THE PRICES OF MATERIAL AND INTERMEDIATE INPUTS IN UK MANUFACTURING

By

Professor Paul Stoneman
Warwick Business School
University of Warwick

and

Dr. Giuliana Battisti*
Aston Business School
University of Aston

Abstract: In this paper we explore the patterns and determinants of the prices or raw material and intermediate inputs in to UK manufacturing using the net (n) and gross (g) price indexes of materials and fuels (PIMF) as indicators. It is shown that (i) the PIMF series exhibit considerable fluctuations and nominal growth over time but real reductions (ii) PIMFn is stationary around a step mean, while PIMFg is stationary around a step mean and an underlying step trend with both series showing similar structural breaks (i.e. 1979-85, 1985-90, 1990-95, 1995-00) (iii) the PIMF series are independent of the demand for inputs and thus cost determined. A model of the cost of MII is developed that endogenises the prices of such inputs produced within the UK and estimated on monthly data between 1979 and 2000. The main drivers of PIMFn and PIMFg are shown to be a stochastic trend, the prices of imported semi manufactured inputs, oil prices (including duties) and commodity prices, the latter three also reflecting exchange rate changes. In addition it is shown that the PIMFg is affected by lagged output prices.

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* Corresponding author: OIM Group, Aston Business School, Aston University, Aston triangle, Birmingham, B4 7ET, UK. E. Mail, g.battisti@aston.ac.uk,

1. INTRODUCTION

The prime objective of this paper[1] is to explore the time path of, and determinants of changes in, the prices of material and intermediate inputs (hereinafter MII) in UK industry, which seem to have merited very little attention in both macroeconomic and microeconomics literatures. A search of the standard literature databases has not thrown up any recent publications in this area. Yet, from Census of Production data, in UK manufacturing as a whole in 1995, MII costs represented 68% of sales, whereas wages, which are much more commonly studied, represented only 16%.

Although the relative importance of MII costs is in itself sufficient justification to explore their pattern and determination further, there are (inter alia) three other reasons for looking at MII costs and prices.

(i) Oulton and O'Mahony (1994) have previously illustrated that the UK economy in recent years has experienced negative MII productivity growth (when output is measured as real gross sales). This suggests that to some degree the observed historically high rates of labour productivity growth may reflect movements in the relative prices of labour and materials.

(ii) One mechanism by which inflation can be transmitted across countries is through the costs of MII. An early paper by Beckerman and Jenkinson (1986) illustrates how UK inflation may be related to the world price of commodities, and the price of MII inputs will reflect such prices.

(iii) With the spate of privatisations in the UK in the late eighties and the nineties, a large part of the UK economy was 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 changes in the price and costs of MII.

In the next section we discuss the nature of MII and measures of MII prices. In section 3 the time profile of the indicators is analysed. Section 4 contains some theoretical modelling of determinants, section 5 presents estimates of the models and discussion. The paper concludes in section 6.

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 isolated: materials and fuels including intermediate inputs and semi- manufactured products bought in, non industrial services and industrial services, with relative shares in total MII inputs in 1990 and 1995 as detailed in Table 1.

Table 1: MII shares in the total costs of manufacturing (%)

	1990	1995
Materials, fuels, and intermediate manufactured products	53	56
Industrial Services	4	3
Non Industrial Services	9	9
Total	66	68

Source: Census of Production 1990, 1995. Percentages are relative to total sales and work done, capital costs being defined as total profits.

Although the data therein does not match the census data exactly, further information on the nature of MII, especially as regards intermediate (as opposed to raw material) inputs, can be obtained from the UK Input Output Tables (see Table 2).

[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. Of course any errors remaining in the paper are our responsibility alone.

Table 2. Industry sources of intermediate inputs to manufacturing (% of total intermediate input purchases).

	1984	1990
Agriculture		
Domestic	8	5
Imports	2	1
Energy		
Domestic	6	3
Imports	1	
Manufacturing		
Domestic	41	36
Imports	22	25
Distribution		
Domestic	6	7
Transport		
Domestic	4	5
Business and Other services		
Domestic	9	15
Other	1	3
Total Imports	25	26
Total	100	100

Sources: Input Output Tables for the UK, 1990, 1984. Only values greater than 1% included.

This data clearly indicates that that the majority of the intermediate inputs to manufacturing (61% in 1990) themselves originate from the manufacturing sector with approximately (in 1990) 40% of such inputs being imported. Services in 1990 represent 15% of inputs, and thus jointly the two comprise 76% of total intermediate inputs.

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 (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 including inputs sourced from manufacturing. For the net index, a “ring fence” is placed around the 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 gross series reflects the costs of total purchases of materials and fuels from UK producers (including those in manufacturing) plus total purchases from abroad. The net series only reflects purchases from abroad plus purchases of materials and fuels from UK producers outside the manufacturing sector.

The gross index is made up (from 1995) of 146 separate components (the net has 70) with weights reflecting the value shares of each input and input prices either taken from the output prices of sectors supplying inputs or import prices. It should be noted that the 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. 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. The gross series is only available without seasonal adjustment, and for this reason 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.

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 in Table 1, 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.

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

3.1 Graphical representations

In Figure 1 we plot the gross and net PIMF series for the period from 1979 – 2000 with both being set to a common base of 100 in 1995, and also the Retail Price Index. In Figure 2 we plot the net PIMF series over the period from 1957 – 2000, the RPI and the ratio of PIMFn to the RPI labelled the real net PIMF or RPIMFn. From these figures we observe that:

(i) For the period from June 1986 through to Spring 1996 the net and gross PIMF series track each other quite well however, from January 1979 to February 1984 the net series grows faster than the gross whereas from January 1996 through to 1998 the gross falls more quickly than the net (Figure 1)[2]. The results of these different movements is that over the whole observation period the gross series shows a greater increase than does the net series.

(ii) Over the 1957 – 2000 period the net PIMF grows by a factor of eleven, however most of this growth occurs in the period between January 1973 and December 1984 (See Figure 2). Prior to 1973 the net PIMF 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 back again to reflect relative constancy (with fluctuations) through to 2000.

(iii) Using the RPI as a benchmark against which movements in the PIMF can be judged, we observe that 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 (see Figure 2). Between July 1972 and February 1985 PIMFn grows faster than the RPI, for the remaining of the period up to 2000, the RPI grows faster than the PIMFn. The real PIMFn shows a step up in value between August 1972 and December 1973, relative constancy with fluctuations between 1974 and the end of 1984

[2] We have in fact explored but do not report in detail upon the causality between net and gross PIMF. We find that the net series Grainger causes the gross series (but not vice versa), and that with a varying

and then a declining trend through to the end of the data period. Over the whole 1957 – 2000 period the trend rate of growth of the real net PIMF has been negative, approximately halving over a 45 year period.

Figure 1. PIMF Net (PIMFn) ,Gross (PIMFg) and RPI :1979-2000 (base 1995=100)

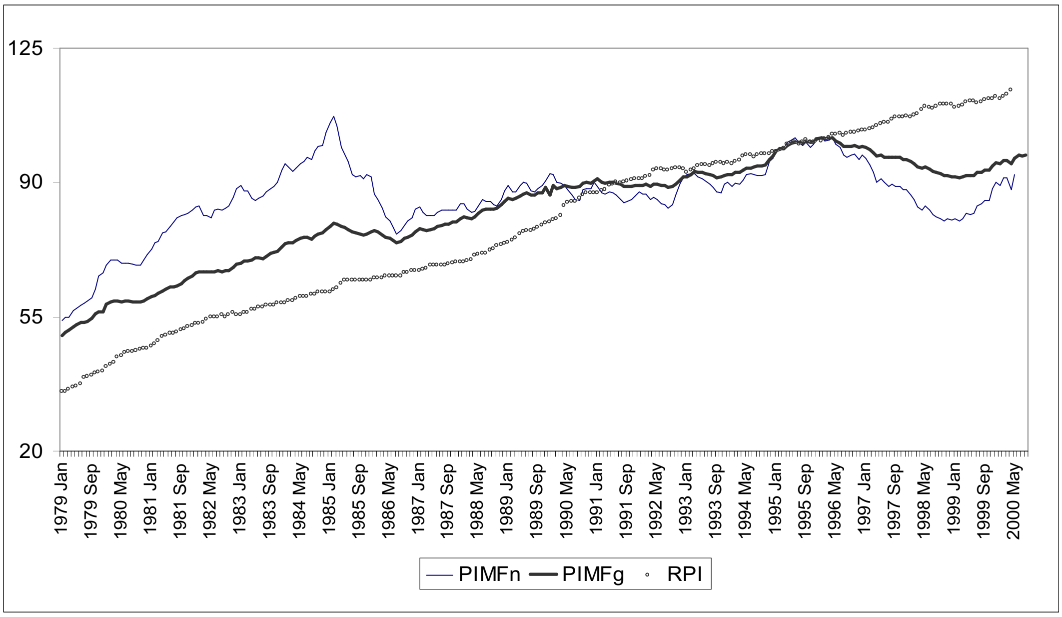
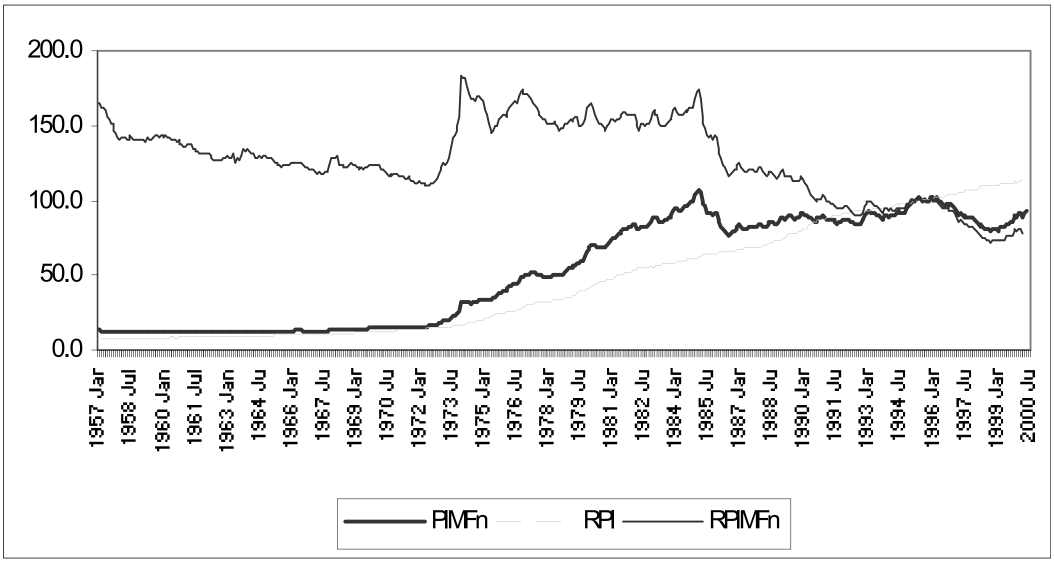


Figure 2. PIMF net (PIMFn) , RPI and real PIMF net (RPIMFg) :1957 – 2000 (base 1995=100)



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lag structure the net series can be shown to lead the gross. This is appropriate given definitions of the two series.

3.2 Time series properties

The time series properties of all the variables used in this analysis are discussed in Appendix 2. There we show that, for the common observation period between January 1979 and August 2000, PIMFn is stationary around a step mean, while PIMFg is stationary around a step mean and an underlying step trend with both series showing similar structural breaks (i.e. 1979-85, 1985-90, 1990-95, 1995-00). There is no clear a priori justification as to why the breaks occur every five years but the net and gross PIMF series have been re-weighted and re-based at five year intervals. As the dates at which this occurred (1980, 1985, 1990, 1995, 2000) seem to approximate the dates of the structural breaks, this re-weighting and rebasing is a prime candidate.

The analysis of the time series properties of the data used the DHF (Dickey, Hasza and Fuller, 1984) and the Osborn (Osborn et al, 1988) tests for seasonal integration versus deterministic seasonality; and the traditional Durbin-Watson (Sargan and Bargawa, 1983), Dickey Fuller (1979), Augmented Dickey Fuller (1981), and Phillips and Perron, (Phillips and Perron 1988) tests of unit roots with deterministic components. The full details of the tests can be found in the Appendix. Here we report only on the generalised version of the Perron test for structural change (Perron, 1989) that allows for the presence of both an AR component (see ADF test), structural breaks and seasonality[3].

The results show that both net and gross PIMF are affected by deterministic seasonality (Fgross=2.7749 (0.0330); Fnet=5.3087 (0.0000)). Allowing for structural

[2] The generalization of the Perron test (Perron , 1989) of structural change tests the presence of structural breaks in the series using a trend (D_T), a Pulse dummy (D_P) or a Level dummy (D_L) for each suspected break in the series and a deterministic seasonal (ΣDS_j) has been specified as follow:

$\Delta y_t = a_1 + \lambda_1 \Sigma_i D_{Li} + \Sigma_i \mu_2 D_{Pi} + \Sigma_i \tau_i D_{Ti} + \phi y_{t-1} + \Sigma_i \beta_i \Delta y_{t-i} + \Sigma_i \gamma_i DS_i + \varepsilon_t$

If the process is non stationary then the pulse dummy (taking value 1 only when a shock is introduced into the system and zero otherwise) will lead to a change in the mean of the process (ϕ=1 and a_1=0, λ_1=0). If the process is stationary or trend stationary, the level dummy (dummy taking value zero before the structural change and one afterwards) will explain a one-time break in the mean of a trend stationary model (ϕ<0, μ_2=0). The change in the trend of the series can be picked up via a trend dummy (D_T) for each break. Thus, the shift in the mean within each of the four partitions is captured by a level dummy, viz.

$D_{L[ta, tb]} = 1$ if $t_a<t<t_b$ where $[t_a; t_b]$=[79:1; 84:12], [85:1; 89:12],[90:1,94:12] [95:1; 00:8]
$D_{L[ta, tb]} = 0$ otherwise

The pulse dummy, viz.

$D_P(\tau) = 1$ if $t = \tau$ where τ =1985:1, 1990:1, 1995:1, 2000:1
$D_P(\tau) = 0$ otherwise

The trend dummy, viz.

$D_{T[ta, tb]} = t$ if $t_a<t<t_b$ where $[t_a; t_b]$=[79:1; 84:12], [85:1; 89:12],[90:1,94:12] [95:1; 00:8]
$D_{T[ta, tb]} = 0$ otherwise

breaks, the gross PIMF series is I(0) (ϕ_n=-0.085 with t=-4.943), and basically trend stationary within each of the four sub-periods: 1979-1985; 1985-1990; 1990-95; 1995-2000. Each of the four five year sub periods are characterized by different drift (D_{Lj}) and growth rates (D_T). The first two periods have almost the same slope ($D_{T\,[79\text{-}85]}$: τ_1=0.025 and $D_{T\,[85\text{-}90]}$: τ_2=0.023) and with slightly different drifts ($D_{L[79\text{-}85]}$: λ_1 = 3.937 and $D_{L\,[85\text{-}90]}$: λ_2= 4.161) suggesting that the series, in these two periods, are affected by a similar underlying trend. The variability along the trend stationary partition [1985-1990] is picked up by a pulse dummy ($D_{P[Jan\ 1985]}$: π_2 =0.585), indicating that any shock had a short memory (i.e. was temporary) with the series after the shock reverting towards its mean value. During the third period the growth rate slows down ($D_{L\,[90\text{-}95]}$: λ_3 =-2.7585 ; $D_{T\,[90\text{-}95]}$: τ_3 =0.012) while in the last period there is another change in the growth rate, which becomes negative ($D_{T[95\text{-}00]}$: τ_4 =-0.002), though not significant.

The results for the net version of PIMF confirm that the series is stationary (PIMFn_1: ϕ_g= -0.0643, t = -4.328). However, the significance of the level dummies indicates that they impact upon the structure of PIMFn. The drift is at its minimum 1985-90. The trend variables are not significant except in one case (i.e. 1985-1990). From Figure 1 a shock to PIMFn in the 1985 – 90 period is apparent and confirmed by a pulse dummy $D_{P[Jan\ 1985]}$[4]. From the comparison of the results for the net and gross PIMF we observe that the impact of this dummy is much greater for the net than the gross series (μ_{2_PIMFn}=2.8578 and μ_{2_PIMFg}=0.585), suggesting that the perturbation of the shock is probably transmitted with lower intensity from PIMFn to PIMFg.

Most of the empirical literature, in line with Nelson and Plosser (1982), would predict that most price series have at least one unit root due to the underlying growth rate of the price series. However, as suggested by Perron (1989) this is not always the case in the presence of structural breaks. This seems to be the case for the PIMF series. But it is worth noticing that despite both series being stationary with structural changes, the

[4] Pulse dummies should not cause permanent changes in stationary series. However, it is reassuring that using a generalized version of the Perron test for structural change (Perron, 1989): a) in the period

coefficient ϕ for both variables over the whole period is close to one (ρ_{net}=(1-0.064)=0.94 and ρ_{gross}= (1-0.086)=0.91). This means that both variables are close to a unit root and thus particular attention is required in both the statistical[5] and theoretical modeling of the PIMF variables.

3.2.3 PIMF and Manufacturing output

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).

For the modelling process below it is important to initially establish whether one can reasonably assume that the price of inputs is not affected by the demand for inputs. The demand for MII is a derived demand, with the demand being a function, for given input prices, of manufacturing output. We have thus undertaken some causality tests of the relation 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.

Measuring output by the index of industrial production, monthly[6], non seasonally adjusted (labelled OUTPUT) we test for the presence of stochastic seasonality by the DHF (Dickey et al.1984) and the Osborn modification (Osborn et al.1988) methods for the period 1979-2000. These tests indicate that the seasonality can be simply picked up by deterministic dummies without the need to seasonally difference the variable (DHF: t=-14.101 and O_DHF: t =-4.732.). The order of the non-seasonal

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1985-90 the impact of the drift in the intercept is higher than the pulse dummy; b) the other pulse dummies are not significant. (see Appendix 2 Table A2).

[5] Monte Carlo studies indicate that when the true data-generating process is stationary but has a root close to unit, the one step ahead forecasts from a differenced model are usually superior to the forecasts from a stationary model. However the long term forecasts of a model with a deterministic trend will be quite different from those of the other models (W. Enders 1995).

component is examined using the traditional integration order tests: Phillips and Perron (1988), Dickey Fuller (1979) and Augmented Dickey Fuller (1981) tests. They all show that the variable is stationary around a positive trend, it is affected by deterministic seasonality and it is correlated up to lag 14 (PP_t=-10.93; DF_t =-3.429 and ADF_t [14] =-3.808). The time series properties of the PIMF series have been established above. In essence, PIMFg and OUTPUT show similar time series properties, but the net PIMF and OUTPUT do not (see Table 3).

Table 3. Time series properties of PIMFn, PIMFg and OUTPUT: deterministic components

Variable	Drift	Trend	Seasonality	max Δy_t lag
PIMFn	√	-	√	5
PIMFg	√	√	√	15
OUTPUT	√	√	√	14

To establish the direction of causality between PIMF and OUTPUT we use the Granger causality definition and apply the original Granger-test (Granger, 1969) and the SIMS-test (Geweke, Meese and Dent, 1983) and (following Enders, 1995) in addition include among the lagged regressors the current values of x_t so as to also explore strong Granger Causality (exogeneity) viz.

$$Ho: \Sigma_{j=0}\beta_j=0$$

$$y_t=AoDET_t + \Sigma\alpha_j y_{t-j} + \Sigma_{j=0}\, \beta_j x_{t-j} + \varepsilon_t$$

where DET is the set of deterministic components. Similar to the Granger test, in this variant exogeneity can be tested via the significance of $Ho: \Sigma_{j=0}\beta_j=0$ (y is 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.

[6] Monthly figures were generated by linear interpolation of quarterly data.

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

a) $PIMF_j$ (j=net , gross) Granger causes OUTPUT

Test [lags]	Ho	PIMFn-> OUTPUT	PIMFg ->OUTPUT
Granger –F [15]	$\Sigma_{j=1}\beta_{j, PIMF}=0$	F(15,208)= 2.4058 [a] *P=0.0032*	F(15,200)=2.7399 [b] *P=0.0007*
SIMS –F [6]	$\Sigma_{j=1}\delta_{t+j,OUTPUT}=0$	F(4,222)=3.9267 *P=0.0001*	F(6, 235)=8.5682 *P=0.000*
CONCLUSION	**PIMFj=>OUTPUT**	***PIMF Granger causes OUTPUT***	***PIMF Granger causes OUTPUT***
Exogeneity–F[15]	$\Sigma_{j=0}\beta_{j,PIMF}=0$	F(16, 198)=2.7396 [a] P=0.0006	F(15, 199)=2.7734 [b] P=0.0006
CONCLUSION	*OUTPUT=f(PIMF$_j$)*	*OUTPUT is not exogenous to PIMF*	*OUTPUT is not exogenous to PIMFg*

[a] deterministic variables in the final model (DET): seasonal dummies , trend (no intercept)
[b] deterministic variables in the final model (DET): seasonal dummies (no trend; no intercept)

b) OUTPUT Granger causes $PIMF_j$ (j=net, gross)

Test [lags]	Ho	OUTPUT -> PIMFn	OUTPUT-> PIMFg
Granger –F [4]	$\Sigma_{j=0}\beta_{j,PIMFn}=0$	F(4,225)=0.7969 [c] P=0.5861	F(14,201)=1.3756 [e] P=0.1675
SIMS –F [6]	$\Sigma_{j=1}\delta_{t+j,OUTPUT}=0$	F(4.223)=0.6360 *P=0.6373*	F(4,225)=2.1352 *P=0.774*
CONCLUSION	***OUTPUT=> PIMFj***	***OUTPUT does not Granger cause PIMF***	***OUTPUT does not Granger cause PIMF***
Exogeneity–Fn[15]; Fg[6]	$\Sigma_{j=0}\beta_{j,PIMF}=0$	F(16,199)=1.5025 [c,d] *P=0.1015*	F(7,224)=3.6915 [e,.f] P=0.0008
CONCLUSION	***PIMF$_j$=f(OUTPUT)***	***PIMFn exogenous to OUTPUT***	***PIMFg not exogenous to OUTPUT***

[c]: deterministic variables in the final model (DET): intercept , seasonal dummies (no trend), pulse dummies (D8912-D9001).
[d]: Exogeneity: the same results are obtain ed if lag [6] is used instead of lag [15] (the latter lag being significant only at 5.2%): F(7,220)= 1.7132, P=0.107.
[e]: deterministic variables in the final model (DET): intercept , seasonal dummies (no trend), pulse dummies (D8912-D9001).
[f]: Exogeneity: the same results are obtained if lag [4] is used instead of lag [6] (the latter lag being significant only for OUPUT): F(5,228) = 3.5818 P=0.0039.

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 the null of no Granger causality (Granger and SIM test) cannot be accepted for PIMFn => OUTPUT or for PIMFg => OUTPUT, nor (see Exogeneity row), can the hypothesis of exogeneity, or no strong causality, be accepted. In summary Table 4.a shows that PIMFn/g 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 tests), the hypothesis of non causality (OUTPUT≠>PIMFn ; OUTPUT ≠>PIMFg), cannot be rejected in either of the two cases. Whether one uses gross or net PIMF, their past realization are independent of the level of output produced. The exogeneity test (exogeneity row) indicates that while PIMFn is exogenous to OUTPUT , PIMFg is weakly exogenous and it interacts with current levels of OUTPUT (although when the sample size is restricted to 1986-2000, this hypothesis cannot be accepted ($F(5,150)=1.8051$ [0.1151]).[7] We consider that there is sufficient evidence to suggest that PIMF (net and gross) are not caused by manufacturing output and thus we conclude that such prices may be modelled solely as cost determined[8].

4. MODELLING THE PRICES OF MII

Given the definition of the PIMF series, clearly, determinants of changes in PIMF will be the results of changes in the prices of the inputs that are used in its calculation. However we are seeking a relationship to the more basic drivers of MII prices i.e. the exogenous determinants of the prices of the many inputs included in the calculation of PIMF. We thus proceed by (i) identifying those exogenous factors that will drive the various input prices and (ii) allowing for interactions between the prices of outputs from the production process in different sectors and the prices of inputs to manufacturing. We proceed upon the assumption that the supply curve for MII is flat (there is an infinite elasticity of supply).

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[7] As a further cross check we have explored the relationship between real net / gross PIMF and output. The result indicates that the conclusions are unchanged. Moreover, given that the PIMF series is borderline between a random walk and a white noise the causality test has been carried out using PIMF at differences rather than levels. Also in this case the conclusion is unchanged.

[8] 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.

It is useful to consider that the large number of individual MII inputs defined in the PIMF series can be aggregated in to eight categories of material and intermediate inputs (see Tables 1 and 2). We label these inputs X_1 to X_8 with prices P_1 to P_8 respectively. The inputs are: are domestically and overseas sourced: raw materials (e.g. crude oil or coal), labelled inputs 1 and 2; other non service intermediate inputs produced outside manufacturing (e.g. electricity or meat) labelled inputs 3 and 4; service inputs from home or overseas (e.g. computer and transport services) labelled inputs 5 and 6; and intermediate inputs produced within manufacturing (at home or overseas) labelled inputs 7 and 8. It may be noted that, as we have shown above (Table 2), imported services are sufficiently small to be ignored, and in any case the gross and net PIMF series do not directly include service prices. We then argue as follows

(i) The prices of material inputs are determined on world markets and there is infinite elasticity of supply at world prices. Thus the prices in sterling of material inputs sourced from home and overseas are considered to be equal and essentially determined by world commodity prices and prevailing exchange rates. We thus allow that $P_1(t) = P_2(t)$.

(ii) For intermediate inputs produced outside manufacturing (e.g. electricity or meat) we separately consider those produced at home and overseas with prices $P_3(t)$ and $P_4(t)$ respectively. For such inputs produced overseas we make a small country assumption and assume an infinite elasticity of supply at current prices with current prices being exogenous to the cost of MII to domestic manufacturing. Thus $P_4(t)$ is taken as exogenous[9]. For such inputs produced domestically we assume constant returns to scale and fixed mark ups and thus prices of such inputs, $P_3(t)$, will be solely dependent upon their costs of production.

(iii) Service inputs (e.g. computer and transport services) are almost wholly sourced domestically and thus we need not discuss imports of services to any

[9] At a more basic level such prices and the prices of imported intermediate inputs will be a function of the exchange rate, the cost of raw material inputs to overseas producers, overseas wages and capital costs and total factor productivity (TFP) overseas, but this is a not a trail that we follow.

extent (we assume, although it has no material impact that the price of imported services, $P_6(t)$ is given and determined exogenously). The prices of domestically produced services $P_5(t)$ will depend upon the costs of producing services and perhaps the demand for services but by extending the assumption of constant returns to scale to the service sector we may put demand issues to one side.

(iv) For manufactured intermediate inputs imported from overseas we make a small country assumption and assume an infinite elasticity of supply at current prices with current prices being exogenous to the cost of MII to domestic manufacturing. Thus $P_8(t)$ is taken as given and exogenous. For such inputs sourced domestically the price $P_7(t)$ will be equal to the net or gross producer price index[10] in manufacturing depending upon whether we are looking at net or gross relationships. At a second level however, assuming constant returns to scale, these prices will be a function of the unit costs of production in manufacturing.

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 within the system. All other prices are considered to be determined exogenously.

The net PIMF

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

$$PIMFn(t) = s_1(t)P_1(t) + s_2(t)P_2(t) + s_3(t)P_3(t) + s_4(t)P_4(t) + s_8(t)P_8(t) \quad (1)$$

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

[10] 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

inputs. The shares used in the construction are recalculated each five years and are thus 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 in the calculation of the PIMFn only $P_3(t)$ is left to be determined.

To model the determination of $P_3(t)$ define $C_i(t)$ as the unit cost of producing output i in time t, i =3, 5, 7. In steady state our assumptions imply that $P_i(t) = \pi_i(t)C_i(t)$, where $\pi_i(t)$ equals one plus the mark up, and is again allowed to be time dependent to capture any changes in the mark up over time. However out of steady state there may be lags in the pricing equation, we thus write for each i,

$$P_i(t) = (1 - \lambda_i)\, \pi_i(t)\, C_i(t) + \lambda_i\, P_i(t - 1) \qquad (2)$$

To model $C_i(t)$, i = 3, 5 or 7, under a linear production technology[12] we define $\alpha_{ij}(t)$ as input j per unit of output i (j = 1..8) which is again allowed to be time dependent to allow for technological change. For the **net scenario** and on account of the arguments above we assume that $\alpha_{33}(t) = \alpha_{55}(t) = \alpha_{36}(t) = \alpha_{56}(t) = \alpha_{76}(t) = \alpha_{77}(t) = 0$. We allow that wage rates, W(t), and capital costs (interest rates) R(t), are the same for all sectors (to reduce the number of parameters being considered), and define $\alpha_{iL}(t)$ and $\alpha_{iK}(t)$ as inputs of L and K respectively in the production of product i . This yields that

$$C_3(t) = (\alpha_{31}(t) + \alpha_{32}(t))P_1(t) + \alpha_{34}(t)P_4(t) + \alpha_{35}(t)P_5(t) + \alpha_{37}(t)P_7(t) + \alpha_{38}(t)P_8(t) + \alpha_{3L}(t)W(t) + \alpha_{3K}(t)R(t) \qquad (3)$$

$$C_5(t) = (\alpha_{51}(t) + \alpha_{52}(t))P_1(t) + \alpha_{53}(t)P_3(t) + \alpha_{54}(t)P_4(t) + \alpha_{57}(t)P_7(t) + \alpha_{58}(t)P_8(t) + \alpha_{5L}(t)W(t) + \alpha_{5K}(t)R(t) \qquad (4)$$

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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.

[11] In principle these shares could be considered as endogenously determined, however for the sake of simplicity we assume that they are exogenous.

[12] 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

$C_7(t) = (\alpha_{71}(t) + \alpha_{72}(t))P_1(t) + \alpha_{73}(t)P_3(t) + \alpha_{74}(t)P_4(t) + \alpha_{75}(t)P_5(t) + \alpha_{78}(t)P_8(t) + \alpha_{7L}(t)W(t) + \alpha_{7K}(t)R(t)$ (5)

Solving (2) – (5) for an expression for $P_3(t)$ as a function only of exogenously determined variables or variables predetermined in time t yields (6)

$P_3(t) = b_1(t)P_1(t) + b_2(t)P_4(t) + b_3(t)P_8(t) + b_4(t)W(t) + b_5(t)R(t) + b_6P_3(t\text{-}l) + b_7(t)P_5(t\text{-}1) + b_8(t)P_7(t\text{-}1)$ (6)

where the elements of the parameter vector **b(t)** are time dependent complex combinations of previously defined parameters. Substituting from (6) into (1) yields (7)

$PIMFn(t) = \beta_1(t)P_4(t) + \beta_2P_8(t) + \beta_3(t)W(t) + \beta_4(t)R(t) + \beta_5(t)P_1(t) + \beta_6(t)P_3(t\text{-}l) + \beta_7(t)P_5(t\text{-}1) + \beta_8(t)P_7(t\text{-}1)$ (7)

Which we rewrite in vector form as

$PIMFn(t) = \beta\mathbf{(t)P(t)}$ (8)

Given the time dependency of the parameter vector β**(t)** we allow that

$\beta\mathbf{(t)} = \beta + \mathbf{z(t)}$ (9)

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 reflects three factors. The first is the 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 reweight 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

series are designed and the results achieved are in line with expectations we report solely upon that approach.

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 reweighting will lead to a reduced PIMF.

The second factor is 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. This will imply negative values for the relevant components of **z(t)** and we would expect that due to technological change PIMF will fall over time.

The third factor incorporated in **z(t)** is changes over time in mark ups in domestic sectors supplying the manufacturing sector. If the mark up increases the relevant element of **z(t)** will increase (and vice versa). Increases in mark ups should yield a higher PIMF. Small (1997) and Britton, Larsen and Small (2000) illustrate that there is considerable intertemporal variation in mark ups in UK industry. We should note however that we have shown that manufacturing output does not cause PIMF and as such it may not be the case that cyclical variations in mark up are that important, however a systematic upward (or downward) trend in mark up may well impact upon PIMF.

For empirical purposes below, substituting from (9) into (8), and allowing that **z(t)P(t)** can be represented by a trend term F(t), we write the resultant expression for PIMFn(t) as (10)

$$\begin{aligned} \text{PIMFn}(t) &= \beta\mathbf{(t)P(t)} = \{\beta + \mathbf{z(t)}\}\ \mathbf{P(t)} \\ &= \beta\mathbf{P(t)} + F(t) + u(t) \end{aligned} \tag{10}$$

where u(t) is an error term that will pick up, inter alia, any missing input prices not covered by our modelling (given that only eight have been considered here and the

PIMFn series encompasses 70). The detail of the trend term is to be discussed further below.

The price of raw materials in (7), $P_1(t) = P_2(t)$, is still to be specified. We argue that these prices will mainly reflect and be determined by world oil and commodities prices corrected for changes in exchange rates and UK duties on oil. We thus replace $P_1(t)$ by a weighted sum (with weights to be determined in the estimation process) of the price of Primary Commodities (excluding Oil), and the price of crude petroleum in developing and developed countries[13] allowing for exchange rates and duties (see Appendix 1). As there may be lags in the relationship between the sterling prices of raw material inputs and their determinants we have experimented with different lag structures. We report results below however that include only current and one period lagged values.

Introducing this variation in to (7) yields the final estimating equation (11)

$$PIMFn(t) = \beta_1 P_4(t) + \beta_2 P_8(t) + \beta_3 W(t) + \beta_4 R(t) + \beta_5 P_{comm}(t) + \beta_6 P_{oil\_ex\_tax}(t) + \beta_7 (P_{comm}(t-1) + \beta_8 P_{oil\_ex\_tax}(t-1) + \beta_9 P_3(t-l) + \beta_{10} P_5(t-1) + \beta_{11} P_7(t-1) + F(t) + u(t) \qquad (11)$$

The gross PIMF

The gross price index for materials and fuels (PIMFg) is measured as

$$PIMFg(t) = s_1(t)P_1(t) + s_2(t)P_2(t) + s_3(t)P_3(t) + s_4(t)P_4(t) + s_8(t)P_8(t) + s_7(t)P_7(t) \qquad (1')$$

where $P_7(t)$ is the GPPI, i.e. the gross output price index for manufacturing, and the share estimates are appropriately redefined as shares of all MII including domestically manufactured inputs. Working with gross output the restriction that $\alpha_{77}(t) = 0$ which

[13] We have also experimented with including the price of minerals (excluding oil) but this was redundant.

was imposed for the net case (in net terms domestically manufactured inputs are not used in manufacturing) has to be lifted. This leads to modifications of (3) to (5) but particularly (5) which has now to be written as (5')

$$C_7(t) = (\alpha_{71}(t) + \alpha_{72}(t))P_1(t) + \alpha_{73}(t)P_3(t) + \alpha_{74}(t)P_4(t) + \alpha_{75}(t)P_5(t) + \alpha_{77}(t)P_7(t) + \alpha_{78}(t)P_8(t) + \alpha_{7L}(t)W(t) + \alpha_{7K}(t)R(t) \qquad (5')$$

where $P_7(t)$ is again the GPPI. However in the equivalent versions of (3) and (4), which we do not write out again, and which have not changed from the original versions, the P_7 series is in fact the net PPI (i.e. the price of output from manufacturing that crosses the ring fence). In principle we should proceed distinguishing clearly between the net and gross PPI. However, in practice, we observe that in the data there is no apparent divergence between the net and gross PPI. We thus assume that the price of manufacturing outputs used as manufacturing inputs is the same as manufacturing outputs that cross the ring fence and that we need only to work with one such price, which we write as $P_7(t)$.

Using (5') instead of (5) makes the algebra a bit more extensive, but still yields an expression for $P_3(t)$ equivalent to (6). The inclusion of GPPI = $P_7(t)$ in the expression for the PIMFg also necessitates the derivation of an expression for $P_7(t)$ equivalent to that for $P_3(t)$ in (6). The form will however be the same as in (6). The final expression for the PIMFg is thus as in (11')

$$PIMFg(t) = \beta'_1P_4(t) + \beta'_2P_8(t) + \beta'_3W(t) + \beta'_4 R(t) + \beta'_5P_{comm}(t) + \beta'_6P_{oil\_ex\_tax}(t) + \beta'_7P_{comm}(t-1) + \beta'_8P_{oil\_ex\_tax}(t-1) + \beta'_9P_3(t-l) + \beta'_{10}P_5(t-1) + \beta'_{11}P_7(t-1) + F'(t) + u'(t) \qquad (11')$$

Compared to (11) we can expect a larger coefficient upon $P_7(t-1)$ in (11') for the prices of home produced manufactured inputs impact not only upon the prices of other inputs but also directly upon the PIMFg(t) whereas they do not impact directly on PIMFn(t).

5. ESTIMATING THE PRICE MODELS

Equations (11) and (11') have been estimated using monthly data for the period from 1979 – 2000. Although the net PIMF equation could have been estimated also using earlier data, comparability was considered valuable and moreover prior to 1979 the definition of the manufacturing sector in ONS data is somewhat different. The definition and measurement of all variables used in this analysis are detailed in Appendix 1.

In initial estimates we model F(t), the trend as linear with level g_1 and slope g_2 , i.e.

$$F(t)=g_1+ g_2t. \qquad (12)$$

We have also included in (11) and (11') a number of seasonal dummies (ΣDS_j j= Jan, Feb, Mar, …). We have shown above that PIMFn and PIMFg are not stationary and may also be trended, while most of the independent variables (see the Appendix) are unit root. Consequently, OLS estimates of levels equation may well be spurious. In fact estimates of this kind over the whole sample were unsatisfactory with high unexplained residual autocorrelation and unrealistically high R^2 (close to 1). Given that the PIMF series are characterised by four structural changes in the drift as shown above, the model was also estimated in levels within each sub-period using OLS. This did not solve the residual autocorrelation problem. Consequently (11) and (11') have been re-specified in first difference form and re-estimated. With the F(t) term represented by (12), in the first difference equation the intercept will be equal to the slope of the underlying trend, i.e. g_2, a constant.

The OLS estimates of both the PIMFg and PIMFn differenced models applied to the whole data period are reported in Table 5 columns 1 and 4 respectively. The diagnostic indicators illustrate that the residuals are well behaved and the residual autocorrelation is quite low (DW_g=1.92; DW_n=1.93) indicating that the model, despite structural shifts in the PIMF series, is reliable over the whole data period. One model can thus be used to encompass the whole data series. The explanatory power of the model is very reasonable for a first difference model. For all variables other than the intercept, both recursive least squares estimates and Hansen statistics (Hansen, 1992) confirm the constancy of the parameters over time. The parameter instability statistics

(Hansen ,1992) for the intercept are H_DPIMFg= 0.55 and H_DPIMFn=1.24) [14]. This result indicates that although PIMFi (i = gross, net) shows structural breaks, those breaks can be adequately explained by two factors, the first being the structural breaks in the underlying data generating process for the independent variables (e.g. exogenous changes in the dollar price of oil or the exchange rate) and the second being changes in the slope of the trend (i.e. the constant, g_2).

Our estimate of g_2, the slope of the trend is significant and positive (one possible technical reason for which is that the intercept may be picking up the variability of the 12th seasonal dummy omitted to avoid multicollinearity among the regressors[15]) in both net and gross models, however the Hansen test indicates that, contrary to model structure, the intercept is non constant. To address this non constancy issue we allow the intercept to be different in each of the four critical sub-periods identified above [1979-1984; 1985-1989; 1990-1994; 1995-2000]. This is equivalent to including a series of step variables in the differenced estimating equation. i.e. $g_2(t) = g_{2,79-84}+g_{2,85-89} + g_{2,90-94} + g_{2,95-00}$. If g(t) changes linearly over time at a constant rate, all the intercepts (g_{2i}) will be the same across structural breaks otherwise one would expect to observe as many significant steps in DPIMFi as changes in the original slope (g_{2i}).

The estimates of the model with step dummies for the structural change in the linear trend are reported in Table 5 columns 2 and 5. The test of joint parameter equality of the steps variables (Ho: $\beta_{s79-84} = \beta_{s85-89} = \beta_{s90-94} = \beta_{s95-00}$) cannot be accepted at the 1% significance level (Wald test for linear restrictions: Rb = r: DPIMFg: LinRes F(4,235)=115.36 [0.0000] and DPIMFn : LinRes F(4,233)= 50.501 [0.0000]).This confirms the instability indicated by the Hansen's statistics, indicating that the trend does not have a constant growth rate and consequently it is not linear. The sub period estimates of g_2 also indicate that the trend is not monotonic.

[14] This statistics is calculated in absence of dummy variables over the unrestricted model with intercept and no step variables. Its significance was also confirmed by the visual inspection of the coefficient stability plot derived from recursive least square estimates (using PCGive).

[15] In fact when both the intercept and the seasonal dummies are jointly specified, in order to avoid multicollinearity, only 11 seasonal dummy variables are included in the rhs of the model. The estimates of the model with 12 seasonal dummy variables (without the intercept) gives estimates equivalent to the model with intercept and 11 seasonal dummies.

Given the apparent non linearity in the trend, a preferred modelling is to allow g(t) to adjust over time picking up the stochastic movements in the slope (g_2). Smoothed estimates of the trend can then be estimated using the structural time series approach. On the basis of Harvey (1991) one can argue that such an approach is equivalent to using a stochastic specification of the PIMF model in which the parameters are time varying and re-estimated every time a new observation is made available. In this approach $g_2(t)$ is allowed to change over time and is modelled by a continuous function, not necessarily linear and not necessarily constant.

Mathematically, the deterministic step variables (g_{2i}) in the previous model, typical of the OLS fixed parameters approach, is replaced by a dynamic structural specification with stochastic drift specified as

$$\Delta y_t = g_2(t) + \beta\Delta X(t) + \varepsilon(t)$$
$$g_2(t) = g_2(t-1) + \zeta_t$$

where ε_t and ζ_t are assumed to be IID variables ($\varepsilon_t \sim NID\ (0,\sigma^2_\varepsilon)$ and $\zeta_t \sim NID\ (0,\sigma^2_\zeta)$. Using this specification seasonality enters the model separately and can be isolated from the intercept.

The ML estimates for this n structural model are summarised in Table 5 columns 3 and 6. The diagnostic statistics for both estimates are satisfactory. The non-linear stochastic trend ($g_2(t)$) is significant for both PIMFn and PIMFg . The estimates of the DPIMFg intercept at the end of the period is β_T=-0.010 with RMSE=0.080 but with q-ratio =0.09 and σ_{g2}=0.022[16]. The model does not show any residual correlation (r(1)=-0.004 and r(14)=-0.008). The resultant smoothed estimates of $g_2(t)$ are reported in Figure 3 showing a general downward path[17].

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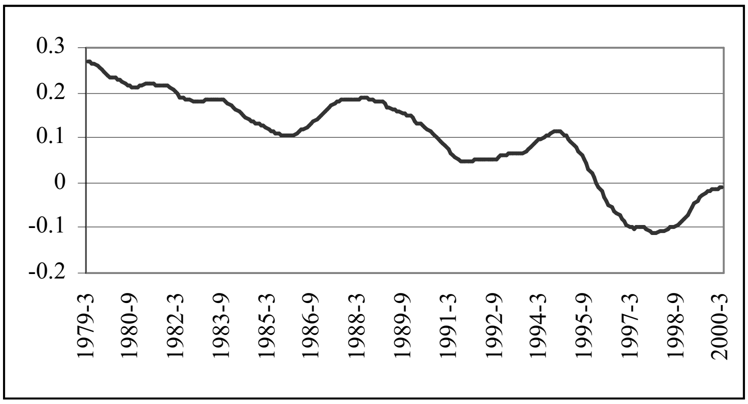
[16] RMSE= Residual Mean Square Error while q-ratio shows the proportion of residual variability explained by the stochastic slope and σ_{g2}.is the estimated standard deviation of the disturbances i.e. if σ_{g2}=0 the stochastic component collapses to a deterministic one.
[17] It is worth noting as well that we have experimented with the inclusion of a stochastic trend in the difference equation as opposed to the levels equation but as in the difference equation all left and right hand side variable are stationary, this is inappropriate.

For the PIMFn the estimates of the trend are very similar to PIMFg in character. However the final state estimate of $g_2(t)$ is β_T=-0.003 with RMSE =0.1274 indicating that the final value at the end of the period is not significant. However, in this structural approach this value does not have the same meaning as the OLS intercept. In fact the estimated standard deviation of the residuals shows that $\sigma_{\zeta t=}$ 0.022 with q-ratio 0.033 indicating that $g_2(t)$ is not constant.

Figure 3: Smoothed estimates, slope of the stochastic trend, PIMFg (1980-2000)



We discuss these estimates of the trend in more detail below. Here we concentrate upon other aspects of the results. The three different sets of estimates presented in Table 5 give similar indicators of the main deterministic factors that drive PIMFn and PIMFg. These factors jointly explain a reasonable proportion of the total variability of the PIMF series. The results indicate that (as well as trend effects) the significant drivers of changes in the gross index are oil prices (without any lag), commodity prices (with a one period lag) the price of imported semi manufactured inputs (representing both the price of imported non service manufactured inputs and the prices of imported manufactures) and the price of domestically manufactured outputs (with a one period lag) all with the expected positive sign. The earnings variable is not significant but has the correct sign. The capital cost variable is not significant (and carries the wrong sign) but such costs are notoriously difficult to measure. In addition we can find no impact from the PPI for agriculture or the price of domestically produced service inputs. In essence therefore, apart from the PPI for manufacturing, we find that the PIMFg is 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). Possible reasons why domestic price factors (the PPI for agriculture, the price of domestically produced services , wages and capital costs) do not play any significant role are that (i) the lagged output price is picking up the effects of these variables (ii) they make only a minimal contribution to manufacturing costs as measured by the PIMFg (iii) the stochastic trend is picking up their effect. In terms of deterministic effects it is clear however that, apart from the lagged output price, the PIMFg is largely driven by external factors.

It is oil and commodity prices but with a slightly different lag structure, combined with the price of imported semi manufactured inputs that drives PIMFn. Earnings, capital costs, and the PPI for agriculture are not significant. In the estimates with a stochastic trend, service prices are also significant but of the wrong sign. We note that for net PIMF the price of domestic manufactured outputs is not significant whereas it is significant for the gross PIMF. This is exactly what the theory based upon the different definitions of net and gross PIMF above suggested.

Essentially these results indicates that apart from the trend term, the PIMF is mostly driven by fluctuations in the prices of commodities, oil and semi-manufactures imported from abroad[18]. The gross version also shows a significant impact of the lagged PPI of gross output, which may represent a feedback of PIMFn into PIMFg.

[18] In case it be thought that all we have done here is to reproduce the weights used in the ONS construction of the PIMF series it should be noted (a) the PIMF constructions do not include any lagged terms (b) the ONS series does not allow for a stochastic trend and (c) the ONS weights are often quite different to our parameter (e.g. oil in the PIMFg series carries a (1995) weight of 0.035 compared to our coefficient of 0.018).

Table 5. Model Estimate, DPIMFg and DPIMFn : 1979 (2) –2000 (3)

	DPIMFg		
	1	2	3
	OLS With intercept (with 11 seasonal dummies)	OLS With step dummy in the levels	STAMP Stochastic trend (level)
g2-79/00	**0.408 (4.786)**		
g_2_79/84		**0.522 (5.843)**	-
g_2_85/89		**0.488 (5.730)**	-
g_2_90/94		**0.104 (4.580)**	-
g_2_95/00		**0.275 (3.101)**	-
Stochastic Drift $g2_t$	-	-	-0.010 RMSE (-0.08)
DEAR	0.025 (1.087)	0.030 (1.344)	0.028 (1.236)
Dkcost	0.003 (0.039)	-0.025 (-0.312)	-0.037(-0.465)
DSEMI	**0.190 (7.653)**	**0.181 (7.539)**	**0.173 (7.181)**
Doil_ex_tax	**0.017 (6.823)**	**0.018 (7.411)**	**0.018 (7.353)**
Doil_ex_tax(-1)	0.001 (0.262)	0.002 (1.006)	0.003 (1.028)
Dcomm	0.003 (0.332)	-0.001 (-0.102)	-0.0003(-0.031)
Dcomm(-1)	**0.025 (2.923)**	**0.023 (2.583)**	**0.023 (2.77)**
Dservice (-1)	0.027 (0.675)	0.006 (0.145)	0.012 (0.309)
DPPIagr (-1)	0.006 (0.490)	0.001 (0.089)	-0.001 (-0.067)
DOUTg(-1)	**0.220 (3.918)**	**0.161 (2.917)**	**0.135 (2.457)**
Seasonality (Wald test)	F(11,229) = 8.209	F(23,226) = 9.034	X^2(11)=122.22
d8912 **d9001**	-2.692 (-7.928) 2.2034 (6.612)	-2.658 (-8.313) 2.183 (6.747)	-2.636 (-8.367) 2.137 (6.6948)
Sample size	**253**	253	T=253 n=241
F_test	F(23,229)=18.442	F(23,226) = 20.96	-
DW	1.93	1.99	2.005
R^2 $R^2_{D,S}$	0.65 0.73	0.71 0.75	0.73 0.74

	DPIMFn		
	4	5	6
	OLS With intercept (with 11 seasonal dummies)	OLS With step dummy in the levels	STAMP Stochastic trend (level)
g2-79/00	**1.732 (7.872)**	-	
g_2_79/84	-	**1.740 (7.902)**	**-**
G_2_85/89	-	**2.132 (4.136)**	**-**
G_2_90/94	-	**2.069 (3.840)**	**-**
G_2_95/00	-	**1.868 (3.479)**	**-**
Stochastic drift $g2_t$	-	-	-0.0029 RMSE (0.123)
DEAR	0.027 (0.483)	0.032 (0.569)	0.062 (1.141)
Dkcost	0.30 (1.498)	0.255 (1.257)	0.200 (1.034)
DSEMI	**0.34 (5.604)**	0.032 (5.303)	**0.337 (5.807)**
Doil_ex_tax	**0.047 (7.630)**	**0.049 (7.840)**	**0.049 (8.249)**
Doil_ex_tax (-1)	**0.021 (7.630)**	**0.023 (3.562)**	**0.022 (3.622)**
Dcomm	**0.049 (2.336)**	**0.050 (2.315)**	**0.057 (2.871)**
Dcomm (-1)	**0.052 (2.363)**	**0.048 (2.188)**	**0.037 (1.702)***
Dservice (-1)	-0.687(-0.754)	-0.086 (-0.931)	**-0.234 (-2.381)**
DPPIagr (-1)	-0.10 (-0.378)	-0.015 (-0.559)	-0.009 (-0.342)
DOUTn (-1)	-0.22 (-1.001)	-0.299 (-1.318)	-0.036 (-0.168)
Seasonality (Wald test)	F(11,230)=11.32	F(11,226)=13.36	X^2(11)=187.93
D8504 **D8601** **D8602**	-1.350 (-4.570) 5.527 (6.883) -4.595 (-5.407)	-1.746 (-3.170) -4.603 (-5.424) 5.658 (6.999)	-4.762 (-5.871) -5.664 (-7.360) -1.621 (-2.039)
Sample size	254	254	T=254 n=-241
F-test	F(24,229)=20.72	F(26,226) =19.69	-
DW	1.92	1.94	2.026
R^2 $R^2_{D,S}$	0.68 0.68	0.69 0.68	0.70 0.70

NB. '-' non specified; '*' significant at 8.8%. F/X^2-Test= test of the overall parameters significance (seasonal variables ; full model); $R^2_{D,S}$=goodness of fit relative to seasonal and differences

In Table 6 we detail the resultant elasticity estimates based upon the stochastic trend estimates for all variables with significant coefficients of the expected sign. In terms of elasticities at sample means, for PIMFn, imported semi manufactured inputs are quantitatively most significant. Taking account of lagged effects, oil prices carry an elasticity of 0.073 and commodity prices an elasticity of 0.092. These however may be underestimates, for it might also be the case that changes in oil and commodity prices may feed through to the prices of imported semi manufactured products but this is not dealt with explicitly.

PIMFg is particularly sensitive to the price of imported semi manufactured inputs (elasticity 0.154) and the prices of domestically produced manufactured output

(0.140). Oil prices and commodity prices also impact but the elasticities are smaller (0.027, 0.024). However with PIMFg, the lagged output price term may be interpreted as a possible dynamic effect. An increase in PIMFg will lead to an higher output price which will then feed in to a higher PIMF. Given that the sample mean of PIMFg is 82.6 and that of the PPI is 85.4, a coefficient of 0.135 on the output price yields a multiplier of 1.163 on the short term elasticities to generate long term elasticities resulting in estimates of 0.179 on imported semi manufactured inputs, 0.031 on oil prices and 0.028 on commodity prices.

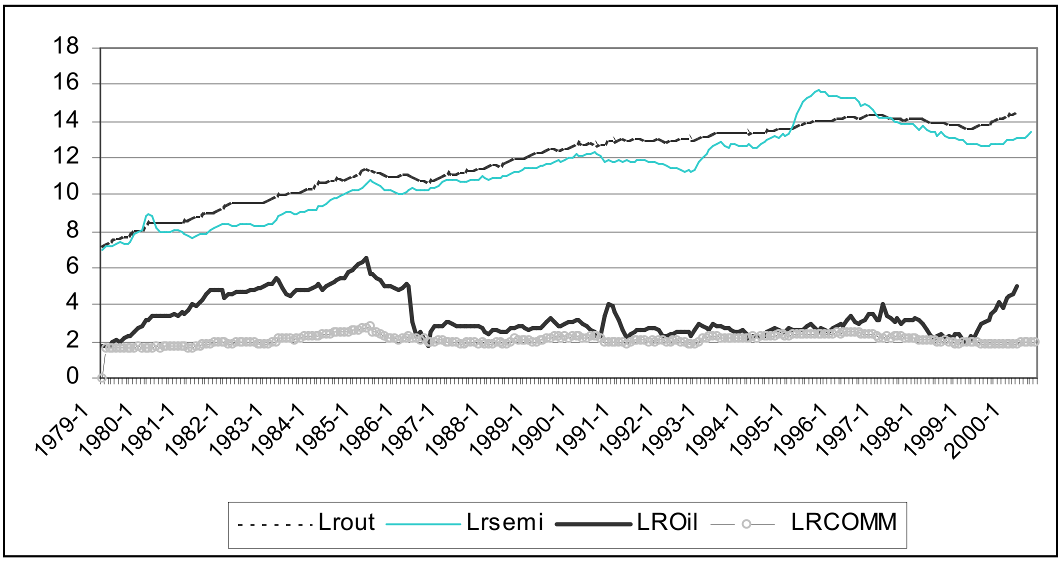
One may also note that given the construction of the oil price variable (oil.ex.tax) that the elasticities of PIMF to changes in duties is the same as the elasticities to changes in the price of oil. The elasticity of PIMF to the sterling dollar exchange rate, given the construction of the price of commodities, 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.0.224 for PIMFg and 0.502 for PIMFn (including lags).

Table 6: Elasticity estimates

				PIMGg			**PIMFn**		
(1979:3-2000:3)	**sample mean at D**	**sample mean at levels**		**Estimated Coefficient β**	**Elasticity at means of D**	**Elasticity at sample means**	**Estimated Coefficient β**	Elasticity mean D	Elasticity mean levels
DPIMFg	0.177	82.623							
DPIMFn	0.145	86.361							
Stoch. Drift $g2_t$	0.18			-0.010	**0.055**		-0.003	**-0.19**	
DSEMI	0.15239	73.492		0.173	**0.149**	**0.154**	0.337	**0.354**	**0.29**
Doil_ex_tax	0.47313	124.20		0.018	**0.048**	**0.027**	0.049	**0.160**	**0.041**
Doil_ex_tax(-1)	0.47661	123.72					0.022	**0.072**	**0.032**
Dcomm	0.0504	87.180					0.057	**0.020**	**0.055**
Dcomm(-1)	0.05156	87.126		0.023	**0.007**	**0.024**	0.037	**0.013**	**0.037**
DOUTg(-1)	0.2047	85.402		0.135	**0.156**	**0.140**			

In Figure 4, using the same parameter estimates we present an impact analysis of the various determinants (excluding the trend term) on the level of PIMFg over time, measured as the contribution of each component to the level of PIMFg at each point in time. This illustrates the larger contribution of domestically produced output and imported semi manufactured inputs than the other two factors, the former also tending upward over time. The contribution of commodity prices is lower and generally constant. The impact of oil prices is quantitatively similar to that of commodity prices but is particularly larger between 1980 and 1987, with a take off again in the last few observation periods. Of particular interest here given its recent nature, is the explanation for the downward path of PIMF after July 1996 and its consequent increase again post January 1999 apparent in Figure 1. Figure 4 illustrates that the downward pressure came mainly from both the price of oil and the price of imported semi manufactures both of which were reversed from 1999. As we shall see below, these forces were also bolstered by similar movements in the trend.

Figure 4: Impact analysis of components upon the level of PIMFg.

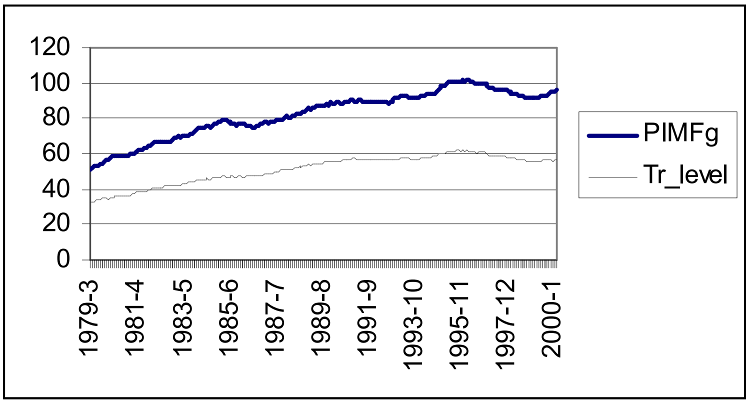


Legend: Gross Output (LRout), Semimanufactured (LRsemi), oil (LRoil) and Commodities (LRcomm) prices.

In addition to input prices, the stochastic trend makes both a significant contribution to the explanation of the level of PIMF and to changes in PIMF over time. To illustrate this, we have re-estimated the model for PIMFg at levels rather than first differences. In the levels estimates the slope of the trend is the same as in the difference estimates and the coefficients are quite robust in both models. From the levels equation we thus feel confident that we can recover estimates of the level of the trend (which one cannot do from the estimates in differences). The resulting estimate is plotted alongside PIMFg in Figure 5. As can be seen the trend represents about 60% of PIMFg.

The time profile of the trend is upward, until 1985 after which it declines (at least until 1999). Given the contribution of the trend to explaining the level and also the time profile observed, we have explored whether it is possible to deconstruct the trend into more basic parts.

Figure 5: PIMFgross and trend (levels)



From equation (10) the trend is equal to **z(t)P(t)** where **P(t)** is the vector of input prices and **z(t)** is a vector of deviations of parameters from their average or base values. It was argued that **z(t)** will reflect technological change, reweighting of the series and also (demand independent) changes in mark ups in industries supplying manufacturing inputs. It is also possible that the trend would pick up omitted inputs but we considered that this effect would be included inter alia in the error term. It was argued that technological change and reweighting would tend to generate a declining trend whereas increases in mark ups would suggest an upward trend.

We have undertaken a number of experiments relating the estimated trend (or its difference) to a series of variables that might reflect these arguments. In particular we have regressed the trend either individually or in combination on:

(i) the wage share in the whole economy as a measure of average mark ups
(ii) the level and/or growth of GDP to reflect cyclical productivity effects
(iii) a simple time trend to reflect technological change
(iv) various input prices and PIMF itself reflecting equation (10)

however in no case were we able to further decompose the trend.

Overall we thus find that the two PIMF series are driven by a stochastic trend (contributing about 60% to the level) and a deterministic component largely driven by prices determined outside the UK. The long run elasticity estimates suggest that for PIMFn (PIMFg) the elasticity of material and intermediate input prices to the dollar price of oil and to UK duties on oil is 0.073 (0.031), to the dollar prices or raw materials or commodities is 0.092 (0.028), to the price of imported semi manufactures (in sterling) is 0.337 (0.179) and to the dollar sterling exchange rate is 0.502 (0.224).

The fact that the prime determinants of the deterministic component are externally determined implies that the prices of material and intermediate inputs in UK manufacturing are largely outside the control of government. This, allied with the relative importance of the stochastic drift component, implies that the possibility of forecasting movements in the series over time is very limited.

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 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. It is shown that the PIMF series exhibit considerable fluctuation over time, have a growth factor (net) between 1957 and 2000 of eleven in nominal terms but fall in real terms over the same period by about 50%. The analysis of the time series properties of the two series shows that PIMFn is stationary around a step mean, while PIMFg is stationary around a step mean and an underlying step trend with both series showing similar structural breaks (i.e. 1979-85, 1985-90, 1990-95, 1995-00).

It has been 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. Estimates of this model on monthly data between 1979 and 2000 illustrates the main drivers of PIMFn and PIMFg to be a stochastic trend, the prices of imported semi manufactured inputs, oil prices (including duties) and commodity prices, the latter three also reflecting exchange rates. In addition it was shown that the PIMFg was affected by lagged output prices. It has thus been found that the prime determinants of the deterministic component are externally determined, implying that the prices of material and intermediate inputs in UK manufacturing are largely outside the control of government. The stochastic trend (reflecting technological change in domestic sectors supplying MII to manufacturing, re-weighting of the PIMF series and changing mark ups) largely trended upwards until the middle of the 1990's (apart from a spell in the mid 1980s) after which it began to fall until 1999 (after which it moved upwards again). We were unable to decompose the trend further. The relative importance of the stochastic trend component allied with the external determination of the deterministic component, implies that the possibility of forecasting movements in the price of material and intermediate inputs over time is very limited.

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APPENDIX 1: DEFINITION, MEASUREMENT AND SOURCES OF VARIABLES

The PIMF series, PIMFn and PIMFg, 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

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

and for oil

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

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.

P3(t), the prices of domestically produced non service, non manufactured inputs.

These prices were from the ONS. Three series were tried, (a) the PPI for agriculture (BYEP) (b) RPI for fuel and light (CHBG) and (c) PIMF for agriculture (BYEA). The results above report the use of the first of these.

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.

P5(t), the price of domestically produced service inputs.

The Price Index for Services is generated using the implicit deflator(s) of real service VA (the ratio of Gross Value Added of Total Services at Constant Prices (GDQS) and Current (QTPZ) prices) available only in a seasonally adjusted form. This time series is unpublished and was provided by the ONS. However, there are some reservations on its validity and it is used only as no better indicator is available.

P7(t), the price of domestically produced manufactured inputs

This is measured by the net (PLLU) or gross (POKE) Producer Price Index for manufacturing as appropriate. While the former is available from MM22 the latter was provided by Paul Stoneman (1979-1990) based on data supplied earlier by the ONS and the ONS (1991-2000).

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. This price 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 (Whole Economy). Other series such as the Average Earnings Index GB: Manufacturing Industries (Industry:

15-37) and Average Earnings Index GB: Production Industries (Industry: 10-41) were also considered. However, their use does not significantly affect the results.

R(t), capital costs.

Here we define capital costs as the real interest rate times the price of capital goods. For the real interest rate we take the rate on twenty year treasury bonds (AJLX) and subtract the rate of growth of retail prices (RPI). 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.

APPENDIX 2: TIME SERIES ANALYSIS

In this appendix we discuss the time series properties of the variables used above, with particular emphasis upon PIMFn and PIMFg, over the period from January 1979– August 2000. Dealing with monthly data the time series properties of all variables have been established using ad hoc tests for the presence of stochastic versus deterministic seasonality and the order of non seasonal integration in order to achieve stationarity, I(d). They are:

a) the DHF (Dickey, Hasza and Fuller, 1984) and the Osborn (Osborn et al, 1988) to test for the presence of seasonal integration versus deterministic seasonality.

b) trend versus difference stationarity test (Nelson and Plosser 1982 and Dickey and Fuller 1981)[19].

c) the traditional Integration Durbin-Watson (Sargan and Bargawa, 1983), Dickey Fuller (1979) and Augmented Dickey Fuller (1981) test of unit roots deterministic components.

d) the Phillips and Perron (1988) test that relaxes some of the assumptions concerning the error process of the DF and ADF test, in that it has a greater power to reject the null of a unit root when unnecessary nuisance parameters are specified into the model.

e) the Perron (1989) test of 'additive outlier' for structural breaks

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[19] The testing procedure here used specifies a general model ($y_t = a + \beta t + \rho y_{t-1} + (\Sigma D_s) + e_t$) where the presence of a trend and a drift is investigated using the F statistics on the parameter restrictions so that:

- if $\beta=0$ and $\rho=1$ then y_t is a unit root, non stationary at levels but stationary at differences (Difference Stationary Process)
- if $\beta\neq0$ and $\rho<1$ then y_t is stationary at levels but with stationary deviations about the trend (Trend Stationary Process)

Other possibilities are that y_t is itself stationary without a trend ($\beta=0$ and $\rho<1$), or unit root with a quadratic trend ($\beta\neq0$ and $\rho=1$) or it might show an explosive process ($\beta=$. and $\rho>1$), however the latter is hardly observable in economic series. This means that if the hypothesis of joint parameter restriction (Ho: $\beta=0$ and $\rho=1$) is retained then one can reasonably assume that the series is a Difference Stationary (DS) process, i.e. unit root without a trend. If on the contrary, if the null cannot be retained, the alternative that the model is Trend Stationary (TS) must be accepted. Other intermediate cases can be tested looking at the test statistic on each individual restriction. Dickey and Fuller (1981) have provided the critical values of the joint hypothesis (F_test: Φ_3) as well as the tabulated values for the

f) generalized Perron test (1989) for structural breaks

The results for PIMFg and PIMFn are reported in Table A1

Table A1. Unit root tests of PIMFn and PIMFg (sample 1979:1-2000:8)

	test of seasonal integration			**Test of non-seasonal integration**			
	DHF	**Osborn**		**IDW**	**PP**	**DF**	**ADF [lags]**
					Intercept	*C+Seasonality*	*C+Seasonality*
PIMFn	t_z=-3.405	d_{zo}=-3.614		d=1.22	Z=-3.3023	$\tau_{ao,\gamma}$=-3.979	$\tau_{ao,\gamma}$[5]=-3.0428
PIMFg	t_z=-10.578	d_{zo} =-10.21		d=1.50	Z=-3.0324	$\tau_{ao,\gamma}$=-4.6058	$\tau_{ao,\gamma}$[15]=-2.382
5%[a]	[-1.83-1.73]				*(-2.8728)*	*(–2.873)*	*(-2.873)*

[a] Theoretical values of the tests are outsourced from: DHF: Charmeza and Deadman (1991); DHF Osborn: Osborn ( ); DF and ADF: PCGive 9.1; PP: Davidson and MacKinnon (1993).

The statistics in column one and two show that the hypothesis of a seasonally integrated process (i.e. $SI_{12}(0,1)$) is rejected for both the net and gross PIMF and seasonality can be modeled via dummy variables.

For the net PIMF all tests (b-d) reject the null hypothesis of a unit root implying that the net PIMF is stationary (random walk with drift). The DF and ADF test also indicate the presence of a drift and a deterministic seasonal component in the stationary data generating process. As can seen in Figure 1, the series graphically seems to show mean reversion with fluctuation around a long term mean.

For the gross version of PIMF the PP tests (with a structural break) and the DF test reject the null hypothesis of a unit root however the ADF does not reject this hypothesis. Perron (1989) shows that when there exist structural changes or when the underlying trend is non linear the ADF tends to wrongly accept the hypothesis of a unit root, as it will tend to overestimate the unit root coefficient in order to compensate for the random variations around different underlying permanent shifts in the slope or/and the drift in the series. To take account of these structural breaks in testing for unit roots, we use for the PIMFg a specification similar both to the ADF

individual hypothesis in the presence of a drift, trend and unit root (t-test: τ_j) based upon the and that proposed by Perron (see Perron (1989) test of ‘additive outlier’ for structural breaks). Furthermore , we extend the test also to the PIMFn series to investigate seasonality and whether the breaks affect also the net series.

The Perron (1989) test of ‘additive outlier’ (d), has been used to investigate stationarity in presence of various types of shocks. In fact, another problem arising when using the Dickey-Fuller type of tests is that in the presence of a structural break in an I(0) series, they tend to falsely accept the null of a unit root even when the process is stationary each side of the structural break point (Charmeza and Deadman, 1999). To overcome this type of problems, the order of integration of a variable is tested under the hypothesis of a non-stationary stochastic process subject to a single pulse intervention at a known date, t=b, versus a stationary process subject to the same shock with a permanent effect on the mean of the process. Formally the null hypothesis is that of a non stationary process with a pulse dummy (D_p=1 if t=b and D_p=0 otherwise), i.e. Ho: $\Delta y_t = \mu + \phi D_P + y_{t-1} + \varepsilon_t$, while the alternative is that of a stationary process with drift and step dummy ($D_S = 1$ if t ≥b and o otherwise), i.e. Ho: $\Delta y_t = \mu + \omega D_S + \varepsilon_t$. [20]

A more generalised test that incorporates (a) - (d) is the generalized Perron test for structural change where the integration order, the presence of step/level/pulse dummies, trend seasonality is tested simultaneously using the following specification:

$$\Delta y_t = a_1 + \lambda_1 \Sigma_i D_{Li} + \Sigma_i \mu_2 D_{Pi} + \Sigma_i \tau_i D_{Ti} + \phi y_{t-1} + \Sigma_i \beta_i \Delta y_{t-i} + \Sigma_i \gamma_i DS_i + \varepsilon_t$$

Level dummies:

$D_{L[ta, tb]} = 1$ if $t_a < t < t_b$ where $[t_a; t_b]$=[79:1; 84:12], [85:1; 89:12],[90:1,94:12] [95:1; 00:8]

$D_{L[ta, tb]} = 0$ otherwise

The pulse dummies:

$D_P(\tau) = 1$ if $t = \tau$ where τ =1985:1, 1990:1, 1995:1, 2000:1

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specification $\Delta y_t = a + \beta t + \rho y_{t-1} + (\Sigma D_s) + e_t$ with and without the augmented form.

[20] The testing procedure suggested by Perron to test the TS versus DS hypothesis, would first eliminate the step from the series by calculating the OLS residuals from $e_t = y_t - \hat{\mu} + \hat{\phi} D_P$. Then would test the stationarity of the residuals. In this way accepting the stationarity of the residuals one would accept the alternative hypothesis. If stationarity cannot be accepted then these residuals are used in the second step equation in order to test for the integration order of the series, i.e. $\Delta e_t = \delta D_P + \alpha e_{t-1} + \zeta_t$. The regression estimates of α significantly negative, lead to the rejection of the null hypothesis in favour of the alternative stationarity assumption (Ha: $\Delta y_t = \mu + \omega D_S + \varepsilon_t$). Tables of threshold critical values are reported in Perron (1989) for several proportions of observations up to the break up point over the total sample size.

D_P (τ)= 0 otherwise

The trend dummies:
$D_{T [ta, tb]}$ = t if t_a<t <t_b where [t_a; t_b]=[79:1; 84:12], [85:1; 89:12],[90:1,94:12] [95:1; 00:8]
$D_{T [ta, tb]}$ = 0 otherwise

The above incorporates the hypothesis of difference stationary versus trend stationary processes with impulse or step dummies (stationarity around a trend and/or with step variables and non stationarity with/without a trend and pulse variable). Moreover, given the non monthly non-seasonally adjusted nature of the data the equation has been specified including also a series of seasonal dummies SD_i=Σi SDi where i =January, February, etc.

The Phillips and Perron test for structural changes in PIMFnet and gross are reported in Table A2 and are discussed in the paper.

Table A2. Analysis for the presence of structural breaks

Variable	**PIMFg**			**PIMFn**		
	Coefficient	**t-value**	**t-prob**	**Coefficient**	**t-value**	**t-prob**
Constant	8.8866	4.942	0.0000	8.2502	4.453	0.0000
D_L						
D7985	**-3.9371**	-3.944	0.0001	**-2.5936**	-1.978	0.0492
D8590	**-4.1613**	-4.766	0.0000	**-4.5804**	-3.571	0.0004
D9095	**-2.7586**	-3.591	0.0004	**-3.9308**	-2.444	0.0154
D_T						
T7985	**0.025315**	3.330	0.0010	0.0231	1.702	0.0902
T8590	**0.023387**	5.091	0.0000	**0.0249**	2.733	0.0068
T9095	**0.011985**	3.223	0.0015	0.0143	1.682	0.0941
T9520	-0.0016509	-0.945	0.3460	-0.0069	-1.665	0.0974
PIMF_1	**-0.085844**	-4.943	0.0000	**-0.0643**	-4.328	0.0000
$\Sigma_i \beta_I \Delta PIMFn_{t-I}$	joint significance test-lag[11] F(11,199)=3.303 [0.0003]			joint significance test -lag[3] F(3,207)=5.8494[0.000]		
$\Sigma_i \gamma_i SD_{-I}$	Joint significance test F[11,211)=2.7749 (0.0330)			Joint significance test F(11,207)=5.3087 (0.0000)		
D_P						
D8501	**0.58543**	2.147	0.0330	**2.8578**	4.190	0.0000
D9001	-0.10249	-0.312	0.7553	0.0402	0.051	0.9593
D9501	0.63450	2.015	0.0452	1.0154	1.339	0.1820

NOTE: PIMFg: R^2 = 0.42 ; F(33,199)=4.402 [0.000]; σ=0.426 ; DW=2.01 RSS= 36.15; N=233 observations;
PIMFn: R^2 = 0.47; F(25,207)=7.246 [0.000] \ σ=1.054, DW = 2.00; RSS=229.82 N=233 observations;

In summary the analysis of the time series properties of the series has highlighted that PIMFn is stationary around a step mean, while PIMFg is stationary around a step mean and an underlying step trend with both series showing similar structural breaks (i.e. 1979-85, 1985-90, 1990-95, 1995-00).

In the analysis of the PIMF series the main variables of interest, aggregated in to eight categories of material and intermediate inputs (X_1 to X_8 with prices P_1 to P_8 respectively), are summarised in column 1 and 2 in Table A3 below.

The time series analysis has pointed out that the regressors, typical of price series, are difference stationary. The exception is imported semimanufacturers, which is borderline between a trend stationary and difference stationary process, the unit root being very close to one (ρ=0.99).

The seasonal dummies are significant for all the variables with the exception of the cost of imported minerals, agriculture RPI, the prices of imported semimanufactures, service prices and capital cost. Finally most of the variables, similar to PIMF, are stationary with structural breaks at the four critical points 1985; 1990;1995;2000.

Table A3: Analysis of the seasonal (s) and non-seasonal (d) integration order of the relevant variables

VARIABLE	DEFINITION	TIME SERIES PROPERTIES[1]
DEPENDENT VARIABLES		
PIMFg : Gross Price Index of Fuels and Mater ials		S(0;0) Trend Stationary Process
PIMFn : Net Price Index of Fuels and Materials		S(0;0) Stationary Process with drift
INDEPENDENT VARIABLES		
P1/P2 : domestically and overseas sourced raw materials[a]		
➢ Oil_ex_tax	World Price Index of crude petroleum net of VAT	S/I(1) Difference Stationary P[85:03]
➢ Comm_ex	World Price Index of Primary Commodities (excluding oil)	SI(1) Difference Stationary P[85:03]
➢ Miner_ex	World Price Index of Minerals (excluding oil)	I(1) Difference Stationa ry P[85:03]
P3: other non service intermediate inputs produced outside manufacturing at home		
➢ RPI f&m	Retail Price Index of fuels and materials	I(1) Difference Stationary with T and two pulse dummies P[94:03] & P[97: 08]
➢ PIMFagr	PIMF Agricultural Production	SI(1) Difference Stationary
➢ PPI agr.	Producer Price Index of agricultural products	SI(1) Difference Stationary no T
P4: other non service intermediate inputs produced outside manufacturing overseas		
➢ Semi M	Price index of imported Semi manufactures	I(1) and P[95:01] or TS and S[95:01]
P5: domestic service inputs		
➢ Service_P	Price Index of Total Services	I(1) Difference Stationary + weak D[86:01] No T
P6: imported service inputs		
➢ -	-	-
P7: domestic intermediate inputs produced within manufacturing		
➢ PPIoutput_net:	Producer Price Index of Net Industrial Output of manufacturing industries	SI(1) Difference Stationary No T
➢ PPIout_gr	Producer Price Index of Gross Industrial Output of manufacturing industries	SI(1)
P8: intermediate inputs produced within manufacturing overseas		
➢ Total /Final Manuf:	Price index of imported Total and Final Manufactures	-
W(t): Wage rates[b]		
➢ Average earnings	Average Earnings Index GB: whole economy	SI(1) Stationary. No T
R(t) : capital costs[c]		
➢ Capital cost	Cost of capital goods	I(1) Difference Stationary /inconclusive

NOTE: SI(d) indicates that deterministic seasonality is present and need to be modelled by seasonal dummies; I(d) means that the series does not present any seasonality ; 'd' is the order of integration required to obtain stationarity