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An Australian fuel substitution tax model: ORANI-LFT

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1. INTRODUCTION

Over the past ten years, the revenue collected by Australia's Commonwealth government from excises and royalties on liquid fuels has increased substantially. These revenues have risen from around six per cent of total taxation in 1975-76 to nearly 12.5 per cent in 1985-86, and from 43.6 per cent of total excise revenue to 76 per cent over the same period (Figure 1).

The proportion of liquid fuels excise and royalties raised from each of crude oil and petroleum products has also varied considerably, and changed particularly dramatically during 1986-87 (Figure 2). These changes have been induced variously by movements in volumes produced and demanded and by policy decisions affecting import parity prices and tax rates. For example, it is clear from Figure 3 that the dramatic fall in crude oil revenue can be associated with falls in all three of the import parity price, the crude oil levy rate, and the production of indigenous crude. But in Figure 4, the corresponding substantial increase in products revenue is most closely aligned with an increased excise rate.

A major general purpose of this paper is therefore to identify the principal aggregate and structural impacts which result from a substantial switch to petroleum products excise revenue from crude oil levy revenue. Industrial sector interfuel substitution effects are explicitly allowed for, under conditions of no net change in nominal or real liquid fuel tax receipts[1]. Specific account is also taken of two important strands of the Australian government's pre-1988 oil regulatory framework, namely the import parity pricing (IPP) and domestic allocation systems[2] for crude oil.

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1/ Sensitivity of the major results to different wage indexation and a wider range of macroeconomic assumptions can be reported at a later date, once further software is available. A preliminary idea of the degree of sensitivity can be obtained from work in a non-interfuel substitution context by Dixon (1985) and the Industries Assistance Commission (1986), summarised briefly in section 2 of Hall, Truong and Nguyen (1987).

2/ Broadly, the domestic allocation scheme guaranteed domestic producers a market for their production, and required each refiner/marketer to take up an allocation of indigenous

A two-stage methodological approach is adopted, due to the complex nature of Australia's oil and petroleum products markets. The first stage, set out in section 2, is partial equilibrium in nature, and involves singling out the most significant supply, demand and price features for a stylised single oil market. This information is then used in two dimensional diagrams to get some feel for broad price, quantity and tax revenue directions of movement. The second stage involves the use of a short run general equilibrium (SRGE) model, ORANI-LFT, to obtain illustrative numerical magnitudes.

ORANI-LFT (Liquid Fuel Tax) and its mode of use is described in sections 3 and 4. It consists of three modules. The major module is the standard framework of the ORANI multisectoral model of the Australian economy (Dixon et al. 1982). This has recently been extended by Truong (1986) for short run energy applications, with his ORANI-FUEL model having been used to examine the relative strengths of income and fuel substitution effects on industry output. The third module, LFT, when added to ORANI-FUEL, becomes ORANI-LFT and can be used to simulate tax experiments.

This paper therefore takes SRGE applications in the energy area for Australia a stage further, by developing an analytical tool capable of tackling a range of issues related to liquid fuel tax revenues.

For our revenue switching experiment referred to above, the particular catalyst assumed is a ten per cent fall in the world price of crude oil. The specific set of questions chosen to be addressed are:

- What are the petroleum products excise rate increases required to achieve nominal or real liquid fuel tax revenue neutrality?
- What is the extent of the petroleum products price change, net of the IPP fall and the excise rate increase?
- What are the net comparative static macroeconomic effects on such variables as the ORANI CPI, aggregate employment and the balance of trade?
- What are the net structural effects on industry output and employment?
- To what extent is there substitution from use of other fuels to petroleum products?

Illustrative empirical results corresponding to these five questions are described in section 5. Concluding remarks are set out in section 6.

2. A STYLISED MARKET FOR CRUDE OIL

As the liquid fuel issues being addressed are empirically complex, and the structural detail inherent in ORANI is considerable, an initial appreciation of the key institutional and microfoundation elements is best obtained from a stylised model of the market for crude oil.

Dealing first with oil market volumes, the domestic demand for crude comes primarily from the oil refining industry, and there are three basic avenues for supply: through the domestic partial allocation scheme, the domestic free market, and net imports. The partial allocation scheme has been the dominant source of supply in recent years[3], and therefore provides the

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crude oil in proportion to their market shares of sales of certain refined products (DRE, 1985, 1987).

3/ For example, for the first half of 1985, the domestic free market and net imports were forecast by the DRE (1985, pp. 10-11) to provide only 15000 barrels per day (15 kbd) and 25 kbd respectively, while the partial allocation scheme was to provide 413 kbd. Bass Strait was to provide 350 kbd, and small producers such as those in the Cooper Basin, Barrow Island

Commonwealth government with most of its crude oil levy revenue[4]. Domestic refineries are the primary source of supply of petroleum products which are demanded in substantial quantities by both the industrial (including transportation) and household sectors.

Key features of the crude oil levy, the petroleum products excise and their respective revenue collections are that:

- crude oil levy is imposed primarily on indigenous oil produced under the domestic allocation scheme, and at a rebated amount on free market production. A summary aggregate levy rate (in $/barrel) can be calculated as in Figure 3, from multiplying the marginal percentage levy rates (weighted by relevant volume category) by the IPP (in $/barrel). Crude oil levy revenue can therefore be approximated by the aggregate levy rate times domestic partial allocation and free market production[5].

- petroleum products excise is levied on the domestic demand for products supplied from both domestic and overseas refineries. Rates vary by type of product, but if one assumes an average rate (in cents/litre) for all industries and the household sector, then this tax revenue can be regarded as the average tax rate times volume demanded.

For the SRGE analysis, it will be necessary to take into account key differences between the crude oil and petroleum products markets, but dealing with a single oil market is sufficiently satisfactory for a stylised treatment.

One form of such analysis has recently been presented by Piggott, Veale and Stevens (1987). They have demonstrated (see Figure 5) that, under conditions of no change in the crude oil levy rate, imposition of the levy solely on 'old' (constant short run marginal cost of production) oil, liquid fuel tax revenue neutrality, and an inelastic price elasticity of demand for oil, a fall in the world price of oil would lead to:

- an increase in the petroleum products excise rate, the magnitude of which would lead to a new price (W") still less than the price prior to the world price fall (W);

- an increased demand for oil at the new lower price which has to be met from a combination of higher cost 'new' oil and from imports;

- lower profits for the producers (due to the lower price received, the unchanged crude oil levy rate, and relatively unchanged production costs) and gains to the consumer (from the price fall being greater than the petroleum products excise increase).

But for the purposes of our specific experiments, a somewhat more complex stylised representation is required. So, in Figure 6, allowance is additionally made for the levy to be imposed on both old and new oil, and for both domestic allocation scheme and free market production, under conditions of an initially constant and then a continuously rising short run marginal cost curve(MC). That part of the MC curve from P to R represents the marginal cost of extraction from the large old oil fields, while the later segment from R onwards represents

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and Queensland were to provide the other 63 kbd. Corresponding figures for 1987-88 are available in DRE(1987, pp. 45-46).

4/ Of significance here also has been the influence since 1 July 1985 of various forms of rebate of excise payable on free market sales (mainly exports), where prices realised were below the current IPP (1986-87 Budget Paper No. 1, p. 319).

5/ In 1985-86, the Commonwealth's excise 'take' from crude oil was equivalent to about 56 per cent of the average Bass Strait IPP of A$37.86 per barrel. This price refers to domestically produced, excisable 'old' and 'new' crude oil sold under allocation arrangements. Until recently, the marginal excise rate varied from a high of 87% for old oil (discovered before 18 September 1975) with an annual production level exceeding 600 megalitres, to a low of 35% for new oil with the same production level (1986-87 Budget Paper No.1, p.319).

marginal costs for the new mostly smaller fields. Oil from the old fields (e.g. the volume PQ) can be sold to the domestic free market or exported only after domestic allocation scheme requirements have been satisfied.

In the absence of any crude oil levy, the domestic supply curve for oil is therefore represented in Figure 6 by MC. But with an assumed IPP of P_0 and a crude oil levy schedule applicable solely to domestic allocation production, the *post-levy* domestic supply curve is PQABS. The distance BG represents the volume of imports necessary to satisfy the demand for both light and heavy crudes not able to be produced locally.[6] Total domestic demand for both light and heavy crudes is represented by D'D. The area QABSR reflects crude oil levy revenue obtained at price P_0, with PP_0AQ showing the supernormal profits associated with production for the free market.

The remaining three key aspects of our revenue switching experiment which need to be explained in terms of Figure 6, relate to the tax revenue and other implications of imposing IPP for crude, IPP for petroleum products, and liquid fuel tax revenue neutrality. These implications are as follows:

. *Import-parity pricing for crude*: if the domestic import parity price for crude were to be cut from P_o to P_1, this would result in a loss of crude oil excise revenue. The loss can be described by the area ABLK if the domestic allocation volume were to remain unchanged, and free market production were to continue untaxed.

. *Import-parity pricing for petroleum products*: to recover the loss in crude oil excise revenue, suppose the government were to increase the average excise rate on petroleum products. Although petroleum product is not represented explicitly in Figure 6, the effect of a petroleum product excise increase can be represented by an equivalent increase in the price of crude from P_1 to, say, P_2. If imports of petroleum product of FH are allowed, then it makes sense to assume also that the government wants to maintain import-parity price for petroleum products as well as for crude.[7] Total petroleum products tax revenue raised would then be the area P_1P_2HJ.

. *Liquid fuel tax revenue neutrality*: The relationship between the fall in crude oil excise and the increase in petroleum product excise will be determined by some form of tax revenue neutrality constraint. For example, in terms of Figure 6 the loss in crude oil excise would be completely recovered if the areas KABL and P_1P_2HJ were equal, i.e. (P_1P_2EK + LFHJ) were equal to EABF.

But in more complex partial equilibrium and in general equilibrium analyses, whether P_2 ends up above or below P_0 will depend on the cost structures in particular industries and the tax incidence on those industries and the household sector. To explore this latter issue more thoroughly, it is necessary to turn to the suitably modified applied general equilibrium model explained and illustrated in the next three sections.

6/ Net imports of crude oil have tended to be smaller still, as at times in recent years Australia has exported significant volumes of light crude.

7/ This implies that import duties may have to be levied on imported petroleum product to maintain the import-parity for the *basic* (i.e. before markups) price of petroleum product. To simplify the experiment, however, we assume that the government achieves this by varying the sales tax on imported petroleum product (See Section 4 below).

3. THE FUEL SUBSTITUTION TAX MODEL: ORANI-LFT.

ORANI-LFT consists of three distinct modules. These are:

- the currently available standard version of ORANI, documented in detail in Dixon, Parmenter, Sutton and Vincent (1982) (hereafter DPSV), and presented in schematic outline form in Parmenter and Meagher (1985).

- an industrial sector interfuel substitution module, which together with standard ORANI comprises the model ORANI-FUEL, presented in Truong (1986).

- the 'Liquid-Fuel Taxation' module, LFT, which when considered with ORANI-FUEL, is termed ORANI-LFT.

As the standard ORANI and ORANI-FUEL models have been fully described elsewhere, it is necessary to set down below only the elements and equations of LFT, and those key features of ORANI and ORANI-FUEL considered especially relevant to our experiments. The latter include the following:

- The *basic* price of domestically produced output of good i depends on the cost of all goods used (whether domestic or foreign in origin), the cost of aggregate labour, capital and agricultural land inputs, 'other cost tickets' (including taxes on production such as the crude oil levy), various forms of technical change and relevant cost share variables. The basic price therefore excludes sales taxes and margin costs, and does not vary across industries. DPSV (pp.108-111, including equations (18.2) and (18.3)) provides further details.

- The *purchaser's* prices (see DPSV, pp.115-117, including equations (18.18) and (18.19)) paid by the domestic industrial and household sector users of good i depend on the relevant basic price, sales taxes (such as the petroleum products excise), costs of 'margin' services (such as transportation costs, wholesale and retail margins), and share variables. These prices can therefore vary across users.

- Per unit *tax rates* on production and sales are in turn expressed (see DPSV, p.116, equation (18.20) and equations (5), (6) and (7) below) in terms of an ORANI consumer price index (CPI) influence, and a real ad valorem or real specific tax rate. This enables *tax revenue* to reflect indexation, real tax rate, and volume of output or sales effects.

- The three-tier *production structure* (DPSV, ss.11-12), while allowing for imperfect substitution at the third level between labour skill categories, and at the second level between domestic and imported material inputs and between aggregate labour, capital and agricultural land, assumes at the first level that the n material inputs, the aggregate primary factor, and other cost tickets are combined in Leontief fixed proportions. This standard framework therefore doesn't allow for substitution between individual material (including energy) inputs nor between aggregate energy and other aggregate factor inputs. Consequently, it does not allow for any change in relative prices of energy inputs to affect input demands through the interfuel substitution process nor to affect industry outputs through long run interfactor substitution processes.

- In ORANI-FUEL, allowance is made for *interfuel* (but not interfactor) *substitution* influences, by introducing non-Leontief technology for a separate energy inputs block. This is done, as set down briefly in Appendix A, by taking the relevant Leontief expression with its technological coefficient, $a^{(1)}_{ij}$, equating it with a Theil(1980) cost minimised input demand equation, and finding $a^{(1)}_{ij}$ to be a function of individual fuel price and share variables, own price and cross price elasticity of demand parameters, total energy demand in industry j and its elasticity of demand parameter.

The LFT module consists essentially of a liquid fuel tax revenue constraint allowing the model to be run in either nominal or real revenue neutrality form, although it also needs to be seen in conjunction with the IPP constraints and the single tax rate constraint explained in section 4.

For LFT itself, then, first let:

TAX_1 = the government's revenue from crude oil excise.
TAX_2 = the government's revenue from petroleum product excise borne by industries.
TAX_3 = the government's revenue from petroleum product excise borne by households.[8]

$S_i = TAX_i / (\Sigma_i TAX_i)$
= the share of tax revenue type i (i=1,2,3) in total tax revenue.

tax_i = percentage change in TAX_i.

The principle of liquid fuel tax revenue neutrality implies:

$$\Sigma S_i . tax_i = \delta . \xi(3) \qquad (1)$$

where:

$\xi(3)$ = percentage change in ORANI CPI,
δ = 0 if tax revenue is to be neutral in nominal terms,
= 1 if tax revenue is to be neutral in real terms.

Using standard ORANI notation[9] the three tax revenue components can be expressed as:

8/ The shares of these taxes vary considerably from year to year. As a result, it is important to note the specific values of these shares in the year of the standard ORANI data base used by this experiment, that is 1977-78. In this year (see Blampied, 1985) we have sales tax revenue on 'oil, gas, and brown coal' = \$449.250m, and production tax revenue on 'oil, gas, and brown coal' = \$115.868m. Since 'oil' is used as input into the 'petroleum and coal products'industry(56), 'gas' is used as input into the 'gas' industry(85), and brown coal is used as an input into the 'electricity' industry(84), the proportions of the commodity 'oil, gas, and brown coal' going into these industries must reflect the proportions of sales taxes falling on oil, gas, and brown coal separately. From Blampied (1985), the corresponding sales tax figures are \$445.558m, \$1.156m, and \$1.449m, with the value of \$445.558m being close to the Australian Bureau of Statistics (ABS) figure of \$443.1m depicted for 1977-78 crude oil revenue in Figure 2. What this must imply is that, while the excise on crude oil is represented in the ORANI *data base* simply as sales tax, in our general equilibrium revenue switching experiment, it is necessary for us to use the production tax figure TAX_1 = \$115.868m instead of the sales tax figure \$445.558m. The percentage change in crude oil excise in our experiment will therefore tend to be exaggerated relative to the change in petroleum sales tax revenue, because of the smaller base value having to be used for TAX_1. From Blampied(1985), TAX_2 (= sales tax on petroleum products going to all industries) = \$396.767m, and TAX_3 (= sales tax on petroleum products used by households) = \$440.132m. According to the ORANI data base, the total *sales* taxes on crude and petroleum products are thus \$836.899m, close to the 1977-78 ABS petroleum products revenue figure represented in Figure 2.

9/ Industry j=15 stands for crude (although as explained in Appendix A, the data base currently also includes gas and brown coal); commodity i=58 stands for petroleum (and coal)

$$TAX_1 = P^{(1)}_{g+2,j}\, X_{g+2,j}\ ;\ \text{for } j=15; \quad (2)$$

$$TAX_2 = \Sigma_s\Sigma_j TAX_{2j}$$

$$= \Sigma_s\Sigma_j G(is,j1)\, X^{(1)}_{(is)j}\ ;\ \text{for } i=58;\ s=1,2;\ \text{all } j\text{'s}; \quad (3)$$

$$TAX_3 = \Sigma_s G(is,3)\, X^{(3)}_{(is)}\ ;\ \text{for } i=58;\ s=1,2; \quad (4)$$

where $P^{(1)}_{g+2,j}$ and $X^{(1)}_{g+2,j}$ are the price and demand levels respectively for other cost tickets which are used to simulate production taxes (DPSV, p. 70); $G(is,j1)$ and $X^{(1)}_{(is)j}$ are sales tax on, and the demand level for, commodity i from source s for use in industry j; similarly, $G(is,3)$ and $X^{(3)}_{(is)}$ represent sales tax and demand level by household.

Using lower case to denote percentage or log change[10], and making allowance for each tax to be expressed as a combination of a real specific change and a nominal change indexed to the change in the ORANI CPI , equations (2)-(4) can be re-written (see also DPSV equations (12.25), (18.20), (18.21), (22.7)):[11]

$$tax_1 = p^{(1)}_{g+2,j} + x^{(1)}_{g+2,j}$$

$$= \xi(3) + f^{(1)}_{g+2,j} + z_j\ ;\ \text{for } j = 15; \quad (5)$$

$$tax_2 = \Sigma_s\Sigma_j\, S^*_{sj}\, [g(is,j1) + x^{(1)}_{(is)j}]$$

$$= \Sigma_s\Sigma_j\, S^*_{sj}\, [\xi(3) + v(is,j1) + x^{(1)}_{(is)j}];\ \text{for } i = 58;\ \text{all } j\text{'s}; \quad (6)$$

$$tax_3 = \Sigma_s\, S^{(3)}_s\, [g(is,3) + x^{(3)}_{(is)}]$$

$$= \Sigma_s\, S^{(3)}_s\, [\xi(3) + v(is,3) + x^{(3)}_{(is)}]\ ;i = 58; \quad (7)$$

where:

z_j = percentage change in industry j's activity level;
$f^{(1)}_{g+2,j}$ = the shift term to simulate changes to the price of other cost tickets (production tax);
S^*_{sj} = $[G(is,j1)\, X^{(1)}_{(is)j}] / [\Sigma_j\, G(is,j1) X^{(1)}_{(is)j}]$; for i = 58 ; all j's;
$v(is,j1)$ = the percentage change in *real* excise rates on commodity i from source s purchased by industry **j**;
$v(is,3)$ = the percentage change in *real* excise rate on commodity i from source s purchased by the household sector;
$x^{(1)}_{(is)j}$ = the percentage change in demand for commodity i from source s going to industry j;
$x^{(3)}_{(is)}$ = the percentage change in demand for commodity i from source s going to the household sector;
$S^{(3)}_s$ = $G(is,3)\, X^{(3)}_{(is)} / \Sigma_s G(is,3)\, X^{(3)}_{(is)}$; for i=58; s=1,2.

Substituting (5) to (7) into (1), and re-defining the three tax components to include only the domestic source, equation (1) can now be written in full as:

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products; source s=1 is domestic, source s=2 is imports; industry j=56 is petroleum and coal products (refinery). For more information on ORANI notation, see DPSV, pp 14-15.

10/ This is also the standard ORANI notation. Throughout the paper whenever a lower case is used, the words percentage, or log, change are implicit.

11/ In standard ORANI set up, the price of other cost tickets is 100 percent indexed to the CPI, i.e. the indexation parameter $h^{(1)}_{g+2,j}$ in DPSV equation (22.7) is set to 1. Also, we assume that there are no other discretionary changes to other cost tickets in industry 15, i.e. the shift terms $a^{(1)}_j$, $a^{(1)}_{g+2,j}$ (see DPSV, equation (12.25)) are set to zero for j=15.

$$\delta.\xi(3) = S_1.tax_1 + S_2.tax_2 + S_3.tax_3$$
$$= S_1\{\xi(3) + f^{(1)}_{g+2,j'} + z_{j'}\} +$$
$$S_2\Sigma_s\{\Sigma_j S^*_{sj}[\xi(3) + v(is,j1) + x^{(1)}_{(is)j}]\} +$$
$$S_3\Sigma_s\{\xi(3) + v(is,3) + x^{(3)}_{(is)}\};$$
$$\text{for } j' = 15, i = 58, \text{ and } s=1,2. \qquad (8)$$

4. CONDUCTING EXPERIMENTS WITH ORANI-LFT

When particular experiments are conducted with ORANI-LFT, sets of assumptions have to be made in three broad areas, viz:-

- What short run macroeconomic closure assumptions are to be imposed?
- What ranges of values are chosen for the industrial sector interfuel substitution elasticities?
- What form of regime is chosen for LFT?

In order to focus primary attention on the impact of adding the LFT module, the illustrative experiments reported here imposed only two different closures[12] and Truong's (1986) mid-range interfuel substitution elasticity values[13].

For ORANI's standard short run macroeconomic closure, (see Cooper, McLaren and Powell (1985), it is currently necessary to choose three of the following variables as exogenous:

- either the aggregate price level or exchange rate,
- either the aggregate real wage or level of employment,
- either the real balance of trade or real absorption (real household aggregate expenditure plus aggregate real private investment expenditure plus real government final expenditure).

We chose, for these initial short run experiments[14], to take the nominal exchange rate as fixed, thereby allowing the real exchange rate to vary with the ORANI CPI; to assume an unchanged real wage, implying full wage indexation to the ORANI CPI, labour in excess supply and aggregate employment determined endogenously; and to present results for each of the varying balance of trade and varying real domestic absorption cases.

With respect to the form of regime chosen for LFT, it is necessary to specify both the source of the shock to crude oil levy revenue and the form of regulatory environment applicable to the crude oil market.

As indicated in the Introduction, the source of the shock could be via price channels due to changes in product price and/or excise rates or be the result of volume (i.e. changes in demand or production) effects. The particular shock to revenue chosen was an exogenous 10% fall in the world price of crude oil.

12/ For further explanation of macroeconomic closure assumptions, see Cooper, McLaren and Powell (1985), Meagher and Parmenter (1985), and Powell (1985).
13/ These mid-range own price and cross price elasticities of demand for ten industries are reproduced in Appendix B from Truong (1986, Appendix B). Truong (1986, Tables 4, 5) has reported on the sensitivity of ORANI-FUEL results to changes in these price elasticities.
14/ For short run closure, standard treatment is to take the capital stock employed in each industry as fixed, thereby allowing rates of return in each industry to be determined endogenously.

In terms of the regulatory environment, the basic choice involves the current regulated market as described above, or a "deregulated" market as proposed in DRE (1987). In the remainder of this section and the next section, we present equations and results only for the former.

The impact of the 10% cut in world crude prices can therefore now be explained in standard ORANI terminology as follows:[15]

Assume there is an *exogenous* shock of -10% to the c.i.f foreign currency price of imported crude $p^{(m)}{}_{(i2)}$ (i=17). To maintain export pricing parity, the export price (f.o.b.) of crude oil $p^{e}{}_{(i1)}$ is also shocked by the same percentage (using the shift term $fe_{(i1)}$, i=17). The shock to $p^{(m)}{}_{(i2)}$ is then translated into a shock to the *basic* price of imported crude $p^{(o)}{}_{(i2)}$ (i=17). To maintain IPP for domestic crude, i.e. to preserve the relationship:

$$p^{(0)}{}_{(i1)} = p^{(0)}{}_{(i2)} \text{ ; for } i = 17, \tag{9}$$

it is assumed the government will vary the *production excise on domestic crude*, i.e. the value of $f^{(1)}{}_{g+2,j}$, (j=15). IPP for crude is then translated into IPP for the *basic* price of *petroleum product*, i.e.:

$$p^{(0)}{}_{(i1)} = p^{(0)}{}_{(i2)} \text{ ; for } i = 58. \tag{10}$$

To ensure (10), the government could impose tariff or other measures on imported petroleum product. However, to simplify the analysis, we assume equation (10) can be achieved in a similar manner by letting the c.i.f. foreign currency price of imported petroleum products become endogeneous.

Liquid fuel tax revenue neutrality requires that changes in petroleum product excise be related to the changes in the crude excise. Given that there are only three additional constraints implied by the revenue-neutrality condition (8) and the IPP conditions (9) and (10), we can specify only three more endogenous variables. These are the production excise on domestic crude ($f^{(1)}{}_{g+2,j}$, j=15) and the sales taxes on domestic and imported petroleum product. For convenience at this stage, these taxes are assumed to be the same[16] for both industries and households, i.e:

$$v(is,j1) = v(is,3) \text{ ; for } i = 58;\ s=1,2;\ \text{all } j\text{'s}. \tag{11}$$

Conducting experiments with ORANI-LFT has therefore led to the addition of a liquid fuel tax revenue constraint (8), a uniform petroleum products tax rate constraint (11), and the two IPP market regulation assumptions, (9) and (10)[17]. The new condensed system consists of 7000 variables and 3518 equations, compared with its standard ORANI counterpart of 6159 variables and 2621 equations.

15/ The impact of a cut in world prices can also be traced through ORANI variables in flow chart form. Such a presentation appears in Hall, Truong and Nguyen (1989).

16/ If we want to vary the excise rate for different industry and household users, then additional constraints (or 'rules') must be established. For example, a Ramsey (1927) excise rule may vary the excise rate according to *a priori* established demand elasticities. Some form of government subsidy rule could also be incorporated. This type of explicit variation in excise rates can easily be incorporated into our model, and can be the topic of future studies.

17/ Note that, as explained in Truong (1986, p.15) for ORANI-FUEL, maintaining the domestic-import elasticity of substitution for crude oil at its standard high value of $\sigma^{(1)}{}_{ij}$ = 50 (for i = 17, all j's) together with equation (9), implies that imported crude does not increase its share of the domestic market and that the domestic allocation scheme is therefore preserved.

5. EMPIRICAL RESULTS

Results were obtained using the GEMPACK 2 software (Release 4, September 1986) recently made available for use on VAX computers (Pearson, 1986). Each simulation run took between 5 and 15 minutes (depending on the type of run) on the University of New South Wales' VAX/VMS V4.5.

Illustrative numerical results relevant to the five questions posed at the end of section 1 are presented in Tables 1,2, and 3. All effects are short run in nature, are conditioned by data based on 1977-78 input-output tables, and emanate from a 10 per cent cut in the c.i.f. foreign currency price of imported crude oil. The discussion which follows is for the nominal revenue neutrality cases, as the aggregate effects for this set of experiments are not substantially different from those obtained for the real revenue neutrality cases.

Energy Price, Tax Rate, and Excise Revenue Effects

From Table 1, the uniform petroleum product excise rate increases required to achieve nominal liquid fuel tax revenue neutrality, under mid-range interfuel substitution elasticity assumptions, were:

- 12.9 per cent for the standard macroeconomic closure (i.e. real absorption constant balance of trade varying), and

- 14.2 per cent for the "balance of trade constant" closure.

The corresponding tax revenue figures were:

- a fall of -$115m in crude oil levy revenue, paid for in increased petroleum products excise by the industrial sector ($52m) and by the household sector ($63m)[18], for the case of constant real absorption, and

- a fall of nearly -$129m in crude oil levy revenue, paid for by industries (over $57m) and by households (more than $71m), for the case of constant balance of trade.

When considering the effects of crude oil levy and petroleum product excise on final petroleum product prices, the ***basic*** price and the domestic ***purchase*** price of petroleum products have to be examined. A fall in the basic price of petroleum products can be due to a fall in import price (the case of imported crude) or a fall in government levy (the case of domestic crude), i.e. this is the price prior to the petroleum products excise rate. A fall (and in a minority of cases, a rise) in the purchase price of petroleum products will be due to *both* a fall in import-parity price of crude *and* a rise in petroleum product excise. For the case of constant real absorption:

- the fall in the ***basic*** price of petroleum products is -6.2 per cent, while

- the fall in the domestic ***purchase*** price of petroleum products varies for most industries from a high of -4.0 per cent to a low of -0.06 per cent. But for some industries, including 'wholesale trade' and 'ownership of dwellings', modest net increases in purchasers' price of petroleum products of 0.64 and 0.80 were experienced.

These results are consistent with the proposition in Piggott, Veale and Stevens (1987), and also the arguments put forward in Section 2 and Figure 6 of our paper, that in general the *net* effect of reduced crude oil levy and increased petroleum products excise is a *fall* in the final (purchase) price of petroleum products. The size of this fall will be less than the initial fall

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18/ For real revenue neutrality, the relevant figures are -$116m, $50m and $61m. The difference of around $5m is accounted for by the small (around -.5 per cent) CPI effect.

due to import-parity pricing alone. The few reported cases where the final purchase price of petroleum products rose instead of fell corresponded to situations where the petroleum product excise component is more dominant than the 'basic' price component.

Aggregate Effects, and Effects on Industry Output and Employment

It is clear from the aggregate effects[19] presented in Table 1 and the structural effects set out in Table 3 that the imposition of different macroeconomic environments leads to substantially different consumer price index, output, and employment effects.

When output adjustment has to take place primarily through the balance of trade, an improvement in the balance of trade to the order of $0.23b is recorded, together with a fall in the ORANI index of consumer prices of around -0.5 per cent, and a small improvement of around 0.2 per cent in aggregate employment.

But when the balance of trade is assumed to be constant and output adjustment has to occur through changes in real absorption, an increase in real private absorption of around 0.4 per cent is observed. This leads to a greater increase in aggregate employment of around 0.3 per cent but also a small *rise* in the ORANI consumer price index of around 0.3 per cent.

The percentage changes in industry output and employment levels presented for selected industries in Table 3 indicate significant variation across industries and also according to the different macroeconomic environments assumed.

Fuel Price and Quantity Effects

From column 2 of Table 2, which presents results for a varying balance of trade and nominal revenue neutrality, the 10 per cent cut in the IPP of crude oil is consistent with a fall in the basic price of fuel and transport commodities (except for black coal), and an increase in their industrial activity levels. More specifically, the resulting cut of around -6.2 per cent in the basic price of petroleum products has led to falls of between -0.5 and -1.0 per cent for the *basic* prices of fuel and transport commodities. The basic price of coal rises by 0.1 per cent, due mostly to an increase in economic activity levels. For fuel producing and transport industries, the increases in activity level range from 0.1 to 0.9 per cent.

It is also clear from the industry activity level figures in column 4 that interfuel substitution has been responsible for *higher* percentage increases in the use of oil, petroleum products, and gas, and substantially reduced utilisation of electricity (relative to that under zero interfuel substitution).The impact of interfuel substitution on the black coal and four transport industries is negligible. This is because our particular form of interfuel substitution has been assumed to occur only in the ten industries listed in Appendix B. None of the ten are fuel and transport industries. Thus, interfuel substitution has an effect on fuel and transport only *indirectly* through changes in activity levels. Direct fuel substitution effects could be incorporated in future work by expanding the list of industries in Appendix B to include fuel and transport industries, and the incorporation of a wider range of elasticity values, as presented for example in Truong(1986, Table 6).

For the household sector, figures in column 2 show increased use of oil and petroleum products, some decline in the use of black coal, and negligible effect on the consumption of electricity and gas.

19/ Recall that these are net comparative static outcomes from a relative (oil) price shock, with only limited macroeconomic feedback effects taken into account. For example, such macroeconomic variables as interest rates, the money stock, government bonds held by the non-bank sector, and the level of foreign reserves do not appear explicitly in ORANI.

6. CONCLUDING REMARKS

It is clear from the analytical and empirical work presented in sections 3 to 5, that Australian short run general equilibrium applications in the energy area have now been successfully taken a significant step further.

Analytically, this has been through development of the ORANI-LFT model, suited to examining a range of liquid fuel excise tax issues in an industrial sector interfuel (but not interfactor) substitution framework. Representative empirical results obtained from the new model are consistent with the broad qualitative conclusions derived from the partial equilibrium analysis of Piggott, Veale and Stevens (1987).

The illustrative numerical values presented in section 5 follow from a significant fall in revenue from the crude oil levy, caused by a 10 per cent fall in the c.i.f. foreign currency price of imported crude oil. This revenue fall was offset by a uniform increase in petroleum products excise, so as to achieve either nominal or real liquid fuel tax revenue neutrality. The aggregate and structural values obtained seem sensible, given that the base period data are for 1977-78. The numbers reported should not be used in policy work at this stage, as this would require both an updated data base and further analytical work as indicated below.

The experiments reported take explicit account of two important strands of the Australian government's pre-1988 oil regulatory framework, namely the import parity pricing (IPP) and domestic allocation systems for crude oil. In particular, this meant: (1) ensuring that imported crude does not increase its share of the domestic market, by imposing IPP values for crude from both domestic and foreign sources; (2) requiring IPP values for refined petroleum products from both sources to be the same; and (3) imposing import-export parity pricing through the f.o.b. foreign currency export price and the import price of crude oil having to change in the same proportion.

Analytically, the next step is to modify the model so as to be suitable for investigating "deregulated" oil markets. Examination of a wider range of macroeconomic assumptions and effects should then be undertaken.

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APPENDIX A: ORANI-FUEL.

Interfuel substitution is incorporated into the standard ORANI model by replacing the existing ORANI equation (12.23) with the following (see Truong *et al.*, 1985, equations (30) and (39)):

$$x^{(1)}_{(is)j} = z_j - \sigma^{(1)}_{ij} [p^{(1)}_{(is)j} - \Sigma_s S^{(1)}_{(is)j} p^{(1)}_{(is)j}] + a^{(1)}_{ij} ;$$

$$s=1,2;\ i\in E;\ j\in F; \qquad \text{(A1)}$$

$$a^{(1)}_{ij} = \Sigma_s \Sigma_k S^{(1)}_{(ks)j} p^{(1)}_{(ks)j} \eta^j_{i,k} + [\varepsilon^j_i - 1] z_j ;$$

$$i,k \in E,\ j\in F; \qquad \text{(A2)}$$

where:

- E is the set of substitutable energy commodities (E={16,17,58,86,87}).
- F is the set of industries wherein there is significant interfuel substitution.
- $\eta^j_{i,k}$ is the conditional (i.e. given total fuel demand) price elasticity of substitution between fuels i, k in industry j).
- ε^j_i is the (conditional) Divisia elasticity of demand for fuel i with respect to total energy demand in industry j).

Note that $a^{(1)}_{ij} = 0$ for those industries where there is no fuel substitution and where the Divisia elasticity is unitary.

The term $a^{(1)}_{ij}$ is then related to the variable b_8 of the ORANI- condensed system through equation DPSV (32.17):

$$[b_8]_i = \Sigma_j B^{(1)}_{(i1)j} \{a^{(1)}_{ij} - \sigma^{(1)}_{ij} [v(i1,j1)\ \zeta_2(i1,j1) - \Sigma_s S^{(1)}_{(is)j} v(is,j1)\ \zeta_2(is,j1)]\}$$

$$i\in E;\ j\in F \qquad \text{(A3)}$$

Only the variables b_8 and z_j remain in the ORANI condensed system. Other variables in the above equations, namely, $x^{(1)}_{(is)j}$, $a^{(1)}_{ij}$, $v(is,j1)$, and $p^{(1)}_{(is)j}$ are eliminated from the condensed system, and hence must be recovered. The first two variables are recovered using (A1) and (A2). The latter two are recovered from the ORANI condensed-system variables b_2, $p^{(o)}_{(is)}$, $\xi^{(3)}$, using the following equations (see DPSV equations (32.10) and (32.17):[20]

$$[b_2]_j = \Sigma_i \Sigma_s [v(is,j1)\ \zeta_2(is,j1)\ H^{(1)}_{(is)j}] ; \qquad \text{(A4)}$$

$$p^{(1)}_{(is)j} = p^{(o)}_{(is)}\ \zeta_1(is,j1) + [\xi^{(3)} + v(is,j1)]\ \zeta_2(is,j1)$$

$$+[\Sigma_r M_{(r1)}^{(is)j1}\ p^{(o)}_{(r1)}]\zeta_3(is,j1) ;\ \text{for: } s = 1,2;\ i\in E,\ j\in F \qquad \text{(A5)}$$

Where:

- $\zeta_1(is,j1)$ represents the *basic*-value share in the *purchasers'* price of commodity i from source s for use in current production in industry j.
- $\zeta_2(is,j1)$ is the share of commodity taxes in the purchasers' value of inputs of fuel i from source s for use in current production in industry j.
- $\zeta_3(is,j1)$ represents the share of total margins (excluding taxes) in the purchasers' price of commodity i from source s for use in current production in industry j.

20/ Note that the term $a^{(1)}_{ij}$ is retained in b_8 but not in b_2. This is because we use $a^{(1)}_{ij}$ in b_8 to simulate interfuel substitution (see text, equation (18)). The term $a^{(1)}_{ij}$ in b_2 does not represent interfuel substitution (see also Truong *et al.*, 1985, footnote 7).

$B^{(1)}_{(i1)j}$ is the share of total sales of domestic fuel i which is absorbed by industry j as a direct input into production.

$S^{(1)}_{(is)j}$ is the share of the purchasers' value of fuel i from source s in industry j's total purchases of fuel i for use in current production.

$H^{(1)}_{(is)j}$ is the share of purchasers' value of input of fuel i from source s in the total costs of industry j.[21]

$M_{(r1)}^{(is)j1}$ is the share of input of (margin) good r in the total cost of margins (excluding taxes) required to transfer flows of good i from source s from the producer (or port of entry) to user j for use in current production.

Equations (A1) to (A5) represent the complete interfuel sub-module. However, there are certain additional features which must usually be added on to this sub-module to take account of the fact that the existing ORANI commodity 17 actually consists of three different commodities: oil, gas, and brown coal. Thus any change to the price of commodity 17 implies a shock to the price of gas and brown coal as well as to the price of crude oil. Since gas and brown coal are used as inputs mainly to industries 85 (Gas) and 84 (Electricity) respectively, we can 'compensate' these industries for the inadvertent shocks to their input prices. From DPSV equations (18.2) and (22.7), we can specify the compensating shocks to these industries through the shift variables $f^{(1)}_{g+2,j}$ as follows:

$$f^{(1)}_{g+2,j} = - p^{(1)}_{(i1)j} \, [H^{(1)}_{(i1)j}/H^{(1)}_{g+2,j}] \text{ ;for } i=17, j=\{84,85\}; \qquad \text{(A6)}$$

where:

$H^{(1)}_{(i1)j}$ is the share of the purchasers' value of input of domestic commodity i in the total costs of industry j, and

$H^{(1)}_{g+2,j}$ is the share of 'other costs' tickets in the total cost of industry j.

21/ See DPSV Table 27.1.

APPENDIX B: ELASTICITIES OF INTERFUEL SUBSTITUTION

The following tables provide illustrative interfuel substitution elasticities, based on work done by Donnelly (1983), Magnus and Woodland (1984), Truong (1985), and Turnovsky, Folie and Ulph (1982).

Values given in the Tables are "base case" or "mid-range" values for $\eta^{j}_{i,k}$, as specified in equation A2 of Appendix A. Variations around these values, considered suitable for preliminary sensitivity analysis, appear within the parentheses.

ORANI Industries		ORANI Fuels	
j	Name	i, k	Name
2	Wheat-sheep	15	Black Coal
12	Iron ores	58	Petroleum products
18	Meat products	86	Electricity
50	Other basic chemical products	87	Gas
58	Clay products		
63	Basic Iron and Steel		
64	Other basic metals		
88	Non-residential buildings		
89	Wholesale trade		
90	Retail Trade		

Industries : 2, 12		
i \ k	58	86
58	-.2 (±.2)	.2 (±.2)
86	.2 (±.2)	-.2 (±.2)

Industry : 18

i \ k	16	58	86	87
16	-1.0 (∓.3)	.2 (±.1)	.3 (±.1)	.5 (±.1)
58	.2 (±.1)	-.5 (∓.3)	.1 (±.1)	.2 (±.1)
86	.05 (±.05)	.2 (±.1)	-.3 (∓.2)	.05 (±0.5)
87	.25 (±.1)	.25 (±.1)	.25 (±.1)	-.75 (∓.3)

Industry : 50

i \ k	16	58	86	87
16	-.5 (∓.3)	.15 (±.1)	.15 (±.1)	.20 (±.1)
58	.15 (±.1)	-.5 (∓.3)	.15 (±.1)	.20 (±.1)
86	.15 (±.1)	.15 (±.1)	-.5 (∓.3)	.20 (±.05)
87	.25 (±.1)	.25 (±.1)	.25 (±.1)	-.75 (∓.3)

Industry : 58

i \ k	16	58	86	87
16	-1.0 (∓.3)	.1 (±.1)	.1 (±.1)	.8 (±.1)
58	.2 (±.1)	-1.0 (∓.3)	.2 (±.1)	.6 (±.1)
86	.1 (±.05)	.1 (±.1)	-.5 (∓.2)	.3 (±.05)
87	.8 (±.1)	.1 (±.1)	.1 (±.1)	-.1 (∓.3)

Industry : 63

i \ k	58	86	87
58	-.5 (∓.3)	.15 (±.15)	.35 (±.15)
86	.2 (±.1)	-.5 (∓.2)	.2 (±.1)
87	.35 (±.15)	.15 (±.15)	-.5 (∓.3)

Industries : 64

i \ k	16	58	86	87
16	-.8 (∓.3)	.1 (±.1)	.5 (±.1)	.2 (±.1)
58	.1 (±.1)	-.5 (∓.3)	.1 (±.1)	.3 (±.1)
86	.2 (±.05)	.1 (±.1)	-.5 (∓.2)	.2 (±.05)
87	.1 (±.1)	.3 (±.1)	.1 (±.1)	-.5 (∓.3)

Industries : 88, 89, 90

i \ k	16	58	86	87
16	-.3 (∓.15)	.1 (±.05)	.1 (±.05)	.1 (±.05)
58	.15 (±.1)	.-4 (∓.3)	.1 (±.1)	.15 (±.1)
86	.1 (±.05)	.1 (±.05)	-.3 (∓.15)	.1 (±.05)
87	.1 (±.1)	.2 (±.1)	.2 (±.1)	-.5 (∓.3)

TABLE 1

Short-run Effects of a Fall in Crude Oil Levy Revenue: ORANI-LFT, with Nominal Liquid Fuel Tax Revenue Neutrality+

Macroeconomic closure	Real Absorption Constant		Balance of Trade Constant	
Industrial interfuel substitution price elasticities of demand	Mid-range	Zero	Mid-range	Zero
Key Fuel Price and Excise Revenue Effects				
IPP crude oil	-10.0*	-10.0*	-10.0*	-10.0*
Petroleum products excise rate	12.91	12.53	14.22	13.81
Basic price, petroleum products	-6.24	-6.25	-5.92	-5.93
Purchase price of domestic petroleum products for:++				
Non-residential buildings	-2.82	-2.85	-2.35	-2.38
Basic iron and steel	-2.26	-2.28	-1.90	-1.93
Wheat-sheep	-1.33	-1.39	-0.80	-0.86
Wholesale trade	0.64	0.54	1.31	1.20
Crude oil revenue ($m)	-115.5	-112.3	-128.8	-125.3
Petroleum products excise revenue				
Industrial Sector ($m)	52.3	50.7	57.4	55.6
Household Sector ($m)	63.2	61.5	71.4	69.5
Aggregate Effects				
ORANI CPI	-0.54	-0.54	0.29	0.29
Real private absorption	0.0*	0.0*	0.35	0.35
Balance of trade ($b)	0.23	0.23	0.0*	0.0*
Exports	0.57	0.57	-0.33	-0.33
Imports	-1.02	-1.02	-0.33	-0.33
Employment	0.21	0.21	0.31	0.31

\+ Results are percentage changes, except for the liquid fuel excise revenue and balance of trade figures which are in base period (1977-78) millions/billions of dollars.

++ Reflects petroleum products price change, net of IPP fall and petroleum products excise rate rise. Figures are for four representative industries only. Price changes differ by industry in accordance with industry margins.

* Value chosen exogenously.

TABLE 2

Percentage Changes in Basic Price, Industry Output and Household Commodity Demand Variables for Fuel and Related Industries+

Model	ORANI-FUEL	ORANI-LFT		Percentage difference attributable to imposed interfuel substitution values
Industrial Interfuel Substitution Elasticities	Mid-range	Mid-range (a)	Zero (b)	(((a)-(b))/(b) x 100
Basic Price of Domestic Commodities				
16 Black coal	0.1117	0.1057	0.1067	-0.94
17 Oil, (gas & brown coal)	-10.0*	-10.0*	-10.0*	-
58 Petrol. & Coal products	-6.2468	-6.2421	-6.2483	-0.10
86 Electricity	-0.5877	-0.5470	-0.5339	2.45
87 Gas	-0.6929	-0.6415	-0.6465	-0.77
95 Road transport	-0.9613	-0.9265	-0.9274	-0.10
96 Rail & other transport	-0.6423	-0.6039	-0.6043	-0.07
97 Water transport	-0.6762	-0.6504	-0.6514	-0.15
98 Air transport	-1.0583	-1.0296	-1.0306	-0.10
Industry Activity Levels				
14 Black coal	0.9010	0.8554	0.8565	-0.13
15 Oil, (gas & brown coal)	0.5535	0.4823	0.4448	8.43
56 Petrol. & coal products	0.7454	0.6259	0.5619	11.39
84 Electricity	0.1208	0.1316	0.1439	-8.55
85 Gas	0.0819	0.1109	0.1056	5.02
93 Road transport	0.2364	0.2184	0.2181	0.14
94 Rail & other transport	0.3043	0.2828	0.2820	0.28
95 Water transport	0.2884	0.2713	0.2697	0.59
96 Air transport	0.5674	0.5575	0.5578	-0.05
Household Demand for Domestic Consumption				
16 Black coal	-0.2548	-0.2431	-0.2434	
17 Oil, (gas & brown coal)	3.4477	3.4577	3.4577	
58 Petrol. & coal products	1.4338	1.4355	1.4372	
86 Electricity	-0.0051	-0.0083	-0.0156	
87 Gas	0.0529	0.0445	0.0471	
95 Road transport	0.0402	0.0403	0.0404	
96 Rail & other transport	0.0089	0.0085	0.0085	
97 Water transport	0.7145	0.6903	0.6915	
98 Air transport	0.8631	0.8638	0.8649	

\+ Real private absorption constant, and nominal liquid fuel tax revenue neutrality. The two digit numbers down the left hand side are ORANI industry numbers.

* Value chosen exogenously.

TABLE 3

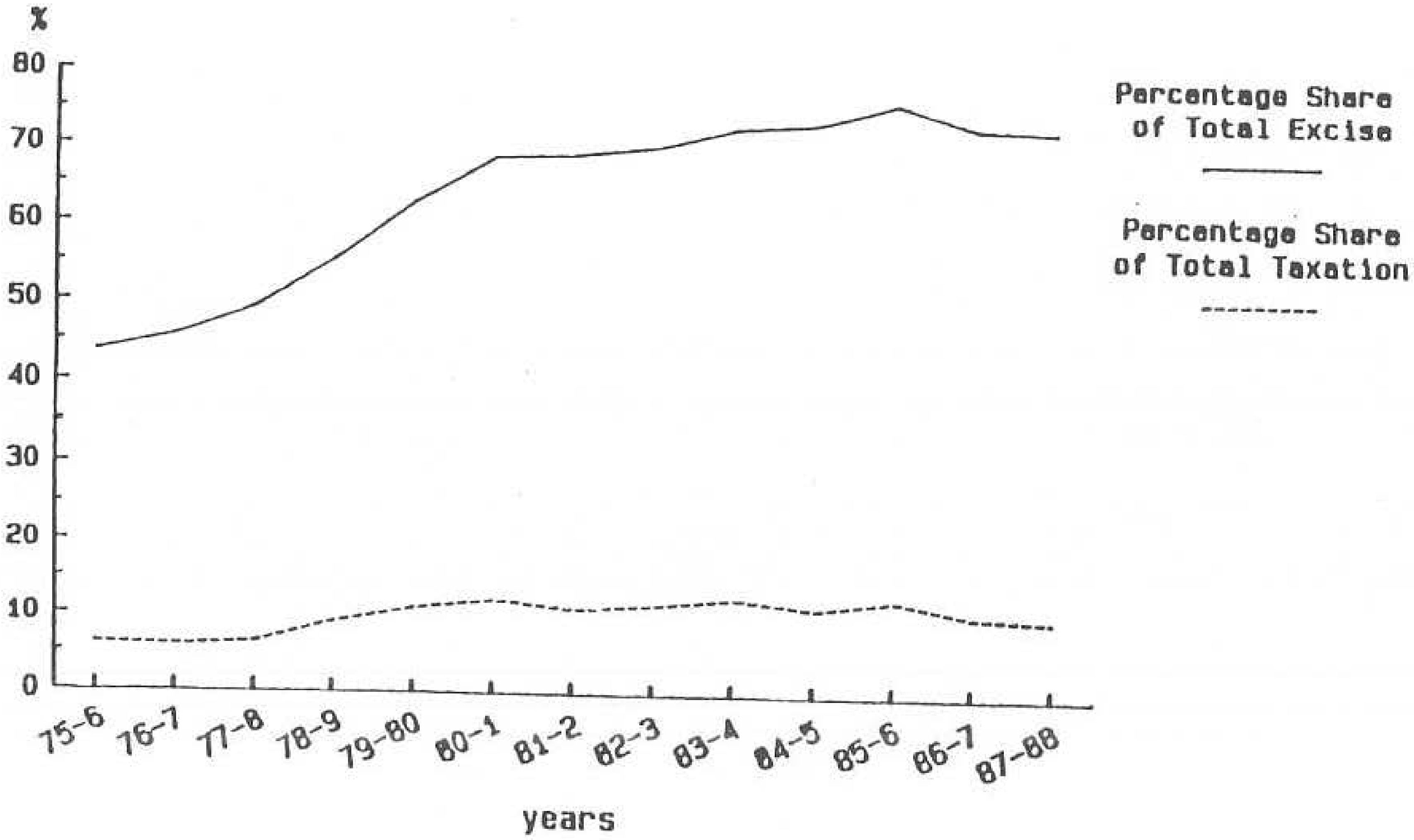
Percentage Changes in Industry Output and Employment Levels[+]

Industry			Real Absorption Constant		Balance of Trade Constant	
			Output	Employment	Output	Employment
	76	Agricultural Machinery	2.22	2.42	-0.77	-0.84
	25	Other food products	1.39	1.93	-0.39	-0.55
	17	Services to mining	1.04	1.14	1.16	1.27
*	64	Other basic metals	0.97	1.66	0.05	0.08
	31	Man-made fibres, yarns	0.88	0.95	-0.19	-0.21
	14	Black Coal	0.86	1.61	-0.12	-0.22
	6	Other farm	0.80	1.17	-0.16	-0.23
	4	Northern beef	0.78	1.61	-0.19	-0.39
*	18	Meat products	0.73	0.89	-0.20	-0.24
	13	Non-ferrous metal ores	0.70	1.36	-0.08	-0.16
	56	Petrol. & coal products	0.63	1.06	0.78	1.32
*	50	Other basic chemicals	0.54	0.83	0.13	0.20
	96	Air transport	0.56	0.68	0.78	0.95
	15	Oil, (gas & brown coal)	0.48	4.72	0.57	6.05
	68	Motor vehicles & parts	0.48	0.50	0.07	0.07
	94	Rail & other transport	0.28	0.28	0.16	0.15
	95	Water transport	0.27	0.36	0.09	0.12
*	89	Wholesale trade	0.23	0.30	0.23	0.30
	93	Road transport	0.22	0.23	0.17	0.19
*	63	Basic iron & steel	0.20	0.23	0.17	0.21
*	58	Clay products	0.20	0.24	0.29	0.36
	84	Electricity	0.13	0.25	0.25	0.48
	85	Gas	0.11	0.20	0.34	0.61
*	90	Retail Trade	-0.02	-0.03	0.31	0.38
*	88	Other construction	-0.03	-0.03	0.34	0.38

\+ From ORANI-LFT, with nominal liquid fuel tax revenue neutrality, and mid-range industrial interfuel substitution price elasticities of demand

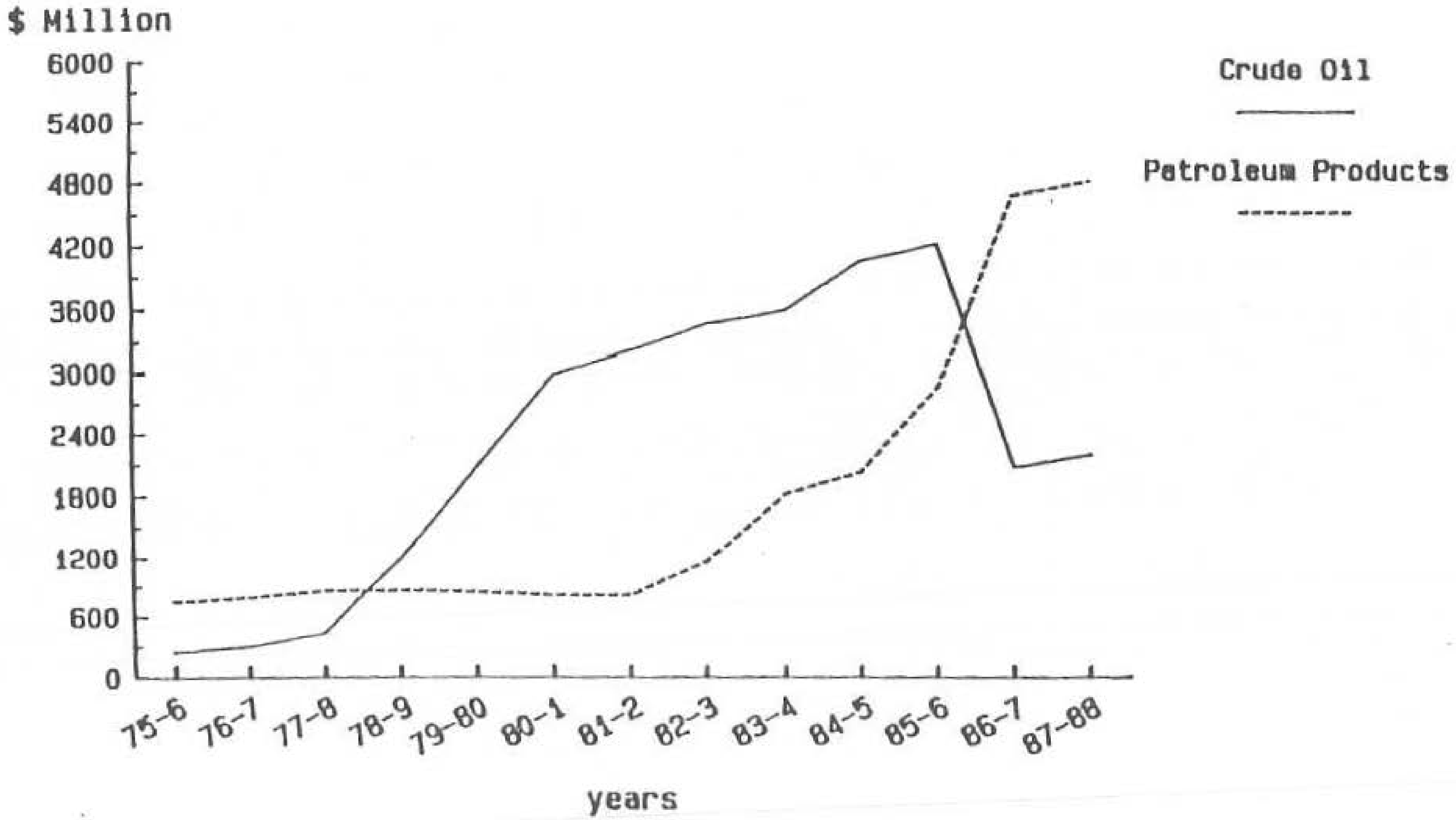
* Indicates an industry for which explicit non-zero own-price and cross-price elasticities of demand were imposed.

Figure 1: Percentage Shares of Revenue from Excise Duty on Crude Oil and Petroleum Products



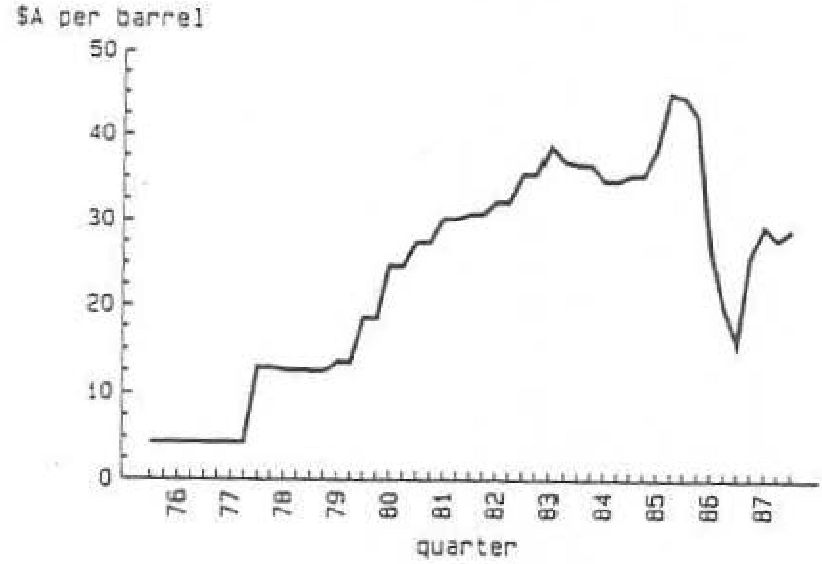
Sources: Budget Statements (A.G.P.S., Canberra).
ABS Catalogue Nos 5427.0 and 5425.0.
IAC Second Draft Report on "Certain Petroleum Products - Taxation Measures" (1986, Table 3.2).

Figure 2: Revenue from Excise Duty on Crude Oil and Petroleum Products

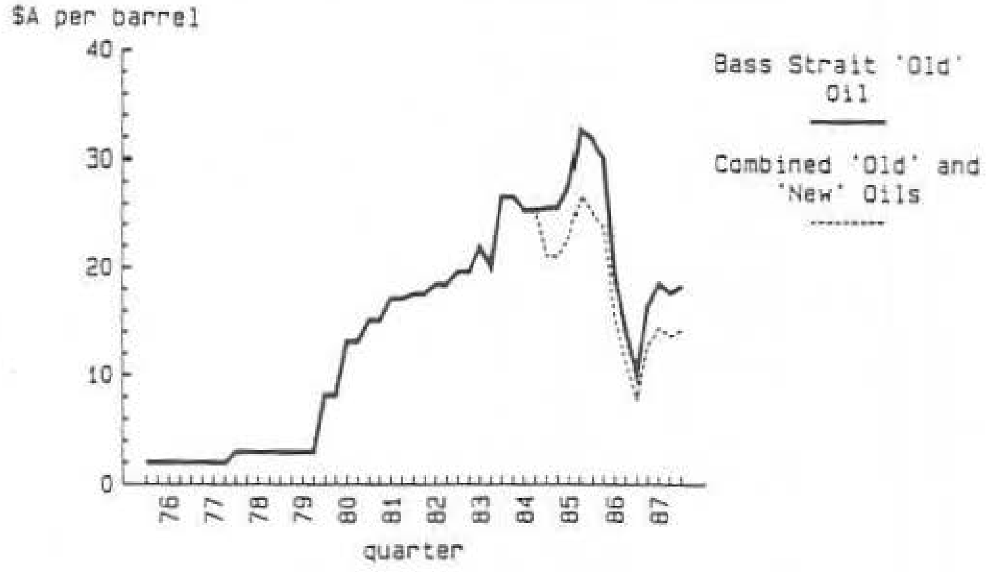


Sources: Budget Statements (A.G.P.S., Canberra).
ABS Catalogue Nos 5427.0 and 5425.0.
IAC Second Draft Report on "Certain Petroleum Products - Taxation Measures" (1986, Table 3.2).

Figure 3: Import Parity Price (Bass Strait)



Weighted Marginal Excise Rates for Crude Oil



Production of Crude Oil

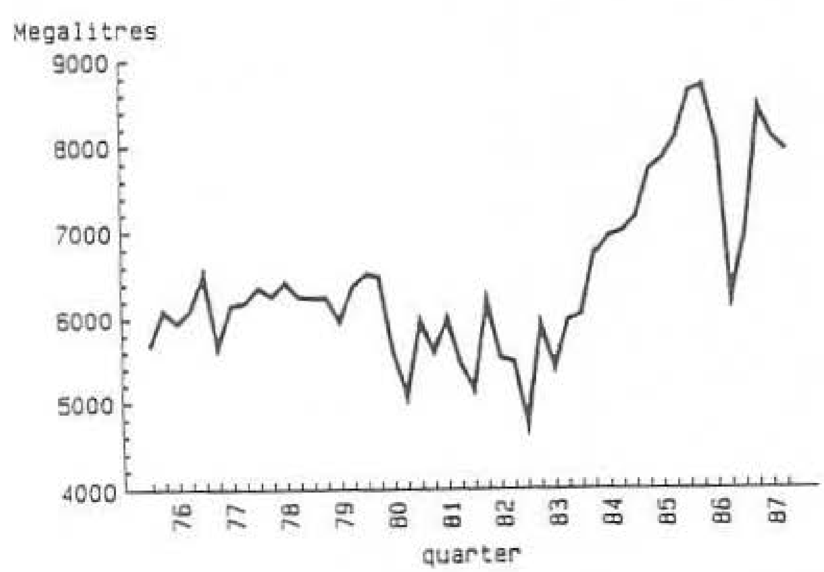
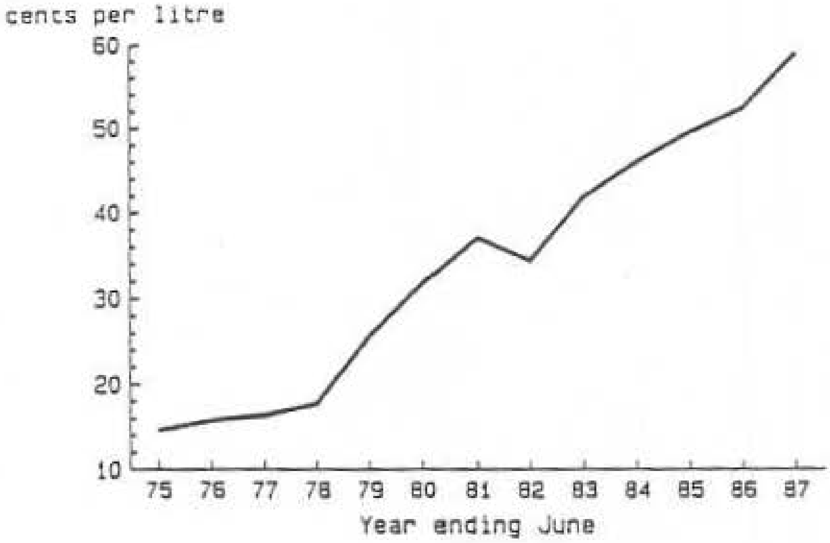
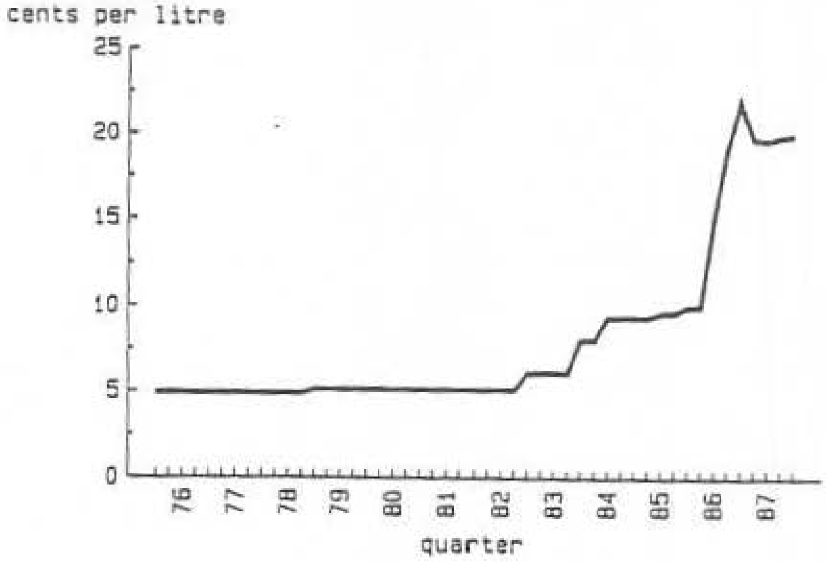


Figure 4: Retail Price of Motor Spirit



Excise Rate on Motor Spirit



Production of Motor Spirit

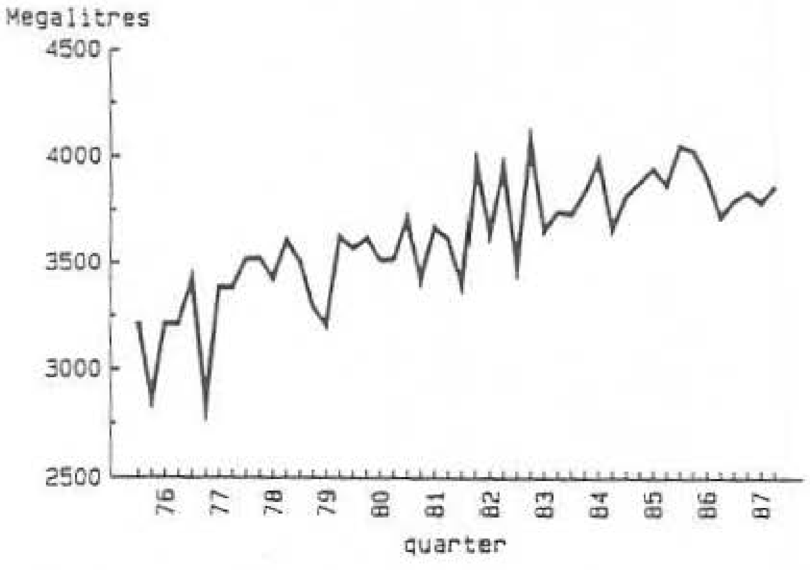
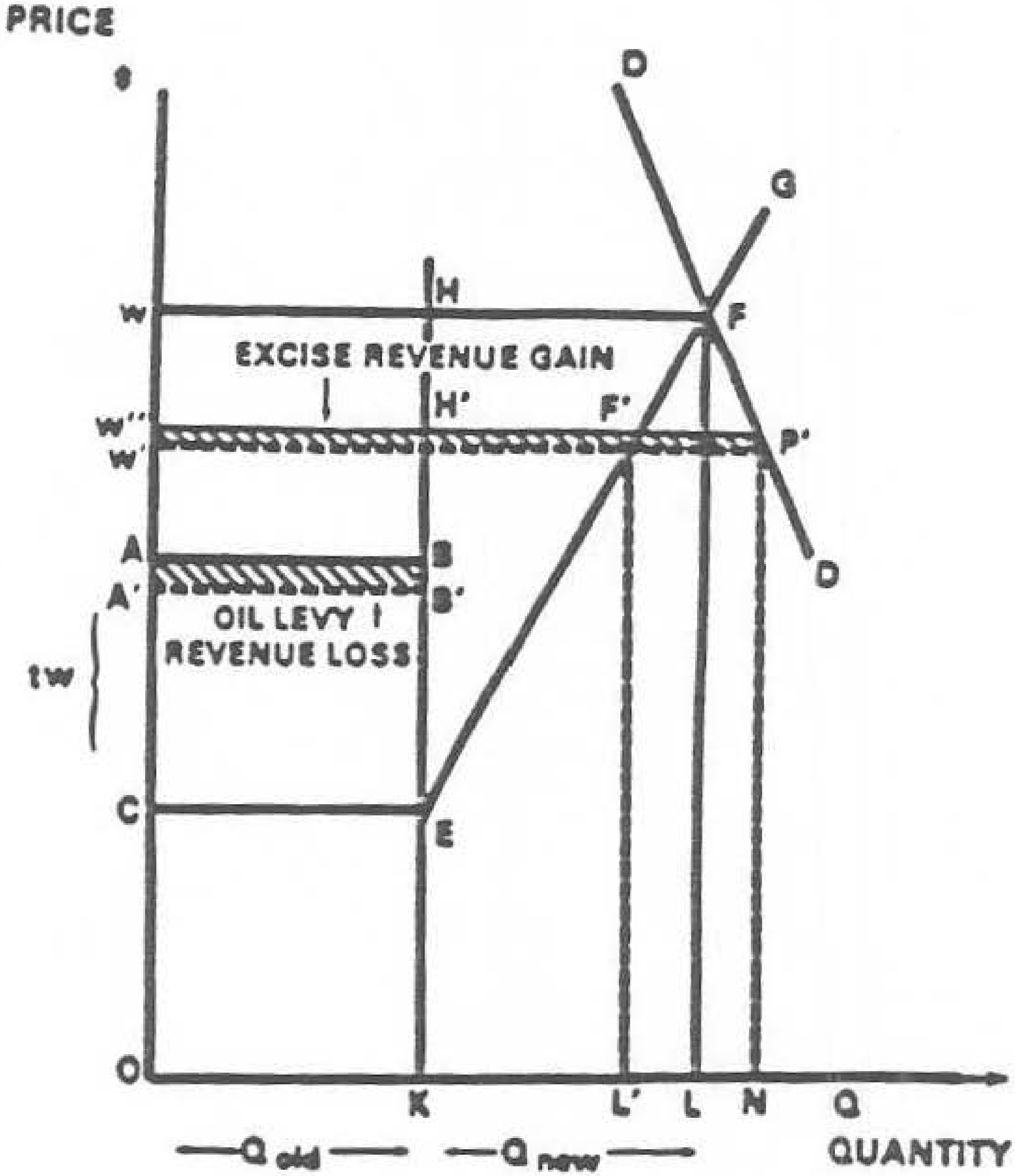


Figure 5: A Stylised Australian Oil Market



Source: Piggot, Veale and Stevens (1987, p.7).

Figure 6: A More Complex Stylised Australian Oil Market