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The Impacts of an Oil Import Fee on U.S. Agriculture*

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This paper investigates the nature and extent of the impacts that a crude oil import fee will have on the producing sectors, consuming sectors and household categories in the United States where the interrelationships between these entities is explicitly considered. Special attention is given to the agricultural sectors of the economy. In the context of a general equilibrium model, the effect of a $5.00 per barrel import fee is calculated. Over the period 1984-1990 with such an import fee (relative to the absence of a crude oil import fee), the model results suggest that there will be a reduction in output by approximately $13.924 billion, there will be a fall in the consumption of goods and services by about $318 million and there will be a decline in aggregate social welfare by $208 million. The government will realize an increase in revenue of $3.622 billion. The agricultural sectors in the aggregate can expect to see a fall in output of $769 million with an attendant increase in the price of the goods it produces.

I. Introduction

A central issue in the current energy debate in the United States is the imposition of a fee on imported crude oil. The participants in this debate range from those who have a vested interest in such a fee (e.g., the domestic crude oil industry) to various consumer groups who are concerned about equity issues. One group that has remained silent during this debate is the agricultural community. That is, farmers have voiced

* The views expressed are those of the authors and do not necessarily represent the policies of the organizations with which they are or have been previously affiliated.

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virtually no objections to (or support for) such a policy initiative. There are several possible explanations for this muteness. For example, the consensus among this group might be that such a fee would have little or no adverse impact on the agricultural sector. Alternatively, it is possible that there is a feeling of impotency against very strong vested interest groups (e.g., the oil industry). Or, perhaps, there are other concerns that have priority over this one and hence there are (is) simply insufficient time and (or) resources to devote to analyzing and arguing about the oil import fee issue. Whatever the reason, this lack of participation in the debate is unfortunate. An analysis of the issue needs to be performed because there are potentially significant costs that the sector will incur if an oil import fee is imposed.

In what follows, such an analysis will be undertaken. The analytical vehicle used will be a computable general equilibrium model that has been disaggregated into twelve producing sectors (four of which relate to the production of agricultural commodities), thirteen consuming sector, six household (income) categories and the government. This level of disaggregation allows for an assessment of the direct effects as well as the indirect effects of an oil import fee, both of which are important to agriculture.

The possible impacts on the agricultural sector arise from a diversity of interrelationships. First, since agriculture uses a variety of refined petroleum products (e.g., motor gasoline, diesel fuel and distillate fuel oil), the prices of which would increase as a result of an increase in the imported price of crude oil, the agricultural sector would encounter higher energy costs.[1] Next, the prices of various factors of production used by agriculture will increase as the input costs (primarily energy-related costs) to manufacturers rise. Finally, the available foreign exchange that might otherwise be used to purchase agricultural commodities will be diverted to the energy (crude oil) sector.[2]

[1] Energy is a significant component of the cost of producing agricultural commodities. In 1986, for example, energy costs accounted for approximately 15 percent of the variable cost of producing a bushel of soybeans, about 19 percent of the variable cost of producing a hundred weight of rice, around 9 percent of the variable cost of producing a bushel of corn and almost 4 percent of the variable cost of producing 100 pounds of milk. (USDA, 1987b) reports these and other daa.) Of these various energy costs, on average and across states and farm sizes, refined petroleum products account for approximately 65 percent of the total. (See USDA (1987a) for more on energy consumption by agriculture.)

[2] The issue of competition for foreign exchange is quite significant for agriculture and correspondingly, it has been studied extensively. A survey of the relevant analysis will not be provided here. Rather, the interested reader is referred to, for example, Abbott (1984) and Sharples and Dixit (1988).

To adequately understand the implications of energy policy initiatives in general and an oil import fee in particular, there must be aggregate measures of the potential benefits and potential costs of the initiatives as well as an identification of which groups stand to gain and which groups stand to lose in order to effectively address the equity considerations as well as the efficiency considerations associated with the initiative. Because this has not heretofore been done, at least in the current debate on an oil import fee, in which follows a disaggregated analysis will be performed using a computable general equilibrium model. Before conducting the analysis, however, a brief overview of the model will be provided.

II. A General Equilibrium Model

A. Introduction

The use of a general equilibrium approach to modeling energy impacts is a logical decision.[3] The interactions between supply and demand, both within the energy markets as well as between these markets and the rest of the economy, are quite significant. Thus, for example, interfuel substitution is a widely recognized phenomenon[4] and the various energy interruptions and price increases have been shown to have important impacts on the remainder of the economy.[5]

Table 1 details the specific producing sectors and types of consumer goods and services considered in the general equilibrium model. The various household categories (classified by income) are delineated in Table 2. This choice of the level of disaggregation was predicated on the availability of data and on the economic variables (producing and consuming sectors and income categories) that are of interest.

B. A General Equilibrium Model[6]

1. Production

The production sector of the general equilibrium model is composed

[3] General equilibrium models in general are not going to be reviewed here. The interested reader is referred to, e.g., Adelman and Robinson (1978), Ballard, et al., (1985), and Harberger (1962, 1974).

[4] See, e.g., Uri (1982a) for more on this.

[5] See, e.g., Darby (1982) and Uri (1982b).

[6] A comprehensive description of the general equilibrium model together with its parameterization is found in Boyd (1988).

Table 1

CLASSIFICATION OF PRODUCING SECTORS AND CONSUMER GOODS AND SERVICES

Industries	Consumer Goods
1. Manufacturing	1. Food
2. Mining	2. Alcohol and Tobacco
3. Service	3. Utilities
4. Chemicals and Plastics	4. Furnishings and Appliances
5. Food and Tobacco Products	5. Housing
6. Petroleum Refining	6. Clothing and Jewelry
7. Financial	7. Transportation
8. Forestry	8. Motor Vehicles
9. Crude Oil and Natural Gas	9. Financial and Other Services
10. Agriculture 1 — Program Crops	10. Reading and Recreation
11. Agriculture 2 — Livestock	11. Nondurable Household Items
12. Agriculture 3 — All Other Agriculture	12. Gasoline and Other Fuels
	13. Savings

Table 2

HOUSEHOLD CATEGORIES BASED ON INCOME

Category	Income Range
I	$0-9,999
II	$10,000-14,999
III	$15,000-19,999
IV	$20,000-29,999
V	$30,000-39,999
VI	$40,000 and over

of an input-output model with some flexibility with regard to the substitution of the factor inputs (capital, labor and land). The degree of flexibility depends, of course, on the choice of functional form for the production function. In the current model, each sector is assumed to have a constant elasticity of substitution (CES) production function[7] where the value added by the specific sector is a function of labor and capital.

[7] Little is gained by explicitly writing out the functional form of this production function since it is so well known. The novitiate, however, can refer to, e.g., Arrow, et al. (1961).

For four sectors,[8] a third factor of production — land — is included. This is done because of the special importance of this input to these sectors.[9] The incorporation into the production function of this factor is accomplished by nesting the CES production function. In particular, an input is defined which is solely a function (in CES form) of land and capital which, in turn, takes the place of capital in the original production function specification. While it would be possible to simply add land as an explicit input in the production function, this would implicitly assume that the elasticities of substitution between all pairs of inputs are the same. By nesting, however, the substitution elasticities are permitted to be different between different inputs.

2. Demand

The output of the twelve producing sectors accrues to the owners of the factors of production (i.e., land, labor and capital) which they sell. With the receipts from these sales, these individuals either consume domestic or foreign goods and services, save or pay taxes to the government. The savings are used for investment and the taxes are ultimately returned to these individuals.

The demand for final goods and services comes from three primary sources. First, final goods and services may be directly consumed by individuals. Second, investment (which is equal to savings) consumes some of the goods and services produced. Finally, foreign demand (in the form of exports) consumes a portion of the goods and services.

A review of Table 1 show that the composition of the consumer goods and services sectors does not match that of the producing sectors because the final goods and services produced by the producing sectors must go through various channels (i.e., transportation and distribution) before they can be consumed. To address this problem, a transformation matrix is introduced that defines the contribution of each producing sector to the composition of each of the final (consumer) goods and services.

For each category of households (refer to Table 2), utility is assumed to be a weighted constant elasticity of substitution function of the thirteen consumer goods and services. The weights on these goods and services (which are household category specific) are computed as the share of total purchases going to a specific consumer good or service. The nature of the CES utility function implies that the elasticity of substitution is the same

8 These sectors are the three agriculture sectors and the forestry sector.
9 See, e.g., Heady and Dillon (1961).

between any pair of goods and/or services. Because reliable estimates of the respective substitution elasticities across pairs of goods and/or services is difficult to obtain, they are assumed to equal one for all of the combinations. Finally, consumers get utility from the consumption of all goods and services including leisure (consumer good and service sector number 10). Hence, it is necessary to determine a weight for this factor in the utility function. For the purpose of the current analysis, this value is assumed to be 0.5 times labor income.[10] The net effect of adding leisure is to explicitly incorporate the fact that consumer not only derive utility from the act of consuming goods and services (which comes through owning the factors of production) but that they also derive utility from leisure. Thus, an increase in leisure can lead to an enhancement of individual well-being in the model.[11]

A household's budget constraint is defined such that expenditures on goods and services must be less than or equal to its income which is defined to equal its portion of the returns to labor plus the returns to capital plus the returns to land. That is, expenditures by a household must be less than or equal to the total factors payments it receives. Maximizing utility subject to this expenditure constraint gives the demand for the various goods and services by household categories.[12] Observe that since savings is considered as one of the items in an individual's utility function, the choice between consumption and savings is made explicit. That is, intertemporal tradeoffs are an integral part of the model.

The second component of the demand for goods and services is investment. Like the final demand by individuals, total investment is disaggregated (through a transformation matrix) by the sector of the economy that produces it. For the purpose of constructing the general equilibrium model and calibrating it, investment is taken directly from the national income and product accounts (as compiled by the Bureau of Economic Analysis of the U.S. Department of Commerce) and, since savings are assumed to exactly equal investment, personal savings are scaled to equal the gross investment observed (measured) for each of the twelve producing sectors.

The final component of demand for goods and services is the demand by foreign consumers. In the model exports (i.e., foreign demand) for delineated by producing sector. That is, a transformation matrix

10 See Boyd (1988) for a discussion of the choice of this value.

11 The astute reader will note that with this specification, there is an explicit treatment of the labor-leisure tradeoff. See, e.g., Deaton and Muellbauer (1980) for more on this.

12 See, e.g., Mixon and Uri (1985), Chapter 5.

analogous to that used for the consmuption of final goods and services is not used. A similar delineation is employed for imports (i.e., foreign supply). The exports and imports are then scaled so that the total foreign account is balanced. By employing elasticity estimates (both demand and supply) found in the literature, export and import demand relationships are constructed for each producing sector.

3. Taxes

Although not used as a policy alternative in the analysis the impact of an oil import fee directly, the government and its tax receipts do enter into the general equilibrium model specification and they do impact the model results with regard to factor use, factor prices and output.

First, there is a question of how to treat the government in a general equilibrium model. For the purpose at hand, it is treated as a separate sector with a constant elasticity of substitution utility function. That is, it is greated in a fashion analogous to one of the household sectors. The elasticity of substitution is assumed to be one.[13] The government collects tax revenue in various forms. The explicitly considered taxes include the personal income tax, labor taxes (e.g., a social security tax), capital taxes (e.g., a corporate income tax), property taxes, and sales and excise taxes. All of the taxes are treated as ad valorem taxes and a marginal rate is used for each household category, consumer good or service, producing sector and factor input.[14] In this respect, the model is a distinct improvement over earlier general equilibrium models which simply employed lump sum transfer schemes or used average tax rates.

With the tax revenues collected, the government produces public goods and redistributes income. Hence, all tax revenue is eventually returned to consumers in the form of transfer payments or subsidies or in the form of payments for capital or labor services (the two factors of production used by the government).

C. *A Mathematical Statement of the Model*

Given these foregoing considerations, it is useful to state precisely the conditions that the model being used here must satisfy for a general equilibrium to exist. First, there cannot be positive excess quantities

13 This means that the production function collapses to a Cobb-Douglas-type production function.

14 Note that in this model, labor is treated as a variable commodity that is subject to taxation.

demanded. That is,

$$(1) \qquad \sum_i a_{ij} M_j - E_i (p, Y) \geq 0 \qquad \text{for c.s. } p_i \geq 0$$

and where i ($i = 1, 2, \ldots, n$) denotes the consumer goods and services, M_j ($j = 1, 2, \ldots m$) denotes the activity levels, a_{ij} denotes the ij th elements in the activity analysis matrix, Y denotes a vector of incomes for the k consumers, p denotes a vector of prices for the n consumer goods and services and E_i denotes the excess demand for good or service i.

The notation c.s. implies that complementary slackness holds for each consumer good and service. That is, if the expression (for a specific good or service i) is multiplied by p_i, then the relationship will hold with equality.[15]

The second requirement for general equilibrium is that the profits associated with a given activity are not positive. That us,

$$(2) \qquad -\sum_i a_{ij} p_i \geq 0 \qquad \text{for c.s. } M_j \geq 0.$$

Finally, all prices and activity levels must be non-negative. That is,

$$(3a) \qquad p_i \geq 0; \qquad i = 1, 2, \ldots, n$$

and

$$(3b) \qquad M_j \geq 0; \qquad j = 1, 2, \ldots, m.$$

The model is solved for a general equilibrium using the iterative algorithm nominally referred to as the Sequence of Linear Complementary Problems (SLCP) developed by Mathiesen (1985a, 1985b.)

D. Data for the 1984 Base Year

The general equilibrium model is calibrated for 1984. For the producing sectors (the twelve enumerated in Table 1), data on capital receipts and taxes are computed from data obtained directly from the Bureau of Economic Analysis of the U.S. Department of Commerce, the U.S. Department of Agriculture, the U.S. Department of Energy and from Hertel and Tsigas (1987). The various elasticities of substitution employed in the analysis were obtained from a variety of sources in the literature on

15 See, e.g., Takayama and Uri (1983).

estimating production functions.[16]

Capital income (earnings) and labor income were obtained from the Bureau of Economic Analysis of the U.S. Department of Commerce. Land income was estimated using factor shares obtained from the Economic Research Service of the U.S. Department of Agriculture and applied to the capital income component noted above.

Data on expenditures on each of the thirteen goods and services by each of the six household categories were obtained from the *Consumer Expenditure Survey: Interview Survey, 1984.*[17] By combining this information with the number of households in each household (income) category (these data come from a Bureau of Economic Analysis), the aggregate expenditures on each category of consumer goods and services by each household category were computed.

The various tax rates used in the analysis were obtained from a variety of sources including the Internal Revenue Service, the Economic Research Service of the Department of Agriculture, Hertel and Tsigas (1987) and Ballard, Fullerton, Shoven and Whalley (1985). These rates, as noted previously, are marginal rates.

The value of exports and imports in 1984 were taken from the *Survey of Current Business* (various issues) with the exception of the energy data which were obtained from the Energy Information Administration of the U.S. Department of Energy and the agriculture data which were obtained from the Economic Research Service of the U.S. Department of Agriculture.

III. General Equilibrium Results

Before discussing the results of the general equilibrium model, several items need to be mentioned. First, as observed in a preceding section, the model is solved by the SLCP algorithm of Mathiesen.

Next, the magnitude of the effect that an oil import fee will have on the quantity of crude oil imported into the United States is an important consideration. Consequently, in an ancillary analysis,[18] the authors empirically estimate this magnitude based on a time series of historical data

16 Boyd (1988) has the details on where the values of the elasticities of substitution were taken from.

17 See Bureau of Labor Statistics (1986) for the complete reference.

18 See Uri and Boyd (1988).

(quarterly) covering the period 1973 QI through 1987 QII. The results suggest that, for the long run, a one percent increase in the price of crude oil leads to a reduction in the quantity imported by 1.17 percent.[19] Because of the importance of this value to the inferences darwn, however, sensitivity analyses are conducted where the responsiveness of crude oil imports to an increase in the price of crude oil is allowed to vary by one standard deviation in both directions around this estimated value.

Finally, before presenting the results and as noted previously, the model is calibrated based on 1984 data. Reference prices for all activities (both producing and consuming) are normalized to one. Changes in the model from this reference calibration (which hereafter will be referred to as the Reference Case) in response to some perturbation(s) are not fully exhausted (that is, the cumulative total impact is not reached) for approximately five to six years after the perturbation(s) occur(s). That is, a new equilibrium will not be realized until approximately 1990. This is simply because of the intertemporal optimization on the part of consumers which is incorporated into the model. Therefore, in assessing, say, the impact of all oil import fee, the model equilibrium (i.e., the equilibrium vector of prices and quantities) represents the cumulative effect of the oil import fee between approximately 1984 and 1990. During this period, the implicit assumption is that the price of crude oil will not change either from the Reference Case (if this is the case being considered) or from the Oil Import Fee Case (if this is the case being considered) in response to factors other than normal market forces. That is, it is not assumed, for example, that the price of crude oil has a built-in exogenous increase (or decrease) of some predetermined percentage.

The Reference Case results (both quantities and normalized prices) are presented in Table 3, Table 4 and Table 5 for the producing sector, the consuming sector, and households (income categories), respectively. Note that the nominal values of the quantities are in hundreds of billions of 1984 dollars. The sector numbers and category numbers correspond to those used in Table 1 and Table 2. By themselves, the values found in Table 3 through Table 5 provide little useful information beyond showing how the model is calibrated. Rather, the significance of the general equilibrium model and of the equilibrium values is in how these values change in response to some policy initiative(s) that perturb(s) the general equilibrium. With this in mind, the impact on the general equilibrium will be addressed where it is assumed that a $5.00 per barrel fee is levied on crude oil imported into the United States. This particular figure (i.e., $5.00 per

[19] The standard error of this estimate is 0.52.

Table 3

REFERENCE CASE — EQUILIBRIUM PRICES (NORMALIZED) AND QUANTITIES (IN HUNDREDS OF BILLIONS OF DOLLARS) FOR THE PRODUCING SECTORS

Sector	Price	Quantity
1	1.00000	18.8762
2	1.00000	0.46231
3	1.00000	23.7818
4	1.00000	2.27376
5	1.00000	3.50580
6	1.00000	1.61239
7	1.00000	5.54883
8	1.00000	0.10592
9	1.00000	1.29059
10	1.00000	0.45214
11	1.00000	1.09923
12	1.00000	0.61131

Table 4

REFERENCE CASE — EQUILIBRIUM PRICES (NORMALIZED) AND QUANTITIES (IN HUNDREDS OF BILLIONS OF DOLLARS) FOR THE CONSUMING SECTORS

Sector	Price	Quantity
1	1.00000	4.52072
2	1.00000	0.83301
3	1.00000	1.17792
4	1.00000	1.46137
5	1.00000	3.74070
6	1.00000	1.83322
7	1.00000	0.28041
8	1.00000	1.46336
9	1.00000	5.84739
10	1.00000	1.66132
11	1.00000	0.67238
12	1.00000	0.91156
13	1.00000	3.03333

Table 5

REFERENCE CASE — EQUILIBRIUM UTILITY LEVELS
(IN HUNDREDS OF BILLIONS OF DOLLARS) BY HOUSEHOLD CATEGORIES

Category	Utility Level
I	2.23826
II	2.10802
III	2.42417
IV	6.01311
V	5.49734
VI	13.7363
Government	7.45752

barrel) was selected because it has been considered by others.[20]

Table 6, Table 7 and Table 8 present the general equilibrium values for prices and quantities for the producing sector, consuming sector and households, respectively as a result of imposing a $5.00 per barrel crude oil import fee. The higher price of crude oil (both the domestic price and the imported price) as a result of this import fee will have several effects. Consider the producing sector first. Domestic output of crude oil will rise by 4.114 percent (that is, by $5.309 billion) as crude oil imports fall (due to the oil import fee) by about 37.437 percent[21] and as the domestic price of crude oil rises by 0.064 percent.[22] In response to the overall higher price of crude oil, total output in the other producing sectors (with the exception of the financial sector) will fall by 0.239 percent or by about $13.924 billion. The financial sector is an anomaly because its output is a non-

20 In particular, the studies by the Department of Energy (1987) and Hogan and Mossavar-Rahmani (1987) and Yanchar and Caton (1987) all consider this value.

21 Note that in order to limit the number of tables, some of the equilibrium prices and quantities will not be explicitly presented although selected values will be discussed. Such is the case with the import prices and quantities. The omitted tables are available from the authors upon request.

22 By way of explaining the results, many of the interrelationships between markets are self-evident and hence the simultaneous nature of these relationships will not be discussed. Thus, for example, domestically produced crude oil is a near perfect substitute for imported crude oil. As a result, an increase in the price of imported crude oil due to an oil import fee will lead to the substitution of domestically produced crude oil for imported crude oil and therefore to a higher price and larger quantity demanded for domestically produced crude oil. That is, the demand for domestically produced crude oil will increase and the explained results will follow. These sorts of interrelationships will not be examined in detail but are implicit in the analysis.

Table 6

$5.00 PER BARREL IMPORT FEE CASE — EQUILIBRIUM PRICES (NORMALIZED) AND QUANTITIES (IN HUNDREDS OF BILLIONS OF DOLLARS) FOR THE PRODUCING SECTORS

Sector	Price	Quantity
1	1.00000	18.8020
2	1.00024	0.45865
3	1.00007	23.7539
4	1.00015	2.26591
5	0.99886	3.49871
6	1.00051	1.59823
7	1.00041	5.55214
8	0.99995	0.10493
9	1.00064	1.34368
10	0.99692	0.44922
11	0.99676	1.09670
12	0.99721	0.61006

Table 7

$5.00 PER BARREL IMPORT FEE CASE — EQUILIBRIUM PRICES (NORMALIZED) AND QUANTITIES (IN HUNDREDS OF BILLIONS OF DOLLARS) FOR THE CONSUMING SECTORS

Sector	Price	Quantity
1	1.99942	4.52352
2	0.99947	0.83348
3	1.00007	1.17763
4	1.00003	1.46105
5	1.00038	3.73873
6	1.00006	1.83280
7	1.00007	0.28034
8	1.00007	1.46299
9	1.00007	5.84596
10	0.99997	1.66111
11	1.00012	0.67218
12	1.00029	0.91115
13	1.00001	3.03257

Table 8

$5.00 PER BARREL IMPORT FEE CASE — EQUILIBRIUM UTILITY LEVELS (IN HUNDREDS OF BILLIONS OF DOLLARS) BY HOUSEHOLD CATEGORIES

Category	Utility Level
I	2.23817
II	2.10790
III	2.42392
IV	6.01230
V	5.49653
VI	13.7363
Government	7.49374

traded good. As such, the (equilibrium) price and quantity behave as expected for this type of good.[23] With regard to the observed results, output falls for a couple of reasons. First, with a higher price of crude oil, the price of one of the intermediate inputs into the production process rises and, given the aforementioned requirement that the equilibrium conditions in all markets must be met, factor use (in physical terms) falls and consequently, output declines. Hence, as an example, with the oil import fee leading to a higher energy price, output in the manufacturing sector will decline by 0.393 percent.[24] Second, with a higher import price of crude oil leading to a reduction in available foreign exchange, there will be a reduction in the quantity demanded by foreigners by domestically produced goods and services with a corresponding reduction in production. The most heavily impacted producing sectors (in terms of a reduction in output) are the forestry sector (experiencing a 0.935 percent fall in output), the petroleum refining sector (experiencing a 0.878 percent decline in output) and the mining sector (experiencing a 0.792 percent reduction in output). The beneficiary, in terms of expanded output, will be the crude oil industry as noted above.

What will happen in the three agriculture sectors plus the forestry sector? Output in the program crops sector will fall by 0.646 percent (or by $292 million), output in the livestock sector will decline by 0.230 percent (or by $253 million) and output in the all other agriculture commodities

[23] The theory of non-traded goods is not developed here. The interested reader rather is referred to, e.g., Caves and Jones (1981, pp. 90 ff.) for a complete analysis.

[24] This is not meant to imply that a higher energy price will be the sole cause of a reduction in output. It will be the primary cause of such a reduction, however.

sector will be reduced by 0.204 percent (or by $125 million). Thus, an oil import fee of $5.00 per barrel stands to potentially impose significant costs, in terms of reduced output, on the agriculture sector (consisting of the three agriculture sectors plus the forestry sector) of about $769 million in the aggregate.

Accompanying the reduction in agricultural output is a fall in the prices of the agricultural commodities. Thus, for example, the price of the output of program crops will decline by 0.324 percent, the price of the output of the livestock sector will fall by 0.279 percent, the price of the outout of all other agricultural commodities will decrease by 0.069 percent and the price of the output of forestry products will fall by 0.005 percent. While these price decreases might seem anomalous at first, they are not when considered in the context of a general equilibrium. Simply recall that the imposition of a crude oil import fee leads to a reduction in the quantity of agricultural commodities demanded (due to a lower quantity of foreign exchange). This, in turn, will result in lower prices for the agricultural commodities. Additionally, this reduction more that offsets the increase in the costs of the factors of production to agriculture as the result of the higher energy (crude oil) price. The net effect, then, is a fall in the prices of the various agricultural commodities.

With regard to the consuming sectors, the oil import fee in general results in slightly higher prices for the various goods and services. The exceptions are for the food sector and the alcohol and tobacco sector.[25] The higher prices for goods and services leads to a reduction of the quantities of these goods and services consumed. Thus, overall as a result of a $5.00 per barrel oil import fee, consuming sector prices will increase by 0.0002 percent and the aggregate quantity consumed will fall by 0.0116 percent ($318 million). This aggregate result, however, masks the effect that the import fee will have on specific goods and services. Sector specific results are more telling. For example, the import fee will reduce consumption in housing sector by 0.053 percent, in the gasoline and other fuels sector by 0.045 percent and in the motor vehicles sector by 0.025 percent. The oil import fee will lead to an increase in consumption in the food sector and in the alcohol and tobacco sector. In understanding this result, recall that the import fee leads to a reduction in the quantity of agricultural commodities demanded and hence to a lower price for the various agricultural commodities. As a consequence, the quantities of these commodities demanded by domestic consumers will rise, all other things constant. All other things, however, are not constant as the income of consumers (from

25 The reading and recreation sector experiences a barely perceptible decline.

labor and capital) falls reducing the demand for all commodities (as the budget line shifts). The net effect, nevertheless, of the changes in relative prices and in income is an increase in the quantity demanded of the agriculture related goods, namely food and alcohol and tobacco.

Utility falls for five of the six household categories. The aggregate reduction in utility is 0.0065 percent ($208 million) for all household categories. The reduction does not fall evenly across households, however. Category VI households (i.e., those with incomes in excess of $40,000) experience no reduction in utility while Category V households suffer a 0.0147 percent ($81 million) reduction in utility with the remaining household categories incurring reductions in utility of lesser magnitudes. Additionally, when all of the effects of an oil import fee are considered (that is, both the direct and the indirect effects), such a fee is not, in general, regressive. That is, it does not fall most heavily on the lowest household (income) category and progressively less heavily on households with larger incomes. Rather, as noted, the effect increases (in both relative and absolute terms) up to Household Category V. Household Category VI is not appreciably impacted because, in the general equilibrium framework, while the prices of the goods and services it consumes do rise, its income, of which a disproportionately large share (relative to the other household categories) comes from capital, rises as well. This has the effect of offsetting the negative impact on utility of the higher prices (and lower quantities demanded) of the various consumer goods and services.

The government is the other beneficiary (besides the crude oil industry) of the oil import fee. Since the fee accrues to the government, its income increases leading to an increase in utility of 0.486 percent or about $3.622 billion. This, in turn, expands transfer payments and the provision of public goods and so on since it has been assumed that in equilibrium the government has a balanced budget.

In sum, then, the impact of a $5.00 per barrel fee on imported oil will be a reduction in output by all producing sectors (except crude oil) of 0.239 percent or about $13.924 billion including a fall in output by the agricultural sectors of 0.340 percent or about $769 million, a reduction in the consumption of goods and services by about 0.0116 percent or $318 million, a fall in total utility by 0.0065 percent or $208 million and an increase in crude oil output of 4.114 percent or $5.309 billion and increased revenue (from the import fee) for the government of $3.622 billion.[26]

[26] In the analysis, the impacts of a $5.00 per barrel import fee have been discussed. In other sequence of computations, however, the impacts of a $10.00 per barrel crude oil import fee were examined. The results from this suggest that a $10.00 per barrel fee would

From these estimates, it is possible to identify specific benefits and costs to producers, consumers and households plus the government as the result of the imposition of an oil import fee whose objective is to enhance energy security. Once these benefits and costs have been identified, the efficiency and equity consequences can be evaluated and relevant questions answered. Thus, for example, is it justifiable to impose costs on, e.g., the agricultural producing sectors, of the magnitudes computed here for the sake of mitigating the potential future costs of an interruption in the supply of foreign crude oil? Answers to such questions, obviously, are subjective and, hence, are not provided here. The analysis, nevertheless, provides a firm foundation from which policy makers and other groups which stand to gain or lose (e.g., farmers) as the result of the policy initiative can proceed.

IV. A Comparison

How do the results obtained here compare with those obtained by others? Other recent available studies do not provide disaggregated (i.e., by producing and consuming sectors and by household categories) estimates of the impact of an oil import fee. They indicate only aggregate values. Thus, for example, the Department of Energy (1987) concludes that the aggregate value of output (Gross National Product) will fall by between $12 billion and $20 billion (depending on the world price of oil). This is on the order of one and one-half of two times larger than the value obtained here. The Department of Energy's estimated welfare loss by households is put at between $370 million and $540 million (depending on the world price of oil). These values likewise are one and one-half of two times as large as the value computed here.

No claim to more realistic values for this study over those of the Department of Energy estimates is made. It should be realized, however, that the model developed here is a general equilibrium model — which by its nature will reflect both the direct as well as the indirect impacts of any policy initiative — whereas the model used by the Department of Energy is a partial equilibrium model and hence will not capture all of the relevant interrelationships.

lead to a decline in output by the producing sector of 0.81 percent, a fall in consumption of goods and services by 0.04 percent and a loss of total utility of 0.02 percent. Government revenues, on the other hand, would increase by 0.53 percent while the output of the domestic crude oil industry would expand by 8.21 percent. A complete analysis of this $10.00 per barrel Oil Import Fee Case is available from the authors upon request.

V. Sensitivity Analysis

No analysis is complete without an examination of the sensitivity of the results to key assumptions. In the foregoing discussion, many assumptions were made with regard to model structure and parameter estimates. A full examination and discussion of these assumption would be almost impossible. Consequently, only the results from the sensitivity analysis of one crucial assumption will be discussed. Namely, what are the effects on the vector of equilibrium prices and quantities of the assumption concerning the crude oil import elasticity? Recall that the estimated (i.e., point estimate) crude oil import elasticity used in the model is −1.17 with a standard error of 0.52. Two separate sets of sensitivity results will be considered. The first set of results is for the case in which the crude oil import elasticity is assumed to be one standard deviation below the estimated value[27] and the second set of results is for the case in which the elasticity is assumed to be one standard deviation greater than the estimated value.

Consider the general equilibrium results where it is assumed that the crude oil import elasticity is one standard deviation less than the absolute value of the point estimate. For a $5.00 per barrel fee on all crude oil imported, output by all producing sectors (except crude oil) will fall by 0.186 percent while consumption of goods and services will decline by approximately 0.0101 percent. Total utility, on the other hand, will remain virtually unchanged. Crude oil output will rise by 2.510 percent while government revenues will expand by $4.007 billion. Thus, the reduction in output will be slightly less if the lower oil import elasticity is, in fact, the correct value while domestic crude oil output and government revenues will likewise be lower with the lower elasticity. Sector specific effects and household category effects are consistent with those found when the higher elasticity value is used with the exception that the magnitudes of the indicated changes are somewhat smaller. Thus, for example, aggregate output in the three agricultural sectors plus forestry will fall by $610 million or 0.269 percent.

Now consider the change in the general equilibrium if it is assumed that the crude oil import elasticity is one standard deviation larger (in absolute terms) than the point estimate initially used. In this instance, producing sector output will fall by 0.259 percent, consumption of goods and services will be reduced by 0.016 percent and utility will decline by 0.009 percent. These values are a somewhat larger than the general equilibrium values obtained when the original point estimate of the crude oil import

[27] This estimated value, it will be recalled, was used in the foregoing analysis.

elasticity is used. Both government revenues and crude oil output will expand by more than they would in the situation where the original point elasticity estimate is used. In particular, government revenues will rise by $3.399 billion while crude oil output will increase by 4.649 percent. Sector and household category specific changes move in a consistent fashion (i.e., consistent with previous changes) with no anomalous fluctuations. Thus, for example, total output in the three agricultural sectors plus the forestry sector will fall by $795 million or 0.351 percent.

These sensitivity results suggest that the value of the crude oil import elasticity, while important in the determination of a general equilibrium and significant in determining the implications of a policy initiative affecting crude oil, is not so pivotal to the model that an error in its value leads to misleading and nonsensical results.

VI. Conclusion

The foregoing analsysis has examined the impact of an oil import fee on the United States economy. The analytical vehicle used in the analysis consisted of a general equilibrium model composed of twelve producing sectors, thirteen consuming sectors, six household categories classified by income and a government. The effect of a $5.00 per barrel crude oil import fee on prices and quantities is examined. Over the period 1984-1990, such a fee would result in lower output by the non-crude oil producing sectors (by about $13.924 billion), lower consumption of goods and services (by about $318 million), and a reduction in welfare (by about $208 million). The government will realize an increase in revenue of about $3.622 billion while the domestic crude oil industry will experience an increase in output of approximately $5.309 billion.

For the agricultural sectors, output overall will fall. Specifically, for the program crops sector, output will decline by $292 million, for the livestock sector, output will fall by $253 million, for all other agricultural commodities, output will decline by 125 million and for forestry, output will be reduced by $69 million. Attendant with these reductions in output will be lower prices for the respective commodities.

Finally, the results when subjected to a sensitivity analysis are fairly robust with regard to the assumption of the value of the crude oil import elasticity. That is, while the model's equilibrium values do vary in response to different assumptions of the value of this elasticity, the fluctuations are not so enormous to suggest that the model is unrealistically sensitive to this parameter nor do the likely effects of an energy policy

initiative involving crude oil imports dramatically change.

As a consequence of this analysis, the implications of a $5.00 per barrel fee on imported oil are clear to the agricultural sector in the aggregate. Namely, the sector will be confronted with declining output and falling prices in the face of an energy policy directed at imposing a crude oil import fee. Whether the agricultural sector wishes to remain silent and not participate in the energy policy debate and hence mutely incur these costs can only be determined by the sector itself.

References

Abbott, P.C., *Foreign Exchange Constraints to Trade and Development,* U.S. Department of Agriculture, Washington, 1984.

Adelman, I. and S. Robinson, *Income Distribution Policy in Developing Countries,* Oxford University Press, Oxford, 1978.

Arrow, K.J., Chenery, H.B., Minhas, B.S. and R.M. Solow, "Capital-Labor Substitution and Economic Efficiency," *Review of Economics and Statistics,* 43, 1961, 225-235.

Ballard, C.L., Fullerton, D., Shoven, J.B. and J. Whalley, *A General Equilibrium Model for Tax Policy Evaluation,* The University of Chicago Press, Chicago, 1985.

Boyd, R., "The Direct and Indirect Effects of Tax Reform on Agriculture," Technical Bulletin Number 1743, Economic Research Service, U.S. Department of Agriculture, Washington, D.C., February 1988.

Bureau of Labor Statistics, *Consumer Expenditure Survey: Interview Survey, 1984,* U.S. Government Printing Office, Washington, 1986.

Caves, R.E. and R. Jones, *World Trade and Payments,* 3rd ed., Little, Brown and Company, Boston, 1981.

Council of Economic Advisors, *Economic Report of the President,* U.S. Government Printing Office, Washington, 1983.

Darby, M.R., "The Price of Oil and World Inflation and Recession," *American Economic Review,* 72, 1982, 738-751.

Deaton, A. and J. Muellbauer, *Economics and Consumer Behavior,* Cambridge University Press, Cambridge, 1980.

Department of Energy, *Energy Security,* U.S. Government Printing Office, Washington, March 1987.

Harberger, A., "The Incidence of Corporate Taxation," *Journal of Political Economy,* 70, 1962, 215-

240.

———, *Taxation and Welfare,* University of Chicago Press, Chicago, 1974.

Heady, E.O. and J.L. Dillon, *Agricultural Production Functions,* Iowa State University Press, Ames, Iowa, 1961.

Hertel, T.W. and M.E. Tsigas, "Tax Policy and U.S. Agriculture: A General Equilibrium Analysis," Staff Paper No. 87-2, Department of agricultural Economics, Purdue University, West Lafayette, Indiana, February 1987.

Hogan, W.W. and B. Mossavar-Rahmani, *Energy Security Revisited,* Harvard University, Cambridge, 1987.

Mathiesen, L., "Computational Experience in Solving Equilibrium Models by a Sequence of Linear Complementary Problems," *Operations Research,* 33, 1985a, 1225-1250.

———, "Computation of Economic Equilibrium by a Sequence of Linear Complementary Problems," *Mathematical Programming Study,* 23, 1985b.

Mixon, J.W. and N.D. Uri, *Managerial Economics,* Macmillan Publishing Company, New York, 1985.

Sharples, J.A. and P.M. Dixit, *Forces that Could Expand U.S. Wheat Exports,* U.S. Department of Agriculture, Washington, January 1988.

Takayama, T. and N.D. Uri, "A Note on Spatial and Temporal Price and Allocation Modelling," *Regional Science and Urban Economics,* 13, 1983, 455-470.

United States Department of Agriculture (USDA), *Energy and U.S. Agriculture,* USDA, Washington, March 1987a.

———, *Economic Indicators of the Farm Sector: Costs of Production,* USDA, Washington, November 1987b.

Uri, N.D., *The Demand for Energy and Conservation in the United States,* JAI Press, Inc., Greenwich, 1982a.

———, "Testing for the Stability of the Investment Function," *Review of Economics and Statistics,* 64, 1982b, 117-125.

Uri, N.D. and R. Boyd, "Crude Oil Imports in the United States," *Applied Energy,* 31, 1988, 101-118.

Yanchar, J. and C. Caton, "Energy Taxes: Still Not a Good Idea," *Data Resources U.S. Review,* Lexington, Massachusetts, March 1987.