1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

THE PRICES OF MATERIAL AND INTERMEDIATE INPUTS IN UK MANUFACTURING: IDENTIFYING THE CONTRIBUTIONS OF WORLD PRICES AND DOMESTIC FACTOR COSTS.

Abstract

In this paper we explore the patterns and determinants of the prices of raw material and intermediate inputs (MII) to UK manufacturing as measured by the net (n) and gross (g) producer price indexes of materials and fuels (PIMF). Despite the importance of MII in total manufacturing costs their prices have been little studied. It is shown that these prices are Granger independent of the demand for such inputs and thus a simple cost based model of price determination is constructed. This model forecasts that MII prices are functions of world prices for oil, commodities and semi manufactured products intermediated by exchange rates and duties, domestic factor prices and a trend reflecting domestic technical change, changes in mark ups and change in weights. By the means of an error correction representation it is found that PIMFn and PIMFg, in the long and short run, are more sensitive to overseas determined prices (of oil, commodities, and semi manufactured products) than domestically determined prices (labour, capital and the trend). It may be argued that to some considerable degree therefore the prices of material and intermediate inputs in UK manufacturing will not be particularly sensitive to policy actions.

JEL Classification: E3, C0

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1.   INTRODUCTION

The prime objective of this paper[1] is to explore the time path of, and the determinants of changes in, the prices of material and intermediate inputs (hereinafter MII) in UK industry between 1979 and 2003 (with some extra observations upon the period from Jan 1957 – Jan 1979). Census of Production data indicates that in UK manufacturing as a whole (in 1995) MII costs represented 68% of total costs (sales)[2] and we contend that as MII represents such a high proportion of costs, they will have a major impact upon the inflationary process. Beckerman and Jenkinson (1986) illustrated some time ago how inflation may be related to the world price of commodities. We thus place particular emphasis upon the pass through from world prices of oil and other commodities as part of MII to domestic manufacturing costs and the lags involved in this process. In addition by tying down the dynamic structure our analysis will provide greater insight in to the rate at which home costs will reflect world price changes and how long policy makers may have to react to world price shocks.

Although there is some work relating to other countries (e.g. Bjornland, 2001 who has explored inflation in Norway explicitly accounting for the role of both domestic and imported inflation) and there is also work on commodities and oil prices (e.g. Chaudhuri, 2001) the analysis of the determinants of the prices of material and intermediate inputs in UK industry seems to have merited very little attention in the literature. A search of the standard databases has not thrown up any recent publications in this area apart from papers from the ONS and the Bank of England discussing basic measurement issues. The importance of the subject has however been observed in that, for example, Mervyn King, speaking as Deputy Governor of the Bank Of England, in a speech in Edinburgh in August 1999, emphasised how falling commodity and food prices had restrained retail prices in the UK. Current concern over movements in world oil prices post the Iraq invasion suggests that this is still a matter of considerable practical concern.

---

[1] We would especially like to thank the ONS for all their patience with our requests for data and the efficiency with which they were met. We also thank participants in the 2003 RES conference for their comments on an earlier version of this paper. Of course any errors remaining in the paper are our responsibility alone.

[2] Compared to wages, which are much more commonly studied but represent only 16%.

In addition to being a mechanism by which inflation can be transmitted across countries there are, inter alia, two other main reasons for exploring MII prices and their determination. First, Oulton and O'Mahony (1994) have previously illustrated that the UK economy has experienced negative MII productivity growth (when output is measured as real gross sales). This suggests that to some degree recently observed historically high rates of labour productivity growth may reflect movements in the relative prices of labour and materials. Some analysis of the determinants of the time path of material costs will thus inform the productivity debate. Secondly, with the spate of privatisations in the UK in the late eighties and the nineties, a large part of the UK economy became regulated by (RPI – x) rules, where x is appropriately defined as the expected rate of reduction (over the period of the price regulation) in real minimum unit costs of production. To make any sense, the measure of output to be applied in the RPI – x formula is gross output and the costs to be measured must involve MII costs. Thus, in setting x, regulators must take account of forecasted changes in the price and costs of MII. Further understanding of the determinants of such prices may improve these forecasts[3].

The next section of this paper discusses the nature of MII and measures of MII prices. Section 3 explores time profiles of such prices, section 4 presents a basic model of their determination, and section 5 contains econometric estimates of the model and discussion. In section 6 we draw conclusions.

2.   MII STRUCTURES AND PRICES

2.1 The Structure of Material and Intermediate input costs

From the Census of Production, three main types of MII to manufacturing can be identified: materials and fuels including intermediate inputs and semi- manufactured products bought in, non industrial services and industrial services. The relative cost shares in total MII inputs in 1995 (1990) were 56% (53%), 3% (4%) and 9 % (9%)

---

[3] Although in some regulated sectors certain major costs may be passed through directly e.g. wholesale gas prices, and thus these would not be part of an appropriately measured index of material prices for that sector.

respectively. From the UK Input Output Tables, in 1990, this date being central to our observation period, 36% of intermediate inputs to manufacturing (% of total intermediate input purchases) were sourced from UK manufacturing with 25% being manufactured imports; distribution, transport, business and other services (all home produced) represented 27%; domestic agriculture and energy represent an 8% share with imports of such having a 1% share.

2.2 The Price Index for material and fuels

The main relevant price series for MII produced by the ONS is the producer price index for material and fuels in manufacturing (which we label PIMF) - with similar series also being available for (some) sub sectors of manufacturing. This series is produced in both gross and net forms (which we label the PIMFg and PIMFn). The gross index is designed to reflect the cost of all MII to manufacturing from UK producers, including inputs sourced from manufacturing itself, plus MII purchases from abroad. For the net index, a "ring fence" is placed around the UK manufacturing sector and only the cost of those inputs that cross the ring fence are included, thus the net series does not reflect the cost of MII produced in the domestic manufacturing sector.

The calculation of the indices has been changed over time (for details of the latest version see the ONS website www.statistics.gov.uk/articles/economictrends/ETAugMorris.pdf). From 1995 to 2003 the gross index was made up of 146 separate components (the net had 70) with weights reflecting the value shares of each input. Input prices are either taken from the output prices of sectors supplying inputs or import prices. According to Business Monitor (MM2, Business Monitor, 1999) all index numbers are compiled exclusive of VAT, but excise duties (on cigarettes, manufactured tobacco and alcoholic liquor) are included as is the duty on hydrocarbon oils (including the CCL for the latest version). Given that VAT can be reclaimed by manufacturing firms but duties and other taxes on fuels, imports and other inputs cannot, this is appropriate.

The net series is available monthly (non-seasonally adjusted) from 1957-1, the gross series only from 1979-1. For later dates (from 1986) the net series is also available in a seasonally adjusted form. As the gross series is only available without seasonal adjustment, only the non-seasonally adjusted series are considered in this study. The

series have been re-based and re-weighted at five-year intervals. As the weights are only changed infrequently, any substitution from expensive inputs to cheaper inputs by firms will only be reflected in the series with a lag. The series may thus tend to overestimate the price of inputs. The view of the ONS is that although certain compromises due to data availability have been made in the construction of the series the compromises are not thought to have seriously impaired the efficacy of the index[4]. The1995 and 2000 weights used for the calculation of PIMFn, at a high level of aggregation, are as in Table 1.

Table 1: PIMFn weights 1995 and 2000 *(percentages)*

Description	Weight 1995	Weight 2000
Fuel inc. CCL*	11.2	6.9
Home produced and imported crude oil	10.1	12.4
Home produced food	18.1	7.8
Other home produced	2.1	1.5
Imported food	7.7	4.4
Imported metals	9.7	7.0
Imported chemicals	15.9	13.2
Other imports	25.2	12.8
Other imports- parts and equipment	-	34.0
Total	*100*	*100*

* Climate change levy

Source: ONS (www.statistics.gov.uk/ppi)

The main criticism and limit of the accuracy of the PIMF series as a measure of the costs of MII is that it does not reflect the costs of services bought by industry. As shown above 12 – 13% of total input costs are the costs of industrial and non-industrial services and such costs are not reflected in either the gross or net PIMF. It is thus clear that the PIMF series (gross or net) is not a perfect measure of the prices of all MII to manufacturing, but it is the best available.

---

[4] We are unable to check or validate this view. Our analysis below suggests that there may have been one possible occasion at the end of 1989/beginning of 1990 when poor data produces an unexplained movement in the PIMFg series, but this may be the failing of the model rather than the data. Table 1 illustrates changes in weights between 1995 and 2000 but the change in the structure of the weights means that the data is not very informative.

3. TIME PROFILES AND TIME SERIES PROPERTIES OF THE PRICES OF MII

3.1 Graphical representations

In Figure 1 we plot, over the period from 1957 – 2003, the PIMFn series, the RPI and the ratio of PIMFn to the RPI i.e. the real net PIMF, labelled RPIMFn. From this data we observe that, prior to 1973 the PIMFn series shows a gradual rate of increase essentially doubling in 12 years. Between 1973 and 1984 the PIMFn series increases by a factor of 6.5 before falling again in 1986, with relative constancy (with fluctuations) thereafter through to 2003. Using the RPI as a benchmark against which movements in the PIMF can be judged, prior to January 1973 the PIMFn and the RPI essentially move together, although the real net PIMF (RPIMFn) shows a gradual decline between January 1957 and July 1972. In 1972 -3 the PIMFn increases much faster than the RPI, with RPIMFn rising to a plateau on which it remains until 1986, at which date there is a fall in the PIMFn relative to the RPI, and RPIMFn falls and continues to fall through to 2003. Over the whole 1957 – 2003 period the trend rate of growth of the real net PIMF has been negative, RPIMFn approximately halving over a 45 year period.

**Figure 1. PIMF net (PIMFn) , RPI and real PIMF net (RPIMFn) : Jan 1957 – Sept 2003 (base 1995=100)**
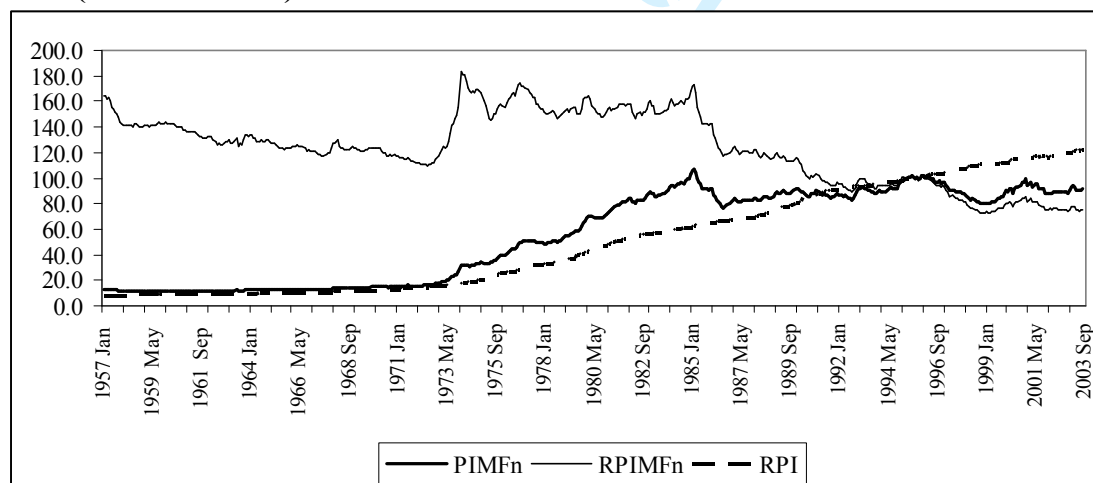
In Figure 2 we plot the gross and net PIMF series for the period from 1979 – 2003 with both being set to a common base of 100 in 1995, and also the Retail Price Index. Over the whole observation period from 1979 to the end of 2003 the gross and the net series shows

a similar increase. However, within the observation period the PIMFn shows greater fluctuations than does PIMFg. For the period from January 1979 to February 1984 the net series grows faster than the gross series, but between 1985 and 1986 the net falls in absolute value and relative to the gross, after which gross and net move together through to 1996, beyond which the net tends to dip below the gross.

For later purposes it is worth noting events at certain dates. Prior to 1972 UK exchange rates were fixed under the Bretton Woods agreement (with a devaluation in 1967) but from June 1972 UK exchange rates were floated and were subsequently more volatile (as observed for a number of countries , see Enders, 1995, pp.237). Figure 1 illustrates quite different behaviour of the PIMF series post 1972 compared to pre 1972. The OPEC cartel began to impact upon oil prices from 1973, but post 1979, the oil price (in sterling and including taxes) and to a lesser extent commodity prices, peaked in April 1985, and then fell dramatically in January 1986 (coinciding with OPEC being much weaker, see Bjørnland, 2001). There was a one off upward blip in the oil price in August/September 1990, reflecting the Iraqi invasion of Kuwait. From Jan 1999 there was a series of increases in the oil price as it rose again nearly to its 1985 peak, after which, from early 2000 the price fell again, although not as dramatically as in 1986. Our data does not encompass the very latest movements in oil prices.

Figure 2. PIMF Net (PIMFn) ,Gross (PIMFg) and RPI : Jan 1979-Aug 2003 (base 1995=100)
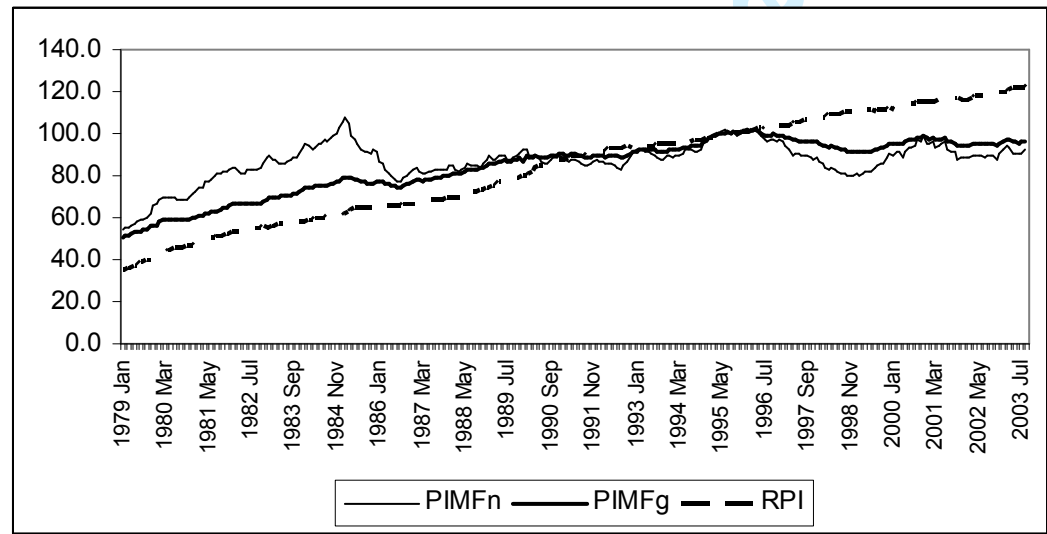
3.2. Time series properties

The result from a time series analysis of PIMFn and PIMFg for the common period January 1979 - December 2003 is summarised in Table 2. The first two columns report the DHF (Dickey et al. 1984) and the Osborn modification (Osborn et al.1988) tests for the presence of stochastic seasonality. These tests indicate that neither of the price variables is affected by stochastic seasonality and therefore the seasonality can be simply picked up by deterministic dummies without the need to seasonally difference the variables.   The order of the non-seasonal component is examined using the traditional integration order tests, namely Integration Durbin Watson Statistics (Sargan and Bargawa, 1983); Dickey Fuller (DF) and Augmented Dickey Fuller (ADF) tests (see Dickey and Fuller 1979, 1981); and the Phillips and Perron (1988) test (which has greater power to reject the null of a unit root when unnecessary nuisance parameters are specified in the model).   These tests, reported in the last four columns of Table 2, suggest that PIMFn and PIMFg are unit root (and affected by deterministic seasonality). The same conclusion was reached when the series were tested for second order unit roots but for space reasons we have omitted these results.

Table 2. Unit root test of PIMFn and PIMFg (1979:1-2003:12)[a]

	test of seasonal integration			Test of non-seasonal integration			
	DHF	**Osborn-DHF**		**DF [b]**	**ADF [lag] [b]**	**PP**	**IDW**
PIMFn [a]	t_z=-12.019 **	t_{zo}=-11.890 **		$\tau_{\mu,\gamma}$ = -2.538	$\tau_{\mu,\gamma}[11]$ = -2.509	t =-2.8806	0.021
DPIMFn	–	-		$\tau_{\mu,\gamma}$ =-13.324**	$\tau_{\mu,\gamma}[2]$ =-7.009**	t=-11.0530**	1.45**
PIMFg	t_z =-1.428 **	t_{zo}=-11.171**		$\tau_{\mu,\gamma}$ =- 3.650	$\tau_{\mu,\gamma}[14]$ =-2.280	t =-3.219	0.002
DPIMFg	-	-		$\tau_{\mu,\gamma}$=-12.667**	$\tau_{\mu\,\gamma}[2]$ = -6.2301**	t =-13.655**	1.60**

[a] Theoretical values of the tests: for DHFs (n=200 (-1.83;-1.71) and n=300 (-181;-1.698) see Charemza and Deadman (1992) table 5, pp.300); for DF, ADF ($\tau_{\alpha,\gamma}$= -2.872 (5%) ; -3.455 (1%)) and PP (Pimfn/n: -2.87(5%); -2.57(10%); -3.46(1%): Dpimfn/g: -2.87 (5%);-2.57 (10%); -3.46 (1%)) [b]$\tau_{\alpha,\gamma}$= test value (model with intercept and deterministic seasonality), note that the results of the DF and ADF tests are consistent with the test of the joint restrictions on intercept and/or trend and/or unit root, as well as the test on higher integration order (the Pantula approach) but they are not reported for space reasons.

It was also found that the dynamic of PIMFn is affected by 3 major shocks (picked up by a series of pulse variables taking value one in the presence of the shock and zero otherwise) occurring in April 1985, January 1986 and December 2000. These dates correspond to: (i) the beginning of the slow down in oil prices in 1985 (ii) the drastic oil

price (and to a lesser extent commodity price) falls in 1986 and (iii) the beginning of the oil price reduction at the end of 2000. PIMFg however is affected only by one shock occurring at the end of 1989/beginning of 1990. We have been unable to isolate the cause of this although data error is a possibility.

The non-stationary nature of the PIMF series is in line with a large empirical literature that recognises that most price series have at least one unit root due to the underlying growth rate of the price series (see Nelson and Plosser 1982). However, this might not always be the case in the presence of shocks and perturbations as these can easily be mistaken for permanent shocks in a unit root when in fact the series is stationary around a deterministic component that has been subject to a structural break. In the case of PIMFn the graphical inspection would not rule out the possibility that the three shocks might have caused permanent shifts in the mean around which the series exhibits stationary fluctuations. The presence of structural breaks in a stationary variable can invalidate the ADF, DF and the Phillips and Perron tests which have been proved to be biased towards the non rejection of a unit root in the series (Perron 1989). We therefore used the unit root test in the presence of structural change (see Perron 1989) to test the hypothesis that the PIMFn series is stationary subject to a permanent change in its mean at the date of each shock, i.e. April 1985, January 1986 and December 2000, versus the hypothesis that it is non-stationary and subject to a one off pulse at the known dates. The test when contrasted against the critical values (corresponding to the sample size (n) and the proportion of observations up to the break point in the sample (λ)), confirms that the PIMFn series is non-stationary (I(1)) and subject to pulse intervention in April 1985 ($t_{04\text{-}1985}$= -2.493, critical upper value at 5% $P_{\lambda=\ 24;\ n=308}$ = -3.18; January 1996 ($t_{01\text{-}1986}$= -3.104, critical upper value at 5% $P_{\lambda=70;\ n=308}$ = -3.26 and December 2000 (and $t_{12\text{-}2000}$ = -2.933, critical upper value at 5%, $P_{\lambda=90;\ n=308}$=-3.01). The same conclusion was drawn when the analysis was carried out on PIMFg with respect to a pulse occurring at the end of 1989/beginning of 1990.

4. MODELLING THE PRICES OF MII

The purpose of the rest of this paper is to model the determinants of PIMFn and PIMFg. Given the definition of the PIMF series, clearly changes in PIMF will be the results of

changes in the 146 or 70 or so prices of the inputs that are used in their calculation. However, viewing matters in this way does not allow for any lags between input price change and changes in the PIMF series nor does it account for the fact that many of the prices that are determinants of the PIMF series are endogenous to the economy and affected or determined by the PIMF with or without lags. Here our purpose is to model PIMFn and PIMFg as determined by only their exogenous drivers and to explore the time profiles by which changes in those drivers feed through to the PIMF series.

4. 1 Supply and demand drivers

In principle the prices of MII i.e. PIMFg and PIMFn will be the result of the interaction between the demand for and supply of such inputs. However if the supply curve of inputs is flat (there is an infinite elasticity of supply) input prices will not be affected by changes in the level of demand for the inputs. An infinite elasticity supply curve would be consistent with constant returns to scale in the production of inputs and either a demand invariant mark up or perfect competition (and thus marginal cost pricing with a constant mark up of zero).

To initially establish whether the price of inputs is affected by the demand for inputs, it is argued that the demand for MII is a derived demand, with the demand being a function, for given input prices, of manufacturing output. We thus undertook causality tests, following both the Granger (1969) and the Sims (1972) approaches, of the relationship between the prices of MII and the level of manufacturing output. The argument is that if output "causes" input prices then demand will be impacting upon such prices. If however it is found that input prices "cause" manufacturing output then one may infer that such prices are not affected by demand.

The output variable is here measured by the non-seasonally adjusted index of industrial production, monthly, (labelled OUTPUT) and input prices by the net or gross PIMFn or PIMFg index. The preliminary time series analysis suggests that the PIMF series are unit root with deterministic seasonality (see Table 2). The time series properties of the OUTPUT series are more problematic to establish as it is borderline between being

stationary around a positive trend and a unit root (see Table 3). However, after some

investigation[5] it was concluded that the series has a unit root.

Table 3. Unit root test of manufacturing OUTPUT (1979:1-2003:12)

	test of seasonal integration			Test of non-seasonal integration			
	DHF	**Osborn-DHF**		**DF**	**ADF[lag]**	**PP**	**IDW**
OUT	t_z= -2.245**	t_{zo}=-2.246**		$\tau_{\mu,\gamma,\beta}$=-7.366**	$\tau_{\alpha,\beta,\gamma}$ [14]=-3.2534	t=-5.9671**	0.641
DOUT	–	-		$\tau_{\mu,\gamma}$=-31.314**	$\tau_{\alpha,\gamma}$ [11]=-4.844**	t=-36.80**	3.07**

Theoretical values of the tests:DHF: n=200 t=-1.83 (5%); n= 300 t=-1.81 (5%) see Charemza and Deadman, table 5, pp.300, 1992. DF and ADF: $\tau_{\alpha,\gamma}$= -2.872 (5%) ; -3.455 (1%) ; $\tau_{\alpha,\beta,\gamma}$ = -3.427 (5%) -3.994 (1%) PP-test: PPout:-3.4276 (5%); -3.1369 (10%); -3.9950 (1%) (c,t) ; PPDout: -1.9408 (5%); -1.6163 (10%); -2.5731 1% . DW critical value about 0.60

The econometric testing was based upon three tests: the Sargent (1976) test of Granger

causality, the Geweke, Meese and Dent (1983) test of causality a la Sims and a test based

upon the Granger (1988) causality definition corrected for short and long run dynamics

derived within a co-integrating framework estimated a la Johansen (1988, 1990).

In particular, the Granger causality test states that x is a Granger cause of y, if y can be

predicted with better accuracy by including in the information set the past values of x

rather than by not doing so (other information being identical). The ad hoc test developed

by Granger (1969) and later modified by Sargent (1976) can be specified using an

unrestricted autoregressive system viz.

$$y_t = A_o D_t + \Sigma \gamma_j y_{t-j} + \sum_{j=k}^{m} \beta_j x_{t-j} + \varepsilon_t \qquad (1)$$

where D denotes the deterministic (non stochastic) variables of the equation, i.e.

intercept, deterministic trend, seasonals, etc., A_o is a vector of parameters and ε_t is a

vector of white noise error terms. The hypothesis of non-causality $\Sigma_{j=1}\beta_j=0$ (i.e. x does

not cause y) can be tested using the Lagrange Multiplier Statistics in its F-form (LMF)[6].

The exogeneity test can be tested via the significance of Ho: $\beta_1=\beta_2=\dots=\beta_m = 0$ (y is

---

[5] As shown in table A3.1 both the DF and the PP test tests seem to suggest that the OUTPUT series is stationary around a trend, while both the IDW and the ADF are borderline. The ADF is superior to the DF, however it is highly sensitive to both the sample size and the number of first differences (lags) used in the testing procedure. As the lag length reduces below 12 months the hypothesis of a unit root cannot be rejected but as the lag length increases to over 12 months the hypothesis that the series is trend stationary is difficult to reject. The seasonally adjusted version of the index of manustrial production (CKYY series, ONS source) was also analyzed and was shown to have a unit root (results available upon request) and thus it was concluded that the non-seasonally adjusted series also has a unit root.

[6] The LMF instead of having the usual χ^2 distribution with k degrees of freedom, has asymptotic F distribution with degrees of freedom equal to the number of restrictions imposed (k) and the difference between the sample size and the number of parameters in the unrestricted model (T-h).

exogenous to x). If this hypothesis is rejected, while the Granger test is accepted then x does not strongly Granger cause y, that is the variable is not completely exogenous.

The SIMS approach to causality is based upon the concept that the future cannot cause the present (Sims, 1972) and is here tested using the test developed by Geweke, Meese and Dent (1983) viz.

$$x_t = \lambda D_t + \sum_{j=1}^{m} \beta_j x_{t-j} + \sum_{j=-k}^{-m} \delta_j y_{t-j} + \sum_{j=1}^{m} \gamma_j y_{t-j} + v_t \qquad (2)$$

where $\Sigma_{j=-k} \delta_j y_{t-j}$ are the leading values of y_t, i.e. $y_{t+1}, y_{t+2}, .. y_{t+m}$. If the coefficients on leading *y*s are jointly equal to zero (Ho: $\delta_{-1} = \delta_{-2} = ... = \delta_{-m} = 0$) then x does not cause y. On the contrary, if the coefficients are non zero, since the future cannot cause the present (future y cannot cause the current x) x is a Granger cause for y. Similar to the Granger causality, the SIMs-GMD test consists of running the LMF joint significance test on the subset of parameters δ's under the hypothesis that the tested restrictions are valid.

The implicit assumption behind these tests is that the variables are stationary.
In this study the variables of interest need to be differenced to be reduced to stationarity. In so doing the long run components of the series will be removed and the outcome of the Granger causality test can only be interpreted as short run causality test. However, if there exists a common long run relationship, the standard causality test can be modified as to incorporate the long run effect. As suggested by Johansen (1988) and Johansen and Juselius (1990), the co-integration analysis within a VAR framework, enables one to overcome most of the problems arising when variables are not stationary. The Granger representation theorem (Engle and Granger, 1987) would allow for a restricted error correction representation of their relationship such as:

$$\Delta y_t = \lambda_1 D_t + \sum_{j=k}^{m} \gamma_{1j} \Delta y_{t-j} + \sum_{j=k}^{m} \beta_{1j} \Delta x_{t-j} + \alpha_1 (z_{t-1}) + \varepsilon_{2t} \qquad (3)$$

$$\Delta x_t = \lambda_1 D_t + \sum_{j=k}^{m} \gamma_{2j} \Delta y_{t-j} + \sum_{j=k}^{m} \beta_{2j} \Delta x_{t-j} + \alpha_2 (z_{t-1}) + \varepsilon_{2t} \qquad (4)$$

where D is a set of deterministic variables such as intercept and seasonality, and z_{t-1} is the error correction term estimated from the Johansen cointegrating relationship ($y_{t-1} - \zeta x_{t-1}$). On the grounds that if a cointegrating relationship exists there must be Granger causality in at least one direction (see Granger, 1988), (A3.3/4) allows one to carry out

the Granger causality test, within a VAR framework, based upon the short run (difference

terms) and the long run (ECM term) dynamics. Failure to reject the hypotheses that $\beta_1 =$

$\beta_2 = ... = \beta_m = 0$ and/or $\alpha_1 = 0$ leads to the conclusion that x causes y either in the long

and/or in the short run.

Table 4. Testing the causality between OUTPUT and PIMF (net/gross)

a) PIMF$_j$ (j=net , gross) Granger causes OUTPUT: F-test of joint significance

Test	Ho	DPIMFn->DOUT	DPIMFg->DOUT
SIMS-GMD	$\delta_{t+j,OUT}=0$ j=1...m	0.2618 [12] p = 0.0102	2.4370 [14] p=0.0034
Granger –F	$\beta_{t-j, PIMF}=0$ j=1...m	3.1565 [15] p=0.0001	2.4087 [13] p=0.0046
Granger ECM	$\alpha_i = 0$		5.9826 [13] p=0.0152
	$\beta_{i,j, PIMF} = 0$ j=1...m		2.6897 [13] p=0.0015
	Joint: $\alpha_1 = 0$ and $\beta_{i,j,PIMF} = 0$ j=1...m	No long run relationship	2.9027 [13] p=0.0005
	Conclusion:	*PIMFn causes OUTPUT*	*PIMFn causes OUTPUT*
Exogeneity[a]	$\beta_{t-j, PIMF}=0$ j=0...m	3.2339 [15] p=0.0000	2.8388 [13] p=0.0006
	Conclusion:	*OUTPUT is not exogenous to PIMFn*	*OUTPUT is not exogenous to PIMFg*

b) OUTPUT Granger causes PIMF$_j$ (j=net, gross): F-test of joint significance

Test	Ho	DOUT->DPIMFn	DOUT->DPIMFg
SIM-GMD	$\delta_{-j,OUT}=0$ j=1...m	1.0218 [9] p=0.4231	1.172 [13] p=0.3015
Granger –F	$\beta_{j, OUT} = 0$ j=1...m	1.0745 [15] p=0.3810	1.3503 [13] p=0.1854
Granger ECM	$\alpha_i = 0$		3.2878 p=0.0711
	$\beta_{i,j, OUT} = 0$ j=1...m		1.442 p=0.1414
	Joint: $\alpha_1 = 0$ and $\beta_{i,j, OUT} = 0$ j=1...m	No long run relationship	1.5013 p=0.1117
	Conclusion:	*OUTPUT does not cause PIMFn*	*OUTPUT does not causePIMFn*
Exogeneity[a]	$\beta_{j, PIMF}=0$ j=0...m	1.2619 [15] p=0.2229	1.6931 [13] p=0.0582[a]
	Conclusion:	*PIMFn is exogenous to OUTPUT*	*PIMFg is exogenous toOUTPUT*

NB. [maximum lag] ; p= significance level; [a] exogeneity test adjusted for long run dynamic

The empirical results of the three tests for the strong and weak causality of PIMFn/

PIMFg and OUTPUT are summarized in Table 4a/b. In Table 4.a the first two rows show

that SIMs causality (SIMsF test) and Granger causality cannot be accepted for DPIMFn

=> DOUTPUT or for DPIMFg => DOUTPUT. The possibility that causality may arise

from long run level effects and not only from the short run dynamics implied by the

differentiated terms is tested in row three (see Granger-ECM causality). The result of this

test procedure shows that PIMFg does Granger cause OUTPUT in both the short (β_j) and

the long run (α). In the case of PIMFn we could find no equilibrium level relationship

indicating the absence of feedback between the levels of PIMFn and OUTPUT in the

long run. The last row (see Exogeneity row), indicates that OUTPUT is not exogenous to both net and gross PIMF. In summary Table 4.a shows that PIMF both strongly and weakly Granger causes OUTPUT. However, the opposite it is not true. As shown in the first two rows of Table 4.b. (Granger and Sims GMD tests), the hypothesis of non causality (DOUTPUT≠>DPIMFn ; DOUTPUT ≠>DPIMFg), cannot be rejected in either of the two cases. Moreover, for PIMFn, the results in row three (column one) confirm the absence of any long run equilibrium relationship between PIMFn and OUTPUT.

Row three column two confirms that the null of no Granger causality cannot be accepted for PIMFg in the short run. In the long run this hypothesis cannot be rejected at 7%, suggesting that perhaps there might exist some demand pull effects in the long run but they are offset by high perturbations in some of the components of input prices. However, testing the joint significance of short and long run dynamic adjustment it emerges that demand pull effects do not exert any significant impact upon PIMFg (Ho: $\beta_{ECM} = \beta_{DPIMFg} = 0$, F=1.5013 [0.1117]). Therefore, one can safely conclude that there is no evidence of either short or long run feedback of OUTPUT into PIMFg.

The exogeneity test, in the last row of table 4.b, indicates that while PIMFn is exogenous to OUTPUT, there is some evidence that PIMFg, when adjusted for the long run dynamic, is weakly exogenous and it interacts with current levels of OUTPUT. However, this hypothesis can only be accepted at the 6% significance level
The evidence therefore is that PIMF (net and gross) are not caused by manufacturing output and thus we conclude that such prices may be considered solely as cost determined[7].

---

[7] This issue relates to but is not quite the same as the issue addressed by Britton Larsen and Small (2000) hereafter BLS (2000). These authors explore whether for the economy as a whole the mark up of prices over costs is pro or anti cyclical. They find procyclicality (see also Small (1997) and Haskel, Martin and Small (1995).This would imply that in periods of high demand prices will be higher (given costs), and thus the price of (domestically produced) inputs would be higher in periods of high demand. Our finding does not confirm this for inputs as a whole of which domestically produced inputs are only a part. The different results may be due to the fact that we are only considering manufacturing as opposed to the economy as a whole, it may be due to the fact that by considering only manufacturing we have had to make fewer data approximations than have BLS (2000), or it may be due to our considering all inputs and not just domestically produced inputs.

4.2 Price determination

Having established that the PIMF series may be considered independent of domestic demand factors we proceed upon the assumption that the supply curve for MII is flat. We further assume that there are linear production technologies[8] throughout the economy.

For expositional and measurement purposes we aggregate the large number of individual MII inputs defined in the PIMF series to eight, labelled X_1 to X_8, with prices (in sterling) P_1 to P_8 respectively (see Table 5). The sterling exchange rate is considered exogenous to the PIMF series. It may be noted that, as we have shown above imported services are sufficiently small to be ignored, and in any case the gross and net PIMF series do not directly include service prices.

Table 5. MII aggregates

Label	Description
X_1	Domestic sourced raw materials and fuels (e.g. coal and oil)
X_2	Imported raw materials and fuels
X_3	Domestic sourced other non service intermediate inputs produced outside manufacturing (e.g. electricity or meat)
X_4	Imported other non service intermediate inputs produced outside manufacturing
X_5	Domestic sourced service inputs (e.g. computer and transport services)
X_6	Imported service inputs
X_7	Domestic sourced intermediate inputs produced within manufacturing
X_8	Imported intermediate inputs produced within manufacturing

We then argue as follows

(i)   The prices of material inputs are determined on world markets thus the prices of material inputs sourced from home and overseas are considered to be equal i.e. $P_1(t) = P_2(t)$. We further assume that there is an infinite elasticity of supply of

---

[8] In the absence of prior knowledge on the nature of the prevailing production technology in the economy for both the net and gross PIMF we explored one case where the technology is linear and another where the prevailing technology in each sector is Cobb Douglas - in each case assuming constant returns to scale. However, as the linear approach is more suitable for the way that the PIMF series are designed and the results achieved are in line with expectations we report solely upon that approach.

such inputs at world prices and, as the sterling exchange rate is considered exogenous to the PIMF, we model $P_1(t) = P_2(t)$ as determined exogenously.

(ii)   For domestically produced intermediate inputs from outside manufacturing (e.g. electricity or meat) we consider the price $P_3(t)$ to be endogenous to the system. For such inputs produced overseas a small country assumption is made and an infinite elasticity of supply at current prices assumed with such prices, $P_4(t)$, therefore being taken as exogenous.

(iii)   The price of imported services, $P_6(t)$, is assumed given and determined exogenously. The prices of domestically produced services, $P_5(t)$, are endogenous, but we assume constant returns to scale in the service sector thus such prices will depend solely upon the costs of producing services and not the level of demand.

(iv)   We make a small country assumption for imported manufactured intermediate inputs and thus take $P_8(t)$ as exogenous. For manufactured intermediate inputs sourced domestically the price, $P_7(t)$, will equal the net or gross producer price index[9] in manufacturing (depending upon whether one is looking at net or gross relationships). We proceed arguing that $P_7(t)$ will be a function of the unit costs of production in manufacturing and as argued above, independent of input demand.

Thus of the defined eight material and intermediate inputs, three i.e. numbers 3, 5 and 7, (domestic produced inputs of non manufactured/non service products, services, and manufactured products) are argued to have prices that are determined endogenously. All other prices are considered to be determined exogenously. For the endogenously priced inputs we assume a Leontief technology defining $\alpha_{ij}(t)$ as input j per unit of output i (j = 1..8) in time t. Thus for i =3, 5, 7, we assume that, in the long run at least (short versus long run dynamics are discussed below), $P_i(t) = \pi_i(t)C_i(t)$, where $\pi_i(t)$ equals one plus the mark up on unit costs of production at time t, $C_i(t)$, which in turn are given by:

---

[9] Just as there are net and gross input price series so there are net and gross output price series. The net price series considers only the prices of good that cross the manufacturing ring fence whereas the gross series also considers the prices of manufactured goods used in manufacturing. One should note (a) that the net and gross output price series track each other much more closely that the net and gross input price series and (b) that both output price series refer only to products sold on the home market. Export sales are excluded in the construction of the series.

$$C_i(t) = \sum_{j=1}^{8}\alpha_{ij}(t)P_j(t) + \alpha_{iL}(t)W(t) + \alpha_{iK}(t)R(t) \qquad (1)$$

where $\alpha_{iL}(t)$ and $\alpha_{iK}(t)$ are inputs of labour (L) and capital (K) respectively in the production of product i . Wage rates W(t), and capital costs (interest rates) R(t), are assumed the same for all i (to reduce the number of parameters to be considered). Thus for i = 3, 5, 7[10],

$$P_i(t) = \pi_i(t)[\sum_{j=1}^{8}\alpha_{ij}(t)P_j(t) + \alpha_{iL}(t)W(t) + \alpha_{iK}(t)R(t)] \qquad (2)$$

4.2.1 The net PIMF

The net price index for material and fuels, PIMFn, is measured as

$$PIMFn(t) = s_1(t)P_1(t) + s_2(t)P_2(t) + s_3(t)P_3(t) + s_4(t)P_4(t) + s_8(t)P_8(t) \qquad (3)$$

where the s_i are the shares of the different inputs, 1…..4, 8 in total (included) MII costs. Note that PIMFn excludes services and domestically produced manufactured inputs. As the shares used in the construction of the index are recalculated each five years they are written as time dependent[11].

Of the prices in the PIMFn expression $P_1(t) = P_2(t)$, $P_4(t)$ and $P_8(t)$ have been argued to be given exogenously and thus only $P_3(t)$ is endogenous. Using (2) for i = 3, 5 and 7, solving for $P_3(t)$ as a function of $P_2(t)$, $P_4(t)$ and $P_8(t)$ and substituting in (3) yields (4)

$$PIMFn(t) = \beta_1(t)P_1(t) + \beta_2(t)P_4(t) + \beta_3P_8(t) + \beta_4(t)W(t) + \beta_5(t)R(t) \qquad (4)$$

where the β parameters are messy combinations of the s and α parameters. Notice that compared to the standard accounting definition for PIMFn, this expression contains only

---

[10] Such equations as that which follows may be written in net or gross form, dependent upon whether own sector price is solved out of the rhs. Net forms would involve $\alpha_{33}(t) = \alpha_{55}(t) = \alpha_{77}(t) = 0$.

exogenously determined prices and not endogenously determined prices, and also includes labour and capital costs. These labour and capital costs enter indirectly as partial determinants of the prices of (non manufactured) endogenous inputs and partial determinants of the prices of manufactured inputs used in the production of domestic non-manufactured inputs. However wage and labour costs in domestic manufacturing do not enter directly as domestic manufactured inputs are netted out from this expression.

4.2.2. The gross PIMF

The gross price index for materials and fuels, PIMFg, is defined as

$$PIMFg(t) = s'_1(t)P_1(t) + s'_2(t)P_2(t) + s'_3(t)P_3(t) + s'_4(t)P_4(t) + s'_7(t)P_7(t) + s'_8(t)P_8(t) \quad (5)$$

where $P_7(t)$ is the gross output price index for manufacturing, and the share estimates are appropriately redefined as shares of all MII including domestically manufactured inputs. We assume that the price of manufacturing outputs used as manufacturing inputs is the same as manufacturing outputs that cross the ring fence and thus we need only to work with one such price. Following similar procedures to above, solving for $P_3(t)$ and $P_7(t)$ and substituting, yields the final expression for the PIMFg, (4'), which is of the same algebraic form as (4) but the coefficients may be of different size.

$$PIMFg(t) = \beta'_1(t)P_1(t) + \beta'_2(t)P_4(t) + \beta'_3(t)P_8(t) + \beta'_4(t)W(t) + \beta'_5(t)R(t) \quad (4')$$

The difference in coefficients between (4) and (4') will reflect inter alia that (i) in PIMFg wage costs and capital costs will now also directly include such costs incurred in manufacturing and (ii) the pass through of costs may well have a different time structure in the gross compared to the net relationship. The relative sizes of the coefficients in the two equations will reflect the different input intensities in different economic sectors and as such we have no a priori expectations.

---

[11] In principle these shares could be considered as endogenously determined, however for the sake of simplicity we assume that they are exogenous. Changes in the shares/weights are explicitly allowed for in section 4.2.3.

4.2.3 Trends

(4) and (4') can conveniently be written in vector form as

$$PIMF(t) = \beta(t)P(t) \tag{6}$$

where the elements of the parameter vector $\beta(t)$ are time dependent complex combinations of previously defined parameters and the elements of $P(t)$ are $P_1(t)$, $P_4(t)$, $P_8(t)$, $W(t)$ and $R(t)$. Given the possible time dependency of the parameter vector $\beta(t)$ allow that

$$\beta(t) = \beta + z(t) \tag{7}$$

where β is a vector of time independent average or base level parameters and $z(t)$ is a vector of the time varying components of the parameters. The $z(t)$ term will reflect three factors.

(i) Changes in the weights of the ONS PIMF series. As time proceeds and the relative proportion of different inputs in total input costs change so the ONS rebase and re-weight their series. Essentially the weights are reduced on inputs that have reduced shares in total input costs. Over time elements of $z(t)$ relating to inputs where weights are increased will be positive while those for which weights are decreased the elements will be negative. If the elasticity of substitution of an input is less than unity then as the price of an input rises its share and thus its weight will fall. For a given series of input prices therefore one can expect that re-weighting over time will lead to a reduction in PIMF over time.

(ii) Technological change. One would expect that in sectors 3, 5, 7 i.e. the domestic production of non manufacturing non service inputs, the domestic service sector and domestic manufacturing itself, that for given input prices technological change would generate lower output prices which directly and indirectly would feed into lower values for PIMF.

(iii) Changes in mark ups over time in domestic sectors supplying the manufacturing sector may also generate changes in elements of **z(t).** Reductions in mark ups should yield a lower PIMF. Although Small (1997) and Britton, Larsen and Small (2000) illustrate that there is considerable intertemporal variation in mark ups in UK industry, we have shown that manufacturing output does not cause PIMF and thus pro-cyclical variations in mark up are not important, however there is still the possibility of long run systematic upward (or downward) movements in mark up that may impact upon PIMF.

For empirical purposes, substituting from (7) into (6), and allowing that **z(t)P(t)** can be represented by a trend term F(t), we write the resultant expression for PIMF(t) as (8)

$$\text{PIMF(t)} = \mathbf{\beta(t)P(t)} = \mathbf{\{\beta + z(t)\}\ P(t)}$$
$$= \mathbf{\beta P(t)} + F(t) \tag{8}$$

and, unless there are specific countervailing upward movements in mark ups over time, the expectation from the arguments above is that F(t) will decrease with time. Introducing this variation in to (4), and as detailed in Appendix 1 (where the measures for R(t) and W(t) are also described) substituting for $P_1(t)$ with a weighted sum of $P_{comm}(t)$, the world price of commodities in sterling and $P_{oil}(t)$, the price of oil in sterling after tax, and measuring both $P_4(t)$ and $P_8(t)$ by the sterling import prices of semi manufactured products $P_{semi}(t)$, leads to the long run price equation (9) (with differing parameters for PIMFg and PIMFn):

$$\text{PIMF(t)} = b_1 P_{oil}(t) + b_2 P_{comm}(t) + b_3 P_{semi}(t) + b_4 W(t) + b_5 R(t) + F(t) \tag{9}$$

This expression essentially states that the prices of raw material and intermediate inputs to UK industry are determined by (i) world prices of oil, commodities, and semi manufactured inputs intermediated via the exchange rate and duties (ii) home factor prices (wages and capital costs) and (iii) a trend picking up technological change at home, trends in mark ups and weight changes in the calculation of the PIMF series.

4.2.4 Dynamic structure

Equation (9) is best viewed as a long run relationship that ignores the existence of any disequilibrium relationship between MII costs and their long run determinants both at the start of the estimation period and throughout. However, given that the data is observed on a monthly frequency it is likely that the system has a memory and that shock transmission mechanisms extend over a longer period of time than one month or that the system adjusts differently in the short than in the long run.   We therefore allow for a dynamic structure in the adjustment of PIMF to changes in its determinants based upon the dynamic error correction model specification. The latter allows us to introduce the necessary autoregressive components and to determine the speed of response to changes in the determinants of input costs in the short run and the speed of adjustments to deviations from the long run equilibrium.

The model specification and testing procedure is similar to the two step procedure originally proposed by Engle and Granger (1987), except that in the first step, following Johansen (1988) and Johansen and Juselius (1990), we use a multivariate unrestricted vector autoregressive (MVAR) representation to account for the possible non uniqueness of the long run equilibrium relationship among the level components, z^*_t, viz

$$\Delta z_t = \Gamma_1 \Delta z_{t-1} + \ldots + \Gamma_{k-1} \Delta z_{t-k+1} + \Pi z^*_{t-k} + \lambda D_t + u_t \qquad (10)$$

where D_t is a set of deterministic variables (constant, seasonals, etc.) that are allowed to enter the model unrestricted, u_{jt} is the vector of Gaussian residuals ($IN(0;\Sigma)$) and z^*_t is the vector containing the variables of interest plus a time trend ($F(t)$) restricted to lie in the co-integration space, i.e. $z^*_t = (PIMF(t) ; P_{oil}(t); P_{comm}(t); P_{semi}(t) ; W(t) ; R(t); F(t))$. In this framework, the test for the presence of any long run equilibrium relationships among the vector of the level components is determined by whether Π (the matrix accounting for the impact of the level variables upon the Δz_t – see (10)) is not full rank. In fact, Johansen proves that Π can be decomposed into the product of the matrix of long run coefficients (γ) times the speed of adjustment to disequilibrium (δ), i.e. $\Pi = \delta'\gamma$. Under certain conditions, the rank number of Π reflects the number of independent linear combinations of the original vector z_t, or similarly the number of long run equilibrium level relationships.

In the second step having established the number of long run equilibrium level relationships, i.e. the number of co-integrating vectors $\gamma^{*'}z_t$, we estimate the restricted autoregressive model imposing the fixed number of cointegrating relations:

$$\Delta z_t = \Gamma^*_1 \Delta z_{t-1} + \ldots + \Gamma^*_{k-1} \Delta z_{t-k+1} + \Sigma_i \delta_i^* (\gamma_i^{*'} z_{it}) + \lambda D_t + u_t^* \qquad (11)$$

where Γ^*s are the short run adjustments, $\delta_i^{*'}$ contains the speed of adjustments to the long run equilibrium, γ_i^* is the matrix of long run normalised coefficients and $\gamma_i^{*'}z_{it}$, contains the residuals of the 'i' co-integrating relationship i.e. the error correction term (ECT_{it}), i.e.

$$ECT_{it} = PIMF(t) - \gamma^*_{i1} - \gamma^*_{i2} P_{oil}(t) - \gamma^*_{i3} P_{comm}(t) - \gamma^*_{i4} P_{semi}(t)$$
$$- \gamma^*_{i5} W(t) - \gamma^*_{i6} R(t) - \gamma^*_{i7} F(t) \qquad (12)$$

This model allows the short run dynamics to be combined with the dynamic adjustment to the long run equilibrium via the estimates of the parameters Γ^*s and δ^*s respectively. Moreover, if Π contains only one linear independent column the equilibrium relationship exists, it is unique and the restricted ECM representation can be estimated by OLS.

5. MODEL ESTIMATION

The Error Correction representation has been estimated for both net and the gross PIMF using monthly data for the period from 1979 (7) to 2002 (5). Table 6 reports the descriptive statistics of all the variables used in the testing of the model (except the trend term which is assumed to be linear). Further detail on the variables definitions can be found in Appendix 1[12].

---

[12]Although not strictly necessary for the Johansen co-integration analysis, we have carried out a preliminary time series analysis of the variables used to model the PIMF indexes. Similar to PIMFg and PIMFn (see table 2) we performed tests for seasonal integration versus deterministic seasonality and tests of unit roots. The results suggest that typical of price series all of them are difference stationary and are affected by pulse dummies. Moreover it was found that oil and semi manufactures prices are affected by weak deterministic seasonality. None of the series is affected by stochastic seasonality.

Table 6: Descriptive Statistics (N=275)

	Min	Max	Mean	5% Trimmed Mean[a]	Std. Dev.	St.Error
PIMFg	53.62	101.60	84.39	84.99	12.65	0.76
PIMFn	58.60	107.40	87.38	89.03	8.27	0.50
Poil	65.53	237.48	129.78	127.79	40.96	2.47
Pcomm	66.85	115.01	87.01	86.82	9.49	0.57
Psemi	47.66	102.23	74.84	74.80	13.52	0.82
R	54.73	136.10	90.33	90.11	18.05	1.09
W	23.90	133.20	77.68	77.60	32.01	1.93
DPIMFg	-1.71	2.41	0.15	0.15	0.54	0.03
DPIMFn	-5.60	3.70	0.11	0.14	1.39	0.08
DPoil	-70.53	37.17	0.38	0.62	10.32	0.62
DPcomm	-8.30	7.57	0.04	0.03	2.02	0.12
DPsemi	-3.95	4.65	0.11	0.10	0.92	0.06
DR	-9.02	8.45	-0.01	0.00	3.08	0.19
DW	-2.00	3.90	0.40	0.37	0.59	0.04

[a] Trimmed means are presented to indicate impact of outlying observations.

5.1. The long run relationship

For both model (4) and (4') the optimal lag-length MVAR representation has been chosen by sequentially testing the joint significance lags up to maximum of 10 lags and using the usual Akaike's Information Criterion, the Shwartz's Criterion and the Hannan-Quinn Criterion. For both models the best representation that satisfies the above criteria as well as the residual properties, is a MVAR of order 6. We also found that a long run relationship with all variables of the correct sign existed for both PIMFn and PIMFg after the inclusion of an unrestricted step change in the multivariate VAR specification starting in Jan 1986. Therefore, using a MVAR of order 6 and a set of unrestricted[13]

---

[13] We also experimented with imposing the step variable (taking value zero before 1986 01 and 1 thereafter) to be restricted to the co-integrating space. We found that the equilibrium relationships still hold and the parameters estimates are quite robust:

$$\text{PIMFg} = \beta_{Dg} D_g(t) -18.21 \text{ Step86} + 0.065 P_{oil}(t) + 0.401 P_{comm}(t) + 0.099 P_{semi}(t) +$$
$$+ 0.074 R(t) + 0.841 W(t) - 0.293 F(t) + u_g(t).$$
$$\text{PIMFn} = \beta_{Dn} D_n(t) - 13.27 \text{ Step86} + 0.140 P_{oil}(t) + 0.553 P_{comm}(t) + 0.111 P_{semi}(t) +$$
$$+ 0.070 R(t) + 0.600 W(t) - 0.262 F(t) + u_n(t)$$

The test of the significance of the step variable in the restricted co-integrating representation is significant for both models (LR-test, rank=1; $X_G^2(1) = 16.866$ with p=0.00; $X_N^2(1) = 18.32$ with p=0.00). However, it was also found that the step dummy was jointly significant across the equations of the unrestricted MVAR (joint restriction test : Fgross= 5.37065 p=0.00; F_{net} (6, 227) = 5.42723 p=0.00). This would suggest that the unrestricted specification of the step variable would be appropriate. To decide whether to restrict the step to the LR relationship, we followed the Pantoula principle based upon the comparison of the trace and the max eigenvalue test of different specifications values against the Osterwald-Lenum critical values (see

deterministic variables (a step dummy taking value zero before Jan 1986 and 1 thereafter, an intercept dummy and a small number of dummy variables required by the presence of extreme observations in the residual elements of the MVAR) we found that the following cointegrating relationships exist for PIMFn and PIMFg and are unique:

$$\text{PIMFn} = \gamma_{1n} D_n(t) + 0.140\, P_{oil}(t) + 0.553\, P_{comm}(t) + 0.113\, P_{semi}(t) +$$
$$+ 0.068\, R(t) + 0.616\, W(t) - 0.269\, F(t) + u_n(t) \qquad (13)$$

$$\text{PIMFg} = \gamma_{1g} D_g(t) + 0.0646\, P_{oil}(t) + 0.403\, P_{comm}(t) + 0.106\, P_{semi}(t) +$$
$$+ 0.070\, R(t) + 0.865\, W(t) - 0.304\, F(t) + u_g(t) \qquad (14)$$

where $u_n(t)$ and $u_g(t)$ are the usual stationary Gaussian residuals.

The presence of the unrestricted step dummy (Step86) necessary to identify the co-integrating relationships would suggest that both long run equilibria, but not necessarily the level of either PIMFg or PIMFn, are subject to a shift, starting in January 1986. January 1986 coincides with a period of dramatic oil price falls (see Bjørnland, 2001**),** to a lesser extent commodity price falls and the end of a period of high exchange rate fluctuations. However, our prior analysis of the time series properties of the variables have indicated that while the PIMFn is affected by a pulse in 1996, the PIMFg is not affected by any significant structural change starting at that date (see Perron Test in section 3.2.). This would suggest that, after Jan 1986 one or more of the PIMF components (and therefore the equilibrium relationship) fell dramatically, but neither PIMFn and PIMFg (gross more than net) fully reflected this fall and as a result were higher than one might have expected based on past relationships. There are several potential reasons why this might have happened of which the following appear most relevant. First it is possible that not all of the fall (in oil prices in 1986) was passed through in to lower costs (e.g. there were higher margins). Second, it may be that the world is only locally linear rather than globally as assumed and as such the model has difficulty in accurately coping with such large price changes. Thirdly the medium term fixed weights used in the calculation of PIMF may have led to biased measures.

Appendix 2 for further details). The results were inconclusive in the PIMFn case while in the PIMFg case the test suggested that the unrestricted Step model was to be preferred. We therefore decided to use the unrestricted specification for both PIMFg and PIMFn and to allow the restricted ECM to determine its short and long run significance.

5.2. An Error Correction Representation

Given that the equilibrium relationship exists and it is unique for both the PIMFg and PIMFn we proceed by modelling in one specification the short run and the long run impact of each input price. This is done by estimating the ECM representation for $j = $ PIMFn and PIMFg, imposing the unique co-integrating restriction $ECT_{j,t-1} = \gamma_j^{*\prime} z_{j\ t-1}^{*}$ (see 13 and 14) derived in the first step of the model and a vector of deterministic components that in addition to the step dummy (Step86) also includes a dummy variable (Dstep86) to account for the step dummy presence in the long run relationship and a constant reflecting both the intercept of the system and the slope of the trend term.

Table 7: Restricted Error Correction model [1979 (7) to 2002 (5)]

DPIMFn				DPIMFg			
Variable	Coeff.	Std.E.	t-prob	Variable	Coef	Std.E.	t-prob
Constant	-0.515	0.210	0.0149	Constant	-0.009	0.0608	0.8863
DPIMFn(t-1)	0.240	0.046	0.0000	DPIMFg(t-1)	0.206	0.0438	0.0000
DPoil(t)	0.065	0.006	0.0000	DPoil(t)	0.022	0.0021	0.0000
DPoil(t-3)	0.019	0.006	0.0011	DPoil(t-3)	0.008	0.0020	0.0002
DPcomm(t)	0.172	0.032	0.0000	Dpcomm(t)	0.031	0.0114	0.0077
DPcomm(t-1)	-0.065	0.032	0.0431	Dpcomm(t-2)	-0.020	0.0106	0.0651
DPsemi(t)	0.267	0.067	0.0001	Dpsemi(t)	0.174	0.0249	0.0000
DR(t-3)	-0.050	0.019	0.0123	DR(t-5)	0.017	0.0067	0.0116
DW(t)	0.081	0.095	0.3940	DW(t)	0.072	0.0338	0.0337
Dstep86	-5.330	0.928	0.0000	DStep86	-0.998	0.3503	0.0047
Step86	0.842	0.304	0.0061	Step86	0.347	0.1511	0.0047
ECT_n(t-1)	-0.072	0.020	0.0005	ECT_g(t-1)	-0.023	0.0079	0.0033
				d8912, d9001,d9002	*Wald test* F(3,259) = 42.719 [0.0000]		

N= 274
R^2 = 0.59[a]; R^2_seas adj =0.65
F(11,262) = 34.343 [0.0000]
RSS = 216.936; DW = 1.95
AR 1- 7 F(7,255) =   1.9414 [0.0493]
ARCH 7 F(7,248) =   1.4255 [0.1954]
Xi^2   F(20,241) =   0.85189 [0.6485]
Xi*Xj   F(66,195) =   0.88545 [0.7134]
RESET   F(1,261) =   1.1246 [0.2899]

N= 274
R^2=0.64; R^2_seas adj =0.74
F(14,259) = 33.197 [0.0000]
RSS = 28.089; DW = 1.91
AR 1- 7 F(7,252) =   0.98594 [0.4419]
ARCH 7 F(7,245) =   0.8582 [0.5403]
Xi^2   F(23,235) =   1.0354 [0.4216]
Xi*Xj   F(69,189) =   0.9171 [0.6555]
RESET   F(1,258) =   0.18647 [0.6662]

[a] Including a further dummy variable for April 1985 in the PIMFn relationship increases the R^2 to 0.623361 but as the parameters are not significantly changed we have not made this addition.

The estimates of both the PIMFg and PIMFn models applied to the whole data period are reported in Table 7. For both models the diagnostic indicators illustrate that the residuals are well behaved and the explanatory power of the models is reasonable. This indicates

that the error correction representation is a good representation of the dynamic of the PIMF series and the factors used to model the variability of PIMFn and PIMFg jointly explain a reasonable proportion of the total variability of the PIMF series. The analysis of the ECM lag structure indicates that the system has a memory and that current values of PIMF reflect both the short run adjustment to movements in its main components and the long run adjustment to the equilibrium level.

In the PIMFg estimates, in the short run, all the variables (oil prices, commodity prices, semi manufactured prices, wages and capital costs) although with different lag structures, are significant drivers of the PIMF series and all carry a coefficient of the expected sign. The short run impact of the prices of the three imported inputs (oil, commodities, and semi manufactured products) upon the PIMF index accounts for about 36.5% (27% if we use seasonally adjusted R^2) of the variability of PIMFg while domestic factor prices (excluding the trend), account for only 1.5% (1.1% if we use seasonally adjusted R^2).

In the case of the PIMFn only the world price variables, and with a slightly different lag structure than that found for PIMFg, are significant drivers in the short run. Of the domestic factor prices, the labour cost variable is not significant while capital cost, despite being significant, is of the wrong sign. The contrast with the findings for PIMFg may well reflect that in PIMFg the impact of W and R is much more direct, coming as it does through the cost of domestic manufacturing inputs to the domestic manufacturing process.

Due to the nature of the model specification the short run dynamic adjustment to changes in the trend is difficult to disentangle from the intercept which turns out to be significant only in the PIMFn case. The intercept in the short run model incorporates the impact of: a) the (possible) intercept in the short run model; b) the slope of the trend F(t) in the level equation and c) the (possible) intercept in the cointegrating relationship. In the PIMFg case the intercept is not significant indicating that these three factors cancel out.

Altogether the short run impact of world prices accounts for about 43% (36% if we used seasonally adjusted R^2) of the total variability of the PIMFn while only 1% (0.01% if we used seasonally adjusted R^2) is accounted for by the domestic input prices, excluding the trend. This suggests that the PIMFn is more sensitive to short run input price fluctuations

than the PIMFg. In addition, in the short run PIMFn is mostly driven by prices that, for a given exchange rate, are essentially determined outside the UK (except for any UK duties incorporated in the oil price).

The dynamic adjustments of PIMFn and PIMFg to deviations from the long run equilibrium is shown by the significance of the Error Correction Term (see $ECT_g(t-1)$ and $ECT_n(t-1)$ in table 7). In both cases the sign of the ECM term is negative, as expected, although the magnitudes suggests that PIMFn adjusts faster to deviations from the long run equilibrium than does PIMFg.

The significance of the step variable in both ECM representations would suggest that the 1986 break cannot be adequately explained by the underlying data generating processes of either PIMF or the independent variables (i.e. exogenous changes in the dollar price of oil or the exchange rate). Its short run impact accounts for just 0.73% (0.53% if we used the seasonally adjusted R^2) of the total variability of PIMFg and 1.2% (1% if we used the seasonally adjusted R^2) of the total variability of PIMFn.

Finally it is worth noticing that the two ECM representations include a series of dummy variables. D8601 accounts for the pulse in the stationary part of the model caused by the step change in 1986. This variable is significant in both models. Its magnitude, as expected, is higher for the net than the gross PIMF.

For PIMFg we also found that a series of dummy variables (d8912, d9001, d9002) were necessary to model the (upward) blip that occurred between December 1989 and February 1990 (see the joint significance test $F(3,259) = 42.719$ p=0.000 in table 7). Their inclusion improves the goodness of fit as well as the predictive power of the model (see table 7.a). The same dummies were found to be significant in the univariate time series analysis of PIMFg presented in section 3 (where we were unable to track down the cause of the blip). This indicates that the blip was not caused by the index components used in the model. Despite showing only a temporary impact upon PIMFg, the blip was not absorbed by the system and was therefore transmitted to PIMFn[14].

---

[14] In the univariate time series analysis reported in section 3 it was found that PIMFg is affected only by one shock occurring between Dec 1989 and February 1990 while PIMFn is affected by three pulse dummies in April 1985, Jan 1986 and Dec 2000. The Perron test confirmed that the three exogenous shocks

Table 7.a. Information Criteria and goodness of fit statistics

Dummies*	Schwarz Criterion	Hannan-Quinn	Final Prediction Error	AIC	R^2	$R^2_{Seas\_adj}$	σ	RSS
Included	-1.970	-2.089	0.114	-2.168	0.642	0.74120	0.329	28.089
Excluded	-1.630	-1.725	0.167	-1.788	0.465	0.61315	0.400	41.988

Note: Dummies* = d8912, d9001, d9002

As a further cross check on the validity of the ECM representation, we have investigated its predictive and forecasting capability. We split the sample at end 1999 and Figure 3 shows the DPIMFg within sample fitted values for 1999 and the forecasted values for the remaining period. Both of them seem to suggest that the model is a good model. The forecast tests (Chow test: $F_{30,229} = 0.983$ p = 0.496 and $\chi^2_{30} = 37.17$ p = 0.172) based upon the comparison of the within and post sample residual variances confirm that the predictions are accurate.

Figure 3. Observed fitted and forecasted values of DPIMFg.

---
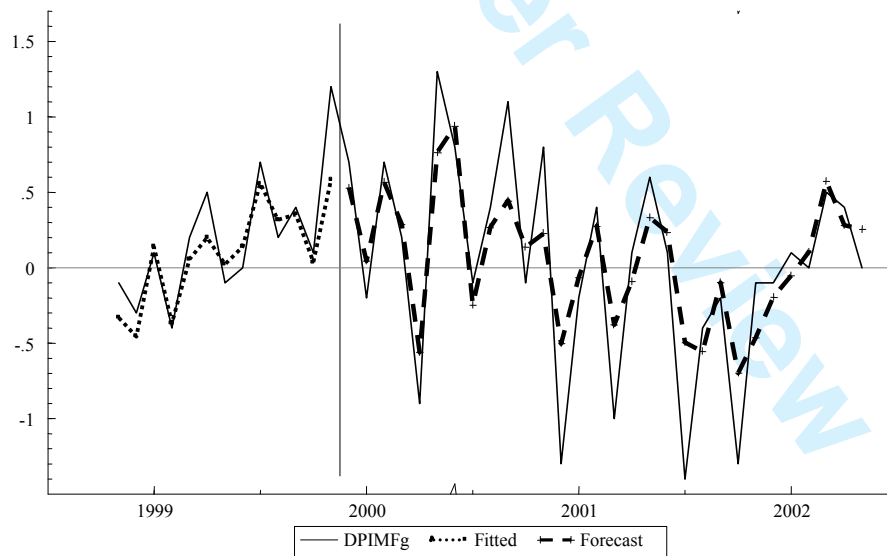
did not cause any structural change to the indexes. However, in the multivariate PIMFn ECM representation (i.e. when explanatory variables are added) only the 1986 shock was highly significant indicating that the other two shocks had been absorbed by the system. In particular, the April 1985 pulse corresponds to the peak of a five year dramatic escalation of oil and commodity prices and a symmetric downward trough in the $/£ exchange rate. Despite its marginal significance (its inclusion would improve the model fit by less than 3%) the particularly favourable exchange rate might have counterbalanced the impact of the oil price reduction. In the year 2000 oil prices started increasing quite rapidly (as did commodity prices to a lesser degree) but the effect was partly counterbalanced by the rapid reduction in the interest rate (and therefore the cost of capital R) that moved towards its current historical minimum (4-5%) This smoothed out the impact of the oil price crisis upon the PIMFn index.

In Table 8 we detail the elasticity estimates based upon the estimated parameters of the long run relationship and the short run impact estimated by the restricted error correction model. At sample means, for PIMFn, in the short run the prices of oil and semi manufactured inputs are quantitatively most significant. Taking account of lagged effects, oil prices carry a short run elasticity of 0.369 and semi manufactured prices a short run elasticity of 0.345. In the long run, prices of imported commodities (0.415), and oil (0.099) are still important, but the quantitative significance of the prices of imported semi manufactures decreases, with the elasticity with respect to wages (0.548) and the trend increasing (-0.279). This suggests that in the long run (non-manufactured) endogenous inputs and other manufactured inputs used in the production of domestic non-manufactured inputs have a quantitatively significant impact upon the PIMFn index.

In the short run PIMFg is particularly sensitive to the domestically determined prices such as labour cost (elasticity 0.236), and the prices of imported semi manufactures (0.162), all the other components having elasticities less than 0.09. In the long run wages (0.796) and imported commodities (0.415) carry the highest elasticities with the trend also carrying a quantitatively significant coefficient. (-0.279).

Table 8. Elasticity estimates of input prices to PIMFn (for sample means see Table 6)

	Poil	Pcomm	Psemi	R	W	F	Exch rate
Short Run (calculated at the sample mean of the variables in first differences)							
PIMFg	0.095	0.004	0.162	0.002	0.236		0.261
PIMFn	0.384	0.055	0.345	0.008	*(0.368)*		0.769
Long Run (calculated at the sample means of the levels)							
PIMFg	0.099	0.415	0.094	0.075	0.796	-0.279	0.608
PIMFn	0.208	0.550	0.096	0.070	0.548	-0.239	0.854

One may also note that given the construction of the oil price variable (see Appendix 1) the elasticities of PIMF to changes in duties is the same as the elasticities to changes in the price of oil. The elasticity of PIMF to the sterling dollar exchange rate, given the construction of the price of commodities, the price of oil and the price of imported semi manufactured inputs, may be calculated as the sum of the elasticities for oil and commodities and semi manufactured inputs, i.e. 0.272 for PIMFg and 0.769 for PIMFn (including lags). Moreover, such elasticities are higher in the long than in the short run i.e. 0.608 for PIMFg and 0.854 for PIMFn (including lags).

5.3 Impact Analysis

In this section we explore the impact of different factors on PIMFg and PIMFn in more detail. In Figure 4a and 4b, using the parameter estimates of the long run relationship, we present an impact analysis of the determinants of the level of PIMF over time at a high level of aggregation. We separate out the long run contribution of domestic factors (factor prices and the trend - $W(t)$, $R(t)$ and $F(t)$) and external factors (world prices i.e. $Poil(t)$, $Pcomm(t)$ and $Psemi(t)$) to the level of PIMFg and PIMFn at each point in time. Figure 4a illustrates that world prices explain most of the variability of the PIMFn series and exert a greater influence on PIMFn than domestic factors. It also illustrates that after 1986 a downward shift occurred in the aggregate contribution of world prices that was not fully reflected in the level of PIMFn. In Figure 4b, the same exercise is repeated for PIMFg. This shows that although domestic factors exert an impact on PIMFg almost twice as large as that identified for the PIMFn, the total domestic impact is still less than world prices. In addition the 1996 step change in the equilibrium relationship is still present. These results suggest that in the long run, the main drivers of the PIMF series are world prices, although domestic prices cannot be ignored.

Figure 4a Long run aggregated impact of domestic factors and world prices upon PIMFn
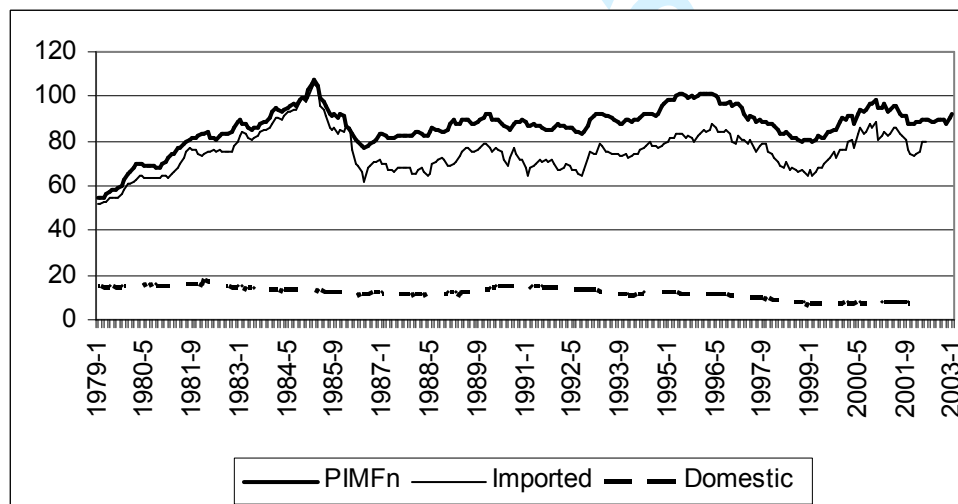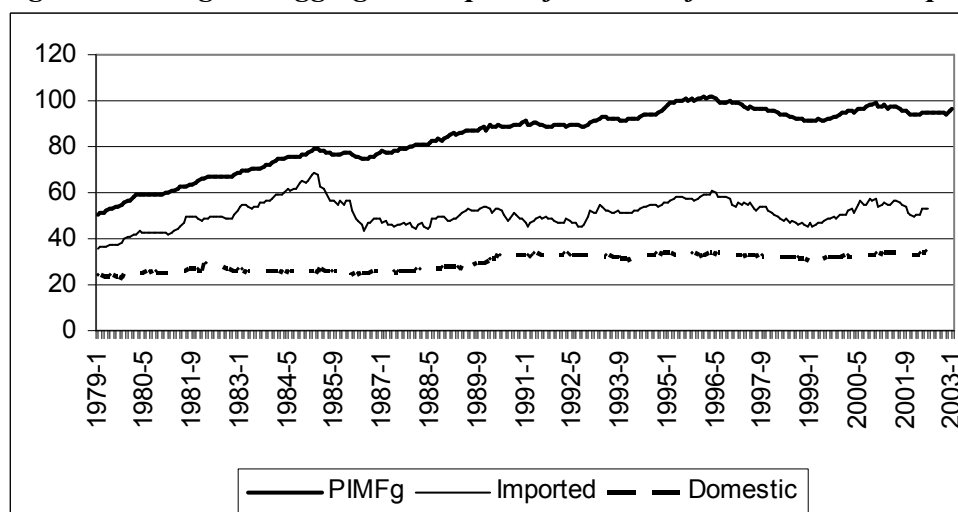
Figure 4b Long run aggregated impact of domestic factors and world prices upon PIMFg

For reasons of brevity from this point on we concentrate upon the analysis of PIMFg although similar analysis can be provided for PIMFn (with similar findings). In Figure 5, using the long run parameter estimates, we present a less aggregated impact analysis of the long run contribution of each component to the level of PIMFg at each point in time. This illustrates that commodity prices have been the largest contributor to the level of PIMFg. The impact has been fairly constant accounting for about 42% of the level of PIMFg.   However, despite its statistical relevance, Pcomm has made little contribution to the upward growth in PIMF over the observation period. In addition the impact of the prices of other imports, i.e. oil and semi-manufactures, is also low. They are responsible on average for about 16% (9.9% Poil and 6% Psemi) of the level of PIMF gross. Moreover, their typically high volatility (especially in the case of oil prices) seems to be reflected only in small drift around the PIMF, rather than any dramatic shift in its growth path. Once again this confirms that PIMFg is not particularly sensitive to short run movement in its imported inputs components. Altogether imported input prices jointly account on average for about 57% of the level of PIMFg.

During the observation period the average joint contribution of domestic input prices (including the trend) is about 43% of the level of PIMFg. However, over the observation period this contribution has increased by about 15% with respect to the 1979 value. As shown in Figure 5, the contribution of labour cost and the trend move in opposite directions over time. The contribution of capital cost to PIMFg is far lower than labour cost and the trend and reduces over time from about 14% in Jan 1979 to about 7% in Dec 2002 (due possibly to the reduction in interest rates which started in mid 90's and then

stabilised after 1999). This means that most of the increase in the domestic contribution

to PIMFg is due to increasing labour cost. However, it is worth remembering that in this

context domestic input prices account not only for wage and labour costs in domestic

manufacturing but also for such costs incorporated in the price of (manufacturing and non

manufacturing) inputs to manufacturing . Therefore, in the PIMFg case, the impact of

domestic factor prices includes the feedback from that part of PIMFn not specifically

accounted for by oil, commodities and semi-manufactured (i.e. services and other non-

manufactured inputs) into PIMFg.

**Figure 5: Impact analysis of components upon the level of PIMFg**
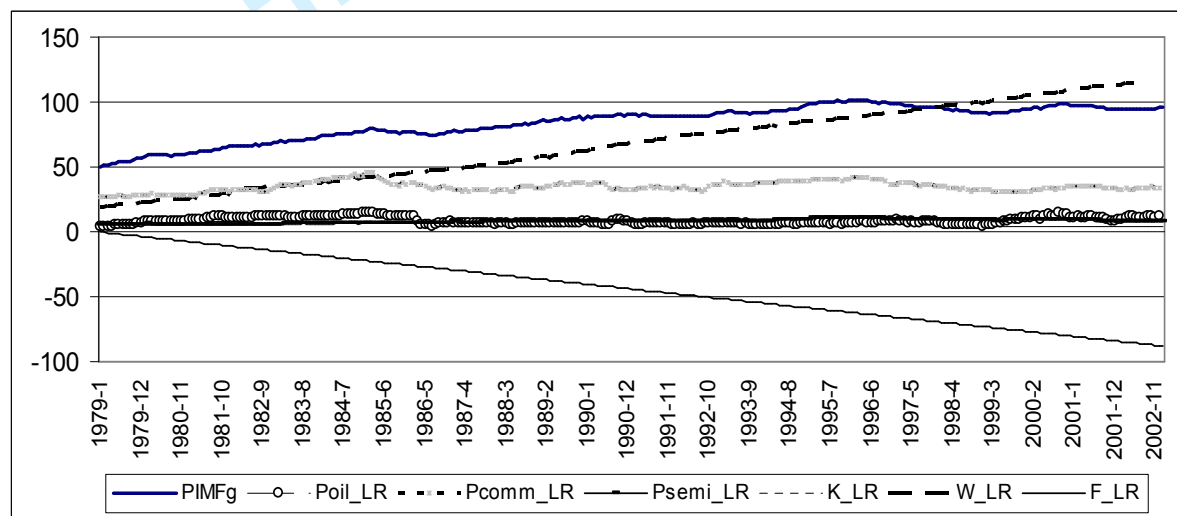
Note: LR = long run impact

In order to further explore the sensitivity of PIMFg to import prices and to disentangle

the role played by exchange rate fluctuations, we carry out a predictive exercise. In

Figure 6 we plot the PIMFg series and the simulated values assuming, in turn, for the

whole observation period: i) constant oil prices; ii) constant commodity prices; and iii)

constant exchange rate, where the constants equal mean values over the observation

period. For each series the gap between the observed and the simulated series indicates

the impact exerted by the variable being kept constant.

The results show that that if oil prices had stayed constant over the whole observation

period, PIMFg would not have been much different from what was actually observed.

However if commodity prices had stayed constant then PIMFg would gave been

significantly different in different periods, especially prior to 1983 when it would have

been higher, between 1983 and 1986 when it would have been lower and between 1992 and 1998 when it would have again been lower. Especially noticeable as well is the impact of the exchange rate in the first half of the eighties indicating that PIMFg, would have been almost stationary (if not downward sloping) had the exchange rate been constant. In addition, from about September 1992 (to 1998) the constant exchange rate series becomes persistently lower (on average – 5.5%) than the observed PIMFg. This suggests that the exchange rate in the nineties had an adverse effect upon the price of UK manufacturing inputs.

Figure 6: PIMFg assuming Oil prices, Commodities prices and exchange rates equal to sample means
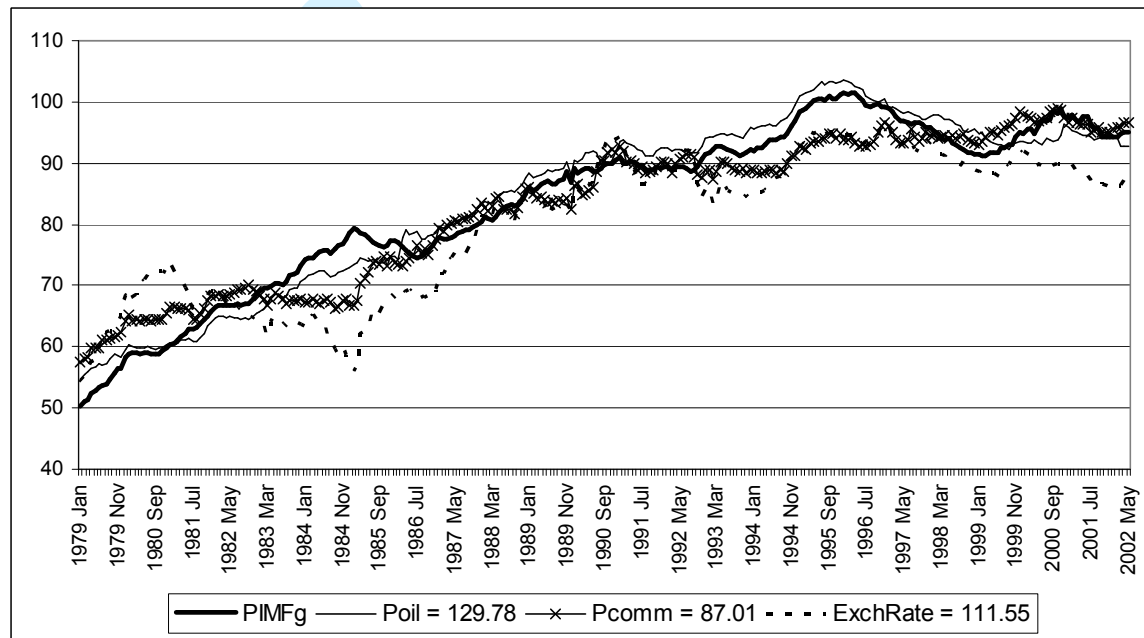
The results above are mostly concerned with the long run equilibrium relationship. In order to investigate the dynamics of the transmission mechanism of an exogenous shock (intervention) within the system we carry out an impulse response analysis taking into account both short and long run relations among the variables as well as the autoregressive nature of the model,. Following Lütkephol and Reimers (1992) we derive the effect of a positive impulse within the Restricted Vector ECM representation. This allow us to model the response of PIMFg at time t+1, t+2, etc. to a one unit (exogenous) shock in time t in one of its determinants, provided no other shock occurs. We repeat the

exercise allowing each determinant in turn (except the trend term F(t)) to be affected by a similar unit shock.

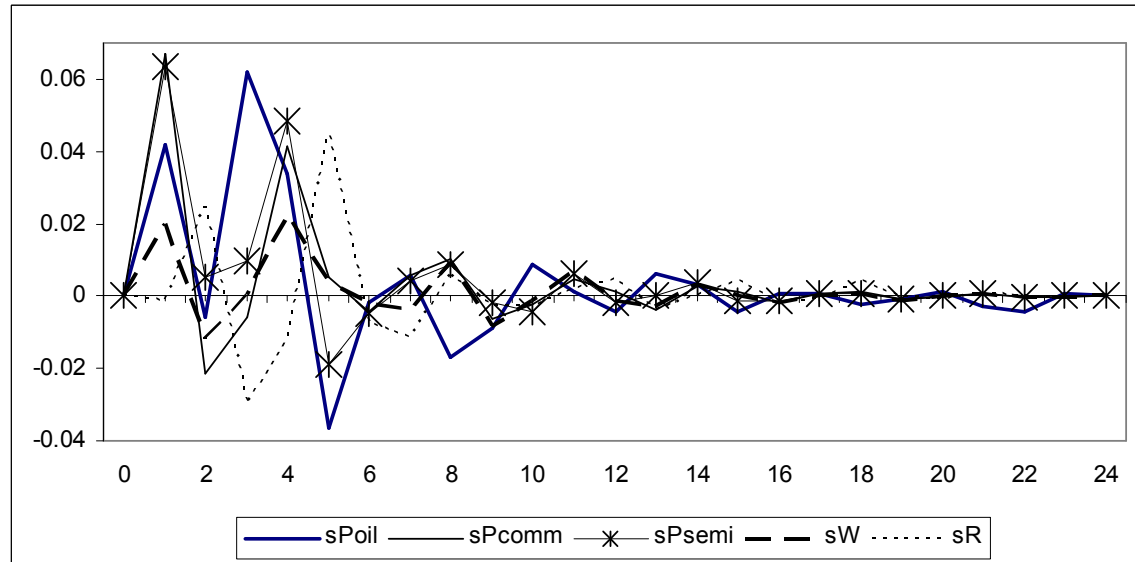**Figure 7. Response of PIMFg to perturbations (s.) in its main components**

Figure 7 illustrates the time paths or impulse responses of PIMFg in month one, two, three etc.(see x-axes) for the whole observation period in response to a unit perturbation in the price of oil (sPoil), commodities (sPcomm), semi-manufactured (sPsemi), wage costs (sW) and capital cost (sR).   A unitary positive shock in any of the input prices leads to an increase in PIMFg whose intensity and timing is input specific. The perturbations that the shock might cause are also clearly affected by seasonal fluctuations Interestingly, however, the effect is largely worked through after about 16 months for all of the different input prices.. This suggests that there is no explosive response and the equilibrium relationship is quite stable. However there are differences in the way each shock feeds back into PIMFg.

A unit increase in the prices of imported commodities and semi-manufactured is transmitted almost immediately into PIMFg. The impact is quite large up to month 4 after which it reduces over time. More persistent is the impact of a unit increase in oil prices, the intensity of which peaks after three months. The smallest responses are to shocks in domestic input prices with the response to a unit increase in wage being least and the response to changes in the interest rate peaking five months after the shock (then quickly levelling off to zero).

Figure 8. Cumulated response of PIMFg to perturbations (s.) in its main components
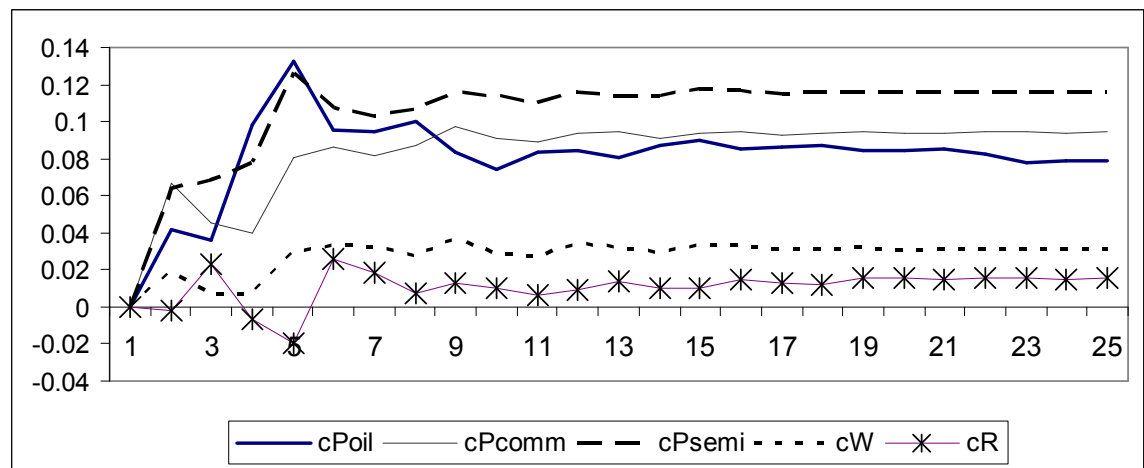
The relative impact of an increase in domestic prices upon the growth of PIMFg can be better seen in Figure 8 showing the cumulated effect of each unit shock upon PIMFg allowing for both short run and long run dynamics. Consistent with previous findings the response of PIMFg to an upward movement in wages and capital cost is far lower than that in response to an increase in the prices of imported inputs. Import price inflation exerts an impact about six times higher than that of domestic price inflation. Among import prices the highest response is generated by commodity prices followed by semi-manufactured input prices. The temporal response pattern is such that the impact of a shock in oil prices is high in the early months but smoothes out more quickly than for shocks in the other two world (input) prices. For oil and semi manufactures there also seems to be some evidence of overshooting that is later corrected.

It is not immediately clear why there should be differences in the intertemporal response patterns although the differences in total response will reflect the differing shares in costs (e.g. labour shares tend to be lower than material shares). The capital cost response is relatively delayed but this could be because borrowing may well be at fixed rates for longish periods with more infrequent changes in rates. The impact of wage costs may be slow (compared to the response to commodity prices) for the impact will perhaps in large part arise from resultant movements in the prices of intermediate goods that take time to come through. On the other hand changes in the prices of oil, commodities and semi manufactures will impact more directly upon industry and rather more immediately and so the reaction of the index to such changes will be more immediate.

6.   CONCLUSIONS

In this paper we have explored the patterns and determinants of the prices or raw material and intermediate inputs in to UK manufacturing. Despite their relative importance in total costs such inputs seem to have been relatively ignored in the existing literature. The main indicators of such prices (costs) are the producer price indexes for materials and fuels in gross and net forms (the net form encompassing only those costs that arise outside the manufacturing sector) although the series have their limitations.

Between 1979 and 2003 both PIMFn and PIMFg increase, with fluctuations, but both decline relative to the RPI over this and longer periods (the real PIMFn approximately halves over the 45 year period from1957 – 2003). It is shown that the PIMF series are independent of the demand for inputs and thus cost determined. A model of the cost of MII was developed that endogenised the prices of inputs produced within the UK itself. Using an ECM formulation, estimates of this model on monthly data between 1979 and 2002 illustrates that in the long run both PIMFn and PIMFg are determined by the world prices of oil, commodities and semi manufactured products intermediated by duties and the exchange rate, average UK earnings, UK capital costs and a linear trend (reflecting technological change in the UK, changes in mark ups and weight changes) although with different parameter values for the net and gross series.

Although it has been found that in the long and short run PIMFn and PIMFg are more sensitive to the overseas determined prices of oil, commodities, and semi manufactured products than to domestic input prices (including the trend) during the observation period the average joint contribution of all domestic input prices (including the trend) is about 43% of the level of PIMFg. However, over the observation period this contribution has increased by about 15% with respect to the 1979 value. The main determinants of the growth of PIMFg are thus to be found in the domestic input prices components. The contributions of labour cost and the trend move in opposite directions over time. The contribution of capital cost to PIMFg is far lower than labour cost and the trend and reduces over time from about 14% in Jan 1979 to about 7% in Dec 2002.

A major reason for looking at MII prices is that they will feed directly in to home product prices and thus inflation. Although domestic input prices (wage rates and capital costs)

may well be under the (partial) control of government, it has been found that it is overseas determined prices (of oil, commodities, and semi manufactured products) which have the greatest impact upon PIMFn and PIMFg in the long and short run and these components are largely externally determined. The prices of material and intermediate inputs in UK manufacturing are thus largely outside the control of the domestic government. It is thus not possible to make inflation control recommendations (and as we find that prices are cost and not demand determined this is doubly so). However by looking at elasticities and the timing of responses one may gain some idea of how large will be the long and short term responses to changes in world prices.

For example, elasticity estimates based upon the parameters of the long run relationship and the short run impact estimated by the restricted error correction model indicate that for PIMFn, in the short run, the prices of oil and semi manufactured inputs are quantitatively most significant. Taking account of lagged effects, oil prices carry a short run elasticity of 0.369 and semi manufactured prices a short run elasticity of 0.345. In the long run, prices of imported commodities are still important, but the quantitative significance of the prices of imported semi manufactures decreases, while the elasticity with respect to wages and the trend are greater. In the short run PIMFg is particularly sensitive to the price of domestically determined prices such as labour cost followed by the prices of imported semi manufactures, all the other components having elasticities less than 0.09.   In the long run wages and imported commodities carry the highest elasticities with the trend also carrying a quantitatively significant coefficient Given the construction of the oil price variable the elasticities of PIMF to changes in duties is the same as the elasticities to changes in the price of oil. Given the construction of the price of commodities, the price of oil and the price of imported semi manufactured inputs, the elasticity of PIMF to the sterling dollar exchange rate may be calculated as the sum of the elasticities for oil and commodities and semi manufactured inputs which is 0.272 in the short run for PIMFg and 0.769 for PIMFn (including lags). Moreover, these elasticities are higher in the long than in the short run i.e. 0.608 for PIMFg and 0.854 for PIMFn (including lags).

In terms of the time profile of response, a unit increase in the prices of imported commodities and semi-manufactured is transmitted almost immediately into PIMFg. The impact is quite large up to month 4 after which it reduces over time. More persistent is

the impact of a unit increase in oil prices, the intensity of which peaks after three months. The smallest responses are to shocks in domestic input prices with the response to a unit increase in wage being least and the response to changes in the interest rate peaking five months after the shock (then quickly levelling off to zero). Nearly all impacts are exhausted after 14 months. A government may thus see that although the PIMF is to a considerable degree out of its control, the impacts of shocks will be quickly felt and short lived and thus of course, the benefits of a beneficial shock will be quickly enjoyed.

REFERENCES

Beckerman W. and T. Jenkinson (1986), "What Stopped the Inflation? Unemployment or Commodity Prices?", *The Economic Journal*, vol. 96, no. 381, pp. 39-54.

Bjørnland H.C. (2001), " Identifying Domestic and Imported Core Inflation", Applied Economics, vol. 33, pp.1819-31.

Britton E., D. D. J. Larsen and I. Small (2000*), "Imperfect Competition And the Dynamics of Mark-ups*", Working Paper Series no.110, Bank of England

Charmeza W. W. and D. F. Deadman (1999), "*New Directions in Econometric Practice*", Edward Elgar Publishing Limited, Cheltenham, UK.

Chaudhuri K. (2001)"Long run Prices of Primary Commodities and Oil Prices" *Applied Economics*, 33, 4, 531-538.

Dickey D. and W. Fuller (1979), "Distribution Free Estimates for Autoregressive Time Series with a Unit Root", *The Journal of the American Statistical Association*, vol. 74, no. 366, pp. 427-431.

Dickey D. and W. Fuller (1981),"Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root", *Econometrica*, no.49, pp.1057-72.

Dickey D. A., D. P. Hasza and W. A. Fuller (1984), "Testing for Unit Roots in Seasonal Time Series (in Theory and Methods)", *Journal of the American Statistical Association*, Vol. 79, no. 386, pp. 355-367.

Enders W. (1995), *Applied Econometric Time Series*, John Wiley and Sons Inc., New York, US.

Engle R. F. and C.W. J. Granger (1987) 'Co-Integration and Error Correction Representation, Estimation and Testing', *Econometrica*, Vol 55, pp.251-276.

Geweke J. M R. and W.Dent (1983), " Comparing Alternative Tests of Causality in Temporal Systems: Analytic Results and Experimental Evidence", *Journal of Econometrics*, vol. 21, pp. 2161-94 .

Granger C. W. J. (1969), "Investigating Causal Relations, by Econometric Models and Cross-spectral Methods", *Econometrica*, vol. 37, no.3 , pp. 424-438.

Granger C.W.J. (1988) 'Some recent Developments in a concept of Causality', *Journal of Econometrics*, Vol.39, pp.199-211.

Haskel J., Martin C., Small I. (1995), "Price, Marginal Cost and the Business Cycle", *Oxford Bulletin of Economics and Statistics,* vol. 57, no.1, pp. 25-41.

Johansen S.(1988) 'Statistical Analysis of Cointegation Vectors', *Journal of Economic Dynamics and Control*, Vol. 12, pp.231-254.

Johansen S. and K. Juselius (1990) 'Maximum Likelihood Estimation and Inference on Cointegration - with Applications to the Demand for Money', *Oxford Bulletin of Economics and Statistics*, Vol. 52, pp.169-210.

Johansen S, Mosconi R. and Neilsen B. (2000) 'Cointegration Analysis in the Presence of Structural Breaks in the Deterministic Trend', *Econometrics Journal*, Vol.3, pp.216-249.

Lütkephol, H. and H-E. Reimers (1992) "Impulse Response Analysis of Cointegrated Systems". *Journal of Economic Dynamics and Control* 16, 53-78.

MM2: Business Monitor (1999), Office for National Statistics, UK.

Nelson C. R. and C. I. Plosser (1982), "Trends and Random Walks in Macroeconomic Time Series: Some Evidence and Implications", *Journal of Monetary Economics,* vol. 10, no.2, pp.139-62

Osborne D. R., Smith, J. P. and C. R. Birchenhall (1988), "Seasonality and the Order of Integration for Consumption", *Oxford Bulletin of Economics and Statistics*, vol.50, no.4, pp. 361-77.

Oulton N. and O'Mahony M. (1994), *Productivity and growth: A study of British industry, 1954-1986*", National Institute of Economic and Social Research Occasional Papers, vol. 46. Cambridge; New York and Melbourne: Cambridge University Press.

Perron P. (1989), "The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis", *Econometrica*, vol. 57, no. 6, pp. 1361-1401.

Phillips P. and P. Perron (1988), " Testing for a Unit root in Time Series Regression", *Biometrica*, no. 75, pp.335-46.

Sargan J. D. and A. Bargawa (1983) , "Testing Residuals from Least Squares Regression for Being Generated by the Gaussian Random Walk", *Econometrica*, vol. 51, no. 1. (Jan., 1983), pp. 153-174.

Sargent T. J. (1976) 'A classical Macroeconomic Model for the United States' Journal of Political Economy Vol. 84, pp.207-238.

Sims C. A (1972), "Money, Income, and Causality", *American Economic Review*, vol. 62, No. 4., pp. 540-552.

Small I. (1997), '*The Cyclicality of Mark-ups and Profit Margins. Some Evidence form Manufacturing and Services'*, Working Paper no. 72, Bank of England

APPENDIX 1: DEFINITION, MEASUREMENT AND SOURCES OF VARIABLES

The PIMFn and PIMFg series are sourced from the ONS and are available for dates as discussed in the text above. The remaining variables are defined, measured and sourced as follows.

$P_1(t) = P_2(t)$, the prices of raw materials

This series is made up of a weighted sum of the prices of commodities and the price of oil with weights determined in the estimation. Both prices are sourced from the *UN Monthly Bulletin* in dollars. The conversion into UK sterling is carried out using the dollar sterling exchange rate, e(t), available from ONS, while for oil prices the correction for excise duties on oil, d(t), is done using the 'Excise tax on Light Fuel Oil for Industry', sourced from *Energy Prices and Taxes*, International Energy Agency, OECD. The final series used are, for commodities

$$P_{comm}(t) = P_{UN\_comm}/e(t)$$

and for oil

$$P_{oil}(t) = [P_{UN\_oil\,(t)}/e(t)] *[1+d(t)]$$

There are other series available from ONS on the import price in sterling of Basic Materials (BPEP) and/or Fuels (BPEC). Our analysis of this data confirms that fluctuations in world prices of basic commodities and oil, exchange rates and duties on oil explain most of the variability in the ONS series.

P4(t), the price of produced imported non service, non manufactured inputs

In the absence of any better measure this price is proxied by the import prices of semi manufactured products (BPED) in sterling, sourced from ONS and labelled $P_{semi}(t)$.

P8(t), the prices of imported manufactures

Three price series could be used to measure the prices of imported manufactures. They are all sourced from the ONS and expressed in sterling they are: the import prices of (a) Semi Manufactures (BPED) (b) Finished Manufactures (BPEE) (c) Total manufactures (BPES). It is use of the first that is reported above. $P_{semi}(t)$ thus represents both the prices of imported manufactures and the price of produced imported non service, non manufactured inputs.

W(t), wage rates.

Here we use the ONS supplied index of average earnings in manufacturing industries, seasonally adjusted (LNMR). Not significantly different from the latter are the Average Earnings Index for the whole economy (LNMQ) and for production industries (LNMS). The seasonally adjusted form was preferred due to the unusual (highly heteroschedastic) seasonal pattern shown by the non seasonally adjusted version.   It was suggested to us that we use unit wage cost rather than the average earnings measure, but the use of the former did not yield a significant co-integrating relationship.

R(t), capital costs.

Here we define nominal capital costs as the interest rate times the price of capital goods. For the interest rate we take the rate on twenty year treasury bonds (AJLX). For the price of capital goods we take the quarterly implicit deflator used to generate the ONS series on gross investment (Total Gross Fixed Capital Formation- Monthly Digest of Statistics) at constant prices.

All the variables are indexes based 1995=100.

APPENDIX 2: COINTEGRATION ANALYSIS

This section reports the test of the rank order of $\Pi = \delta\gamma'$ for expression (10) as discussed in section 4.2.4 above. For a co-integration relationship to exist Π should have reduced rank, i.e. there should be $r \leq n-1$ cointegration relationship in γ (where n=number of dependent variables). This is equivalent to testing in a reduced rank regression whether there exist a number r of eigenvectors so that $r \leq n-1$ (see Johansen, 1988 for more details on the technique). The resulting test estimated by maximum likelihood using MVAR of order 6 are reported in table A.4.1 for the PIMFn model and in Table A.4.2.for the PIMFg model.

Table A.4.1. Test of the co-integration rank: PIMFn - 1979(7) to 2002(5)

λ'	loglik	rank	Ho:rank=p	$-T\log(1-\lambda'_{p+1})$	Za	95%	$-T\Sigma\log(1-\lambda')$	Zb	95%
	-622.93	0	p == 0	51.91**	45.12*	44.0	135.4**	117.7*	114.9
0.1720	-596.97	1	p <= 1	26.63	23.14	37.5	83.5	72.57	87.3
0.0923	-583.57	2	p <= 2	20.97	18.22	31.5	56.87	49.42	63.0
0.0734	-573.17	3	p <= 3	18.44	16.03	25.5	35.9	31.2	42.4
0.0649	-563.95	4	p <= 4	10.96	9.529	19.0	17.46	15.17	25.3
0.0233	-558.47	5	p <= 5	6.492	5.642	12.3	6.492	5.642	12.3

NB λ'= eigenvalue ; Za=-(T-nm)log(1-λ'_{p+1})and Zb=-(T-nm)Σlog(1-λ') where n=dependent variables and m=lag length

Table A.4.2. Test of the cointegration rank: PIMFg - 1979(7) to 2002(5)

λ'	loglik	rank	Ho:rank=p	$-T\log(1-\lambda'_{p+1})$	Za	95%	$-T\Sigma\log(1-\lambda')$	Zb	95%
	-290.495	0	p == 0	52.91*	45.98*	44.0	137.3**	119.4*	114.9
0.1750	-264.040	1	p <= 1	28.9	25.12	37.5	84.43	73.38	87.3
0.0998	-249.590	2	p <= 2	22.43	19.49	31.5	55.53	48.26	63.0
0.0783	-238.374	3	p <= 3	19.14	16.63	25.5	33.1	28.77	42.4
0.0672	-228.806	4	p <= 4	10	8.694	19.0	13.96	12.14	25.3
0.0357	-223.804	5	p <= 5	3.96	3.442	12.3	3.96	3.442	12.3

NB λ'= eigenvalue ; Za=-(T-nm)log(1-λ'_{p+1}); Zb=-(T-nm)Σlog(1-λ') where n=dependent variables and m=lag length

In order to determine whether the Step86 variable should enter the model unrestricted we followed the Pantula principle and tested the joint hypothesis of both rank order and the specification of the deterministic component (Step86). The results of the model with Stpe86 restricted to the co-integrating space are reported below:

Table A.4.3. Test of cointegration rank with restricted Step: PIMFn-1979(7) to 2002(5)

n-p	Ho:rank=p	$-T\log(1-\lambda'_{p+1})$	Za	OL(95%)	$-T\Sigma\log(1-\lambda')$	Zb	OL(95%)	RS(95%)
6	p == 0	51.94**	45.14*	44.0	144.7**	125.8**	114.9	103.8
5	p <= 1	29.79	25.89	37.5	92.79*	80.64	87.3	77.0
4	p <= 2	26.37	22.91	31.5	63*	54.75	63.0	54.1
3	p <= 3	18.48	16.07	25.5	36.63	31.84	42.4	35.2
2	p <= 4	11.23	9.761	19.0	18.15	15.77	25.3	20.1
1	p <= 5	6.914	6.009	12.3	6.914	6.009	12.3	9.2

NB: λ'=eigenvalue; Za=-(T-nm)log(1-λ'_{p+1}) and Zb=-(T-nm)Σlog(1-λ') where n=dependent variables and m=lag length; RS =Johansen, Mosconi and Nielsen (2000) critical values for the trace test

Table A.4.4. Test of cointegration rank with restricted Step: PIMFg-1979(7) to 2002(5)

n-p	Ho:rank=p	$-T\log(1-\lambda'_{p+1})$	Za	95%	$-T\Sigma\log(1-\lambda')$	Zb	95%	RS(95%)
6	p == 0	52.95**	46.02*	44.0	153.9**	133.8**	114.9	103.8
5	p <= 1	34.51	29.99	37.5	101.0**	87.78*	87.3	77.8
4	p <= 2	28.9	25.11	31.5	66.49*	57.78	63.0	54.1
3	p <= 3	20.36	17.69	25.5	37.59	32.67	42.4	35.2
2	p <= 4	10.45	9.078	19.0	17.24	14.98	25.3	20.1
1	p <= 5	6.791	5.902	12.3	6.791	5.902	12.3	9.2

NB λ' = eigenvalue ; Za=-(T-nm)log(1-λ'_{p+1}) and Zb=-(T-nm)Σlog(1-λ') where n=dependent variables and m=lag length; RS =Johansen, Mosconi and Nielsen (2000) critical values for the trace test

We do not have the exact critical values for a model with step, restricted trend and unrestricted intercept. As an approximation we use the Osterwald-Lenum (OL) critical values for restricted trend and unrestricted intercept model and the Johansen, Mosconi and Nielsen (2000) theoretical values for the $H_L(r)$ specification (RS).

The Pantula principle consists in comparing the trace and the max- eigenvalue test of the restricted and unrestricted specification of Step86. The results suggest that based upon the trace test the specification with the unrestricted Step86 has to be preferred, while the Max-eigenvalue test leads to inconclusive results. We therefore decided to let Step86 enter the VAR representation unrestricted.