup defined as:[9]

$$mu_2 = \left[p_{GDP} - \delta\, px\right] - (1-\delta) ulc \qquad (5)$$

where $\delta = \left(1 - \frac{1}{1+\rho}\right)$.

We can interpret mu_2 as the markup of the price of non-traded GDP on unit labour costs in the following way. The GDP deflator may be defined as the weighted average of the implicit price deflators for exports and domestically consumed GDP , such that:

$$p_{GDP} \equiv \omega\, px + (1-\omega)\, p_D \qquad (6)$$

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9 The terms rer_M and rer_X may be referred to as the 'real exchange rate' due to their similarity to the relative price of traded and non-traded goods used by Swan (1963) as a measure of the real exchange rate.

where p_D is the domestically consumed GDP implicit price deflator and ω is the share of exports in GDP. Substituting for the GDP deflator in (5) using (6) provides the following expression:

$$mu_2 = [(1-\omega)\, p_D - (\delta - \omega)\, px] - (1-\delta)ulc \qquad (7)$$

If the impact of export prices on the GDP deflator is confined only to the direct impact of exports in the price index then the estimate of δ will equal the share of exports in GDP, ω, and the estimated markup, mu_2, collapses to $p_D - ulc$. That is, the estimated markup is of the price of domestically consumed GDP on unit labour costs and will not be affected in the long run by changes in rer_X. However, if export prices have indirect effects on the price of domestically consumed GDP then $\delta > \omega$ and rer_X will have an impact upon the markup $p_D - ulc$ in the long-run.[10] In this case, if we denote by 'non-traded GDP' that part of GDP not subject to the direct and indirect effects of changes in export prices then the estimated markup, mu_2, represents the markup of the price of non-traded GDP on unit labour costs.

The second long-run relationship is between inflation and RPV and written:

$$RPV = \zeta_0 + \zeta_1 \Delta p \qquad (8)$$

where *RPV* is relative price variabiltiy and ζ_0 and ζ_1 are positive parameters.

Following Parks (1978), Blejer and Leiderman (1980), Cukierman and Leiderman (1984), Parsley (1996), and Fielding and Mizen (2001) we calculate relative price variability as

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[10] Indirect effects of higher export prices on the price of domestically consumed GDP may operate through 'supply' and 'demand' channels. The 'supply' effect is due to domestic producers diverting sales overseas reducing the supply of goods and services domestically leading to an increase in the markup of $p_D - ulc$. The 'demand' effect occurs if real export prices increase due to a depreciation of the exchange rate leading to a similar increase in real import prices and therefore to an increase in the price of domestically produced substitutes.

$$RPV = \left(\sum_{i=1}^{n} s_i \left(\Delta p_i - \Delta p_T \right)^2 \right)^{\frac{1}{2}} \qquad (9)$$

where s_i is the share of each component index in the total index, and Δp_i is the rate of inflation of the individual component index and Δp_T is the rate of inflation of the total price index.[11] *RPV*, therefore, is the weighted average of the component inflation rates relative to the aggregate measure of inflation. Quarterly measures of *RPV* are calculated using annualised rates of inflation.

Four alternative measures of RPV are set out in Table 1 of Fielding and Mizen (2001). While these measures all capture the variability of prices around the average, it is apparent that the overwhelming majority of studies use our measure of RPV.[12] In addition, our chosen measure of RPV avoids the problem of trending relative prices in the component indexes due to different productivity growth rates between the sectors.

3.2 Data

The model that we estimate is an I(1) system consisting of four core variables; namely the markup, the 'real exchange rate', inflation and RPV. Estimation of the system is conditioned on a predetermined variable representing the business cycle and a set of spike dummies to capture the sometimes erratic behaviour of the data particularly in the turbulent mid to late 1970s. A trend is included in the cointegrating space and tested out whenever necessary. The models are estimated using data at both the annual and quarterly frequencies for the United States and the United Kingdom. The broad sources and definitions of the data are reported in Table 1. The data appendix provides more detail.

The markup and inflation are derived from national accounts data. Except for the quarterly United States data, RPV is calculated using the component indices of the aggregate price

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11 The data appendix provides details of the how RPV is calculated for each data set.

12 Hartman (1991), Mizon (1991), Ball and Mankiw (1994), Parsley (1996) and Fielding and Mizen (2001) have examined the inflation-RPV relationship using variants of our measure of RPV.

index used for measuring inflation and the markup. The measures of RPV are therefore consistent with the measures of inflation and the markup. For the quarterly United States data, results obtained from using RPV calculated from the All Urban Consumer Price Index (CPI-U) and inflation calculated from the private consumption implicit price deflator or the consumer price index showed some instability and were not robust to changes in the lag structure of the system. Consequently, although there were numerous indicators that the results were consistent with those from the other data sets, the United States quarterly inflation and the markup are calculated using national accounts gross domestic product data and RPV is calculated using CPI-U data.[13]

Table 1: Sources and Broad Definitions of the Data

United States	*Inflation and the Markup*	*RPV*	*Sample*
Annual	BEA: Private gross domestic product implicit price deflator at factor cost, exports implicit price deflator and unit labour costs.	BEA: National accounts industry data.	1948 to 1997
Quarterly	BEA: Gross domestic product at factor cost implicit price deflator, exports implicit price deflator and unit labour costs.	BLS: CPI-U data.	March 1967 to June 2001
United Kingdom			
Annual	ONS: Gross domestic product implicit price deflator at factor cost, exports implicit price deflator and unit labour costs.	ONS: National accounts industry data.	1948 to1999
Quarterly	ONS: Private final consumption implicit price deflator at 'factor cost', imports of goods and services implicit price deflator and unit labour costs.	ONS: Private final household consumption data.	March 1963 to March 2001

(a) Acronyms: BEA: United States Bureau of Economic Analysis. BLS: United States Bureau of Labor Statistics. ONS: United Kingdom Office of National Statistics.

(b) Annual United States data is the same as that used in Banerjee and Russell (2001a) where further details concerning the data can be found.

(c) Unit labour costs derived from aggregate national accounts data as total labour compensation divided by constant price gross domestic product.

(d) Exports and imports prices are measured for goods and services.

(e) The 'factor cost' adjustment of the quarterly United Kingdom consumption price index is $P_{FC} = P_{MP} / tax$ where P_{FC} and P_{MP} are prices at factor cost and market prices respectively, tax is GDP_{MP} / GDP_{FC}, where GDP_{MP} and GDP_{FC} are gross domestic product at market prices and factor cost respectively. While the 'factor cost' adjustment is theoretically appealing, in practice it has little effect on the results.

13 Banerjee and Russell (2001b) found similar instability in the United States estimates using the private consumption implicit price deflator and thought this was due to the aggregate unit labour cost data being a poor proxy for the unit labour costs associated with consumption expenditure.

The short-run impact of the business cycle on inflation, the markup and RPV is represented by the difference in the logarithm of the unemployment rate. The variable is stationary and avoids the 'errors in measurement' problem when using de-trended constant price gross domestic product in association with national accounts price data.[14]

Graph 1 shows the annual and quarterly measures of *RPV* and a number of descriptive statistics of the data are reported in Table 2. From the graphs and the table we observe that *RPV* is highly skewed and bounded at zero.[15] The explosive nature of the 'spikes' in the data often leads to non-normal and serially correlated system residuals. While the contemporaneous impact of these 'spikes' on the dependent variables can be accounted for by the introduction of dummy variables it is more difficult to account for their impact on the dynamic system.[16]

To address this problem we make an adjustment to our measurement of RPV. We reduce the skewness of the data by regressing *RPV* on a series of dummy variables that coincide with observations of more than 2.5 standard deviations from the mean of the series.[17] The adjustment leads to the 'de-spiked' RPV series being centered on zero. Graph 2 shows the de-spiked relative price variability variable, *RPVS*, used in the estimation. Measures of skewness and kurtosis of *RPVS* are also reported in Table 2.

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14 Measurement errors in national accounts data often have a simultaneous impact on the price and output series so as to offset each other. Consequently, estimates of the relationship between price and output data would be contaminated by the presence of common measurement errors. This contamination is not likely to be serious if the price series spans a small component of the output series. However, in our case the span of the price series and output series are the same or very similar.

15 Similarly, Vining and Elwertowski (1976) and Mizon, *et al.* (1991) find that the assumption of normality is strongly rejected for RPV due to strong skewness and kurtosis.

16 The initial system estimates based on *RPV* provide similar results to those we report below. However, the system diagnostics were at times poor and the estimates sometimes sensitive to changes in sample and lag length.

17 For the quarterly United Kingdom data it was found that to reduce the skewness to 'manageable' levels in terms of the system diagnostics, dummy variables were necessary for observations greater than 2 standard

Table 2: Descriptive Statistics of *RPV* and *RPVS*

	Mean	*Variance*	*Skewness*	*Kurtosis*
US Annual	3.51	3.63	1.73 [0.00]	3.54 [0.00]
De-spiked	0.00	1.95	1.07 [0.00]	1.35 [0.07]
UK Annual	3.69	5.45	1.75 [0.00]	3.83 [0.00]
De-spiked	0.00	2.87	0.90 [0.01]	0.46 [0.54]
US Quarterly	3.21	1.90	1.17 [0.00]	1.64 [0.00]
De-spiked and seasonally adjusted	0.00	1.13	0.68 [0.00]	0.81 [0.06]
UK Quarterly	6.73	6.32	0.88 [0.00]	0.64 [0.11]
De-spiked and seasonally adjusted	0.00	3.79	0.47 [0.02]	- 0.04 [0.93]

Note: Reported in square brackets [ ] are probability values of the test that skewness and kurtosis are zero.

The dummies coincide with periods of high inflation and, therefore, removing these observations is likely to make it more difficult to find a positive relationship between inflation and *RPV*. After removing the spikes we continue to find that the results below are consistent with the general view in the literature of a positive relationship between inflation and RPV. Furthermore, removing the spikes to our measure of RPV helps us avoid the criticism of earlier empirical work made by Fischer (1981), Hartman (1991) and Driffill, *et al.* (1990) that simultaneous shocks to inflation and RPV lead to an over-estimate of the positive relationship between RPV and inflation.

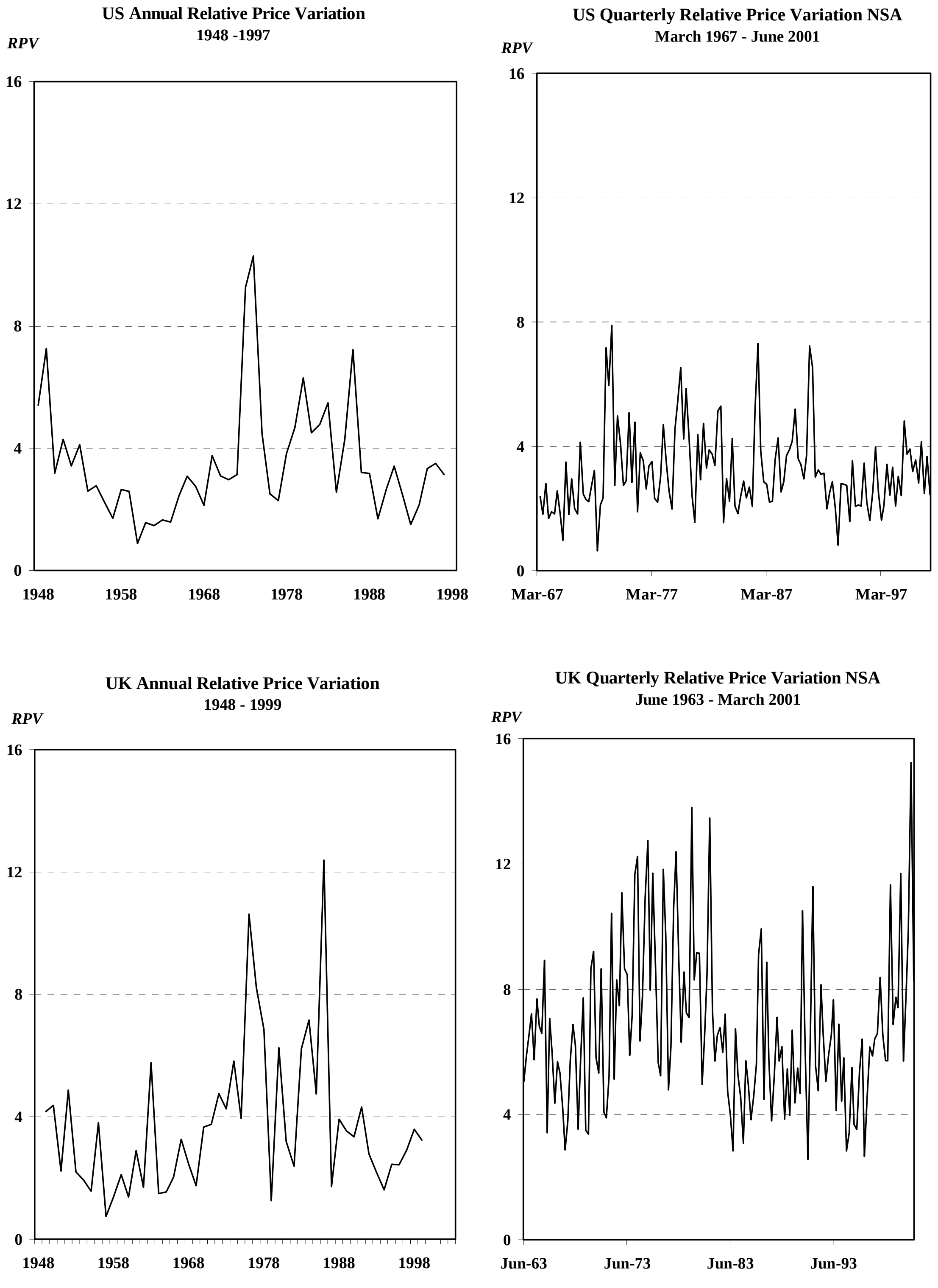
Prior to estimation of the model the integration properties of the data were investigated using PT and DF-GLS univariate unit root tests from Elliot, Rothenberg and Stock (1996).[18] We find that inflation, the markup, the 'real exchange rate' and RPVS variables may be

deviations from the mean. The quarterly measures of *RPV* were seasonally adjusted using four quarter centred seasonal dummies simultaneously with the 'de-spiking' process.

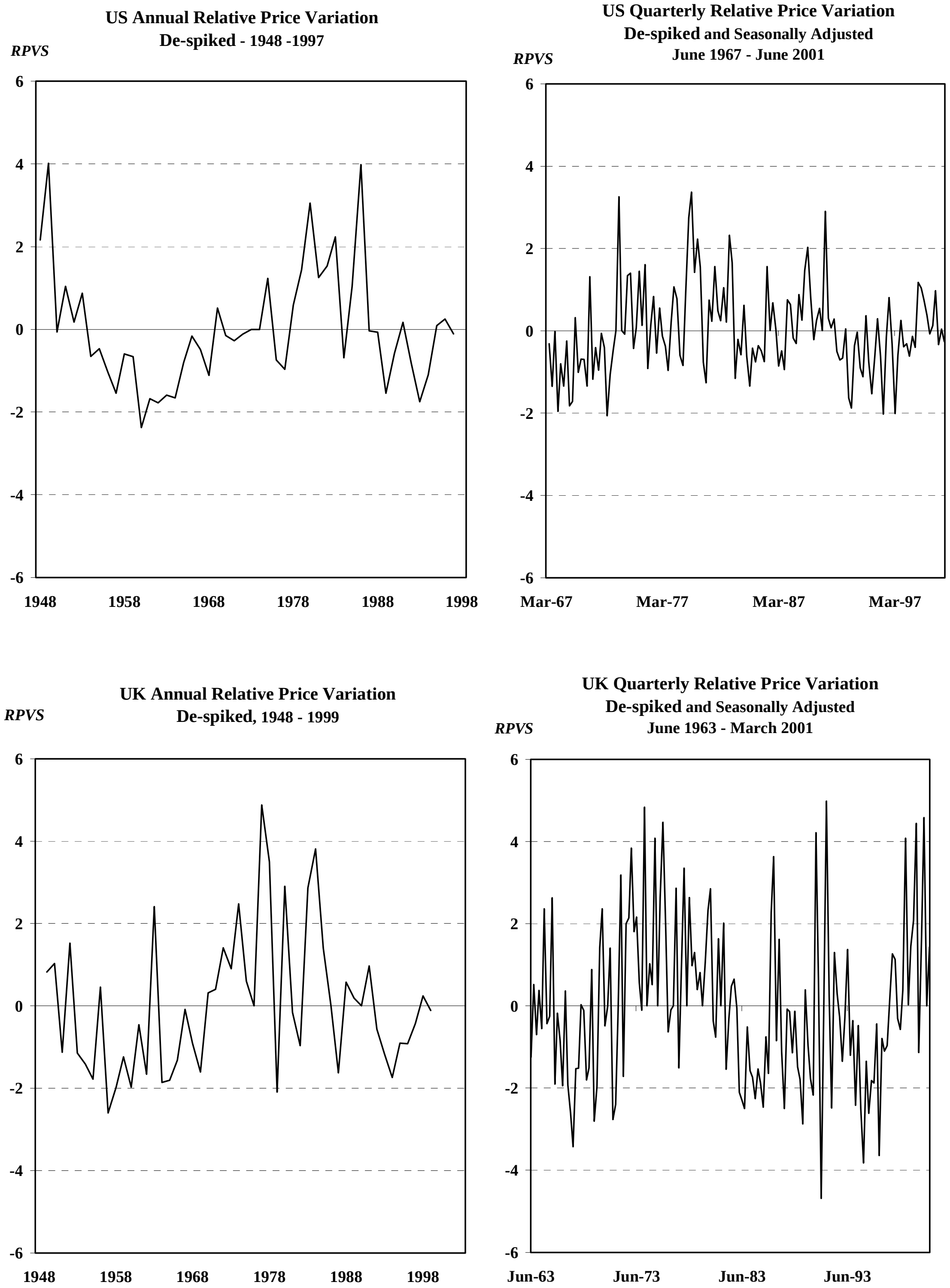
18 These results are available on request from the authors.

characterised as I(1). These findings are supported by the systems analysis that follows. Finally, the logarithm of the unemployment rate is I(1).

Graph 1



Graph 2


US Annual Relative Price Variation
De-spiked - 1948 -1997
RPVS
6
4
2
0
-2
-4
-6
1948
1958
1968
1978
1988
1998
US Quarterly Relative Price Variation
De-spiked and Seasonally Adjusted
June 1967 - June 2001
RPVS
Mar-67
Mar-77
Mar-87
Mar-97
UK Annual Relative Price Variation
De-spiked, 1948 - 1999
RPVS
UK Quarterly Relative Price Variation
De-spiked and Seasonally Adjusted
June 1963 - March 2001
RPVS
Jun-63
Jun-73
Jun-83
Jun-93

4. EMPIRICAL RESULTS

We turn first to determining the number of cointegrating vectors. Table 3 establishes the existence of two cointegrating vectors in each system. In all cases we can reject the null that there is at least one cointegrating relationship between the variables, but we cannot reject the null that there are at least two (the value of the test statistic can be compared to the critical value in brackets beneath). Further evidence of two cointegrating vectors are provided by the roots in modulus of the companion matrix and the stationarity of both cointegrating vectors.[19] We proceed with the hypothesis that there are two cointegrating vectors.

The last column of Tables 4a to 4d provide the two cointegrating vectors for each of the four data sets with the first cointegrating vector normalised on the markup on unit labour costs and the second vector normalised on inflation. The choice of normalisation does not imply that causation runs to the variable whose coefficient is normalised on unity since we could normalise on any of the variables in the cointegrating vector. The first four columns in each table give the adjustment coefficients of each of the two cointegrating vectors for each equation. The diagnostic tests reported in Tables 4a to 4d accept the null of no serial correlation and normality of the residuals in all cases.

The common feature of the four estimated inflation-markup relationships is a negative and significant relationship between the markup and inflation with a small positive trend being present in the cointegrating space in some cases. In the second relationship we find that in all cases there is a positive and significant relationship between inflation and RPVS. This result is obtained even though the outliers have been removed from the RPV series. In some cases there is also a trend in the cointegrating relation, which is very small but significant. These findings confirm the most commonly reported results in the empirical literature cited above since they deliver the expected signs of the coefficients in all cases.

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19 The roots in modulus of the companion matrix are consistent with the maintained hypothesis of two cointegrating vectors in a four variable system where we expect the first two roots to be unity and the remaining roots bounded away from unity. Both cointegrating vectors in each case visually appear stationary and this can be verified by univariate unit root tests.

Table 3: Testing for the Number of Cointegrating Vectors
Estimated Values of Q(r)

UNITED STATES

Annual			Quarterly		
$H_0 : r =$	Eigenvalues	*Q(r)*	$H_0 : r =$	Eigenvalues	*Q(r)*
0	0.7750	121.65 {58.96}	0	0.2945	85.93 {58.96}
1	0.5530	50.05 {39.08}	1	0.1737	39.53 {39.08}
2	0.1485	11.41 {22.95}	2	0.0727	14.15 {22.95}
3	0.0741	3.69 {10.56}	3	0.0304	4.11 {10.56}

UNITED KINGDOM

Annual			Quarterly		
$H_0 : r =$	Eigenvalues	*Q(r)*	$H_0 : r =$	Eigenvalues	*Q(r)*
0	0.5247	77.80 {58.96}	0	0.2292	72.07 {43.84}
1	0.4234	41.35 {39.08}	1	0.1755	33.54 {26.70}
2	0.2532	14.37 {22.95}	2	0.0321	4.98 {13.31}
3	0.0013	0.06 {10.56}	3	0.0010	0.15 {2.71}

Notes: Reported are the test statistics of the parsimonious models reported in Table 4. *Q(r)* is the likelihood ratio statistic for determining the number of cointegrating vectors, *r*, in the I(1) analysis. 90 percent critical values shown in curly brackets { } are from Tables 15.3 and 15.4 of Johansen (1995).

Table 4a: Cointegrating Vectors and Adjustment Coefficients

UNITED STATES ANNUAL 1950 to 1997					
	Markup Equation Δmu	'RER' Equation Δrer_X	Inflation Equation $\Delta^2 p$	RPVS Equation $\Delta\ RPVS$	Cointegrating Vector
1	- 0.240 (- 4.0)	- 0.097 (- 1.0)	- 0.454 (- 8.1)	1.641 (0.4)	$\underset{\{0.171\}}{mu} + \underset{\{0.063\}}{0.319\,rer} + \underset{\{0.188\}}{1.483\Delta p} - \underset{\{0.00032\}}{0.00192T}$
2	- 0.002 (- 0.1)	- 0.066 (- 1.2)	- 0.039 (- 1.3)	21.167 (9.4)	$\underset{\{0.195\}}{\Delta p_t} - \underset{\{0.003\}}{0.037\,RPVS_t}$

Core and pre-determined variables
One lag of the core variables: the markup on unit labour costs, the 'real exchange rate', inflation, RPVS and trend. Predetermined variables: dummies for 1951, 1973, 1974, 1983 and 1986 and the contemporaneous change in the logarithm of the unemployment rate. Number of observations, 48.

Implicit relationships
Implicit long-run markup-inflation relationship: $mu_2 + 1.124\Delta p$ where the implicit markup is $mu_2 = [p - 0.242\,px] - 0.758\,ulc$.

Tests for serial correlation

LM(1) $\chi^2(16) = 10.76,\quad p-value = 0.82$

LM(4) $\chi^2(16) = 11.50,\quad p-value = 0.78$

Test for normality

Doornik-Hansen test for normality: $\chi^2(8) = 11.29,\quad p-value = 0.19$

Likelihood ratio test of cointegrating vector restrictions
Estimated coefficients are zero for RPVS in cointegrating vector 1 and for the markup, 'real exchange rate' and trend in cointegrating vector 2 accepted $\chi^2(2) = 1.61,\quad p-value = 0.45$.

NOTES

Reported in ( ) are t-statistics and in { } are standard errors of the estimate. Normalised cointegrating vectors reported after imposing 2 vectors on the cointegration space.

The annual estimation began with two lags of the core variables, the contemporaneous and first lag of the unemployment variable and a trend in the cointegrating space. The quarterly estimation began in a similar fashion except with four lags of the core variables and four lags of the unemployment variable. The parsimonious form of the model was sought with the trend variable and the longest lags of the core variables and the unemployment variable eliminated if insignificant. Spike dummies were introduced for periods with residuals greater than 3 standard errors from zero.

Table 4b: Cointegrating Vectors and Adjustment Coefficients

UNITED STATES QUARTERLY
June 1968 to June 2001

	Markup Equation Δmu	'RER' Equation Δrer_X	Inflation Equation $\Delta^2 p$	RPVS Equation $\Delta\, RPVS$	Cointegrating Vector
1	- 0.123 (- 4.3)	- 0.084 (- 2.1)	- 0.032 (- 2.1)	- 1.507 (- 0.3)	$\underset{\{0.368\}}{mu} + \underset{\{0.057\}}{0.272}\, rer + \underset{\{1.249\}}{6.169}\,\Delta p - \underset{\{0.00033\}}{0.00082}\, T$
2	0.185 (1.8)	0.344 (2.3)	- 0.134 (- 2.4)	109.514 (6.2)	$\underset{\{0.163\}}{\Delta p} - \underset{\{0.001\}}{0.007}\, RPVS - \underset{\{0.00002\}}{0.00011}\, T$

Core and pre-determined variables
Three lags of the core variables: the markup on unit labour costs, the 'real exchange rate', inflation, RPVS and trend. Predetermined variables: dummies for September 1968, June 1973, March 1974, December 1977, June 1978, March 1981, March 1982 and March 1991 and the change in the logarithm of the unemployment rate lagged one period. Number of observations, 133.

Implicit relationships
Implicit long-run markup-inflation relationship: $mu_2 + 4.850\,\Delta p$ where the implicit markup is $mu_2 = [p - 0.214\, px] - 0.786\, ulc$.

Tests for serial correlation

LM(1) $\chi^2(16) = 22.05, \quad p-value = 0.14$

LM(4) $\chi^2(16) = 23.89, \quad p-value = 0.09$

Test for normality

Doornik-Hansen test for normality: $\chi^2(8) = 10.71, \quad p-value = 0.22$

Likelihood ratio test of cointegrating vector restrictions
Estimated coefficients are zero for RPVS in cointegrating vector 1 and for the markup and 'real exchange rate' in cointegrating vector 2 accepted $\chi^2(1) = 0.03, \quad p-value = 0.87$.

See also the notes at the bottom of Table 4a.

Table 4c: Cointegrating Vectors and Adjustment Coefficients

UNITED KINGDOM ANNUAL 1951 to 1999					
	Markup Equation Δmu	'RER' Equation Δrer_X	Inflation Equation $\Delta^2 p$	RPVS Equation $\Delta\, RPVS$	Cointegrating Vector
1	- 0.426 (- 3.0)	0.269 (0.7)	- 0.625 (- 3.4)	- 13.675 (- 0.8)	$\underset{\{0.113\}}{mu} + \underset{\{0.040\}}{0.340}\,rer + \underset{\{0.070\}}{0.400}\,\Delta p - \underset{\{0.00034\}}{0.00509}\,T$
2	0.063 (1.6)	- 0.147 (- 1.4)	0.081 (1.6)	31.536 (6.7)	$\underset{\{0.210\}}{\Delta p} - \underset{\{0.005\}}{0.041}\,RPVS + \underset{\{0.00041\}}{0.00094}\,T$

Core and pre-determined variables
Two lags of the core variables: the markup on unit labour costs, the 'real exchange rate', inflation, RPVS and trend. Predetermined variables: dummies for 1951, 1974, 1975, 1976 and 1981 and the contemporaneous change in the logarithm of the unemployment rate. Number of observations, 49.

Implicit relationships
Implicit long-run markup-inflation relationship: $mu_2 + 0.299\,\Delta p$ where the implicit markup is $mu_2 = [p - 0.254\,px] - 0.746\,ulc$.

Tests for serial correlation

LM(1) $\chi^2(16) = 23.29,\ \ p-value = 0.11$

LM(4) $\chi^2(16) = 26.56,\ \ p-value = 0.05$

Test for normality

Doornik-Hansen test for normality: $\chi^2(8) = 11.85,\ \ p-value = 0.16$

Likelihood ratio test of cointegrating vector restrictions
Estimated coefficients are zero for RPV in cointegrating vector 1 and for the markup and RER in cointegrating vector 2 accepted $\chi^2(1) = 0.93,\ \ p-value = 0.34$.

See also the notes at the bottom of Table 4a.

Table 4d: Cointegrating Vectors and Adjustment Coefficients

UNITED KINGDOM QUARTERLY **June 1964 to March 2001**					
	Markup Equation Δmu	'RER' Equation Δrer_M	Inflation Equation $\Delta^2 p$	RPVS Equation $\Delta\ RPVS$	Cointegrating Vector
1	- 0.136 (- 5.6)	0.020 (0.4)	- 0.074 (- 4.6)	1.800 (0.4)	$\underset{\{0.187\}}{mu_t} + \underset{\{0.043\}}{0.176}\, rer_t + \underset{\{0.591\}}{4.254}\,\Delta p_t$
2	0.030 (1.1)	0.059 (1.0)	- 0.003 (- 0.1)	24.035 (4.9)	$\underset{\{0.483\}}{\Delta p_t} - \underset{\{0.004\}}{0.023}\, RPVS_t$

Core and pre-determined variables
Three lags of the core variables: the markup on unit labour costs, the 'real exchange rate', inflation and RPVS. Predetermined variables: dummies for March 1973, March and December 1975, September 1979 and June 1991 and the change in the logarithm of the unemployment rate lagged one period. Number of observations, 148.

Implicit relationships
Implicit long-run markup-inflation relationship: $mu_1 + 3.617\,\Delta p$ where the implicit markup is $mu = p - 0.850\,ulc - 0.150\,pm$

Tests for serial correlation

LM(1) $\chi^2(16) = 21.09, \quad p-value = 0.17$

LM(4) $\chi^2(16) = 11.71, \quad p-value = 0.76$

Test for normality

Doornik-Hansen test for normality: $\chi^2(8) = 15.08, \quad p-value = 0.06$

Likelihood ratio test of cointegrating vector restrictions
(a) Estimated coefficients are zero for RPV and trend in cointegrating vector 1 and for the markup RER and trend in cointegrating vector 2 accepted, $\chi_1^2 = 1.63$, $p-value = 0.65$.
(b) Estimated coefficients are zero for RPV in cointegrating vector 1 and for the markup and RER in cointegrating vector 2 accepted $\chi^2(1) = 1.58, \quad p-value = 0.21$.

See also the notes at the bottom of Table 4a.

Table 5: $\chi^2(1)$ Tests of Significance of Markup in Cointegration Vectors

	Cointegrating Vector 1	*Cointegrating Vector 2*
US Annual	13.62, $p-value=0.00$	0.23, $p-value=0.63$
US Quarterly	5.65, $p-value=0.02$	2.63, $p-value=0.10$
UK Annual	12.09, $p-value=0.00$	13.48, $p-value=0.00$
UK Quarterly	17.28, $p-value=0.00$	3.42, $p-value=0.06$

Note: The systems reported in Tables 4a to 4d are reformulated as

$$\text{Cointegrating Vector 1: } v_0\, mu + v_1\, rer + v_2\, \Delta p + v_3\, trend$$
$$\text{Cointegrating Vector 2: } \varpi_0\, mu + \varpi_1\, rer + \varpi_2\, RPVS + \varpi_3\, trend$$

The reported individual $\chi^2(1)$ tests are that $v_0 = 0$ in cointegrating vector 1 and $\varpi_0 = 0$ in cointegrating vector 2.

Once annualised, the estimates from quarterly data are similar to those derived from annual data for the United States.[20] However, some divergences are evident for the United Kingdom. For example, for quarterly data, the annualised 'inflation cost' coefficient on inflation is 1.064 which contrasts with 0.400 derived from annual data. Moreover, and also in contrast with the corresponding results for the annual data, the system estimated with quarterly data does not have any significant trends in the cointegrating space. The sensitivity of the United Kingdom results to sampling frequency may be explained by the different price indexes used for the two different frequencies and the presence of a trend in the proportion of 'non-traded GDP' in the economy (in the annual data estimates). The latter may also explain the significant trends in the United States results.

We test and can accept for all the data sets the restrictions that RPVS is not significant in the inflation-markup long-run relationship and the markup is not significant in the inflation-RPVS long-run relationship. This identifies the inflation-markup and inflation-RPVS pairs as the long-run relationships in the data. We note that we could alternatively have identified the

[20] The long-run coefficients in the inflation-markup relationship are also very similar to those reported in Banerjee and Russell (2001a, 2001b).

cointegrating vectors by restricting the inflation term to zero in the first cointegrating vector, leaving the identifying restriction for the second cointegrating vector unchanged.

Our argument in favour of the first instead of the second identifying scheme is supported by Table 5. This table reports a reformulation of the systems in Tables 4a to 4d without imposing identifying restrictions (see notes to Table 5). For the second identifying scheme to be considered appropriate would require that we accept the restriction that *mu* is equal to zero in CV 1 and reject the restriction that the coefficient on *mu* is equal to zero in CV 2. Table 5 shows that this combination of restrictions cannot be supported for any of the four data sets. For three of the data sets we reject the restriction that *mu* is equal to zero in CV 1 and accept the restriction that the coefficient on *mu* is equal to zero in CV 2, while for the fourth (annual United Kingdom) we reject the hypothesis that the coefficient on *mu* is zero in both cointegrating vectors. This is evidence in favour of considering the relationship between inflation and the markup to be the 'primitive' one, with the second identifying scheme being a rewriting of the first.

We take the above to imply that inflation cannot be replaced by RPVS in the inflation-markup relationship. Equally, the markup does not appear in the inflation-RPVS long-run relationship. By implication, the explanations provided by Athey, *et al.* (1998), Bénabou (1988, 1992), and Diamond (1993) of the inflation-markup relationship (based on the argument that RPV measures the dispersion of prices or costs) do not explain our long-run empirical results. We note however, that acceptance of these restrictions does not disallow the possibility that these variables may still be related in the short-run through the dynamics of the system.

The existence of two distinct cointegrating vectors does not necessarily imply that single-equation estimation of each relationship is valid. Such a simplification requires weak-exogeneity conditions to hold and these may be investigated using our results in Tables 4a to 4d by noting how the error correction terms enter the system.

For example, our annual United States results (Table 4a) show that the second cointegrating relationship enters significantly only into the RPVS equation. Taken together with the result that RPVS is not present in the first cointegrating relationship, we would expect that in a bivariate system consisting of inflation and RPVS, the cointegrating relationship between inflation and RPVS would not enter with a significant coefficient in the inflation equation. This would in turn establish the weak exogeneity status of inflation in this bivariate system and would justify the estimation of the relationship between RPVS and inflation (with RPVS being the dependent variable) using single-equation methods.[21]

While this is also true for the annual and quarterly United Kingdom results (Tables 4c and 4d), the quarterly United States results in Table 4b (where the second cointegrating relationship enters with significant coefficients in the inflation equation) indicate that inflation is unlikely to be weakly exogenous in a bivariate system and this can be verified formally. In order to highlight the impact of the endogeneity of inflation in the inflation-RPVS relationship, Table 6 reports the single-equation and system estimates of the inflation-RPVS long-run relationship for all four data sets. The single equation estimates are derived from estimating the Bewley (1979) transform of the ADL(m,n) model and the system results are taken from the models reported in Tables 4a to 4d. Consistent with our finding that inflation is endogenous in the quarterly United States data, the single equation estimate differ from the system estimate by approximately 50 percent. For the remaining data sets, where inflation is weakly exogenous, such divergences do not appear.

In contrast, based on the results presented in Tables 4a to 4d on the adjustment coefficients and the associated *t*-statistics, we may deduce that single-equation estimation of the inflation-markup relationship is unlikely to be justified, since neither inflation nor the markup on unit labour costs is weakly exogenous in the four-variable system.

Finally we turn to the graphical illustration of our results. Graphs 3 to 6 show as solid lines the long-run relationships between inflation and the markup and between inflation and RPVS and are labelled as LR(1) and LR(2) respectively.[22] Shown as dots on the graphs are the

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21 Although not reported here, results establishing the weak exogeneity of inflation in the bivariate system and demonstrating congruence of estimates derived from system and single-equation methods are available from the authors.

22 For ease of interpretation, the graphs show annual inflation as the change in the natural logarithm of the price index multiplied by 100. Similarly, the quarterly inflation rate is annualised by multiplying by 400.

actual values for inflation and RPVS along with the estimated markup from the system analysis. Marked with crosses are the observations corresponding to the dummy variables in the system analysis. The negative long-run relationship between inflation and the markup and the positive long-run relationship between inflation and RPV can be seen in the data and in the solid lines.

Table 6: Estimates of the Inflation-RPVS Long-run Relationship

	Single Equation Estimate	*Systems Estimate*
United States Annual	30.200 {11.200}	27.036 {5.274}
United States Quarterly	98.548 {23.817}	147.152 {23.986}
United Kingdom Annual	21.849 {5.332}	24.448 {5.134}
United Kingdom Quarterly	51.795 {22.095}	44.281 {21.392}

Note: Reported in brackets { } are standard errors. The single equation estimates of the cointegrating parameter, ϑ, and its standard error are derived from estimating the Bewley (1979) transform of the ADL(m,n) model given by:

$$RPVS_t = c + \vartheta\Delta p_t + \sum_{i=0}^{m-1}\alpha_i\,\Delta RPVS_{t-i} + \sum_{j=0}^{n-1}\beta_j\,\Delta^2 p_{t-j}$$

The Bewley transform is estimated using 2SLS with the lagged endogenous variables and current and lagged exogenous variables as instruments. A trend is included if significant. The system estimates are from Tables 4a to 4d normalised on RPVS.

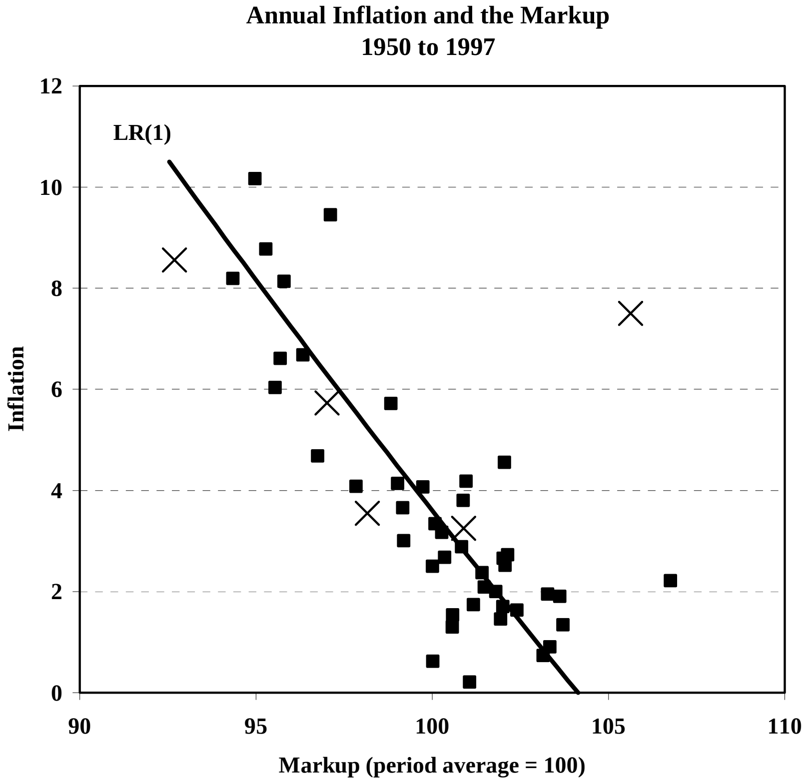
5. CONCLUSION

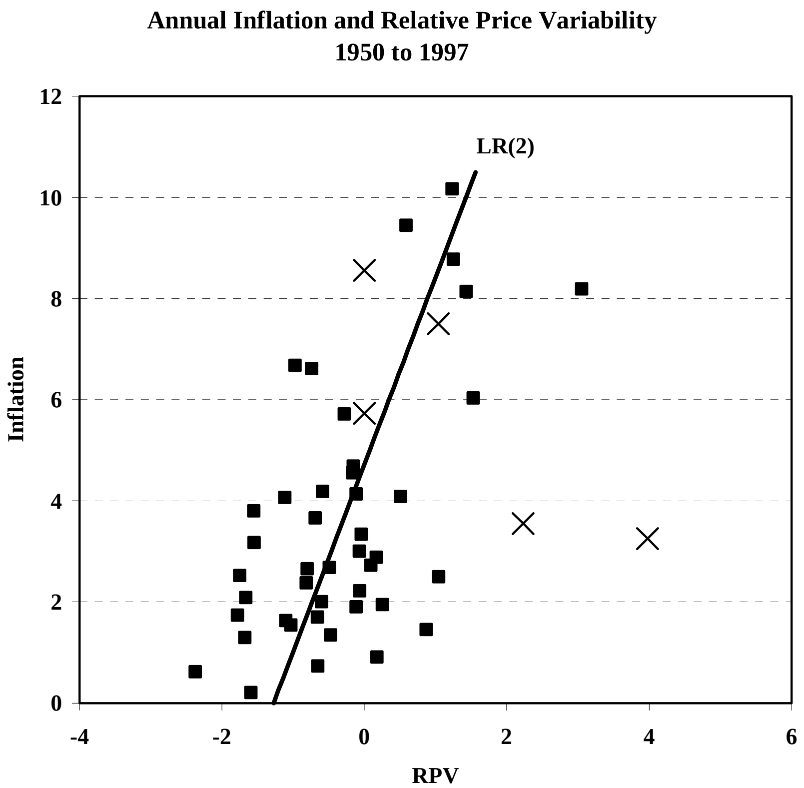
In this paper we argue that work on the relationships between inflation and the markup and between inflation and RPV have developed separately even though they have a number of common theoretical and empirical elements. For example, some authors have rationalised that the existence of the inflation-markup relationship is due to the price dispersion associated with inflation. Implicitly, these authors have argued that inflation is a proxy for RPV. In order to examine this conjecture and to explore whether it is justifiable to keep the inflation-markup and RPV-inflation relationships separate, as the empirical literature has done up to this point, we estimate a system comprising inflation, the markup and RPV. We find that RPV cannot displace inflation in the inflation-markup equation, and that the markup can be excluded from the inflation-RPV relationship in the long run. Consequently we conclude that inflation is not a proxy for price dispersion in the inflation-markup long-run relationship.

Our investigations are conducted on a broad base. We construct measures of the markup, inflation and RPV for two countries, the United States and the United Kingdom, and at two frequencies, annual and quarterly. In all four cases we accept that there are two cointegrating or long-run relationships. These two relationships are reduced to the inflation-markup and the inflation-RPV equations.

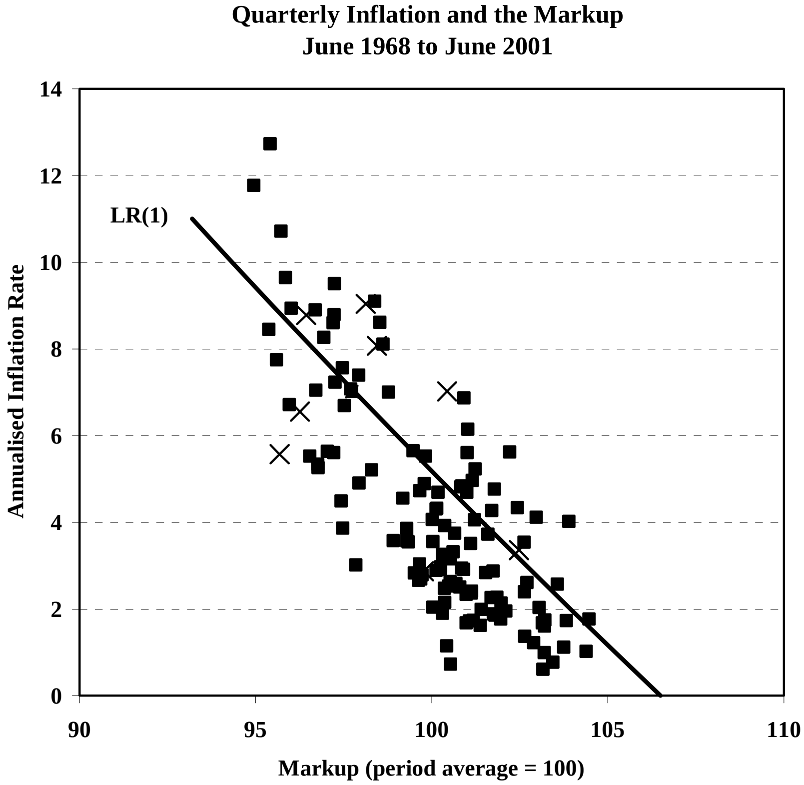
It is surprising that such closely related literatures that use similar theoretical foundations, and in many cases similar data sources for their empirical verification, should remain apart. The analysis shows that the integration properties of the data, the inter-linkages between the relationships and the exogeneity status of the variables are all important for a proper analysis of the two interrelated themes in the literature. We have shown that only a systems analysis of the kind undertaken in this paper, which pays due attention to all the important modelling issues, is capable of judging the validity of the simplifications adopted in much of the existing empirical literature. Finally, our results are estimated more consistently than those of the single equation studies and permit short-term dynamic interactions that the former studies ignore.

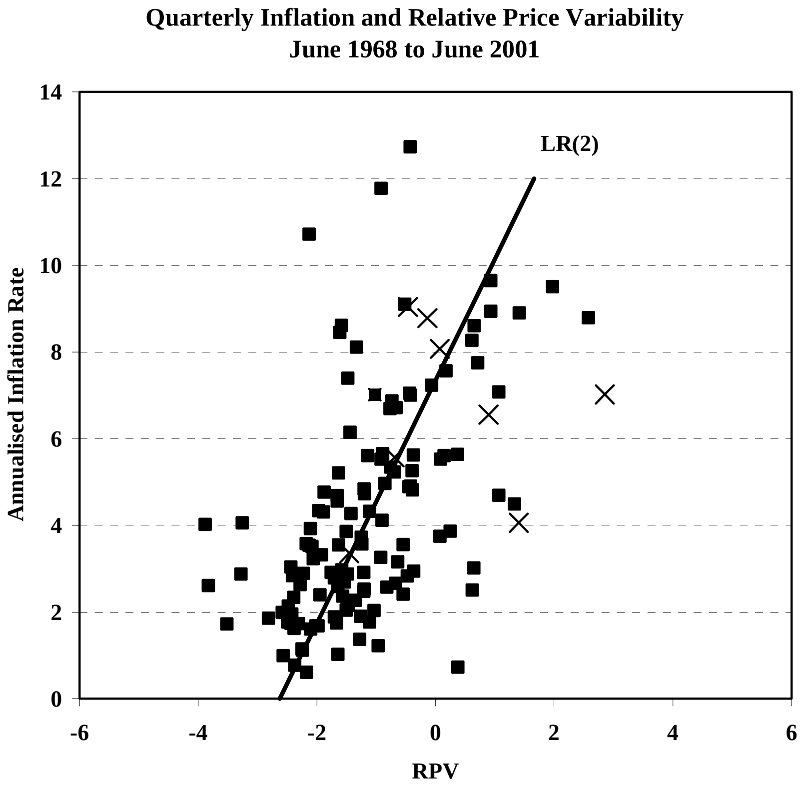
Graph 3: United States





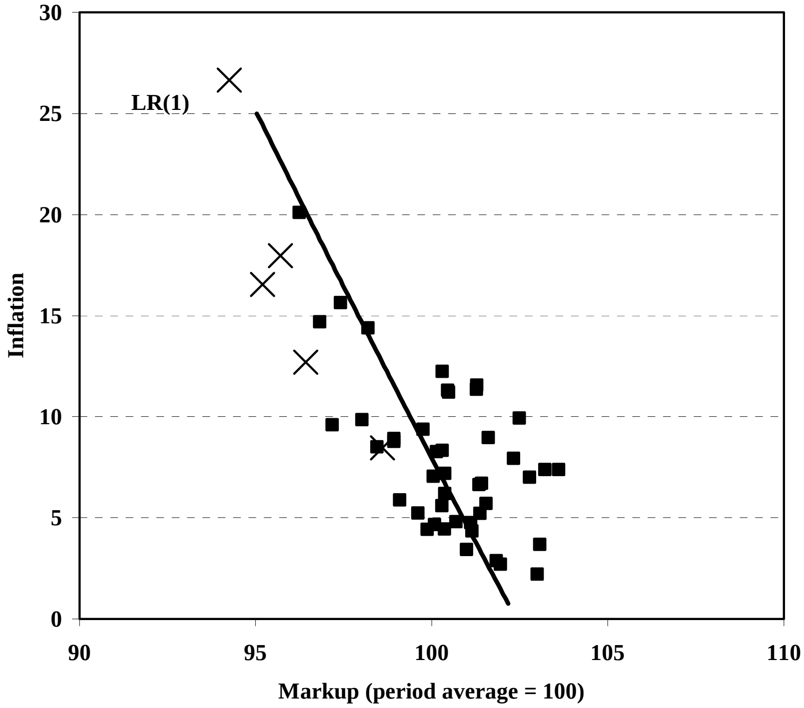
Graph 4: United States



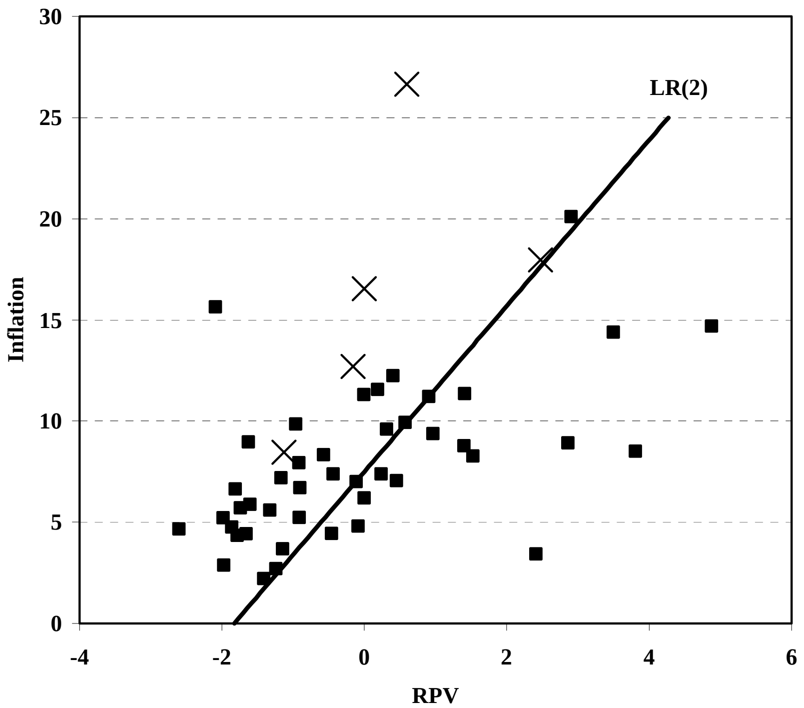


Graph 5: United Kingdom

Annual Inflation and the Markup
1951 to 1999

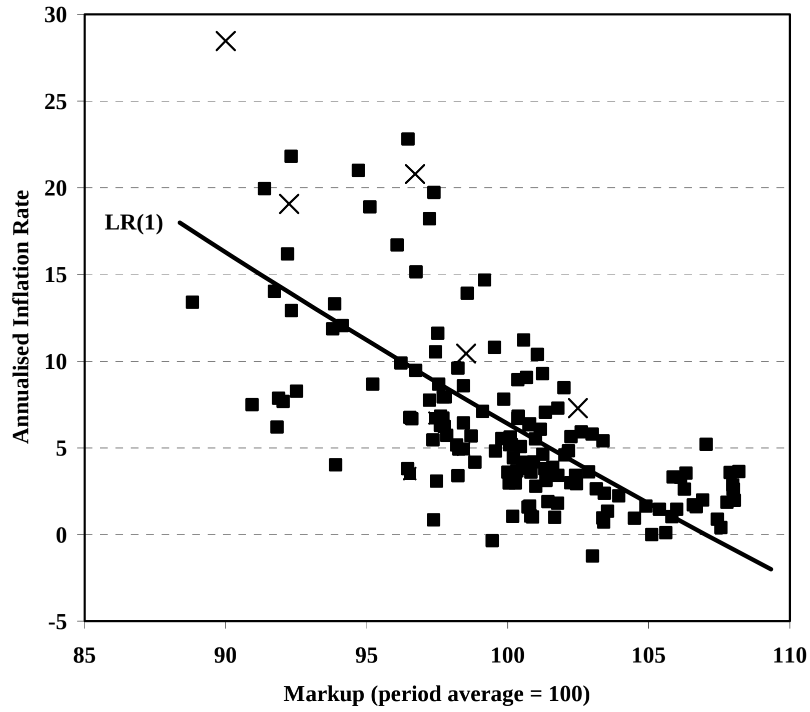


Annual Inflation and Relative Price Variability
1951 to 1999

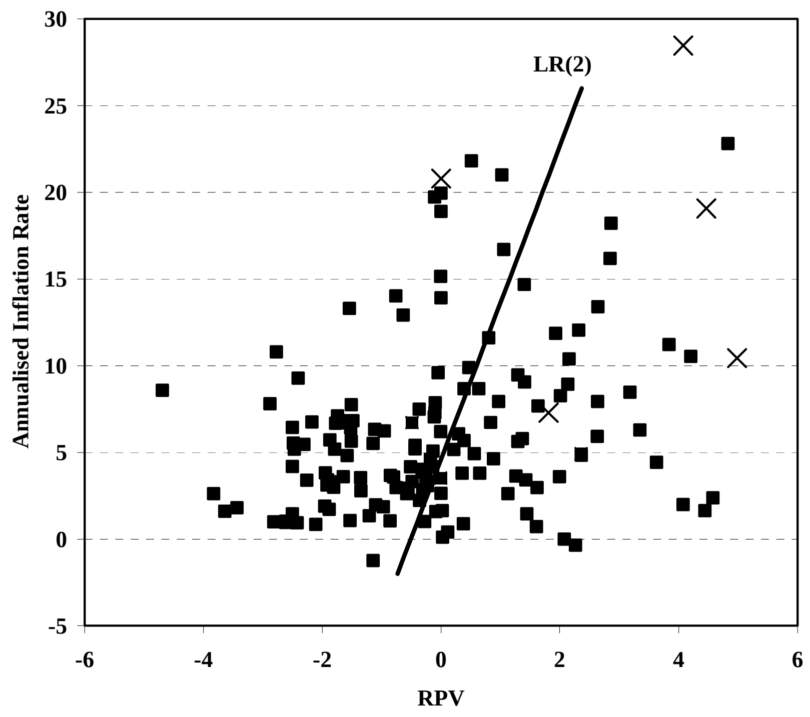


Graph 6: United Kingdom

Quarterly Inflation and the Markup
June 1964 to March 2001



Quarterly Inflation and Relative Price Variability
June 1964 to March 2001



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7. DATA APPENDIX

US ANNUAL DATA

(a) The annual gross product originating by industry data is from 1947 to 1997 and taken from the November 1998 *Survey of Current Business* published by the United States Department of Commerce. The data is the same as that used in Banerjee and Russell (2001a) where further details concerning the series can be found. Prior to 1987, the data uses the 1972 SIC codes.

(b) The price and markup data is calculated for 'private industries' defined as total GDP less government (1987 SIC Code: 01-42, 44-89).

Name of Series	Source of Series	Notes
1. 'Private industries' markup of price on unit labour costs	Gross product originating by industry at current dollars GPC; Indirect tax and non-tax liabilities by industry IBT; Subsidies SUBSIDIES; Compensation of employees by industry COMP	Private sector is calculated as total less government. Markup is calculated as (GPC less IBT less SUBSIDIES) / COMP Note that SUBSIDIES are published as negative values.
2. 'Private industries' gross product originating by industry implicit price deflator at factor cost	Gross product originating by industry at current dollars GPC Indirect tax and non-tax liabilities by industry IBT Subsidies SUBSIDIES Gross product originating by industry at constant chained 1992 prices GPR	Private sector is calculated as total less government. Implicit price deflator is calculated as (GPC less IBT less SUBSIDIES) / GPC
3. Relative Price Variability	RPV is calculated using gross product originating by industry data.	See following for details concerning the calculation of RPV RPV was 'de-spiked' using 'spike' dummies for observations greater than 2.5 standard deviations from the mean. Spike dummies are 1973 and 1974.
4. Exports of Goods and Services implicit price deflator	Current price expenditure on exports of goods and services NIPA Table 1.1; Constant price expenditure on exports of goods and services NIPA Table 1.2.	Exports price deflator = current price exports / constant price exports.
5. Unemployment rate	Unemployment rate civilian labour force (seasonally adjusted quarterly) Bureau of Labor Statistics: LFS21000000	Annual rate is the average of quarterly seasonally adjusted unemployment rates.

CALCULATION OF ANNUAL RELATIVE PRICE VARIABILITY

The gross product originating by industry data is from the November 1998 *Survey of Current Business* published by the United States Department of Commerce.

The weighted average relative price variability, RPV, is calculated as $RPV = \left(\sum_i s_i \left(Dp_i - Dp_T \right)^2 \right)^{\frac{1}{2}}$

where s_i is the share of each component's share of total current gross product originating by sector at factor cost (i.e. GPC less IBT less SUBSIDIES), Dp_i and Dp_T are the annual rates of inflation of the $i\,th$ component series and 'Private Industries' respectively.

a) The data is annual from 1947 to 1997.

b) The data is back-spliced prior to 1987 using 1972 SIC code data.

The gross product originating by industry SIC codes are set out in the table below. RPV is calculated using industries, 3, 4, 5, 7, 8, 10, 11, 12, 13, 14, 15, and 16 from the table below.

Classification of Industries in Gross Product Originating by Industry Data

	Industry	*1987 SIC Code*		*Industry*	*1987 SIC Code*
1	Total GDP	01-97	9	Transportation and public utilities	40, 42, 44-49
2	Private Industries	01-42, 44-89	10	Transportation	40-42, 44-47
3	Agriculture	01-09	11	Communications	48
4	Mining	10-14	12	Electricity, gas & sanitary services	49
5	Construction	15-17	13	Wholesale trade	50-51
6	Manufacturing	20-39	14	Retail trade	52-59
7	Durable goods	24, 25, 32-39	15	Finance, insurance and real estate	60-67
8	Non-durable goods	20-23, 26-31	16	Services	70-89
			17	Government	43, 91-97

US QUARTERLY DATA

(a) The data is quarterly from the June 2001 NIPA tables (published 29 August) downloaded from the Bureau of Economic Analysis web site on 2 September 2001 unless otherwise stated.

(b) Data is seasonally adjusted unless otherwise indicated.

(c) The data is quarterly from March 1967 to June 2001 unless otherwise indicated.

	Name of Series	Source of Series	Notes
1.	Unit Labour Costs	Compensation of Employees Table 1.14; Constant Gross Domestic Product Table 1.2	Unit Labour Costs is compensation of employees / constant price GDP
2.	Private Consumption implicit price deflator at 'factor cost'.	Current Private Consumption Table 1.1; Constant Private Consumption Table 1.2; Current GDP at market prices Table 1.1; Indirect business tax and nontax liability Table 1.9; Subsidies less current surplus of government enterprises Table 1.9	Deflator at market prices: P_{MP} = current consumption / constant consumption $GDP_{FC} = GDP_{MP}$ less indirect business and nontax liability plus subsidies Consumption deflator at factor cost: $P_{FC} = P_{MP}/tax$ where tax is GDP_{MP}/GDP_{FC}
3.	Relative Price Variability	RPV calculated from monthly not seasonally adjusted CPI-U data.	Data from June 1967 – June 2001. See following for details concerning the calculation of RPV RPV was seasonally adjusted using centered seasonal dummies and 'de-spiked' using 'spike' dummies for observations greater than 2.5 standard deviations from the mean. Spike dummies are March and September 1973, June 1986 and December 1990.
4.	Exports of Goods and Services implicit price deflator	Current price exports of Goods & Services Table 1.1 Constant price exports of Goods and Services Table 1.2	Deflator is current price exports / constant price exports.
5.	Unemployment rate Civilian Labour Force	Bureau of Labor Statistics, Labor Force Statistics, Monthly unemployment rate Series ID : LFS21000000	Quarterly average of monthly data.

CALCULATION OF QUARTERLY RELATIVE PRICE VARIABILITY

The underlying data is monthly, All Urban Consumers (i.e. CPI-U data) and not seasonally adjusted. The monthly data is converted to quarterly data by averaging the monthly levels of the respective indexes.

Relative price variability, RPV, calculated as $RPV = \left(\sum_i s_i \left(Dp_i - Dp_{AI} \right)^2 \right)^{\frac{1}{2}}$ where s_i are the expenditure weights of the components in the All Items index, Dp_i and Dp_{AI} are the annualised quarterly rates of inflation of the ith component indexes and All Items indexes respectively.

Difficulties exist in terms of the change in definitions of the indexes. The BLS publishes back data of the series used to calculate the latest published estimates (in this case the component series of the July 2001 estimates). Therefore, if a series has a major change in its content, the back series is not provided. This problem arises for, Recreation, that only goes back to January 1993. The series used in the calculation of RPV prior to this series is CPI-U 'Entertainment' which is back-spliced onto 'Recreation' at January 1993.

The data is from 3 sources.

I. Downloaded from the CPI home page from the Bureau of Labour Statistics web site. The component series and All Items series are the CPI-U (Consumer Price Index – All Urban Consumers) series. The data was downloaded on 9 September 2001. The data is available from January 1967 to July 2001 unless stated otherwise.

Name of Index	*BLS Series Code*	*Notes*
1. All Items	CUUR0000SA0	January 1913 – July 2001
2. Food and Beverages	CUUR0000SAF	
3. Housing	CUUR0000SAH	
4. Apparel	CUUR0000SAA	January 1941 – July 2001, some sporadic data prior to 1941 back to 1913
5. Transportation	CUUR0000SAT	January 1937 – July 2001, some sporadic data prior 1937 back to 1935.
6. Medical Care	CUUR0000SAM	January 1947 – July 2001, some sporadic data prior to 1947 back to 1935.
7. Recreation	CUUR0000SAR	January 1993 – July 2001
8. Education and communication	CUUR0000SAE	January 1993 – July 2001
9. Other goods and services	CUUR0000SAG	

II. The weights w_i are provided in Tables 7.9 and 7.10 from: Jacobs, Eva E. (ed.) *Handbook of U.S. Labor Statistics: Employment, Earnings, Prices, Productivity, and Other Labor Data*, Editor and Associate Editor Sohair M. Abu-Aish, Bureau of Labor Statistics, Bernan Press, 2001.

The weights used in the calculation.

		Food & Beverages	*Housing*	*Apparel*	*Transportation*	*Medical care*	*Recreation*	*Education & Communication*	*Other goods and services*		*Total All Items*
Old	1935-1939	0.354	0.337	0.11	0.081	0.041	0.028		0.049		1
CPI-W	Dec-52	0.322	0.335	0.094	0.113	0.048	0.04		0.048		1
	Dec-63	0.252	0.349	0.106	0.14	0.057	0.039		0.057		1
	Dec-77	0.205	0.407	0.058	0.202	0.045	0.039		0.044		1
Old											
CPI-U	Dec-77	0.188	0.439	0.058	0.18	0.05	0.041		0.044		1
	Dec-82	0.201	0.377	0.052	0.218	0.06	0.042		0.05		1
	Dec-95	0.173	0.413	0.053	0.17	0.074	0.044		0.071		0.998
	Dec-97	0.175	0.415	0.053	0.166	0.074	0.043		0.074		1
New	Dec-97	0.163	0.396	0.049	0.176	0.056	0.061	0.055	0.043		0.999
CPI-U	Dec-98	0.164	0.398	0.048	0.17	0.057	0.061	0.055	0.046		0.999
	Dec-99	0.163	0.396	0.047	0.175	0.058	0.06	0.054	0.047		1

III. Prior to January 1993 the All Urban Consumers 'Entertainment' index is used in place of the 'Recreation' index. This index is taken from page 222 of:

Darnay, Arsen J. (ed.) *Economic Indicators Handbook: Time Series, Conversions, Documentation*, Gale Research Inc. Detroit, 1994.

UK ANNUAL DATA

(a) The data is from the ONS Blue Book (2000) and from the ONS web site.

(b) Data is annual and from 1948 - 1999

Name of Series	Source of Series	Notes
1. Unit Labour Costs	Total compensation of employees HAEA; Gross Value Added at constant basic prices ABMM	Unit labour costs = HAEA / ABMM.
2. Gross Value Added implicit price deflator at factor cost.	Gross Value Added at current basic prices ABML; Production taxes other than on products NMYD; Gross Value Added at constant basic prices ABMM	Gross Value Added at factor cost (GVAfc) is calculated as ABML less NMYD ipd calculated as GVAfc / ABMM
3. Relative Price Variability	RPV is calculated using national accounts industry data. RPV uses published total inflation not the implicit total inflation (from the weighted sum of industry sectors).	See following for details concerning the calculation of RPV RPV was 'de-spiked' using 'spike' dummies for observations greater than 2.5 standard deviations from the mean. Spike dummies are 1976 and 1986.
4. Exports of Goods and Services implicit price deflator	Current price expenditure on exports of goods and services KTMW; Constant price expenditure on exports of goods and services KTMZ.	Exports price deflator: KTMW / KTMZ.
5. Unemployment rate	UK Unemployment rate (ILO) MGSX; UK Unemployment rate 'un' (see Hendry (2001) for further details of the data).	Prior to 1983 MGSX is backspliced using 'un' plus 0.1861 (the average difference between MGSX and 'un' from 1983 to 1991).

CALCULATION OF ANNUAL RELATIVE PRICE VARIABILITY

The 'basic price' data is annual from 1948 to 1999 and taken from the ONS Blue Book 2000, Gross value added at current basic prices: by industry (Table 2.3) and Gross value added at 1995 basic prices: by industry (Table 2.4). The 'factor cost' data was supplied directly by the Pete Lee at the ONS and is taken from various older publications of the Blue Book.

The weighted average relative price variability, RPV, is calculated as $RPV = \left(\sum_i s_i \left(Dp_i - Dp_T \right)^2 \right)^{\frac{1}{2}}$

where s_i is the share of each component's share of total current value added, Dp_i and Dp_T are the annual rates of inflation of the ith component and Total Value Added respectively.

a) The basic price data is back-spliced using factor cost data at 1984 for Total services and at 1969 for the other series. Whole economy value added is available using basic prices (constant and current) all the way back to 1948.

b) Total value added inflation is the published rate and not the implicit weighted average of the current series. In practice the difference is very small.

Name of Index	*Current Price ONS Code*	*Constant Price ONS Code*
1. Agriculture, hunting, forestry and fishing	QTOP	GDQA
2. Mining and quarrying	QTOT	CKYZ
3. Total Manufacture	QTPI	CKYY
4. Electricity, gas and water supply	QTPJ	CKYZ
5. Total production	QTPK	CKYW
6. Construction	QTPL	GDQB
7. Total service industries	QTPZ	GDQS
8. All industries	ABML	CGCE

UK QUARTERLY DATA

(a) Data is quarterly from Economic Trends Annual Supplement (2000), ONS Blue Book (2000) and from the ONS web site.

(b) Seasonally adjusted unless otherwise indicated.

(c) The data is quarterly from June 1963 to June 2001.

Name of Series	Source of Series	Notes
1. Unit Labour Costs	Total Compensation of Employees DTWM; GDP at constant prices ABMI	Unit Labour Costs = DTWM/ABMI
2. Private Final Consumption implicit price deflator at 'factor cost'.	Current Household consumption ABJQ; Constant Household consumption ABJR; Current GDP at market prices YBHA; Current Taxes less subsidies CMVL	Deflator at market prices: P_{MP} = ABJQ/ABJR. Consumption deflator at factor cost: P_{FC} = P_{MP}/tax where tax is GDP_{MP}/GDP_{FC}
3. Relative Price Variability	RPV calculated using Household final consumption expenditure data less financial services. <u>Not seasonally adjusted.</u> RPV is calculated using the published total implicit household final consumption implicit price deflator.	See following for details concerning the calculation of RPV RPV was seasonally adjusted using centered seasonal dummies and 'de-spiked' using 'spike' dummies for observations greater than 2 standard deviations from the mean. Spike dummies are June 1974, June 1975, December 1976, March 1978, September 1979, June 1981, and December 2000.
4. Imports of Goods and Services deflator	Current price expenditure on imports of goods and series IKBI; Constant price expenditure on imports of goods and services IKBL	Imports price deflator: IKBI / IKBL
5. Unemployment rate	UK Unemployment Rate (ILO) MGSX; UK Unemployment Rate 264284A2 (June 1997 OECD Statistical Compendium).	Prior to June 1992 MGSX is 264284A2 plus 0.4048 (the average difference between MGSX and 264284A2 from June 1992 to June 1997).

CALCULATION OF QUARTERLY RELATIVE PRICE VARIABILITY

The RPV calculation uses national accounts household final consumption expenditure data. The data was downloaded from the ONS web site on 11 September 2001 and is the same data as in Table 1.7 in the Economic Trends Annual Supplement 2000.

The weighted average relative price variability, RPV, is calculated as $RPV = \left(\sum_i s_i \left(Dp_i - Dp_T \right)^2 \right)^{\frac{1}{2}}$

where s_i is the share of each component's current value added in total current value added, Dp_i and Dp_T are the annualised quarterly rates of inflation of the ith component series and Total Value Added respectively.

a) The data is quarterly from March 1963 to March 2001 and RPV starts from June 1963.

b) RPV is calculated for household consumption less financial services (as it is not measured at market prices). Prior to March 1974 there is no constant price data for 'Other Services'.

c) The inflation data is at market prices and not at factor cost.

Name of Index	*Current Price ONS Code*	*Constant Price ONS Code*
1. Durable Goods	AEIT	AEIV
2. Food (Household expenditure)	CCDW	CCBM
3. Alcoholic drink and tobacco	CDFH	FCCA
4. Clothing and footwear	CDDE	FCCB
5. Energy products	CCEC	CCBS
6. Other goods	ABZN	ABZP
7. Rent, water and sewerage changes	ABRG	ABRI
8. Catering	CDEY	CCHS
9. Transport and communications	ABOZ	ABPD
10. Other services	ABOY	ABPC
11. Total value added	ABPB	ABPF

5 December 2001.