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Special Article

in

**QUARTERLY
ECONOMIC
COMMENTARY**

March 1974

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ESTIMATED PRICE INCREASES DUE TO HIGHER COSTS OF PETROLEUM AND OTHER IMPORTS, AS CALCULATED FROM A 38-SECTOR 1968 INPUT-OUTPUT MODEL¹

By E. W. HENRY and S. SCOTT

In December 1973 the Arab Oil States declared their intention to raise the posted price of crude oil to over 350 per cent of its pre-October price. Assuming that operating costs, company profits, freight and insurance are unlikely to remain at their original levels per barrel, the average rise in the c.i.f. price which importing countries will now have to pay for crude petroleum is of the order of 200 per cent.

Our model is intended to estimate and analyse the effects of such a price rise on the prices of other goods in Ireland, and the overall effect on the cost of living and other categories of final demand. The framework is the 1968 input-output table with certain key sectors broken down in finer detail.

In the first part of this paper we outline the structure of the model and the data sources, then in turn we examine the separate applications of the model and the numerical results, the assumptions made and the validity of using 6-year-old data. What follows is to be read as a preliminary report and in no way finalised.

Structure of the model

The variables (using ordinary input-output notation) and symbols are defined as:

P : a row vector of prices

A : a matrix of direct domestic input coefficients

V : a row vector of aggregate primary input coefficients including both similar and complementary imports, indirect taxes, subsidies, wages/pensions/profits and depreciation. Each of these subdivisions can be expressed as a separate primary row e.g. V

wages

T : transpose.

The price model takes the usual form:

$$P^T = (I - A^T)^{-1} V^T$$

1. Thanks are due to the Central Statistics Office and the Departments of Transport & Power, and Industry & Commerce for assistance with data and queries.

Similar analyses of price increases resulting from the oil price rise can be found in:

1. "The Oil Situation" in Technical Annex of OECD Economic Outlook, December 1973, using Input-Output models for 1962, 1963 and 1965.
2. "Where Energy Costs Bite", A Hines, P. Momferratos and D. Simpson, in Financial Times, 17 January 1974, using U.K. 1969 Input-Output model.

If ΔV^T is the change in cost of V^T , then the change in the price vector is ΔP^T given by

$$\Delta P^T = (I - A^T)^{-1} \Delta V^T$$

The transpose of these equations gives:

$$P = V(I - A)^{-1}$$

and $\Delta P = \Delta V(I - A)^{-1}$

So by calculating $V(I - A)^{-1}$, which will be recognised as the direct and indirect primary contents, we can readily see the effect of any proportionate change in primary costs on prices. Price rises, for each item of primary input, are additive.

Data Sources

The 33-sector 1968 input-output table, which has imports separate, was enlarged by 5 sectors to give separate detail for oil refining and for transport broken down into 5 categories: road passenger transport, road freight, rail transport, air transport, and sea and water transport. The oil refining sector was extracted from the original sector (16) "other manufacturing", with the aid of OECD "Oil Statistics 1968" which gives the input of crude oil and output of all petroleum products and also via average import prices*. The transport sector was disaggregated mainly on a pro rata basis using the 1964 table breakdown for this sector. The 1968 disaggregated totals were already available, as also were disaggregated primary rows for imported crude petroleum, imported refined petroleum and petroleum tax.

Applications

The possible applications of the model fall into two categories: one which examines the results of factors occurring abroad and which are outside Ireland's control and the other which examines results of factors occurring inside Ireland. In the first category we have the rise in the price of imported crude petroleum, imported refined petroleum and petroleum products, other fuel, and finally all other imports in general. The second category includes the effects of possible changes in petrol taxes and profit margins and of wage rises that might result from cost of living rises. In this paper we concentrate on the first category.

Effects of Price Rise of Imported Crude Petroleum and Refined Petroleum

Calculations of the changes in sectoral prices resulting from a crude petroleum price rise were made using:

$$P = V \quad (I - A)^{-1}$$

crude petroleum

*"External Trade Statistics 1969", Central Statistics Office, Dublin.

TABLE 1: Breakdown of rises in producers' prices attributable to 100% increase in c.i.f. price of imported crude petroleum.

Sectors	Effect of 100% increase in c.i.f. import price of crude petroleum	Effects of consequent 81.9% rise in price of imported refined petroleum			TOTAL effects
	% increase (1)	Via imported refined petroleum Similar % increase (2)	Via imported refined petroleum Complementary % increase (3)	Via imported refined petroleum Invisible % increase (4)	
1. Agricultural livestock	0.488	0.220	0.047	0.002	0.758
2. Agricultural crops (except peat)	1.009	0.627	0.229	0.003	1.868
3. Forestry	1.345	1.078	0.017	0.001	2.442
4. Fishing	4.502	2.982	0.044	0.002	7.530
5. Solid fuel	0.903	0.552	0.143	0.005	1.603
6. Stone/ores/gravel	0.802	0.514	0.016	0.008	1.340
7. Food	0.753	0.410	0.055	0.006	1.224
8. Drink/tobacco	0.687	0.382	0.031	0.010	1.109
9. Textiles (except hosiery)	0.628	0.375	0.119	0.007	1.128
10. Clothing/hosiery etc.	0.365	0.197	0.061	0.006	0.629
11. Wood/furniture	0.469	0.255	0.016	0.006	0.745
12. Paper/printing	0.712	0.415	0.016	0.008	1.152
13. Chemicals	0.376	0.181	0.154	0.010	0.720
14. Clay/cement/pottery	2.491	1.737	0.032	0.008	4.269
15. Metal/engineering/vehicles	0.267	0.196	0.008	0.005	0.476
16. Other manufacturing (excluding petrol refining)	0.367	0.194	0.012	0.007	0.579
17. New construction	0.585	0.423	0.012	0.005	1.024
18. Repair construction	0.646	0.449	0.013	0.004	1.112
19. Electricity/gas/water	4.634	2.784	0.061	0.004	7.483
20. Trade margin	1.011	0.567	0.017	0.009	1.605
21. Road passenger transport	1.174	0.681	0.015	0.004	1.874
22. Banking/insurance	0.121	0.068	0.007	0.013	0.209
23. Other financial	0.214	0.117	0.007	0.004	0.342
24. Communications	0.263	0.159	0.031	0.028	0.481
25. Medical services, private	0.163	0.935	0.010	0.002	1.109
26. Education	0.000	0.000	0.000	0.000	0.000
27. Rent of dwellings	0.055	0.036	0.003	0.001	0.094
28. Personal services	0.756	0.466	0.010	0.002	1.234
29. Hotel/catering	1.738	0.829	0.025	0.007	2.600
30. Sport	1.058	0.522	0.016	0.004	1.599
31. Domestic service/handicrafts	0.000	0.000	0.000	0.000	0.000
32. Government services	0.403	0.285	0.023	0.015	0.727
33. Artificial sectors n.e.s.	0.936	0.299	0.047	0.039	1.321
34. Road freight	1.677	0.982	0.022	0.004	2.684
35. Rail transport	1.324	0.778	0.019	0.005	2.126
36. Air transport	0.076	0.041	2.163	2.162	4.443
37. Sea/water transport	0.732	0.430	0.581	1.497	2.582
38. Petrol refining	81.904	0.247	0.723	0.000	82.874

Note: This table can be used to calculate the results of any percentage rise in the c.i.f. import price of crude petroleum by *pro rata* multiplication. See text.

If the crude petroleum c.i.f. import price rises by 200 per cent then the percentage change in sectoral prices is $200 \sqrt{I-A}^{-1}$. Results for 100 per cent price rise in imported crude petroleum are given in Table 1. If one is interested in the result of a 150 per cent or 300 per cent price rise, the figures in Table 1 require multiplication by 1.5 or 3 respectively. It will be noted that the price of petrol refining is increased by 82 per cent (sector 38, column 1). We presume that this is also the price rise of refined petroleum imported into Ireland on the assumption that a rise in price of crude petroleum affects refineries equally.¹ This is applied to the imports of similar and complementary refined petroleum and to invisible imports of refined petroleum (bought by ships and planes abroad). The breakdown of results obtained from applying the 82 per cent rise in the price of imported refined petroleum is given in columns 2, 3 and 4 of Table 1, and the total effect of imported petroleum price rises, be they imports of crude or refined, is given in the final column. It must be remembered that these percentages are expressed in producers' prices which exclude distribution costs of the final product. A 100 per cent crude petroleum price rise affects fishing, and electricity/gas/water to the extent of 4.5 per cent and 4.6 per cent; this also indicates that they bought a large proportion of their fuel from the domestic oil refining sector. The total price rise of these two sectors is of the order of 7.5 per cent. Next in line are air transport, clay/cement/pottery and sea/water transport with 4.4 per cent, 4.3 per cent and 3.2 per cent respectively. Between 2 per cent and 3 per cent rises are found in the forestry, hotel/catering, road freight, and rail transport sectors. Rises in the ranges 1 per cent to 2 per cent are found in the sectors road passenger transport, agricultural crops, trade margin, solid fuel, sport, stone/ores/gravel, artificial sectors n.e.s., personal services, food, paper/printing, textiles, repair construction, drink/tobacco, medical services private, and new construction. Thirteen sectors show price rises below 1 per cent.

These detailed results of a 100 per cent rise in the c.i.f. import price of crude petroleum need to be summarised to give their effects on the cost of living. This is shown in Table 2, along with rises in other categories of final expenditure. The cost of living is calculated to rise by 1.55 per cent, exports are expected to have a higher price rise of 2.31 per cent. The cost of government net current expenditure and gross fixed capital formation both rise by less than 1 per cent. As mentioned above these results can be scaled to any percentage rise in the c.i.f. import price of crude petroleum.

Actual Short Term Effects

So far in our calculations we have taken into account the effects of oil price rises in isolation. The import price of coal and other solid fuel is estimated to rise during the six months from September 1973 by approximately 50 per cent, the price of non-fuel imports by up to 8 per cent.¹ The sectoral results for these calculations show one sector, other manufacturing excluding oil refining, with a price rise

1. This assumption is discussed in a later section.

TABLE 2: Percentage Increases in Prices of Expenditure on Final Demand Resulting from 100 per cent Rise in Price of Imported Crude Petroleum and Consequent 81.9 per cent Rise in Price of all Refined Petroleum.

Source of Price Rise	Personal Expenditure	Exports excluding Tourism	Government Net Current Expenditure	Gross Fixed Capital Formation
<i>Via Productive Sectors</i>				
Imported Crude Petroleum	0.978	1.563	0.327	0.420
Imported Refined Petroleum:				
Similar	0.347	0.328	0.229	0.299
Complementary	0.035	0.187	0.016	0.019
Invisible	0.009	0.163	0.010	0.029
<i>Direct to Final Demand</i>				
Imported Refined Petroleum:				
Similar	0.103	0.069	0.000	0.000
Complementary	0.080	0.000	0.000	0.000
Total Price Rise	1.552	2.310	0.582	0.767

Note: See Table 1 note.

of 5 per cent. Metal/engineering/vehicles and chemicals show rises of 4.4 per cent and 4 per cent. Air transport, clothing/hosiery, textiles and wood/furniture rise between 3 per cent and 4 per cent. Rises of between 2 per cent and 3 per cent appear for drink/tobacco, paper/printing, and new construction. The remainder are under 2 per cent.

The effects of these price increases on the cost of living and other final expenditure can be seen from Table 3.

TABLE 3: Percentage Increases in Prices of Expenditure on Final Demand Resulting from 50 per cent Increase in Price of Imported Solid Fuel (such as Coal) and 8 per cent Increase in Price of Other Imports.

Source of Price Rise	Personal Expenditure	Exports excluding Tourism	Government Net Current Expenditure	Gross Fixed Capital Formation
<i>Via Productive Sectors:</i>				
Solid Fuel Imports	0.051	0.030	0.055	0.021
Other Imports	1.076	2.559	0.677	1.745
<i>Direct to F.D.:</i>				
Solid Fuel Imports	0.321	0.003	0.000	0.000
Other Imports	0.873	0.229	0.062	1.933
<i>Total:</i>				
Solid Fuel Imports	0.372	0.033	0.055	0.021
Other Imports	1.949	2.788	0.739	3.678
Total Price Rise	2.321	2.821	0.794	3.699

1. Estimates used in Quarterly Economic Commentary, March, 1974.

We have also tried to isolate the price rises from Other Imports which are attributable to oil prices in the exporting country. This could only be an incomplete analysis, undertaken on the assumption that imported goods are equally oil intensive as their domestic near-equivalents. This is a somewhat unjustified super-imposition of Irish technology on foreign countries and could only be avoided by the use of simultaneous calculations using input-output tables of Ireland's trading partners: an exercise possible in the foreseeable future when EEC tables compatible with one another have been produced. In our experiment we find that Other Imports' price rises attributable to oil costs are of the order of 1 per cent per 100 per cent increase in c.i.f. price of crude oil.

We can summarise the total effects considered so far. Assuming the c.i.f. price of imported crude oil is increased by 200 per cent, with 164 per cent for refined oil, we combine these with the rise in price for solid fuel imports and the oil-induced price rise of other imports. These are shown in the first row of Table 4 and can be compared with rises caused by other (non-fuel) imports, excluding effects of their oil content. The assumptions used in calculating Table 4 results are listed below the table. The bottom row of Table 4 is in fact twice that of Table 2 plus once that of Table 3.

TABLE 4: Likely Percentage Increases in Prices of Expenditure on Final Demand, Due to Increased Costs of Imports

Source of Price Rises	Personal Expenditure	Exports excluding Tourism	Government Net Current Expenditure	Gross Fixed Capital Formation
Fuel Imports (including all Oil effects)	3.964	5.350	1.403	2.475
Other Imports (excluding Oil effects)	1.462	2.091	0.554	2.759
Total Price Rise due to Increased Costs of Imports	5.426	7.441	1.957	5.234

Assumptions for Table 4: Price Rise of 200 per cent for Imported Crude Oil
 164 per cent for Imported Refined Oil
 50 per cent for Imported Solid Fuel
 2 per cent for Other Imports, due to their Oil Content
 6 per cent for Other Imports, excluding effects of their oil content.

(Thus Other Imports have an assumed price rise of 8 per cent in full).

These figures throw light on the scale of likely price rises and the magnitude of the effects of the oil crisis. Only Gross Fixed Capital Formation is affected less by the oil crisis than by Other (Non-Fuel) Imports. The oil or fuel effects are most marked in Exports, whose overall price is estimated to rise by about $7\frac{1}{2}$ per cent, and then in Personal Expenditure, where the cost of living rises by about $5\frac{1}{2}$ per cent in

all. This then summarises the effects of those price rises which are outside Ireland's control.

We have not yet undertaken calculations to analyse those actions which can be taken or may occur within Ireland in response to the price rises given above. We do however give a breakdown of petroleum tax in Tables 5 and 6. In order to minimise the price-inflating and demand-depressing effects of the oil price rises, the government might wish to reduce the petroleum tax. Alternatively it might increase the petroleum tax if the government's priority were to try to decrease imports of petroleum. At the 1968 rates the direct and indirect effects of this tax were as follows for the sectors most affected:

TABLE 5: Direct and Indirect Petroleum Tax as % of Producers' Price

<i>Sectors</i>	<i>% of Producers' Price</i>
Road freight	9.7
Road passenger	7.2
Sport	4.8
Artificial sectors n.e.s.	4.3
Trade margin	2.3
Stone/ores/gravel	2.2
Clay/cement/pottery, food/agricultural crops	1.7
Drink/tobacco	1.5
Solid fuel, repair construction, agricultural livestock	1.4
New construction, chemicals	1.3
Paper/printing	1.2

Total petroleum tax gathered in 1968 was £36.865m. Since then the rate of taxation has increased by a small amount. The revenue for 1972 was £53.843m. The breakdown of petroleum tax as proportions of final expenditure categories and the proportions of petroleum tax gathered from each category were as follows:

TABLE 6: Direct plus Indirect Payment of Petroleum Tax in 1968 for each Category of Final Demand

	Personal Expenditure	Exports	Government Expenditure	G.F. Cap. Formation	Stocks+ Surpl./Def.	Total
As percent of Expenditure on each Final Demand	2.91	1.37	0.73	0.90	-3.52	1.94
As percent of Petroleum Tax gathered	76.15	15.32	3.33	6.15	-0.95	100

Validity of the Data

The 1968 input-output table is now 6 years out of date and one may well question the validity of using it to obtain information concerning a product which

has been enjoying rapid growth. In 1968 imports of petroleum and petroleum products were valued at £32m., and at £53m. in 1972. However in the context of our exercise we are mainly concerned that the imports of petroleum and petroleum products, (which are a category in the primary inputs) should be a stable proportion of total primary inputs, that is, of G.N.P. plus imports.

The following Table 7 sets out the money values of Gross Imports of petroleum and petroleum products as a percentage of GNP at market prices. Imports less domestic exports are also given. It was not possible to give net imports as no figures for re-exports are obtainable after 1970. As they stand the figures do not indicate that 1968 would be a misrepresentation of the present situation — this comment to be understood to apply exclusively to imports of petroleum products.

TABLE 7: Imports of Petroleum as a Percentage of GNP at Market Prices

Year	(1) Gross Imports of Petroleum and Petroleum Products	(2) Col. (1) less Domestic Exports
1967	2.55	2.09
1968	2.48	2.29
1969	2.39	2.14
1970	2.58	2.33
1971	3.08	2.85
1972	2.38	2.24
1973	2.62*	Not available

Source: National Income and Expenditure, and Trade Statistics of Ireland

*Estimated GNP. Imports available for 6 months only.

We have also investigated whether these percentages calculated in money terms conceal a disproportionate shift in quantity terms. The most recent year for which we have adequate information is 1972. Real changes are illustrated in Table 8.

TABLE 8: Real changes in GNP and imports of petroleum, 1968 and 1972

	1968	1972	% change
GNP at Constant Prices 1968=100	100	115.9	15.9
Imports Crude Petroleum	2.259 m.m.t.	2.410 m.m.t.	6.7
Imports all Finished Petroleum Products	1.481 m.m.t.	2.977 m.m.t.	101.0

Source: National Income and Expenditure, OECD Annual Oil Statistics
m.m.t.: million metric tons.

Here we find real increases in imports which are definitely out of line with the real growth in GNP. We need not concern ourselves that the growth in imports of

crude petroleum is out of line with the growth of imports of all finished petroleum products. This is because the model takes the price rise of crude petroleum to obtain the price rise of refined petroleum, which is then applied as the price rise for imported refined petroleum. So, our results are not affected by varying the proportions of imports between crude and refined petroleum. However, the discrepancy between the growth of these imports and the growth of GNP is large. We need to estimate some overall figure combining the two categories of imported petroleum. This is achieved by scaling down the crude petroleum by the amount of refined petroleum obtained from crude petroleum, namely 97 per cent.* We can now express the imports in refined equivalents which give:

	1968	1972	% Change
Imports All Petroleum (refined equivalent)	3.672 m.m.t.	5.315 m.m.t.	44.7

The real growth is of the order of 45 per cent compared with real GNP growth of 16 per cent. The price of imported petroleum and petroleum products has risen slowly relative to the prices of goods and services produced in Ireland, so that the 1968 input-output table under-estimates the 1972 quantity of these imports relative to other goods and services. But, since our model traces the effects of price increases which are expressed as proportions of money flows, these real discrepancies do not affect the results. What is important in a price analysis is that the money

TABLE 9: Breakdown of Total Quantities of Petroleum Products Supplied in Ireland in 1968 and 1972: Per Cent

	1968	1972
Fuel oil	46.8	51.9
Gas diesel	18.7	18.2
Motor gasoline	14.4	13.4
Aviation gasoline	0.3	0.04
Aviation kerosene (jet)	6.6	6.1
Kerosene (paraffin)	2.3	1.5
L.P.G.	1.5	1.5
Naphtha	1.1	1.0
White spirit, SBP	0.1	0.1
Lubricants	1.0	0.8
Bitumen	1.9	0.1
Paraffin waxes	0.1	0.1
Other	5.2	5.3
Total Finished Petroleum Products	100.0	100.0

Source: OECD Annual Oil Statistics.

*1968, 1972 Refinery input: 2.27 and 2.69 m.m.t. resp. Refinery output 2.20 and 2.62 m.m.t. resp.

flows in the 1968 table should be representative, and we have some indication (Table 7) that they are.

A further concern is that the relative breakdown of different types of oil products used might have altered since 1968. Any major alteration might affect the technology matrix. The percentage breakdown of total quantities supplied is shown in Table 9.

Fuel Oil has increased its relative share but the overall pattern appears to have remained fairly stable. There is however a relative increase in the quantity of imported Finished Petroleum Products over those produced domestically, as shown by the percentage breakdown:

	1968	1972
Domestic Finished Petroleum Products	59.8	46.8
Imported Finished Petroleum Products	40.2	53.2
Total Finished Petroleum Products	100.0	100.0

As mentioned earlier however, in tracing through the effects of price increases, the model uses the same price rise for refined or finished products be they of domestic or foreign origin i.e. 82 per cent for all refined finished products per 100 per cent in cost of imported crude.

It now remains to give a reasonable justification for this approach of drawing no distinction, price-wise, between home and foreign produce. We have been informed by C.S.O. that their method of pricing domestic refined output for inclusion in the annual Census of Industrial Production is, apart from minor adjustments, to apply average import prices to the quantities produced domestically. We feel justified then in using the same price.

Meanwhile other assumptions made in our model must be clearly spelt out. Input-output analysis is the ideal approach insofar as technologies are fairly rigid and the price elasticity of demand for petroleum products may be low¹ (in the short-run), and as petroleum products are inputs to many sectors. Certainly for fuel as a whole, the short-run price elasticity would be low. However, inherent in this approach is another assumption, that only the absolute increase in unit costs is passed on in the form of higher prices. This and the assumption of rigid technology work in opposite direction to each other, to our benefit. But if the actual effects of economisation in the use of fuel by firms are stronger than the effects of firms' maintaining or increasing their margins, then our results overestimate the actual price rises, and vice versa. Also, as stated above, we have not here included the effects of

1. Taking account of the effects of 'demand pull' on prices is thus ruled out.

higher wages etc., resulting from the rise in the cost of living. Our main reason for this exclusion is that at this present moment we do not have usable results available.

Finally, it must be remembered that although our analysis does give sectoral breakdown, it does not give petroleum products broken down in detail. Neither does it take into account such individual considerations as the quantities and prices of petroleum bought on the 'spot' market, as it is not known how far this price will fall from the high December level. So it is important to emphasise that our figures (or, indeed, any other such calculation) give a general idea of the scale of price rises, for certain assumptions, and no more. The authors hope to investigate some of these aspects, including that of possible salary increases, within the near future.