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Partial- And General-equilibrium Evaluations Of The Impact Of Energy Policies In Canada

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PARTIAL- AND GENERAL-EQUILIBRIUM EVALUATIONS OF THE IMPACT OF ENERGY POLICIES IN CANADA

by

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ABSTRACT

This dissertation is primarily concerned with evaluating the welfare implications of the National Energy Program (NEP) for Canada in static, partial- and general-equilibrium frameworks. Foreign participation in the Canadian economy is incorporated in analyzing the allocational and distributional effects of these petroleum pricing and fiscal policies.

The international redistribution of crude oil rents as well as efficiency and intranational revenue redistribution effects of both NEP pricing and fiscal policies on the Canadian crude oil market are addressed in partial-equilibrium analyses.

A unique and relatively simple approach to general-equilibrium modelling (developed in association with John Whalley) is used to analyze the welfare effects of the NEP petroleum pricing policies. The basic model uses the assumption that Canada is a taker of commodity prices on world markets in solving the zero profit conditions to determine cost covering factor prices from given world goods prices. Full employment conditions for factors then determine industry production levels. Once domestic demands are calculated, excess demands for goods are obtained as a residual. The basic approach allows for further complicating structural elements such as foreign participation, price controls, taxes and non-traded goods to be introduced as required.

The NEP pricing and fiscal policies resulted in overconsumption and underproduction of petroleum in Canada compared to the levels of consumption and production that would have resulted from market-determined petroleum pricing and in the absence of the NEP fiscal policies. While allocational inefficiencies reflect a Canadian welfare loss, petroleum rents were also redistributed between foreigners and Canadians. The empirical results suggest that the transfer of rents from foreign producers to Canadians, reflected in a Canadian welfare gain, was not insignificant; indeed, it is found to have dominated the efficiency losses in consumption and production.

A procedure is also developed for calculating compensating and equivalent variation from market demand information. As a corollary to this latter work, it is shown that, under certain conditions, a partial-equilibrium analysis employing consumer's and producer's surpluses is capable of yielding as valid a representation of welfare change (i.e., compensating variation) as that achieved using the general-equilibrium modelling technique.

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The views expressed herein are entirely my own and should not be attributed to any of the above-mentioned individuals or institutions. I also assume full responsibility for any errors in the paper.

I dedicate this paper

to my wife,

Antonietta Lenjosek

to my mother,

Audrey A. Lenjosek

and to
the memory of
my father,

Joseph A. Lenjosek

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LIST OF ABBREVIATIONS

ABP, Alberta Border Price for gas

AERCB, Alberta Energy Resources Conservation Board

CIT, Corporate Income Tax

COGA, Canada Oil and Gas Act

COCLR, Canada Oil and Gas Land Regulations

COOP, Conventional Old Oil Price

COP, Conventional Oil Reference Price

COSC, Canadian Ownership Special Charge

IORT, Incremental Oil Revenue Tax

ITC, Investment Tax Credit

MDIP, Market Development Incentive Payments

MOA, September 1, 1981, Canada-Alberta Memorandum of Agreement on energy pricing and taxation

NDP, Net Domestic Product (at market prices)

NEB, National Energy Board

NEP, National Energy Program of October 28, 1980

NGGLT, Natural Gas and Gas Liquids Tax

NORP, New Oil Reference Price

OEC, Oil Export Charge

OICP, Oil Import Compensation Program

OPEC, Organization of Petroleum Exporting Countries

OSRP, Oil Sands Reference Price

PCC, Petroleum Compensation Charge

PGRT, Petroleum and Gas Revenue Tax

PIP, Petroleum Incentives Program

PIR, Progressive Incremental Royalty

RCT, Royal Commission on Taxation

SCC, Special Compensation Charge

SOOP, Special Old Oil Price

TAP, Transportation Assistance Program

TCGP, Toronto City Gate Price of gas

TCPL, TransCanada PipeLines

TRAC, Toronto Refinery Acquisition Cost of crude oil

TWP, Toronto Wholesale Price of gas

VRIP, Volume Related Incentives Program

INTRODUCTION

1. Purpose of the Study

This dissertation is primarily concerned with evaluating the welfare implications of the National Energy Program (NEP) for Canada. Foreign participation in the Canadian economy is incorporated in analyzing the allocational and distributional effects of these petroleum pricing and fiscal policies. Empirical investigations are conducted within both partial- and general-equilibrium frameworks. A procedure is also developed for calculating compensating and equivalent variation from market demand information. As a corollary to this latter work, it is shown that, under certain conditions, a partial-equilibrium analysis employing consumer's and producer's surpluses is capable of yielding as valid a representation of welfare change (i.e., compensating variation) as that achieved using the general-equilibrium modelling technique.

2. The NEP Regime[1]

Beginning with the National Oil Policy of 1961 and ending with the implementation of the Western Accord on June 1, 1985, the market for crude oil in Canada has been subject to some form of price control. Canadian energy policy did not become particularly contentious, however, until the first world oil price shock in 1973-74. The massive escalation in world oil prices at that time led to a much higher degree of government involvement in crude oil and natural gas markets than had previously been the case. Canadian energy policy became progressively more complex and interventionist in nature. Equity (revenue sharing), efficiency and supply considerations correspondingly increased in importance and contention.

In response to the first world oil price shock, a price ceiling was established and maintained for crude oil produced in Canada through periodic federal-provincial agreements, primarily to the benefit of energy users. Natural gas prices were also regulated, at least partially in response to the international situation, and linked to the price of crude oil. Federal subsidies were provided through the Oil Import Compensation Program (OICP) to reduce the cost of oil imports into eastern Canada to domestically controlled levels. The federal government derived oil revenues from the Oil Export Charge (OEC), income taxes, and sales and excise taxes. Provincial governments substantially raised royalty rates to capture a portion of the revenue windfall that would otherwise have been realised by producers. Provincial petroleum revenues were obtained from land bonus and rental payments, Crown royalties and freehold taxes, income taxes, and, generally, motive fuel taxes; but were reduced by various incentives offered for petroleum exploration and development. In their attempts to balance the interests of producers and consumers in line with their differing constitutional rights and governmental priorities, conflict between the two levels of government had become intense by the time of the second world oil price shock in 1979-80.

The NEP was announced unilaterally by the federal government on October 28, 1980, partly as a consequence of the second world oil price shock and partly due to the inability of the federal and provincial governments to reach a comprehensive agreement on oil and gas pricing and revenue sharing. The NEP was designed to achieve three basic objectives: equitable oil and natural gas revenue sharing; Canadianisation of the petroleum industry; and energy self-sufficiency. To achieve these goals, a significantly revised pricing and fiscal framework was outlined for crude oil and natural gas. The Program marked the beginning of a period characterised by bilateral federal-provincial energy agreements. A direct result of the NEP, the Canada-Alberta Memorandum of Agreement (MOA) on energy pricing and taxation was signed on September 1, 1981. Other federal-provincial energy agreements subsequently followed.

While modifications continued to be made to the petroleum pricing and fiscal regime throughout the period ending May 31, 1985, the basic tenets of the NEP were not significantly altered until the announcement of the Western Accord on March 28, 1985. The provisions of the Accord between the federal government and the governments of the three western producing provinces were generally effective as of June 1, 1985. Crude oil prices were deregulated; provision was made for the eventual deregulation of interprovincial natural gas prices; and all federal taxes and incentives implemented over the period 1973-85 were either eliminated or phased out. Thus, the NEP regime was effectively dismantled through the Western Accord.

A brief description of the NEP policies applicable to crude oil over the period January 1, 1981, to May 31, 1985, is provided below.

a) Pricing Policies

The NEP pricing regime for crude oil was comprised of two components: a complex system of price controls, which maintained prices for most domestic crude oil production below world price levels, and a "blended price" policy. Controlled prices were termed reference prices. Each reference price related to a particular quality of crude oil, defined with respect to density and sulphur content, within broad oil-classification categories.[2] These categories were generally based on the method used to recover the crude oil and the date of discovery of the crude oil reserve. Some reference prices were set at world price levels. Canada was also a small net importer of crude oil over the period of the NEP. The blended price policy, the successor to the OICP, was designed to subsidise the price of crude oil imports and higher-cost domestic production to the lowest, domestically-controlled, reference price levels, with the revenues needed raised through an additional tax on oil users. Through the blended price, NEP fiscal and pricing policies for crude oil became interdependent.

Effective January 1, 1981, crude oil production was separated into three categories for pricing purposes, distinguished by the method of recovery employed: oil recovery through conventional methods; oil recovery by means of tertiary oil recovery techniques; and oil recovery from oil sands mining operations.[3] A reference price and price schedule was established for each type of oil production. The Oil Sands Reference Price (OSRP) was essentialy set at quality-adjusted, world price levels; the tertiary oil reference price, at 80 percent of the OSRP; and the conventional oil reference price (COP) at 45 percent of the OSRP. The latter two reference prices were to rise in regular stages towards world price levels.

This initial price control system was modified through the 1981 energy agreements. Effective January 1, 1982, Canadian oil production was classified as either old or new for pricing purposes. Old oil essentially consisted of conventional and tertiary oil discovered prior to 1981. New oil included post 1980 conventional and tertiary oil discoveries, and oil from oil sands mining operations and the frontier areas of Canada. Reference prices for old and new oil were generally increased above NEP reference price levels. The Conventional Old Oil Price (COOP) was to rise more rapidly towards world levels than under the NEP, but was not to exceed 75 percent of the quality-adjusted, average cost of imported oil at Montreal, i.e., the deemed world price. The New Oil Reference Price (NORP) was to equal the world price.

An additional category of crude oil was introduced in the 1982 NEP Update. It applied to conventional oil discovered between April 1, 1974, and December 31, 1980, that was subject to reduced provincial royalty rates. The applicable reference price was termed the Special Old Oil Price (SOOP) and was set, effective July 1, 1982, at 75 percent of the quality-adjusted average price of imported oil at Montreal. The NORP was also extended, effective January 1, 1983, to oil from tertiary recovery projects and experimental projects that were subject to reduced provincial royalties.

Crude oil price controls were, once again, modified in the 1983 energy amending agreements. The COOP was frozen at its June 30, 1983, level of $29.75 per barrel subject to it neither exceeding, nor falling below 75 percent of, the world price level. The NORP was extended, effective July 1, 1983, to oil that had previously qualified for the SOOP as well as to various other types of oil production.

The reference prices and price schedules that characterized the NEP period were eliminated through the 1985 Western Accord. Crude oil prices were deregulated on June 1, 1985. In 1981, only about 10 percent of the oil produced in Canada was priced at world levels. By 1985, this had risen to over 50 percent with the creation of the SOOP and the later extension of the NORP to various types of Canadian production. Including imports, 75 to 80 percent of the oil refined in Canada in 1985 would have received the world price in the absence of deregulation.

The second component of the 1980 NEP pricing system was the blended price. The Petroleum Compensation Charge (PCC) was imposed on all oil refined in Canada, effective July 12, 1980. Revenues from the charge were used to subsidize Canadian refiners by an amount sufficient to reduce the average cost of both crude oil imports and higher cost domestic production to the average cost of domestic, conventional oil. As initially outlined, the blended price was not to exceed 85 percent of the lesser of the price of imported oil or the average price of oil in the United States (i.e., at Chicago). The 85 percent rule was replaced in favour of the 75 percent COOP rule as a result of the 1981 energy agreements. Further, the federal government agreed to adjust the level of the PCC as necessary so as not to generate any revenues in excess of those required to fully finance oil import compensation and higher-cost domestic production over the period 1981-86. When the PCC was eliminated on June 1, 1985, a deficit existed in the PCC account of approximately $1 billion.

The Government of Alberta cut back crude oil production from the province in early 1981 in reaction to the NEP. The resulting decrease in domestic supply could only be offset through increased imports of crude oil. In order to cover the cost of these additional imports, the federal government introduced the Special Compensation Charge (SCC). Effective from May 3 to September 21, 1981, the SCC worked in the same way as the PCC.

b) Fiscal Policies

A number of fiscal instruments, additional to those in effect from 1974-80, were introduced in the 1980 NEP. Those applicable to crude oil and oil products included the Petroleum and Gas Revenue Tax (PGRT), the PCC, the Canadian Ownership Special Charge (COSC), and the Petroleum Incentives Program (PIP). The SCC was implemented in early 1981. The federal Incremental Oil Revenue Tax (IORT) was outlined in the 1981 energy agreements. Numerous changes were made to the majority of these federal fiscal instruments as well as to provincial Crown royalties, and federal and provincial income taxes over the period of the NEP.

The NEP fiscal regime can be separated into two general categories: fiscal measures affecting the upstream or producing sector of the petroleum industry; and taxes affecting the downstream or refining sector of the industry. The PCC and the SCC, applicable to downstream activities, are discussed in the preceding section. A brief description of the remaining, major, petroleum fiscal instruments is provided below.

i) Provincial governments collect revenues, called land bonus and rental payments, from the sale of oil and gas leases. These leases convey the right for petroleum companies to explore for, develop and produce oil and gas reserves on provincial Crown lands.

ii) Provincial Crown royalties and freehold taxes are levied on the upstream, gross revenues of oil and gas producers. Royalty rates are generally both price and productivity sensitive, and differentiate between types of crude oil production based on the date of discovery of the crude oil reserves and the method of crude oil recovery employed. Oil discovered after 1973 is subject to lower rates than oil discovered before 1974. Higher cost oil recovery operations such as oil sands mining and tertiary oil recovery projects are generally subject to reduced royalty rates. Royalty reductions are also provided to promote exploration and development activities.

iii) The PGRT was levied on the net operating revenues of oil and gas producers. When it was originally introduced on January 1, 1981, the PGRT essentially equalled 8 percent of the difference between gross revenues and operating costs. As the period of the NEP progressed, however, various additional deductions and credits were incorporated into the tax calculation. These included the federal resource allowance, the deductibility of capital expenditures on tertiary oil recovery projects that were subject to reduced provincial royalties, the small producers' credit, and a special rate reduction for oil sands production. The basic PGRT rate was also varied between 16 and 14.67 percent.

iv) The IORT was applicable to crude oil discovered before 1981 (i.e., oil that, for pricing purposes, was defined as old oil).

It equalled 50 percent of the difference between the actual amount producers received based on the COOP of the 1981 energy agreements and the amount producers would have otherwise received based on the COP of the 1980 NEP. Except for production from the Suncor oil sands plant, the IORT was only in effect for the five-month period, January 1 to May 31, 1982.

v) Under the PIP, grants were provided for qualifying petroleum exploration and development expenditures, and certain expenditures on tangible capital assets used in tertiary oil recovery projects. The size of the grant depended on the degree of Canadian ownership and control of the investor, the location of the investment and the type of investment made. The largest grants were made available to Canadian companies exploring in the frontier areas of Canada. The Government of Alberta funded and administered the program within its own province.

vi) Federal and provincial governments levy income taxes on income from the production of oil and gas. In determining taxable income, various deductions are allowed. They include deductions for operating costs, the resource allowance federally or Crown royalties provincially, and exploration, development and tangible capital expenditures. Income tax credits are also available for certain types of activities such as investment in exploration (effective December 1, 1985) or certain tangible capital assets. The basic rate of federal income tax over the period of the NEP was 36 percent; the average provincial rate was about 11 percent.

vii) The COSC was levied on all domestically consumed natural gas, natural gas liquids and crude oil from May 1, 1981, to May 31, 1985. Its rate was fixed throughout the period at $1.15 per barrel for crude oil.

viii) The federal sales tax applies to the majority of petroleum products, including gasoline and diesel fuel. Payable by refiners, its rate was set at 9 percent for most of the NEP period. The federal excise tax is also payable by refiners. During the period of the NEP, it applied to non-commercial users of gasoline and aviation gasoline at the rate of 1.5 cents per litre. All provinces except Alberta and Saskatchewan levied some form of motive fuel tax on gasoline and diesel fuel over the NEP period. The rate for gasoline averaged about 20 percent of the retail price.

The 1985 Western Accord provided for the elimination or phase-out of all the federal taxes and incentives introduced in the NEP and the 1981 energy agreements. The IORT was terminated on January 1, 1985. The OEC, the PCC and the COSC were eliminated on June 1, 1985. The PIP was generally terminated on April 1, 1986; grandfathering provisions were added for certain activities in Alberta until December 31, 1986, and for frontier lands exploration expenditures until December 31, 1987. The PGRT, originally scheduled to be phased out by January 1, 1989, was eliminated on October 1, 1986.

3. Alternative Points of View

Two opposing views exist as to the impact of the NEP pricing and fiscal policies on Canadian welfare. The majority of economists believe that these energy policies resulted in a considerable misallocation of Canadian resources at a substantial cost to the Canadian economy.[4] This belief follows from the general economic principle that, in the absence of externalities, economies to scale, information imperfections, etc., the price which prevails in a competitive market is necessary for a welfare-maximising allocation of a country's scarce resources. Deviations from the competitive market price through, for example, a combination of price controls and fiscal measures, generally result in efficiency losses in consumption and production.

An alternative, less prevalent view takes foreign participation in petroleum production into account. Because of the substantial foreign ownership of the petroleum industry in Canada, it is suggested that the transfer of petroleum rents from foreign producers to Canadians likely outweighed the efficiency losses caused by the non-cancelling, distorting policies of the NEP.[5] This view is, however, incomplete since it ignores the benefits received by foreigners through the direct and indirect consumption of oil and natural gas. The additional consideration of foreign participation in consumption would tend to offset the welfare gain to Canadians that would otherwise result from the rent-transfer effect.

While they suggest that Canada benefitted from the NEP through the rent-transfer against foreigners, the advocates of the alternative view also argue, in a somewhat contradictory manner, that, should higher world prices prove to be permanent, Canadian-produced crude oil should be priced at world levels. This assertion is often conditioned on the implementation of a more efficient mechanism than the combination of price controls and fiscal policies actually used to redistribute petroleum rents to Canadians. Alternatively, it is suggested that the degree of Canadian ownership of the petroleum industry should be increased in order that Canadians capture most, if not all, of the increase in foreign petroleum rents that a movement to world energy prices would otherwise entail. A constitutional issue arises with the former caveat, however, and domestic and international relations issues with the latter. Provincial governments possess the constitutional right to levy taxes and royalties on, and manage non-renewable natural resources within their own jurisdictions. As a consequence, the imposition of, for example, a federal royalty or rent tax to capture petroleum rents is not possible. Previous federal attempts to increase the degree of Canadian ownership of the oil industry met with harsh international criticism as well as criticism from provincial governments and the domestic industry. Such attempts included the creation of a federal petroleum company, the provision of a grant-based incentive scheme for exploration and development which was discriminatory in favour of Canadians, and the legislation of a federal right to 25 percent of all frontier lands petroleum production.

4. Methodologies Employed

The issue of whether or not Canadian energy policies over the period January 1, 1981, to May 31, 1985, were nationally desirable is addressed here using both partial- and general-equilibrium analyses. Within these static, perfectly competitive, equilibrium frameworks, the outcome essentially depends on the net effects of the rent transfer between foreigners and Canadians, and the deadweight losses in consumption and production.

These empirical investigations represent a more complete treatment of the welfare costs and benefits of the NEP than was previously available. Regardless, certain structural and content-related matters which may not be unimportant are not taken into account in the two analyses. Since petroleum is a non-renewable natural resource, for example, it can be argued that a dynamic framework is more appropriate for analyzing petroleum market distortions. Such an analysis could conceivably reveal that a welfare change in one time period is more than offset by an opposite welfare change in a later period. It is also apparent that the crude oil market is not generally compatible with the assumptions underlying perfect competition. Risk is a significant factor affecting the pace of exploration and development activity in the petroleum industry and, therefore, the future availability of petroleum reserves. But neither risk nor exploration and development activities are adequately incorporated into the analyses. Neither are the costs of the NEP policies in terms of their distorting the relative attractiveness of different sources of supply in Canada (e.g., frontier versus provincial lands, oil sands mining versus conventional oil, etc.).

In partial defence of these and other possible criticisms of the analyses, it is equally true that no one theory can be perfectly descriptive of the crude oil market. Assumptions are not selected on the basis of their realism alone; the conclusions, not the underlying assumptions, are tested against reality. The perfectly competitive model has been demonstrated, by and large, to be reasonably capable of depicting real world phenomena. Further, it has been shown that, under certain reasonable conditions, a general equilibrium with two or more non-colluding firms per industry is perfectly competitive.[6] These "reasonable" conditions are employed in the general-equilibrium welfare analysis of the NEP petroleum pricing policies.

Notwithstanding that it is relatively simple, the partial-equilibrium approach can provide strong intuition concerning policy impacts which is often borne out in more sophistocated or complex models such as those of a dynamic or general-equilibrium nature. In many cases, the detailed features of competing policies within a particular market can also be more easily, and comprehensively, incorporated into the partial-equilibrium structure.

The partial-equilibrium framework for welfare analysis has been much criticized, however, as an inadequate and often misleading framework in which to conduct welfare investigations. A common complaint pertains to the ceteris paribus assumption on which this type of analysis is based. Other criticisms are directed towards the particular welfare measures that have traditionally been employed in partial-equilibrium analyses; consumer's surplus and producer's surplus. As concerns the former, these include the arguments that consumer's surplus is only useful when the marginal utility of income is constant, consumer's surplus is only valid for small policy changes, and, since it is only partial in nature, consumer's surplus does not take account of general-equilibrium consequences of policy changes. While, at one extreme, consumer's surplus has been characterized as a "totally useless theoretical toy"[7], producer's surplus has been even more harshly critigized. It has even been suggested that this latter surplus measure should "be struck from the economist's vocabulary"[8].

Theoretically correct monetary measures of the welfare impact of price or fiscal policy changes are compensating and equivalent variation. Compensating and equivalent variation are commonly used in applied general-equilibrium welfare analyses. By its very nature, this type of analysis also addresses one of the major criticisms of partial-equilibrium analyses in that it reflects the more realistic premise that the markets of an economy are fully interdependent; interactions between supply and demand resulting from policy changes affect relative prices, the aggregate income level and, therefore, all demands. Due to their relative importance in the Canadian economy, the impact of changes in the crude oil and natural gas markets on other markets cannot be ignored.

The general-equilibrium approach is not without fault, however. In order to calculate compensating and equivalent variation, for example, a particular functional form for utility first needs to be specified. Utility functions employed are typically convenient (i.e., analytically tractable) and not econometrically justified. Production functions are generally assumed to be homogeneous of degree one. Extraneous substitution elasticity values in consumption and production are adopted, but, again, usually without justifying their validity in the particular functional forms employed. General-equilibrium analyses are also based on the strong assumption that the economy is in equilibrium prior to a policy change; adjustments to the basic data must generally be made to meet this condition. Further, this type of analysis typically assumes zero economic profits for all industries; a premise which may not be realistic for a given industry at a particular point in time.

5. Structure of the Dissertation

The research contained in this dissertation is divided into five chapters and nine appendices.

In chapter I, the traditional partial-equilibrium approach is used to investigate the welfare impacts of the NEP pricing and fiscal regime on crude oil.

Foreign participation in the Canadian crude oil market is explicitly incorporated into a so-modified partial-equilibrium welfare analysis of the NEP in chapter II. The international redistribution of crude oil rents resulting from the NEP as well as the efficiency and intranational revenue redistribution effects are, therefore, addressed. In doing so, the Canadian welfare consequences of the NEP are analysed in a more comprehensive manner than in previous partial-equilibrium studies.

In chapter III, a procedure is developed for calculating compensating and equivalent variation, as defined in a general-equilibrium framework, from observable demand functions and elasticity estimates, thereby removing the need to resort to complex general-equilibrium models and their underlying assumptions. Welfare analysis is considerably simplified. More importantly, since market demand curves are observable, they can be estimated using econometric techniques. The a priori selection of a particular functional form to represent a well-behaved preference ordering in an applied general-equilibrium analysis can be argued to bias the welfare results. It seems a potentially less biased and more flexible approach, first, to determine the statistically most relevant market demand function through econometric estimation and, then, to derive an appropriate utility function or some other procedure for welfare analysis based on this information. The theoretical possibility of obtaining a utility function from a market demand function which satisfies the Slutsky restrictions has been ascertained. To date, however, a practical solution to the integrability problem which allows for the determination of compensating and equivalent variation has not been successfully developed.

The procedure developed in chapter III also yields important insights into the true meaning of producer's surplus and the value of partial-equilibrium analyses. Drawing on this theory, five conditions are outlined in chapter IV under which a partial-equilibrium welfare analysis which utilizes consumer's surplus together with producer's surplus can be expected to yield as valid a representation of welfare change (i.e., compensating variation) as that achieved using the general-equilibrium modelling technique.

A unique and relatively simple approach to general-equilibrium modelling (developed in association with John Whalley) is used in chapter V to analyse the welfare effects of the NEP petroleum pricing policies again by considering international rent transfer and domestic efficiency effects. The basic model uses the assumption that Canada is a taker of commodity prices on world markets in solving the zero profit conditions to determine cost covering factor prices from given world goods prices. Using these factor prices, full employment conditions for factors then determine industry production levels. Once domestic demands are calculated, excess demands for goods are obtained residually. Due to the small country assumption, demand-supply equalities need only hold in domestic factor markets.

The basic approach allows for further complicating structural elements such as price controls, taxes and non-traded goods to be introduced as required.[9]

In appendix I, a detailed description is provided of the evolution of the major, petroleum pricing and fiscal policies in Canada from 1961 to 1986, as well as a brief rationale for their adoption. Appendix II is composed of a series of statistical tables which contain the data underlying the partial-equilibrium analyses of chapters I and II. Properties of homothetic utility functions are outlined in appendix III. The concepts of Marshallian consumer's surplus, Hicksian consumer's surplus, compensating variation and equivalent variation are discussed in appendix IV. Equations underlying the comparative static results of the partial-equilibrium analyses are found in appendix V.

Using a benchmark, general-equilibrium data set, the compensating and equivalent variation welfare equations that are generated by applying the procedure developed in chapter III to the CES demand specification are verified in appendix VI by comparing the numerical results with corresponding general-equilibrium results. The five conditions outlined in chapter IV under which a partial-equilibrium analysis can be expected to yield compensating variation are also numerically substantiated in appendix VI. The demand for crude oil consists of two components: the final demand for a consumption good and the derived demand for an intermediate factor of production. Under certain limited conditions, a partial-equilibrium welfare analysis may accurately incorporate the derived demand characteristics of crude oil in one of two ways; this is elaborated on in appendix VII. An issue of modelling the self-financing price-ceiling policy of the NEP in a general-equilibrium framework is dealt with in appendix VIII. The consequences of adopting the traditional trade theory assumption of a fixed capital endowment versus the assumption of international capital mobility in a general-equilibrium welfare analysis is commented on in appendix IX.

The findings of the theoretical and empirical analyses are summarized and discussed in a concluding section. Due to the extensive usage of acronyms throughout the paper, a glossary of acronyms is provided in the front matter of this dissertation. Lists of illustrations and tables are also included there for ease of reference.

The theory and procedures developed in chapter III are entirely general in their applicability. They provide a relatively simple and easily implementable approach for calculating compensating and equivalent variation which has relevance in many areas and applications of economics. An intuitively appealing justification of the partial-equilibrium approach to welfare analysis also stems from this work. The empirical findings of the partial- and general-equilibrium analyses are not merely of historical interest. They have ramifications for the design of current Canadian energy policies and, more generally, for such topics as the establishment of freer trade with the United States. Under a freer trade agreement, for example, the imposition of a price ceiling on a commodity by one country for the benefit only of the residents of that country would likely be viewed as a violation of the agreement by the other country and could, arguably, lead to its termination. If Canada did indeed benefit from price controls on crude oil because of a redistribution of crude oil revenues from, for the most part, residents of the United States, then the removal of those controls and the pricing of crude oil at unregulated U.S. levels would, ceteris paribus, be to the detriment of Canada. Redistributive mechanisms designed to capture oil-related benefits accruing to residents of the United States would also not be allowed under a freer trade agreement. Neither would discriminatory measures designed to increase Canadian ownership of the petroleum industry in Canada. Canadian welfare would decrease (at least in the short term).

Footnotes

1. A more detailed description of the major petroleum pricing and fiscal measures impemented in Canada since 1961 is provided in appendix I along with a brief rationale for their adoption.

2. For example, the Conventional Oil Price (COP) of the 1980 NEP and the Conventional Old Oil Price (COOP) of the 1981 energy agreements represented the price of oil of the quality 38° API and 0.5 percent sulphur. The COP related to oil recovered using primary recovery techniques; in addition, the COOP applied to oil discovered prior to 1981.

3. Conventional or primary methods are generally defined to include secondary enhanced recovery techniques such as waterflooding. Tertiary oil recovery techniques include thermal processes such as in-situ combustion and steam injection, chemical processes such as polymer or caustic flooding, and miscible and immiscible displacement processes such as carbon dioxide of hydrocarbon flooding.

4. See, for example, Hazledine and Guiton (1984), Melvin (1983), Daniel and Goldberg (1982), Helliwell and McRae (1982a, 1982b and 1981), Helliwell (1981, 1980a and 1980b), Scarfe (1981), Waverman (1980 and 1975), Thirsk and Wright (1977), Gainer and Powrie (1975), and Grubel and Sydneysmith (1975).

5. See, for example, Wilson (1980), and Wilkinson and Scarfe (1980).

6. See Fama and Laffer (1972).

7. Little (1957), p. 180.

8. Mishan (1968), p. 1279.

9. A detailed description of this model is also provided in Lenjosek and Whalley (1986).

CHAPTER I

A TRADITIONAL PARTIAL-EQUILIBRIUM ANALYSIS OF THE NEP

1. Introduction

In this chapter, the allocational and distributional impacts of Canadian energy policy, as it applied to crude oil from January 1, 1981, to May 31, 1985, are assessed in a traditional, static, partial-equilibrium framework.

2. Perfect Competition and the Crude Oil Market

The concept of perfect competition is based on four major conditions. These conditions are discussed here in relation to the crude oil market in Canada. It is found that the crude oil market exhibits a mix of competitive and non-competitive characteristics.

The first of the four conditions underlying perfect competition is the assumption of price-taking demanders and suppliers. It is usually assumed that there is an infinite or, at least, a very large number of economic agents each of which is so small, relative to the market as a whole, that it cannot exert any perceptible influence on the market price. The critical assumption here is not, however, that there are a large number of small economic agents, but rather that each agent acts as if the market price is given. When the number of firms is finite, for example, each individual firm in the industry anticipates that other firms will adjust their output in response to any changes in its output. In making its output decision, each firm, therefore, takes the market price as given (i.e., it perceives the market demand curve facing it to be horizontal) and maximizes profits where price equals marginal cost.

Oil producers in Canada are clearly price takers. In the absence of price controls and fiscal measures, the price of crude oil is set in world markets. Due to relatively small, recoverable crude oil reserves, Canada's ability to influence world oil prices is negligible. Over the period of the NEP, export restrictions basically limited foreign sales to unrefinable, heavy crude oil production. The quantity of oil imported into Canada was also very small relative to world oil trade. Crude oil price controls were imposed on producers and refiners through the NEP: about 70 percent of Canadian production over the period was subject to a price ceiling; the remaining 30 percent received the world oil price. The world price was, therefore, not directly applicable to most Canadian production over this period. Instead it served as a benchmark price against which the domestic ceiling price was determined and oil import compensation was paid. In this role, the world price may be more appropriately termed the opportunity price of crude oil. It represents the price at which domestic producers could have sold and domestic refiners could have purchased the commodity in the absence of price controls, taxes or other market distortions. The foreign sector accomodated Canadian excess demand in crude oil at unchanged opportunity prices.

The upstream sector of the crude oil industry in Canada is not composed of a large number of small firms. While there is a substantial number of smaller firms in the industry, the ten largest petroleum companies consistently accounted for between 58 and 62 percent of upstream industry revenues each year over the period of the NEP.[1] Regardless, all the firms in the industry were price takers due to the price controls imposed through the NEP. In the absence of price controls, they would have been takers of the price set in world markets.

The demand for crude oil is a demand by Canadian refiners. Canadian refineries are owned by a small number of petroleum companies. Each refinery is only capable of refining crude oil meeting particular specifications; the crude oil must satisfy technological requirements concerning its density, and the amount and type of impurities (e.g., sulphur) it contains. Refiners could, therefore, normally be expected to be able to exert some influence over the price of crude oil. Due to government-prescribed price controls and exogenously-determined world prices, however, they did not.

Refiners are not final consumers. The demand for crude oil by refiners ultimately reflects the demand of consumers and oil-using industries for refined oil and oil products, and for commodities which utilise petroleum products as a factor in their production. Due to their relatively small number, the existence of transportation costs, and the absence of formal price controls in downstream markets, refiners are likely able to exert some degree of monopoly power over the price of petroleum products. A number of factors may serve to mitigate this price-setting ability in certain cases, however. Industrial users of petroleum products are, themselves, often large relative to the market for a particular product and, therefore, able to exert some influence on price. Further, certain industrial users possess the ability to conduct some portion of their operations with alternative energy forms, such as natural gas, should relative prices between these energy inputs diverge substantially. Price-fixing allegations relating to highly visible petroleum products such as gasoline also create pressure for refiners to maintain and justify "reasonable" prices.

The second condition underlying the concept of perfect competition is the existence of a homogeneous product so that buyers are indifferent to the firm from which they purchase the commodity. Crude oil and refined petroleum products are heterogeneous goods. In many cases, however, the particular crude oil streams and the particular petroleum products of different firms are close substitutes. While differences exist in the characteristics of certain motive fuels such as regular or unleaded gasoline produced by different companies, for example, the degree of differentiation is usually not a significant factor in consumption decisions.

A third assumption underlying a perfectly competitive market is the free mobility of resources both geographically (internationally as well as intranationally) and between industries. The fact that non-residents are employed in petroleum companies in Canada suggests, at least, a degree of international labour mobility. In response to the NEP, a large number of drilling rigs were moved south of the border into the United States. As with labour, however, impediments exist to perfect capital mobility between countries. Satisfaction of the interindustry factor mobility condition for the petroleum industry is also difficult. The production of crude oil requires a highly specialized labour force and capital stock. Consequently, the skills and attributes these factors possess have only limited applicability in other industries.

Technologies for extracting crude oil differ according to the geology of a particular pool or reservoir. Conventional or primary techniques, secondary techniques such as waterflooding, tertiary techniques such as injection of natural gas liquids, and mining techniques are employed to recover oil from pools and oil sands deposits. Production costs differ with each technique and, generally, each application. As less costly conventional oil stocks are depleted, the use of higher cost techniques such as tertiary recovery and oil sands mining can be expected to grow in importance as can oil production from higher cost and less accessible areas of the country such as in the frontier lands. It is not unusual for higher cost and more remote projects to incur substantial pre-production costs for periods of 5 to 10 years. Economies of scale and barriers to entry, therefore, clearly exist in the industry preventing the free entry and exit of firms.

A final condition underlying perfect competition is the assumption of perfect knowledge. This includes perfect knowledge of current and future commodity prices and costs of production by producers, consumers and factor owners. Of the four conditions used to define perfect competition, this assumption is, perhaps, the least plausible when applied to the petroleum industry. While petroleum companies can reasonably be assumed to know current prices and costs, forecasts of future world oil prices have invariably been unsatisfactory; the influence exerted by OPEC being the primary reason. On the other hand, the NEP price schedules, which were relevant to Canadian production decisions, were well-established for most of the 1981-85 period so that perfect knowledge to this extent did exist. Imperfect knowledge of future production costs clearly exists as it relates to inflation, interest rates, reservoir geology, and exploration and development. Perfect knowledge on the demand side is also a tenuous proposition. Price ranges for particular petroleum products, however, may have been relatively small.

To summarize, the upstream market for petroleum is characterised by price-taking demanders and suppliers. This is not the case for downstream markets, but the ability of economic agents to exert monopoly power is limited to some extent by market structure, the existence of substitutes, and potentially negative public reaction. Neither crude oil nor refined petroleum products are homogeneous goods. Refineries are only capable of refining crude oil meeting particular requirements; particular oil products, on the other hand, are often close substitutes. Labour and capital employed in oil production are not perfectly mobile. Entry and exit of firms into the petroleum industry are not entirely free. Perfect knowledge does not exist either in production or consumption.

Given these characteristics, it is apparent that the crude oil market is not generally compatible with the assumptions underlying perfect competition. Further, since crude oil is a non-renewable natural resource, it can be argued that a dynamic framework may be the most appropriate structure for analysing the market. While these issues are not unimportant, the welfare impacts of the NEP are analysed in a static, partial-equilibrium framework in this chapter. This is justified on the usual grounds. No one theory can be perfectly descriptive of the crude oil market. Assumptions are not selected on the basis of their realism alone; the conclusions, not the underlying assumptions, are tested against reality. The perfectly competitive model has been demonstrated, by and large, to be reasonably capable of depicting real world phenomena. Notwithstanding that it is relatively simple, the partial-equilibrium approach can provide strong intuition concerning policy impacts which is often borne out in more sophistocated or complex models such as those of a dynamic or general-equilibrium nature. In many cases, the detailed features of competing policies within a particular market can also be more easily, and comprehensively, incorporated into the partial-equilibrium structure.

3. The Crude Oil Market in Canada: 1981-85

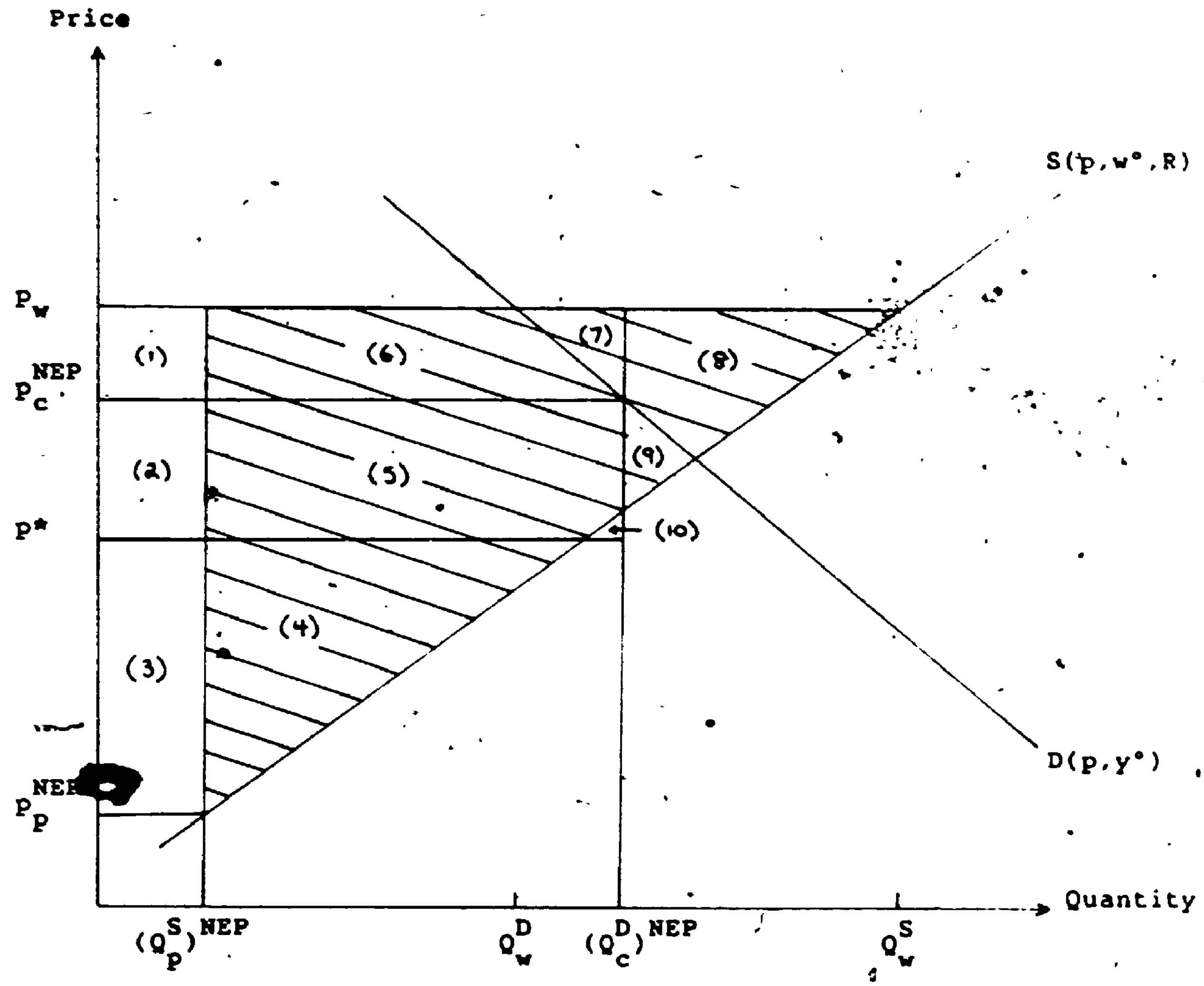
This section deals with characterizing the Canadian crude oil market in a partial-equilibrium framework. It is composed of two parts: a demand-supply depiction of the NEP is provided in part 3(a); and a hypothetical pricing and fiscal regime is developed in part 3(b) to depict a possible, alternative crude oil market scenario had the NEP not been imposed in 1981. Statistics used to generate the prices and quantities for the demand-supply diagrams are provided in appendix II.

a) NEP Demand-Supply Depiction

A partial-equilibrium demand-supply diagram of the crude oil market in Canada for the period January 1, 1981, to May 31, 1985, is provided in figure I. The market supply curve for crude oil is assumed to represent the before-tax, aggregate of the relevant portion

FIGURE I

THE CRUDE OIL MARKET: THE NEP PERIOD



US(p°,p',y°) = (1)+(6)

PS(p°,p',w°,R) = -((1)+(2)+(3)+(4)+(5)+(6)+(7)+(8)+(9))

Upstream Tax Revenues = (3)

Downstream Tax Revenues = (2)+(5)+(10)

Import Subsidization = -((5)+(6)+(7)+(10))

Total Welfare Impact = -((4)+(5)+(6)+(7)+(8)+(9))-(7)

of the marginal cost curves for each of the individual firms in the industry.[2] It is further assumed that the industry supply curve represents some "average", constant-returns-to-scale technology for oil extraction. Under this latter assumption, the supply curve is only well behaved if the supply of at least one primary factor of production is fixed.

The crude oil input in the oil production process is a non-renewable natural resource. It is also an essential primary factor. The stock of ultimately recoverable crude oil in Canada is fixed in supply. The known, recoverable portion, given existing technology and prices, however, is somewhat smaller. Additions to recoverable reserves can, in general, only be made at a substantial cost in terms of exploration, development and time.

As indicated above, Canadian reserves of crude oil were separated into distinct categories for NEP pricing purposes. The various categories can be combined into two major sub-divisions: COOP oil discovered before 1974; and NORP oil discovered after 1973. (SOOP oil was a special category created from COOP oil and later reclassified as NORP oil. It remained in existence for a period of only one year.) At any particular point in time, the stock of COOP oil was, by definition, fixed in supply. Unlike a resource such as land, however, COOP oil is depletable; its production or extraction reduces the remaining recoverable stock. While NORP oil is also a depletable resource, this production effect can be compensated for, over some future period of time, through additions to recoverable reserves of NORP oil. In the long run, of course, the crude oil resource will be entirely used up. As oil prices increased over the

NEP period, marginal oil plays were brought into production. Higher oil prices also led to increased exploration and development, and additions to the recoverable stock from this source as well. For the purposes of this chapter, the known, recoverable stock of crude oil in Canada is assumed to have remained fixed over the period of the NEP.

The supply curve for crude oil in figure I is denoted as $S(p, w°, \bar{R})$ where p is the price producers receive for crude oil, $w° = (w_1°, \ldots, w_m°)$ is the fixed return to each variable primary factor used in crude oil production, and R is the fixed stock of crude oil over the NEP period.

In the short run, the rate of extraction of crude oil is, for economic purposes, inelastic with respect to price; it is largely dictated by natural laws and provincial government regulation. Each oil play is subject to an inherent maximum rate of recovery, but high rates of extraction can adversely affect the total quantity of crude oil that is ultimately recoverable. The time profile of oil extraction is, therefore, an important consideration. Variations in the rate of extraction are typically quite small and very costly. The statistics in tables XXVII and XXIX in appendix II support the hypothesis that the supply of crude oil was inelastic over the 4 1/2-year period of the NEP. The price producers received rose continually over the period as the COOP increased, the SOOP was created and the NORP was extended to various categories of domestic crude oil production. With the exception of 1982, a time of recession in Canada, the production of crude oil increased as well, but rather slowly. These statistics support a price elasticity of supply in the range of 0.2 to 0.3. This range of values is also in accord with literature estimates for the short to medium term.[3] An arc elasticity of supply equal to 0.3 is used in the base-case analysis.

The demand for crude oil consists of two components: the demand for a consumption good (e.g., gasoline, heating oil, etc.) and the demand for an intermediate factor of production. In its role as an intermediate good, the demand for crude oil is commonly referred to as a derived demand, and is partly dependent on the demand for goods that use oil, either directly or indirectly, in their production as well as on other inputs and input prices relevant to these oil-using production processes.

The demand curve, $D(p,y^*)$, in figure I is drawn net of taxes. It is a function of the consumer price for crude oil, p, and the fixed aggregate income level, y^*. The area under this total demand curve for crude oil is referred to here as user's surplus. In recognition of its final and intermediate demand components, user's surplus is also composed of two parts: Marshallian consumer's surplus or the surplus corresponding to a final demand curve; and intermediate surplus or the surplus corresponding to a derived demand curve.

Richard Schmalensee shows that, where an intermediate good is used by a perfectly competitive industry to produce a consumer good, the values of intermediate surplus in the intermediate input market and Marshallian consumer's surplus in the corresponding final product markets are identical.[4] His proof only requires efficient production and marginal cost pricing in the intermediate good-using industry or industries. Thus, under perfectly competitive conditions, intermediate surplus in the crude oil market equals the aggregate of areas of Marshallian consumer's surplus in those markets which use oil as a factor of production. Under perfect competition, the welfare effect of ceteris paribus output changes is reflected in input demand functions and can, therefore, be detected through the analysis of input markets. The decision as to whether to analyse the intermediate input market or the associated final goods market to determine Marshallian consumer's surplus can be appropriately made on the basis of convenience. For simplicity, it is assumed that perfect competition holds in the downstream markets in which the demand for crude oil arises.

It is reasonable to expect the price elasticity of demand for crude oil to have been inelastic over the NEP period, but relatively more elastic than the price elasticity of supply. Two basic factors determine elasticity: the availability of substitute goods and the number of uses to which a good may be put. The oil substitution and conservation initiatives contained in the NEP met with some success, but refined petroleum products remain an indispensible part of the Canadian economy. While there has been some substitution in motive fuels in favour of propane and natural gas, for example, these alternative fuels remain imperfect substitutes. Similarly, inroads were made in providing natural gas for home heating purposes in Quebec, but home heating oil remains an important source of heat in eastern Canada. The supply of crude oil is largely dependent on the fixed resource input; more intensive use of variable factors of production cannot be expected to significantly increase output. Refined oil and oil products, on the other hand, are used in a variety of ways; in final consumption (e.g., motive fuels and heating oil) and as an intermediate good in the production of many other commodities (e.g., petrochemicals). The potential for substitution is, therefore, greater. The statistics in tables XXVII and XXIX support a price elasticity of demand in the range of (negative) 0.5 to 0.8. A literature survey yielded estimates of the price elasticity of demand ranging from (negative) 0.3 to 0.8[5]. An arc elasticity of demand equal to -0.5 is used in the base-case analysis.

George Kouris includes income elasticity of demand estimates in his country-by-country survey of energy elasticity values reported by various authors.[6] He finds that elasticity estimates vary widely due in part to fuel aggregation choices, sectoral breakdowns, dynamic specifications, the use of cross sectional versus time series data, and the time period to which the estimates apply. Income elasticity of energy demand values tend to be concentrated in a narrower range than price elasticity estimates, however, and, in general, are clustered around the value of unity. Positive estimates for Canada suggest that energy is a normal good. Since the elasticity values are close to unity, it is further assumed that the underlying preferences for petroleum products are linearly homogeneous. As a result, Hicksian consumer's surplus can be calculated exactly from user's surplus according to the following equation[7]:

$$(1.1) \quad HCS(p^*,p',y^*) = y^*(1-\exp(-US(p^*,p',y^*)/y^*)).$$

Since the expenditure share for crude oil is small (about 6 percent of net domestic product at market prices over the period of the NEP), user's surplus serves as a reasonable proxy for Hicksian consumer's surplus.[8]

Crude oil is treated as a homogeneous product by averaging oil prices on the basis of quantities produced. Three major price-differentiated oil classifications are used: COOP oil, SOOP oil, and NORP oil. COOP and SOOP oil are further separated into pentanes plus, light and medium oil, and heavy oil sub-categories. In addition to these, NORP oil sub-categories include enhanced recovery oil (i.e., light and medium oil, and heavy oil recovered through secondary and tertiary techniques), and experimental and synthetic oil. Representative prices for each sub-category of COOP, SOOP and NORP oil allow weighted average prices for domestic crude oil production to be calculated. Transportation costs to Montreal are included in calculating consumer and world oil prices. The price of crude oil imports (i.e., the world oil price) is also adjusted to equal the average quality of domestic production. Each unit of crude oil available for consumption is, therefore, assumed to represent an average barrel of oil, i.e., a barrel of oil which possesses the same characteristics as all other barrels of oil, at Montreal. Statistics on crude oil production, imports and demand under the NEP regime are provided in table I, along with quality-adjusted crude oil prices relevant to Canada.

It is evident from table XXVII that Canada was both an exporter and an importer of crude oil from 1981 to 1985. Since a partial-equilibrium analysis is not able to handle this simultaneity, crude oil exports, which accounted for about 15 percent of domestic production, are excluded from the supply curve for oil. The exported quantities are, however, used in the determination of the domestic supply price. An alternative way of dealing with simultaneous exports and imports in a partial-equilibrium framework is to consider net exports. The net supply curve is used in this analysis, however, so

TABLE I

PARTIAL-EQUILIBRIUM PRICES AND QUANTITIES: 1981-85

	NEP Regime	Alternative Regime
Prices (Dollars per Barrel)		
World Price	35.91	35.91
Consumer Price	34.89	47.68[a]
Ceiling Price[b]	22.31	-
Producer Price	11.99	18.43[c]
Base-Case Quantities[d] (Million Barrels)		
Domestic Supply	1,927.1[e]	2,188.5
Domestic Demand	2,322.5	1,988.6
Exports	-395.4	199.9

SOURCES: Based on tables XXVII, XXVIII, XXIX, and XXXI in appendix II.

[a] World price plus estimated sales and excise taxes.

[b] Includes transportation costs to Montreal.

[c] World price minus estimated income taxes, net provincial royalties and land payments.

[d] Actual NEP quantities; deregulated volumes estimated assuming price elasticities of -0.5 for demand and 0.3 for supply. Quantity demanded at the world price is 2,289.3 million barrels; quantity supplied is 2,606.3 million barrels; and exports equal 317.0 million barrels.

[e] Excludes exports.

as to capture the effects of the PCC as it applied to crude oil imports. Treating exports in this way, the quantity of crude oil supplied by producers, $(Q_p^S)^{NEP}$, is 1,927.1 million barrels. Imports equal 395.4 million barrels. The quantity demanded by consumers, $(Q_c^D)^{NEP}$, equals 2,322.5 million barrels and is determined as a residual.

A benchmark price or price ceiling, set below the world oil price level, was established through the NEP. It can be essentially thought of as the COOP. COOP-equivalent ceiling prices for SOOP and NORP oil are determined by subtracting the PCC subsidy to domestic production, on a per barrel basis, from the average SOOP and NORP relevant for the period. A weighted average ceiling price applicable to all Canadian production is, thereby, determined. This ceiling price, p*, equalled $22.31 per barrel.

The quality-adjusted, average world oil price, p_w, relevant for the NEP period was $35.91 per barrel. It is generated from the NEP ceiling price by including transportation costs to Montreal plus the PCC subsidy to imported oil, both of which are expressed on a per barrel basis. Due to the base-case elasticity values employed, Canada is depicted as a net energy exporter at world prices in figure I; the quantity demanded at world prices, Q_w^d, being 2,289.3 million barrels; the quantity supplied at world prices, Q_w^s, being 2,606.3 million barrels. Exports equalled 317.0 million barrels.

The NEP ceiling price, equal to about 60 percent of the world oil price, also forms the basis for the determination of consumer and producer prices. Due to the presence of price controls, consumer and producer prices are determined independently of each other. The burden of downstream fiscal measures falls entirely on oil users. Similarly, producers bear the full burden of upstream taxes and subsidies.

In addition to federal and provincial sales taxes, and the federal excise tax, oil users were subject to the PCC, the SCC, and the COSC. The revenues generated from these downstream taxes and charges are given in table XXVI in appendix II. They are adjusted by the quantity of oil demanded from table XXVII to determine the average, specific tax rate applicable for the period. This average rate equalled $12.58 per barrel. Added to the ceiling price, the tax-inclusive consumer price, p_c^{NEP}, is ascertained. As shown in table I, the consumer price for oil equalled $34.89 per barrel.

Crude oil producers were subject to the PGRT and the IORT in addition to paying provincial royalties, and federal and provincial corporate income taxes and land rentals. Producers also received subsidies in the form of PIP grants, various provincial incentives and higher prices for SOOP oil and NORP oil. As shown in table XXV in appendix II, the net effect of the upstream fiscal measures applicable to producers over the NEP period was $17.15 billion in tax revenues: net provincial tax revenues of $15.01 billion plus net federal tax revenues of $2.14 billion. These net government revenues correspond to a specific tax rate of $8.90 per barrel of oil and an after-tax producer price, p_p^{NEP}, of $11.99 per barrel.

To summarise the characteristics of the Canadian crude oil market under the NEP regime, consumers purchased 2,322.5 million barrels of oil at an average price of $34.89 per barrel while domestic producers supplied 1,927.1 million barrels at $11.99 per barrel. The difference between the quantities supplied and demanded was met through crude oil imports of 395.4 million barrels at the world oil price of $35.91 per barrel. The price ceiling equalled $22.31 per barrel and served as a benchmark price in the determination of the consumer and producer prices.

b) Demand-Supply Depiction in the Absence of the NEP

In conducting any partial-equilibrium analysis, it is necessary to specify an alternative or comparison market equilibrium against which to assess the impacts of some economic policy. Had the NEP not been introduced in 1981, what pricing and fiscal policies would have been applicable to the crude oil market? The number of possible candidates is obviously large. The alternative regime outlined here can be considered as the imposition of the Western Accord five years earlier than when it finally was adopted.

It is often argued that the NEP was designed primarily to benefit energy users. For the purpose of this chapter, the alternative pricing regime is one that would have, in contrast, been most beneficial to the producing provinces and the petroleum industry. Governments of the producing provinces and industry representatives consistently argued for world pricing of Canadian crude oil production during the NEP period. This pricing policy was subsequently adopted in the Western Accord, effective June 1, 1985.

During the NEP period, it was also often proposed that the crude oil market should be treated no differently than any other market in the Canadian economy. Petroleum-specific fiscal policies designed to achieve particular social objectives, such as the uniform, "made-in

Canada" oil price of the NEP and the promotion of frontier exploration activity by Canadian-owned petroleum companies, are, therefore, eliminated in the alternative regime. These policies include all the special taxes and subsidies imposed in the NEP and prior to the NEP. Crude oil remains subject to the same general fiscal measures that are relevant to most other commodities, however. These include income taxes, sales and excise taxes, and, due to provincial ownership of the crude oil resource, land and royalty payments. This fiscal framework is essentially that which was implemented through the Western Accord.

Rather than the NEP ceiling price, the world oil price of $35.91 per barrel forms the basis for the determination of producer and consumer oil prices under the alternative regime. As with price controls, exogenously-determined world oil prices cause a separation between demand and supply. Specific tax rates are calculated and used to determine producer and consumer oil prices.

Under the alternative regime, federal and provincial governments receive upstream tax revenues from land payments, royalties and corporate income taxes. For the purpose of calculating the after-tax producer price, tax and royalty rates are assumed to equal their NEP levels. Since producers receive the higher world oil price for their production, tax receipts from these sources are proportionately higher than under the NEP regime. Under these assumptions, the specific tax rate applicable to upstream production equals $17.48 per barrel; the producer price, p_p, equals $18.43 per barrel.

Similarly, the consumer price would have been higher than the world oil price assuming sales and excise taxes are still imposed in the absence of the NEP. Assuming the rates of federal and provincial sales taxes, and the federal excise tax remain unchanged from the NEP rates under the alternative regime, the specific tax rate applicable to downstream markets equals \$11.77 per barrel. The consumer price, therefore, equals \$47.68 per barrel.

Using the base-case price elasticities of demand and supply, the quantities demanded, Q_c^D, and supplied, Q_p^S, under the alternative regime are 2,188.5 and 1,988.6 million barrels, respectively. As opposed to the situation resulting from the NEP regime, Canada is a small exporter of crude oil; exports equal 199.9 million barrels.

The crude oil market under the alternative regime is illustrated in figure II. Price and quantity observations are again summarized in table I.

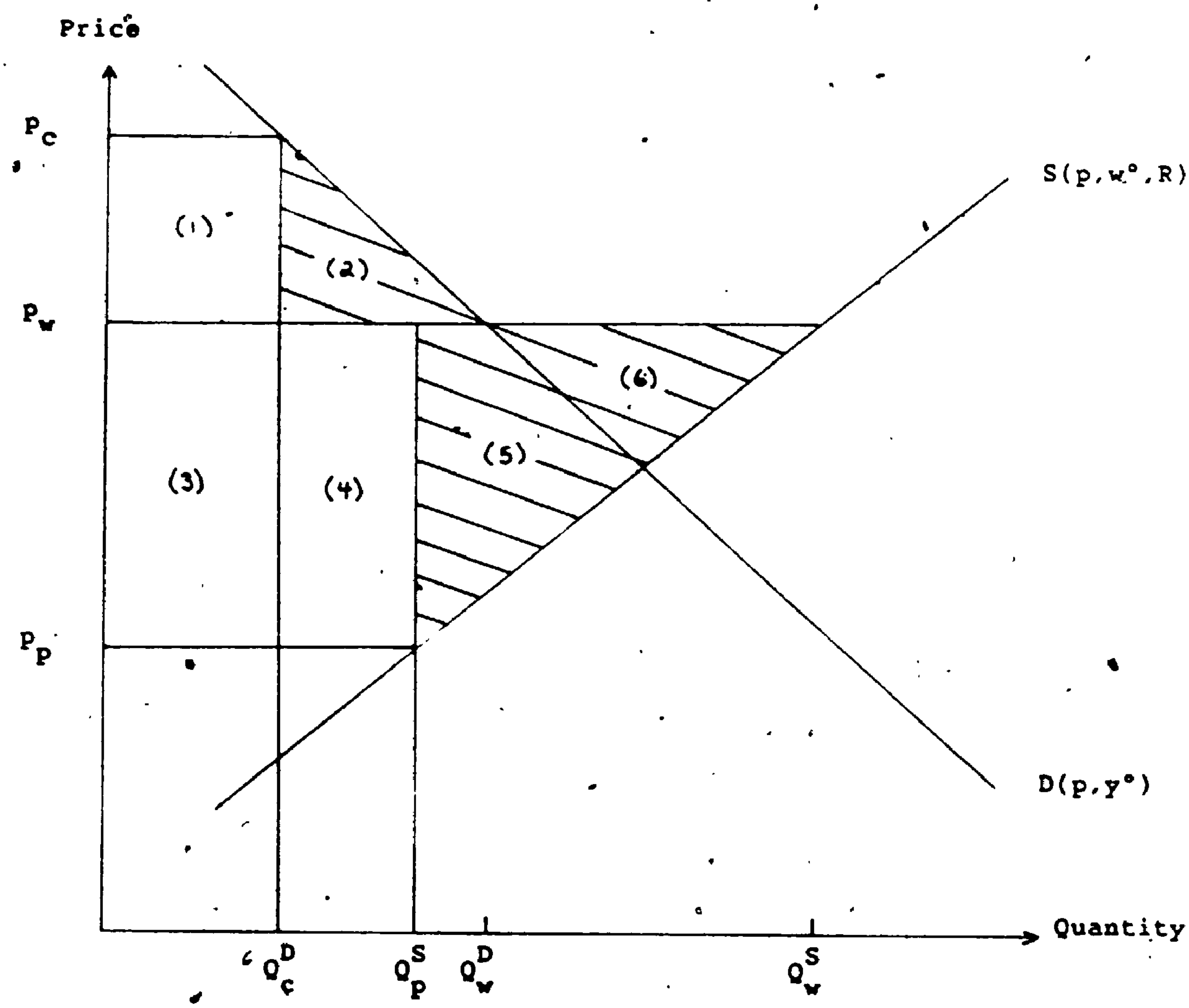
4. Welfare Analysis of Imposing the NEP

The characteristics of the crude oil market outlined in the previous two parts are combined in figure III. This is the basic diagram underlying the welfare analysis conducted in this chapter. In order to conduct a partial-equilibrium analysis of the welfare impacts resulting from the imposition of the NEP, however, additional model parameters need to be specified. These include parameters relating to the sharing of petroleum tax revenues between the two levels of government in Canada. Tax revenues are realized from both the upstream and downstream segments of the industry. Base-case parameter values are reported in table II.

The precise specification of the base-case elasticities of supply, n^S, and demand, n^D, are as follows:

FIGURE II

THE CRUDE OIL MARKET UNDER THE ALTERNATIVE REGIME



US(p°,p',y°) = -((1) + (2))

PS(p°,p',w°,R) = -((3) + (4) + (5) + (6))

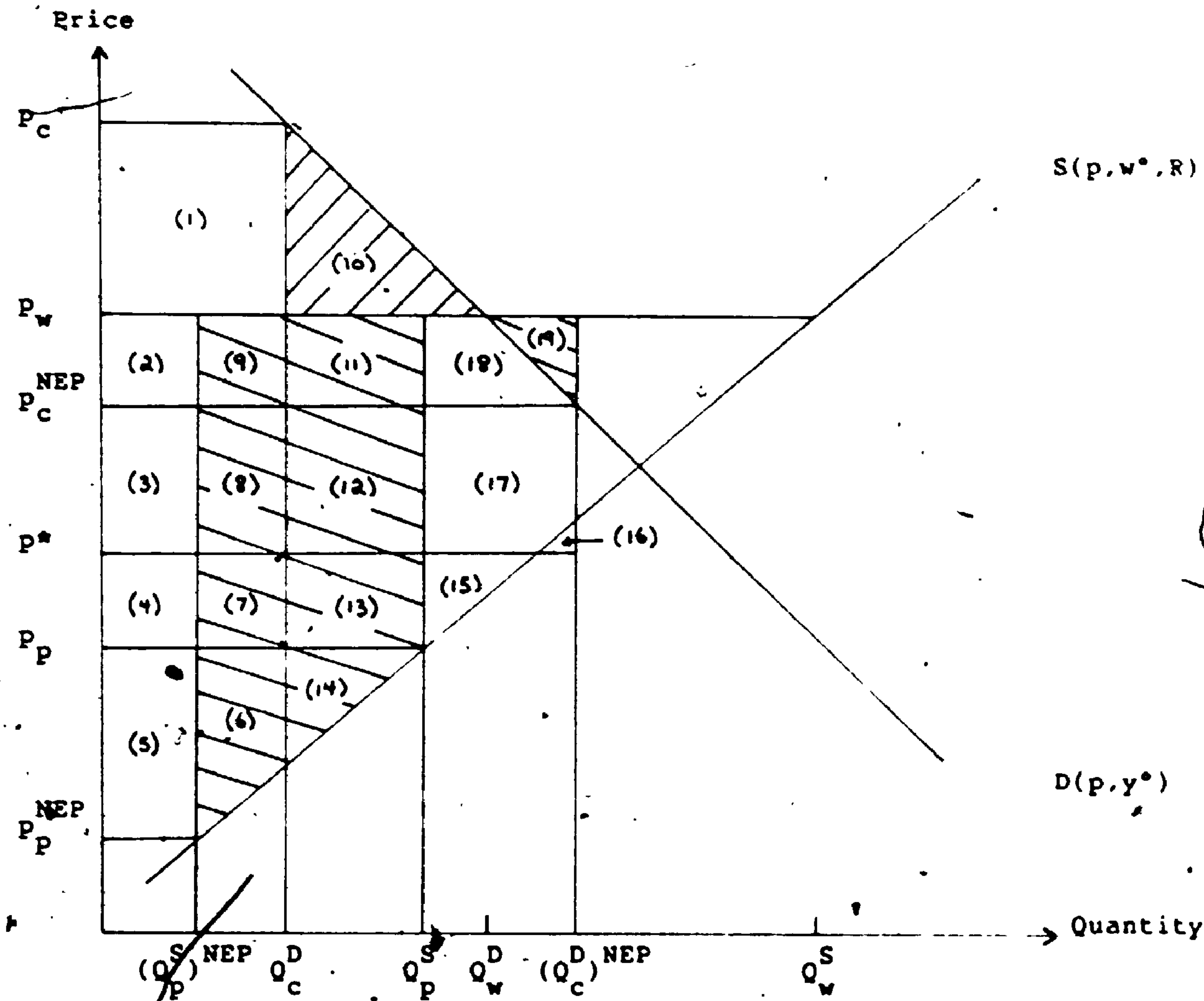
Upstream Tax Revenues = (3) + (4)

Downstream Tax Revenues = (1)

Total Welfare Impact = - (2) - ((5) + (6))

FIGURE III

PARTIAL-EQUILIBRIUM ANALYSIS OF IMPLEMENTING THE NEP



US(p*,p',y*) = (1)+(2)+(9)+(10)+(11)+(18)

PS(p*,p',w*,R) = -((5)+(6)+(14))

Upstream Tax Revenues =(4)+(5)-((2)+(3)+(4)+(7)+(8)+(9)+(11)+(12)+(13))

Downstream Tax Revenues = (3)+(8)+(12)+(16)+(17)-(1)

Import Subsidies = -((8)+(9)+(11)+(12)+(16)+(17)+(18)+(19))

Total Welfare Impact = (10)-((6)+(7)+(8)+(9)+(11)+(12)+(13)+(14))-(19)

TABLE II

PARTIAL-EQUILIBRIUM PARAMETER VALUES

Parameter	Base Case Parameter Value
A. PRICE ELASTICITIES	
Demand (η^D)	-0.5
Supply (η^S)	0.3
B. INDUSTRY OWNERSHIP RATES[a]	
Canadian (i)	0.40
Foreign (1-i)	0.60
C. CONSUMPTION SHARES	
Canadian (c)	1.00
Foreign (1-c)	0.00
D. UPSTREAM TAX REVENUE SHARES[b]	
1. NEP Regime	
Federal (u^{NEP})	0.12
Provincial ($1-u^{NEP}$)	0.88
2. Alternative Regime	
Federal (u)	0.23
Provincial (1-u)	0.77
E. DOWNSTREAM TAX REVENUE SHARES[b]	
1. NEP Regime	
Federal (d^{NEP})	0.64
Provincial ($1-d^{NEP}$)	0.36
2. Alternative Regime	
Federal (d)	0.38
Provincial (1-d)	0.62

[a] Based on the ownership of upstream crude oil revenues in table V.

[b] Based on table XXXII in appendix II.

$$(1.2)\quad n^S = (Q_p^S-(Q_p^S)^{NEP})(p_p+p_p^{NEP})/(Q_p^S+(Q_p^S)^{NEP})(p_p-p_p^{NEP}) > 0$$

$$(1.3)\quad n^D = (Q_c^D-(Q_c^D)^{NEP})(p_c+p_c^{NEP})/(Q_c^D+(Q_c^D)^{NEP})(p_c-p_c^{NEP}) < 0$$

The price producers received under the NEP regime reflects the combined impact of price controls and fiscal policies. Since the NEP producer price was below the estimated price that producers would have received under the alternative regime, a loss in producer's surplus, PS(p°,p',w°,R), was incurred equal to:

$$(1.4)\quad PS(p°,p',w°,R) = -\int_{p_p^{NEP}}^{p_p} S(p,w°,R)dp$$

$$\simeq -(Q_p^s)^{NEP}(p_p-p_p^{NEP})(p_p+p_p^{NEP})/(p_p^{NEP}(1+n^s)+p_p(1-n^s))$$

Since the NEP consumer price is less than the consumer price under the alternative regime, user's surplus is positive.

$$(1.5)\quad US(p°,p',y°) = \int_{p_c^{NEP}}^{p_c} D(p,y°)dp$$

$$\simeq (Q_c^D)^{NEP}(p_c-p_c^{NEP})(p_c+p_c^{NEP})/(p_c^{NEP}(1+n^D)+p_c(1-n^D))$$

Hicksian consumer's surplus is derived from user's surplus according to equation (1.1).[9] It can be seen from equation (1.1) that user's surplus overestimates the benefit to consumers when the surplus value is positive. Due to the relatively small expenditure share for crude oil over the NEP period, however, this error is within 1 percent of Hicksian consumer's surplus.

Tax revenues and import compensation revenues are also taken into account. Net tax revenues from crude oil production are shared by the federal government and the governments of the three western producing provinces. The federal share under the NEP regime, u^{NEP}, equalled 12 percent; the provincial share, $1-u^{NEP}$, was 88 percent. Under the alternative regime, the federal share of upstream tax revenues, u, is estimated to be 23 percent; the provincial share, 1-u, is 77 percent.

Downstream tax revenues were shared between the federal government, the governments of the consuming provinces and the province of British Columbia. The governments of Alberta and Saskatchewan did not levy motive fuel taxes during the period of the NEP. The federal share under the NEP regime, d^{NEP}, equalled 64 percent of downstream tax revenues; the provincial share, $1-d^{NEP}$, equalled 36 percent. Under the alternative regime, the federal share, d, is estimated to be 38 percent; the provincial share, 1-d, is 62 percent.

Under the NEP regime, crude oil demand exceeded supply. The federal subsidy to imported oil, equal to the product of the excess demand and the world-ceiling price differential, is deducted from federal revenues.

The change in federal revenues, FR, resulting from the NEP is equal to the sum of upstream and downstream tax changes plus the revenue loss resulting from oil import compensation:

$$(1.6)\quad FR = u^{NEP}(p^*-p_p^{NEP})(Q_p^S)^{NEP} - u(p_w-p_p)Q_p^S + d^{NEP}(p_c^{NEP}-p^*)(Q_c^D)^{NEP} - d(p_c-p_w)Q_c^D - (p_w-p^*)((Q_c^D)^{NEP}-(Q_p^S)^{NEP})$$

Net revenues received by the governments of the three western producing provinces, PPR, equal:

$$(1.7)\quad PPR = (1-u^{NEP})(p^*-p_p^{NEP})(Q_p^S)^{NEP} - (1-u)(p_w-p_p)Q_p^S$$

Net revenues received by the governments of the consuming provinces and British Columbia, CPR, are given by:

$$(1.8)\quad CPR = (1-d^{NEP})(p_c^{NEP}-p^*)(Q_c^D)^{NEP} - (1-d)(p_c-p_w)Q_c^D$$

Equations (1.1) to (1.8) are used to determine the welfare impact resulting from the imposition of the NEP. The base-case parameter and elasticity values indicate a welfare deterioration of $3.9 billion resulted from the price ceiling and fiscal policies of the NEP relative to a "1981 Western Accord". This loss equals about 1 percent of 1985 NDP at market prices. Base-case welfare results, both aggregate and disaggregate, are reported in table III.

Underlying the aggregate welfare impact for the base case are winners and losers from the NEP. They consist of the producing and consuming provincial governments, the federal government, oil users, and the petroleum industry. The rent transfer to consumers was the largest single effect of the NEP; oil users are estimated to have benefitted by $27.3 billion; an amount equal to the gain in consumer's surplus. The petroleum industry lost $13.3 billion. The federal government realized a net loss of $2.0 billion: a gain of $9.8 billion from downstream tax revenues offset by losses of $6.4 billion and $5.4 billion in foregone upstream tax revenues and oil import compensation, respectively. Of the two levels of government, the producing provinces bore the brunt of the NEP losing $12.0 billion in upstream tax revenues, while the consuming provinces and British Columbia lost $4.0 billion from lowered retail sales tax collections.

The comparative statics of changing the base-case parameters are summarized below.[10] Welfare improves:

i) the lower (i.e., the more inelastic) the price elasticity of supply, n^S;

ii) the lower (i.e., the more elastic) the price elasticity of demand, n^D;

iii) the higher the upstream tax rate, i.e., the lower the NEP producer price, p_p^{NEP}; and

TABLE III

NEP WINNERS AND LOSERS FROM A TRADITIONAL
PARTIAL-EQUILIBRIUM WELFARE ANALYSIS
($ Million)

	Winners	Losers	Net Result
Industry	-	-13,252.2	-13,252.2
Consumers[a]	27,297.2	-	27,297.2
Governments			
•Federal	-	-1,984.9	-1,984.9
•Producing Provinces[b]	-	-11,955.1	-11,955.1
•Consuming Provinces[c]	-	-3,993.5	-3,993.5
Total	27,297.2	-31,185.7	-3,888.5

[a] Equal to Hicksian consumer's surplus.

[b] Alberta, British Columbia and Saskatchewan.

[c] Of the three western producing provinces, only British Columbia levied retail sales taxes on gasoline and petroleum products over the period of the NEP.

iv) the higher the downstream tax rate, i.e., the higher the NEP consumer price, p_c^{NEP}.

A sensitivity analysis of the welfare impact of alternative elasticity assumptions is provided in table IV. The finding that aggregate welfare deteriorated as a result of the NEP is robust over the full range of demand and supply elasticity values employed.

5. Conclusions

The traditional, static, partial-equilibrium approach to policy analysis is relatively simple, but not simpleminded - it has often been demonstrated to offer, at least, significant qualitative insights into the functioning of real world markets. The allocational and distributional impacts of the NEP are assessed in this chapter in a traditional, static, partial-equilibrium framework.

It is found that the price ceiling, tax and subsidy policies of the NEP resulted in overconsumption and underproduction of crude oil in Canada compared to the levels of consumption and production that would have resulted had the Western Accord instead been imposed in 1981. Efficiency losses in consumption and production together with reductions in tax revenues are reflected in a deterioration in aggregate welfare. This traditional analysis suggests that the implementation of a Western Accord in lieu of the NEP would have been a welfare improving change. Oil self-sufficiency could also have been achieved had this alternative policy been followed over the period of the NEP.

The aggregate welfare result is subject to qualification, however. Foreign ownership of the oil industry in Canada has not been

TABLE IV

WELFARE IMPACTS UNDER ALTERNATIVE ELASTICITY ASSUMPTIONS
($1980 Million)

n^d \ n^s	0.1	0.3	0.5	0.75	1.0	1.5
-0.1	-1,667.2	-2,240.4	-2,867.9	-3,741.2	-4,731.7	-7,173.6
-0.3	-2,515.3	-3,088.6	-3,716.1	-4,589.3	-5,579.8	-8,021.8
-0.5	-3,315.2	-3,888.5	-4,516.0	-5,389.2	-6,379.7	-8,821.6
-0.75	-4,253.2	-4,826.4	-5,454.0	-6,327.2	-7,317.7	-9,759.6
-1.0	-5,128.9	-5,702.1	-6,329.6	-7,202.9	-8,193.4	-10,635.3

taken into account; neither has foreign consumption of Canadian oil. These issues are dealt with in chapter II. It is also noted that the crude oil market is not entirely consistent with the concept of perfect competition which underlies partial-equilibrium analyses. Crude oil is a non-renewable natural resource and, perhaps, might more appropriately be analyzed in a dynamic framework. Neither risk nor exploration and development activities are adequately treated in the static, partial-equilibrium analysis. Nor are the indirect impacts of energy market changes on, for example, equalization payments addressed. The criticism that a partial-equilibrium analysis does not consider the general-equilibrium implications of a policy change is addressed in chapter IV.

Petroleum revenues were redistributed between consumers, producers and governments. Oil users were the major winners; in fact, the gain to consumers, primarily due to price controls, is found to be almost as large as the sum of the losses to the other participants in the economy. The petroleum industry was made worse off under the NEP. The federal government, and the governments of the producing and consuming provinces also lost through foregone tax revenues. From a distributional point of view, the impact of the NEP as evaluated using a traditional partial-equilibrium approach can be essentially thought of as a transfer of rents from the petroleum industry and the producing provinces to consumers. The distributional impacts can be considered only as a first approximation, however; they will need to be modified to the extent that revenues are redistributed through secondary mechanisms such as equalization payments.

Footnotes

1. Petroleum Monitoring Agency Canada estimates. The proportion of upstream revenues accounted for by the 10 largest petroleum companies in Canada equalled: 59.9 percent in 1981; 62.2 percent in 1982; 60.2 percent in 1983; 58.4 percent in 1984; and 59.6 percent in 1985.

2. It may be reasonable to expect that production and factor usage can be expanded by any one firm in an industry without affecting factor returns. The simultaneous expansion of output by all firms in an industry is more likely to cause factor returns to vary, and the marginal cost curve to shift, unless factors are internationally mobile and factor returns are set on world markets. If the latter two assumptions are not met, the industry supply curve cannot be obtained from the horizontal summation on the relevant portions of marginal cost curves. In the short run, however, the quantity supplied can still be expected to vary directly with price. A positively sloped industry supply curve is still perfectly determinate (but less precise) as the sum of quantities supplied by all firms at the prevailing set of factor prices.

3. See, for example, Moroney and Bremmer (1986), Scarfe (1981), and Thirsk and Wright (1977).

4. Schmalensee (1976), pp. 239-43. Schmalensee also shows that, under imperfect competition, intermediate surplus will either underestimate or overestimate the Marshallian consumer's surplus valuation in the associated final product market depending on whether the factor cost increases or decreases, respectively. This is directly attributable to the absence of marginal cost pricing in imperfect competition. In the extreme situation where the intermediate factor is used by a pure monopolist, and given certain additional assumptions (e.g. homogeneous production functions), a correction factor can be determined for the input market valuation that yields a close approximation to the final product market valuation for small changes in factor cost.

5. See Kouris (1982), Scarfe (1981), McRae (1979), Hogan and Manne (1977), Thirsk and Wright (1977), and Berndt and Wood (1975).

6. Kouris (1982), pp. 1-41.

7. General properties of homothetic functions are discussed in appendix III. It is shown in appendix IV that Hicksian consumer's surplus can be calculated exactly from Marshallian consumer's surplus when preferences are homothetic. Since user's surplus equals the aggregate of Marshallian consumer's surpluses in the downstream markets for crude oil under an assumption of perfect competition, it follows that Hicksian consumer's surplus can also be obtained from user's surplus when preferences are homothetic.

8. Willig (1976) shows that Marshallian consumer's surplus can serve as a reasonable proxy for Hicksian consumer's surplus when either the expenditures share for the good under consideration is small or the income elasticity of demand for the good is small. These points are elaborated on in appendix IV.

9. For this purpose, aggregate income is taken to equal the discounted value of net domestic product (NDP) at market prices over the NEP period.

10. The equations underlying these comparative static results are found in appendix V.

CHAPTER II

INCORPORATING FOREIGN PARTICIPATION INTO A PARTIAL-EQUILIBRIUM ANALYSIS OF THE NEP

1. Introduction

Foreign participation in the crude oil market in Canada is explicitly incorporated in this chapter into an analysis of the allocational and distributional impacts of the NEP in a static, partial-equilibrium framework. The international redistribution of energy rents resulting from the NEP as well as the efficiency and intranational revenue redistribution effects are, therefore, addressed. By doing so, the Canadian welfare consequences of the NEP are analyzed in a more comprehensive manner than in previous partial-equilibrium studies.

Studies of the impacts of the National Energy Program (NEP) generally focus on allocational and intranational rent redistribution impacts. Canada is assumed to be a small, open economy and, therefore, a taker of world oil prices. The NEP price ceiling and fiscal policies are usually found to have transferred energy rents from the western producing provinces and petroleum industry to the federal government, eastern consumers and eastern industry. Efficiency losses in consumption and production resulted in a deterioration of Canadian welfare. These results are borne out in the partial-equilibrium analysis of chapter I. A number of analyses conducted by other authors within a partial-equilibrium framework also support these findings.[1]

Non-cancelling distorting policies result in triangles of deadweight loss in a static, partial-equilibrium analysis. In most such analyses of the crude oil market in Canada, it is implicitly assumed that these lost rents, whether in consumption or production, correspond entirely to a deterioration in Canadian welfare. The economic agents of most countries, including Canada, however, are comprised of both residents and non-residents. The traditional partial-equilibrium approach does not incorporate this distinction and, therefore, fails to consider the distributional impacts of energy policies between Canadians and foreigners.

Foreign participation in the crude oil market in Canada may take a number of different forms: de facto foreign ownership of crude oil resources through foreign ownership of the petroleum industry; foreign consumption of crude oil and oil products; and foreign ownership of non-petroleum producing firms and consumption of non-petroleum products which use oil as a factor of production. Estimates of Canadian ownership and control of the petroleum industry, based on revenues, assets and exploration expenditures, for the period 1981 to 1985 are provided in table V. Canadian ownership is defined as the portion of the total voting shares of a company held, either directly or indirectly, by Canadian residents; Canadian control of a company is generally deemed to exist when at least 50 percent of the firm's voting shares are held by Canadian residents. As is evident from table V, a substantial portion of the petroleum industry in Canada was owned and controlled by foreigners between 1981-85. Depending on the

TABLE V

CANADIAN OWNERSHIP AND CONTROL OF THE PETROLEUM INDUSTRY IN CANADA: 1981-85

	1981	1982	1983	1984	1985	1981-85[a]
<u>REVENUES</u>						
<u>Crude Oil</u>						
-Ownership	33.7	35.5	39.3	39.9	46.6	39.5
-Control	29.9	31.2	33.3	35.0	43.6	35.1
<u>Upstream</u>						
-Ownership[b]	37.4	39.0	41.3	42.5	48.0	41.9
-Control	36.5	38.3	38.4	40.5	48.4	40.7
<u>Upstream and Downstream</u>						
-Ownership	32.8	34.7	38.9	40.4	48.3	38.8
-Control	25.9	25.5	29.6	32.0	42.8	31.0
<u>EXPLORATION EXPENDITURES</u>						
-Ownership	45.0	57.7	62.0	64.4	65.9	59.2
-Control	50.2	62.2	65.5	67.0	70.7	63.2
<u>ASSETS IN CANADA</u>						
-Ownership	47.1	50.9	52.3	52.4	56.4	51.9
-Control	55.0	56.4	54.2	53.5	59.3	55.7

SOURCE: Petroleum Monitoring Agency Canada, <u>Canadian Petroleum Industry Monitoring Survey</u> (Ottawa: Supply and Services Canada, 1981-85)

[a] Weighted averages based on statistics in table XIX in appendix II.

[b] The NEP objective of 50% Canadian ownership of the petroleum industry by 1990 is based on upstream revenues.

method of measurement employed, the average level of foreign ownership for the period ranged from 41 percent to 61 percent; the average level of foreign control, from 37 percent to 69 percent.

NEP price controls which maintained domestic crude oil prices below world levels resulted in a misallocation of Canadian resources. A national welfare loss clearly arose from overconsumption and underproduction of crude oil. On the other hand, since the petroleum industry in Canada was partly foreign owned, price controls effectively transferred crude oil revenues from foreign producers to Canadians. This revenue redistribution would, to some extent, compensate for the efficiency losses in consumption and production. The net impact of the NEP on Canadian welfare, therefore, depends on two opposing factors: the revenue (rent) transfer from foreigners and the deadweight losses in consumption and production. The appropriateness of the NEP pricing and fiscal policies, from a national point of view, depends on whether aggregate Canadian welfare was enhanced.

2. The Importance of Incorporating Foreign Participation into the Partial-Equilibrium Approach

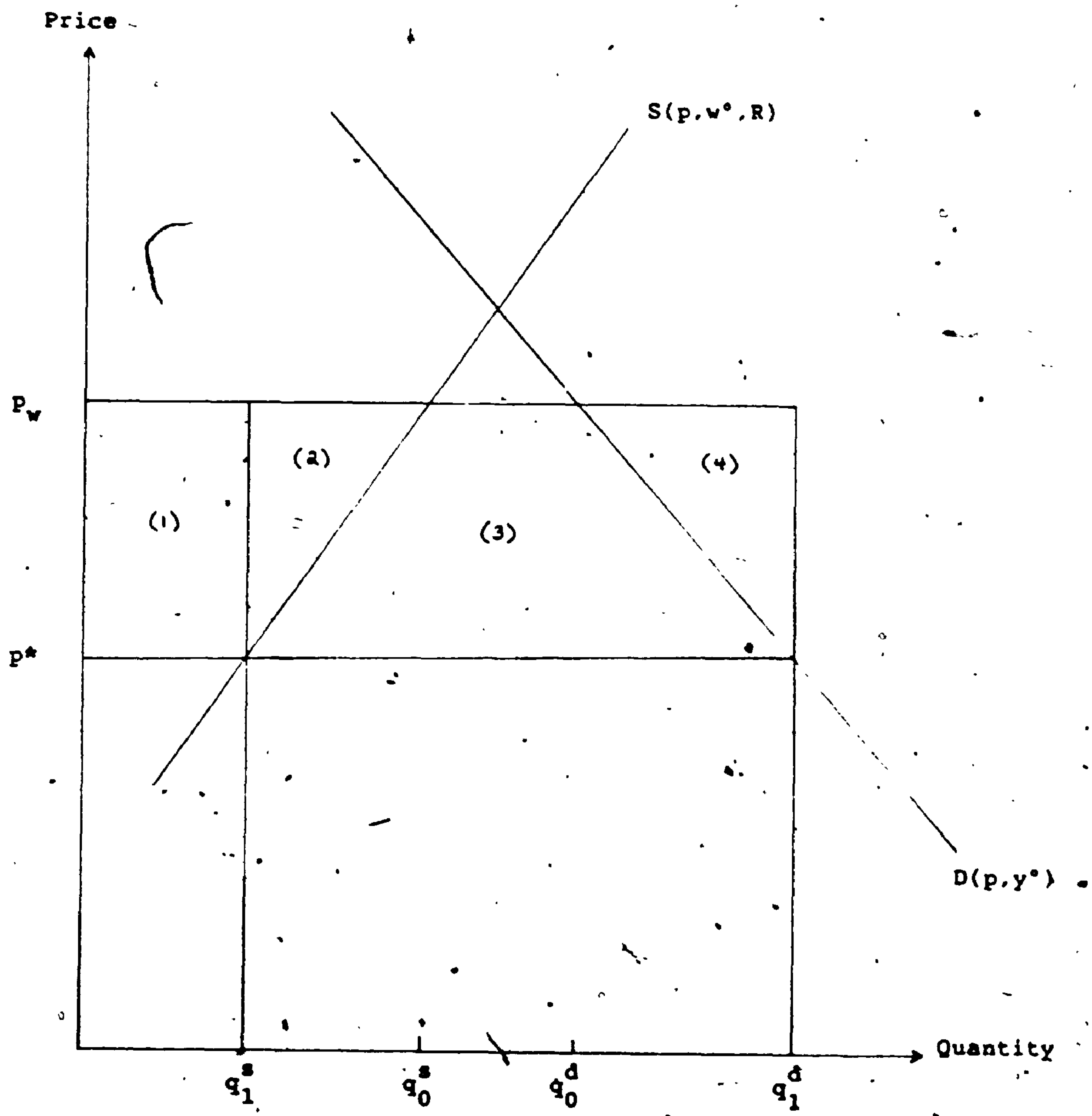
As discussed in the introduction to this dissertation, two opposing views exist as to the impact of the NEP pricing and fiscal policies on Canadian welfare. The majority of economists believe that these energy policies resulted in a considerable misallocation of Canadian resources at a substantial cost to the Canadian economy. An alternative, less prevalent view incorporates foreign participation in energy production. Because of the substantial foreign ownership of the petroleum industry in Canada, it is suggested that the transfer of energy rents from foreigner producers to Canadians likely outweighed the efficiency losses caused by the non-cancelling, distorting policies of the NEP. The additional consideration of foreign participation in consumption would, however, tend to offset the potential welfare gain to Canadian consumers through lower than world oil prices.

The importance of explicitly recognizing foreign participation in a partial-equilibrium analysis, where foreign participation is significant, can be simply illustrated with reference to the partial-equilibrium demand-supply diagram of figure IV. Foreign participation for the purpose of this illustration is taken to mean foreign ownership of the industry under consideration. The welfare impact of a price-ceiling policy is first analyzed using the traditional partial-equilibrium approach, i.e., without recognizing foreign ownership. The welfare results arising from the traditional approach are then compared to the outcome of an analysis in which the industry is assumed to be entirely owned by non-residents.

It is assumed that the expenditure share for the commodity is small so that Marshallian consumer's surplus yields a good approximation of Hicksian consumer's surplus. No taxes or other distortions affect the market. A fixed factor of production is available at no cost to the industry. As a result, rents associated with the fixed factor accrue entirely to the industry. (This situation is conceptually equivalent to provincial governments granting mineral rights to petroleum companies without a corresponding obligation to pay land bonus and rental payments, and Crown royalties

FIGURE IV

FOREIGN PARTICIPATION AND PRICE CONTROLS:
WELFARE IMPLICATIONS



- methods by which petroleum rents are captured.) The domestic market demand and supply curves for the good are given by $D(p,y^{*})$ and $S(p,w^{*},R)$, respectively. Excess demand for the commodity at the world price, p_w, is met through imports. Price controls are imposed which effectively reduce the market price for both producers and consumers below world levels. The price ceiling is denoted as p^{*}. Consumption increases from q_0^d to q_1^d, production falls from q_0^s to q_1^s, and imports rise to meet the increased excess demand for the commodity. A partial-equilibrium welfare analysis of a price-ceiling policy includes three components: Marshallian consumer's surplus, producer's surplus, and an income loss from import price-subsidisation due to the commodity price being controlled below the world price.

a) Traditional Approach

The traditional partial-equilibrium welfare analysis implicitly assumes domestic ownership of the industry and domestic demand for the product. Any deviation from the market price or opportunity cost of a good, therefore, results in a domestic welfare loss. For the situation depicted in figure IV, the price-ceiling policy results in overconsumption and underproduction of the commodity, and a domestic welfare loss equal to the deadweight loss in consumption (area (4)) plus the deadweight loss in production (area (2)).

The policy-induced increase in demand in figure IV can only be met through increased imports of the commodity which must be purchased at the world price due to the small country assumption. The deadweight loss in consumption reflects a marginal consumption valuation for every additional imported unit that is lower than the world price even though the world price must be paid for it. The deadweight loss in production reflects the fact that higher-cost imports displace lower-cost domestic production. Using areas, the net effect of the price ceiling on domestic welfare may be calculated by offsetting areas of gain with equal areas of loss:

Producer's Surplus Loss = (1) + (2)

Consumer's Surplus Gain = (1) + (2) + (3)

Import Subsidy Loss = (2) + (3) + (4)

Net Domestic Welfare Change = -((2) + (4))

b) Foreign Ownership of Resources

Employing the alternative, extreme assumption that the industry is completely owned by foreigners can change the outcome of the welfare analysis dramatically. Under this assumption, the producer's surplus loss resulting from the price-ceiling policy, equal to the change in rents accruing to the fixed primary factor, is fully realized by non-residents. As such, it is not a part of, and should not be included in, the domestic welfare calculation. Contrary to the result of the traditional approach, this consideration leads to an ambiguous domestic welfare impact. The impact on domestic welfare may be derived, with reference to figure IV, as follows:

Producer's Surplus Loss = Zero

Consumer's Surplus Gain = (1) + (2) + (3)

Import Subsidy Loss = (2) + (3) + (4)

Net Domestic Welfare Change = (1) - (4)

Thus, a gain in domestic welfare equal to area (1) is offset by a welfare loss equal to area (4). Area (1) represents a gain in consumer's surplus that is no longer offset by an equal loss in producer's surplus. Area (4) represents the same efficiency loss in consumption as in the traditional analysis.

c) Comparison

The principal finding that emerges from these simple illustrations is that the redistribution of revenues from foreign producers arising from a price-ceiling policy works to offset the deadweight losses that result from overconsumption and underproduction of the commodity. This revenue transfer may not be insignificant. No allowance is made in the analysis, however, to include foreign participation in consumption. Doing so would lower the share of consumption benefits passed on to domestic residents and, consequently, offset the domestic welfare gain or increase the loss in part 2(b). The net welfare impact from the inclusion of foreign participation in consumption and production also depends crucially on the amount of the commodity demanded relative to the amount supplied by the domestic industry, and the elasticities of demand and supply for the commodity.

3. Modifying the Welfare Analysis of Chapter I to Include Foreign Participation

Figure III of the preceeding chapter serves as the basic diagram underlying the welfare analysis conducted in this chapter. In order to modify the partial-equilibrium analysis of chapter I to consider the international and intranational welfare impacts resulting from the imposition of the NEP, additional model parameters relating to foreign participation in production and consumption need to be specified. The importance of recognising foreign ownership of the petroleum industry in Canada is demonstrated in section 2. The potential impact of foreign participation in consumption is also alluded to in that section. Base-case values for these parameters are included in table II of chapter I. The other parameter values that are listed in table II, and that are used in welfare analysis of chapter I, are again used in the analysis conducted in this chapter.

The loss in producer's surplus reported in chapter I was shared by both the Canadian and foreign segments of the petroleum industry in Canada. From table V, Canadian ownership of the upstream, crude oil producing segment of the petroleum industry is taken to be 40 percent. This Canadian industry ownership percentage is labelled i. In order to determine the loss in producer's surplus accruing to the Canadian-owned industry, $CPS(p^{\circ},p',w^{\circ},R)$, equation (1.4) is modified as follows:

$$(2.1) \quad CPS(p^{\circ},p',w^{\circ},R) = i(PS(p^{\circ},p',w^{\circ},R)).$$

The share of consumption benefits realized by Canadians, c, as a result of the NEP generally depends on three factors: the amount of the price decrease passed on to consumers through lower oil prices; the amount of the price decrease passed on to oil-using industries through higher profits and share prices; and the percentage of consumers and shareholders that are foreigners. Under the assumption that the crude oil and oil-using industries are perfectly competitive, however, the amount of the oil price decrease that is ultimately realized by consumers depends on whether firms are generating economic profits. If profits are zero, then consumers realize all the benefits from lower oil prices. In this situation, only the percentage of consumers that are foreigners is of relevance in determining the Canadian consumption share. The foreign share of user's surplus needs to be removed in determining the Canadian welfare impact. Since information on foreign participation in consumption of crude oil and commodities whose production is dependent on crude oil is not readily available, however, Canadians are assumed in the base-case analysis to realize all benefits arising from consumption, i.e., c = 1. Under this assumption, the full value of user's surplus accrues to Canadian residents.

Equation (2.1) is used together with equations (1.1) through (1.8) to determine the aggregate Canadian welfare impact in the base-case analysis of imposing the NEP. Contrary to widespread opinion and the predictions of traditional partial-equilibrium analyses, the base-case parameter and elasticity values indicate an improvement in Canadian welfare of $4.1 billion resulted from the price ceiling and fiscal policies of the NEP relative to a "1981 Western Accord". This gain equals about 1 percent of 1985 NDP at market prices. The base-case welfare results, both aggregate and disaggregate, are reported in table VI.

The aggregate Canadian welfare result indicates that the transfer of rents from foreigners to Canadians outweighed the efficiency losses in production and consumption caused by the NEP. The total welfare impact (Canadian plus foreign) is, of course, negative. It should also be noted that foreign producers owned relatively more COOP oil than Canadian producers. COOP oil was

TABLE VI

NEP WINNERS AND LOSERS INCORPORATING FOREIGN PARTICIPATION IN THE CRUDE OIL MARKET

($ Million)

	Winners	Losers	Net Result
A. Canada			
Industry	-	-5,300.9	-5,300.9
Consumers[a]	27,297.2	-	27,297.2
Governments			
°Federal	-	-1,984.9	-1,984.9
°Producing Provinces[b]	-	-11,955.1	-11,955.1
°Consuming Provinces[c]	-	-3,993.5	-3,993.5
Total Canada	27,297.2	-23,234.4	4,062.8
B. Foreign Industry	-	-7,951.3	-7,951.3
C. All Participants	27,297.2	-31,185.7	-3,888.5

[a] Equal to Hicksian consumer's surplus.

[b] Alberta, British Columbia and Saskatchewan.

[c] Of the three western producing provinces, only British Columbia levied retail sales taxes on gasoline and petroleum products over the period of the NEP.

subject to a significantly lower price than NORP oil. Taking the distribution of crude oil reserves into account would result in an even larger transfer of rents against foreigners, and in favour of Canadians. The aggregate Canadian welfare gain would be even more pronounced.

In order to assess the significance of the unitary Canadian (or zero foreign) consumption share assumption in the aggregate welfare calculation, alternative consumption share values are employed. A 15 percent foreign consumption share is sufficient to result in a neutral aggregate Canadian welfare impact. While this foreign share value is relatively small, it suggests that the welfare impact of the NEP may not have been as devastating as it is often portrayed. A foreign consumption share equal to 30 percent results in a deterioration of aggregate Canadian welfare equal to the gain in Canadian welfare under the base-case assumption that consumption benefits accrue entirely to Canadians; this welfare loss is also approximately equal to the aggregate welfare conclusion stemming from the traditional partial-equilibrium analysis of chapter I.

Underlying the aggregate Canadian welfare impact for the base case are domestic winners and losers from the NEP. They consist of the producing and consuming provincial governments, the federal government, Canadian oil users, and the Canadian-owned petroleum industry. The rent transfer to consumers was the largest single effect of the NEP; the results suggest that this transfer of rents was, in fact, greater than the sum of the remaining domestic distributional impacts. Canadian oil users are estimated to have benefitted by $27.3 billion; an amount equal to the gain in consumer's surplus. The Canadian-owned segment of the petroleum industry lost $5.3 billion. The foreign-owned segment lost $8.0 billion. As in the traditional analysis, the federal government realised a net loss of $2.0 billion: a gain of $9.8 billion from downstream tax revenues offset by losses of $6.4 billion and $5.4 billion in foregone upstream tax revenues and oil-import compensation, respectively. The producing provinces bore the brunt of the NEP losing $11.9 billion in upstream tax revenues, while the consuming provinces and British Columbia lost $4.0 billion from lowered retail sales tax collections.

Additional comparative static results from changing the foreign participation parameters are summarized below.[2] Canadian welfare improves:

i) the higher the share of consumer's surplus that accrues to Canadians, c;

ii) the lower the degree of Canadian ownership of the oil industry, i;

It is interesting to note that comparative static result (ii) suggests that the NEP objective of promoting the Canadianization of the petroleum industry in Canada was not entirely consistent with maximizing Canadian welfare.

A sensitivity analysis of the impact of the elasticity assumptions on Canadian welfare is provided in table VII. The finding that Canadian welfare improved as a result of the NEP is robust over the full range of demand and supply elasticity values employed.

TABLE VII

CANADIAN WELFARE IMPACTS UNDER ALTERNATIVE ELASTICITY ASSUMPTIONS
($1980 Million)

η_d \ η_s	0.1	0.3	0.5	0.75	1.0	1.5
-0.1	5,940.1	5,710.8	5,459.8	5,110.5	4,714.3	3,737.6
-0.3	5,092.0	4,862.7	4,611.7	4,262.4	3,866.2	2,889.4
-0.5	4,292.1	4,062.8	3,811.8	3,462.5	3,066.3	2,089.5
-0.75	3,354.1	3,124.8	2,873.8	2,524.5	2,128.3	1,151.6
-1.0	2,478.5	2,249.2	1,998.1	1,648.8	1,252.6	275.9

4. Conclusions

In this chapter, the allocational and distributional (both international and intranational) impacts of the NEP are evaluated in a partial-equilibrium framework. In doing so, foreign participation in the Canadian economy is explicitly incorporated into the analysis.

In accord with the findings of the traditional partial-equilibrium analysis of chapter I, the price ceiling, tax and subsidy policies of the NEP are still found to have resulted in overconsumption and underproduction of crude oil in Canada compared to the levels of consumption and production that would have resulted had the Western Accord instead been imposed in 1981. While allocational inefficiencies arose, however, the analysis suggests that a Canadian welfare loss may not have, in contrast to popular opinion. The Canadian welfare impact depends on the redistribution of petroleum rents between foreigners and Canadians in addition to efficiency losses in consumption and production. It is found that this rent-transfer effect outweighed the resource-allocation effect so that an aggregate Canadian welfare improvement was recorded for the NEP period. The implementation of a Western Accord in lieu of the NEP would have been a welfare worsening change for Canada; oil self-sufficiency could have been achieved, but, based on economic criteria alone, at a cost of decreased Canadian welfare.

This aggregate Canadian welfare result is subject to qualification, however. Crude oil is a non-renewable natural resource. It is conceivable that a dynamic analysis could reveal that, while Canadian welfare was higher than it otherwise might have been during the NEP period, a Canadian welfare loss will be incurred over the longer term as a result of the NEP policies. It is also noted that the crude oil market is not entirely consistent with the concept of perfect competition which underlies partial-equilibrium analyses. Further, neither risk nor exploration and development activities are adequately treated in the partial-equilibrium analysis. Nor are the indirect impacts of energy market changes on, for example, equalization payments addressed.

Petroleum revenues were redistributed intranationally as well as internationally. Oil users were the major winners; in fact, the gain to consumers, primarily due to price controls, is found to be larger than the sum of the losses to the other participants in the Canadian economy. The petroleum industry in Canada, both foreign-owned and Canadian-owned segments, was made worse off under the NEP; the foreign-owned industry being affected more adversely. The federal government, and the governments of the producing and consuming provinces also lost through foregone tax revenues. It should be noted that the total welfare impact, equal to the sum of these individual impacts, both Canadian and foreign, is negative. Further, the distributional impacts can be considered only as a first approximation; they will need to be modified to the extent that revenues are redistributed through secondary mechanisms such as equalisation payments.

The efficient allocation of scarce resources, as determined by the price that prevails in competitive markets in the absense of externalities, economies of scale and information imperfections, does not in general maximise a country's welfare when foreign participation is taken into account. As a result, a deviation from the competitive price is not necessarily reflected in a domestic welfare loss. An improvement in domestic welfare may instead result. The traditional static, partial-equilibrium approach to analyzing the impacts of non-cancelling distorting policies needs to be modified to incorporate foreign participation in an economy, where foreign participation is significant, so as to adequately capture the international redistribution of rents in determining the domestic welfare impact of a policy change.

Footnotes

1. See, for example, Scarfe (1981), Wilkinson and Scarfe (1980), and Thirsk and Wright (1977).

2. The equations underlying these comparative static results are found in appendix V.

CHAPTER III

CALCULATING COMPENSATING AND EQUIVALENT VARIATION FROM MARKET DEMAND INFORMATION

1. Introduction

Welfare analyses conducted in a partial-equilibrium framework have traditionally employed the Marshallian consumer's surplus measure and the associated concept of deadweight loss. At the same time, however, consumer's surplus has raised considerable controversy over its appropriateness as a measure of the welfare impact of a policy change.[1] The diversity of opinion as to the value of this welfare indicator ranges from Arnold Harberger's plea to economists that consumer's surplus "be accepted as providing a conventional framework for applied welfare economics"[2] to Ian Little's conclusion that consumer's surplus "is a totally useless theoretical toy"[3].

The basic objective underlying the use of the Marshallian welfare indicator is to obtain a monetary measure of a change in utility. Theoretically correct monetary measures of the welfare impact of price or fiscal policy changes, and those used most commonly in applied general-equilibrium analyses, are Hicksian compensating and equivalent variation. John Hicks describes compensating variation as the change in income that "would just offset the (change) in price, and leave the consumer no better off than before"[4]. Equivalent variation is defined as "the change in income, taking place in the initial price-situation, which induces the same change in utility as is induced by the price change"[5]. The existence of two Hicksian measures arises from the choice of the initial or final price vector in valuing the welfare change.

The Hicksian welfare measures are associated with compensated demand functions. These functions, dependent on utility, are not observable and, therefore, can not be directly estimated. An applied general-equilibrium welfare analysis, based on the Walrasian general-equilibrium structure, explicitly incorporates a utility specification that is analytically tractable (i.e., convenient), but typically without practical justification. Interactions between supply and demand resulting from policy changes affect relative prices, the aggregate income level and, therefore, all demands. Compared to a partial-equilibrium analysis, the welfare calculation reflects the more realistic premise that markets are fully interdependent.

A procedure is developed in this chapter for calculating compensating and equivalent variation, as defined in a general-equilibrium framework, from observable market demand functions and elasticity estimates. The need to resort to complex general-equilibrium models and their underlying assumptions is thereby removed. Welfare analysis is considerably simplified. More importantly, since market demand curves are observable, they can be estimated using econometric techniques. The a priori selection of a particular functional form to represent a well-behaved preference ordering in an applied general-equilibrium analysis can be argued to bias the welfare results. It seems a potentially less biased and more flexible approach, first, to determine the statistically most relevant market demand function through econometric estimation and, then, to derive an appropriate utility function or some other procedure for welfare analysis based on this information. The theoretical possibility of obtaining a utility function from a market demand function which satisfies the Slutsky restrictions has been ascertained. To date, however, a practical solution to the integrability problem which allows for the determination of compensating and equivalent variation has not been successfully developed.

2. Contribution to the Literature

A literature has developed over the past decade in an attempt to address this issue. It should be noted, however, that in all cases, it is not compensating variation as defined above that is derived from observable demand functions, but, rather, what might be termed Hicksian consumer's surplus. Like Marshallian consumer's surplus, Hicksian consumer's surplus is a construct of demand theory. It represents the amount of income necessary to maintain utility at its initial level, or to compensate an individual for a policy change, under conditions which correspond to the ceteris paribus assumption employed in partial-equilibrium analyses. As such, Hicksian consumer's surplus is subject to the same criticisms as the Marshallian measure, except that it is calculated with respect to the Hicksian demand curve. In effect, it is a limiting form of compensating variation which can be derived from a well-behaved market demand curve. It should also be noted that "equivalent variation" calculated under the ceteris paribus assumption is not a particularly useful indicator of welfare change. This fact is overlooked in the recent literature.[6]

John Chipman and James Moore demonstrate the theoretical possibility of calculating compensating and equivalent variation from observable demand functions.[7] It is well-known that Marshallian consumer's surplus yields exactly the same welfare result as Hicksian consumer's surplus when the marginal utility of income is constant. Robert Willig derives general conditions under which Marshallian consumer's surplus can serve as a reasonable approximation for Hicksian consumer's surplus. He also shows that Hicksian consumer's surplus can be calculated exactly from Marshallian consumer's surplus when a market demand function possesses a constant income elasticity of demand.[8] Yrjo Vartia provides two algorithms for estimating Hicksian consumer's surplus from an ordinary demand system with "arbitrary accuracy".[9] Jerry Hausman's approach allows the precise determination of Hicksian consumer's surplus from the estimation of a single demand curve that satisfies the Slutsky restrictions.[10] Neither Willig's, Vartia's nor Hausman's papers deal with the calculation of compensating and equivalent variation from market demand functions, however. The reason is simple. Nowhere is the production-side of the economy incorporated into their analyses.

In the approach outlined in this chapter, on the other hand, the production-side of the economy is captured through the use of price elasticities of demand based on total derivatives. Termed "general elasticities", they are conceptually equivalent to elasticities generated from applied general-equilibrium analyses. The use of general elasticities reflects the assumption of a fully interdependent economy; their value represents the response to a policy change that results from the full interaction of all segments of an economy. The relationship is also established between general elasticities and "partial elasticities", or elasticities based on partial derivatives, as are applicable to partial-equilibrium analyses.

For linearly homogeneous and ELES utility specifications, compensating and equivalent variation are shown to consist of two components: a price effect and an income effect. The income-effect component is the monetary measure of welfare change resulting from a price-induced change in aggregate income. The post-change level of aggregate income is approximated through the use of general price elasticities of demand. For a small country welfare analysis of a single price change, the price-effect component is equivalent to Hicksian consumer's surplus (determined with respect to either the initial or post change level of aggregate income) in the affected market. The approach outlined here is by no means limited to single price changes, however. The small country assumption is employed both to simplify the analysis, and to compare compensating and equivalent variation welfare results, for the case of a single price change, to those generated using Marshallian or Hicksian consumer's surplus. The major difference between these various welfare measures centres on their treatment of aggregate income. The approach also serves to highlight the importance of assumptions on preferences that are implicit in market demand functions; specifically, homothetic versus non-homothetic preference orderings.

In order to apply the procedure developed here, a market demand function must first be specified. To illustrate the practical application of the approach, constant elasticity of substitution (CES) and extended linear expenditure system (ELES) demand specifications are assumed for a small, open, price-taking economy. These functional forms are often used in applied general-equilibrium analyses: the former reflecting a homothetic preference ordering; the latter, a non-homothetic preference ordering.[11] Formulae for compensating and equivalent variation are derived and compared to both Marshallian and Hicksian consumer's surplus formulae for the single price change case. Using a benchmark, general-equilibrium data set, the welfare equations that are generated by applying the procedure to the CES demand specification are verified in appendix VI by comparing the numerical results with corresponding general-equilibrium results.

3. A Procedure for Calculating Compensating and Equivalent Variation From Observable Market Demand Data

Arguments have traditionally been raised against the use of Marshallian consumer's surplus in applied welfare analyses. These include the arguments that consumer's surplus is only useful when the marginal utility of income is constant, consumer's surplus is only valid for small policy changes, and, since it is only partial in nature, consumer's surplus does not take account of general-equilibrium consequences of policy changes. Hausman's approach for deriving Hicksian consumer's surplus from the market demand curve satisfies the first two concerns. It does not, however, satisfy the third. In order to do so requires an approach which incorporates the responsiveness of aggregate income or production to policy changes, and, thereby, allows the derivation of compensating and equivalent variation.

In this section, an alternative approach to general-equilibrium modelling is outlined for the calculation of compensating and equivalent variation which utilizes observable market demand data. Required market demand information consists of values for price and income elasticities of demand, expenditure shares, and income and price changes. A priori selection of a utility function is not necessary; neither are special assumptions on the marginal utility of income nor the income elasticity of demand. The production-side of the economy is captured through the use of general price elasticities of demand, i.e., elasticities based on total derivatives.

a) The Basic Approach

Consider the general form of the indirect utility function, $u = v(p,y)$ where $p_i = p_i(p)$, $i = 1,\ldots,n$. Utility is given as u; commodity prices are denoted by the vector p; and income is represented by the variable y. No assumptions on preferences as concerns, for example, homotheticity are initially imposed. Totally differentiating this function and employing Roy's identity yields:

$$(3.1)\quad \hat{u}y/n_y^u = y(\hat{y} - \sum_{i=1}^{n}\sum_{j=1}^{n} S_i(p,y)(p_j/p_i)(\partial p_i/\partial p_j)\hat{p}_j)$$

where: $\hat{u} = du/u$ is the percentage change in utility;

$n_y^u = (\partial v(p,y)/\partial y)(y/v(p,y))$ is the income elasticity of utility;

$\partial v(p,y)/\partial y$ is the marginal utility of income;

$\hat{y} = dy/y$ is the percentage change in income;

$S_i(p,y) = p_i x_i(p,y)/y$ is the expenditure share for good i; and

$\hat{p}_j = dp_j/p_j$ is the percentage change in the price of good j.

The interpretation of the left-hand side of equation (3.1) is discussed in part 3(c) below. The right-hand side of equation (3.1) can be further modified by considering the total derivative of the income equation, $y = \sum_{i=1}^{n} p_i x_i(p,y)$ where $x_i(p,y)$ is the market demand function for good i. This is given as:

(3.2) $\hat{y} = \sum_{i=1}^{n}\sum_{j=1}^{n} S_i(p,y)(p_j/p_i)(\partial p_i/\partial p_j)\hat{p}_j + \sum_{i=1}^{n} S_i(p,y)\hat{x}_i(p,y)$

where: $\hat{x}_i(p,y) = dx_i(p,y)/x_i(p,y)$ is the percentage change in demand for good i.

Substituting equation (3.2) into equation (3.1) yields:

(3.3) $\hat{u}y/n_y^u = y \sum_{i=1}^{n} S_i(p,y)\hat{x}_i(p,y)$

The percentage change in demand can be expressed in terms of elasticities as:

(3.4) $\hat{x}_i(p,y) = \sum_{j=1}^{n}\sum_{k=1}^{n} n_{ij}^d(p_k/p_j)(\partial p_j/\partial p_k)\hat{p}_k + n_{iy}^d\hat{y}$, $i = 1,\ldots,n.$

Substituting equation (3.4) into equation (3.3) yields:

(3.5) $\hat{u}y/n_y^u = y \sum_{i=1}^{n} S_i(p,y)\left(\sum_{j=1}^{n}\sum_{k=1}^{n} n_{ij}^d(p_k/p_j)(\partial p_j/\partial p_k)\hat{p}_k + n_{iy}^d\hat{y}\right)$

Equation (3.5) is clearly a general-equilibrium result in that no restrictions have been placed on income or prices. It is also a large country result. The change in the price of one good affects the aggregate income level, the prices of all other goods and, as a result, all demands. Further, equation (3.5) is perfectly general in nature: no assumptions have been placed on the value of the marginal utility of income, or the price or income elasticities of demand. Explicit recognition is provided of the relationship between utility, the marginal utility of income, expenditure shares, and the income and price elasticities underlying the system of demand functions.

Equation (3.5) contains a mixture of observable and unobservable demand-data requirements. The latter consist of the utility change and the income elasticity of utility. As such, the relationship shown in equation (3.5) is not directly applicable to an empirical determination of compensating and equivalent variation. To proceed further, the unobservable data requirements need to be eliminated. For simplicity, the analysis will also be confined to the small country case.

b) The Small Country Assumption

A small country assumption reduces the dimensionality of the problem considerably by eliminating the need to consider cross-price effects. In a general-equilibrium model of a small, open economy, it is assumed that a country is a taker of commodity prices on world markets. Assuming all goods are traded, an exogenous change in the price of one good will affect the terms of trade, but will not alter any other commodity prices facing the small economy. Equations (3.4) and (3.5), respectively, simplify to:

(3.6) $\hat{x}_i(p,y) = \sum_{j=1}^{n} n_{ij}^{d}\hat{p}_j + n_{iy}^{d}\hat{y}, \; i = 1,\ldots,n$

(3.7) $\hat{u}y/n_y^u = y\sum_{i=1}^{n} S_i(p,y)(\sum_{j=1}^{n} n_{ij}^{d}\hat{p}_j + n_{iy}^{d}\hat{y})$

Where a system of demand functions satisfy the Engel and Cournot aggregation restrictions[12], equation (3.7) further reduces to:

(3.8) $\hat{u}y/n_y^u = y(\hat{y} - \sum_{i=1}^{n} S_i(p,y)\hat{p}_i) = dy - \sum_{i=1}^{n} x_i(p,y)dp_i$

c) Homothetic[13] Versus Non-Homothetic Preferences

It has been indicated that Hicksian consumer's surplus can be obtained from a single market demand curve when the marginal utility of income is constant, the income elasticity of demand is constant, or

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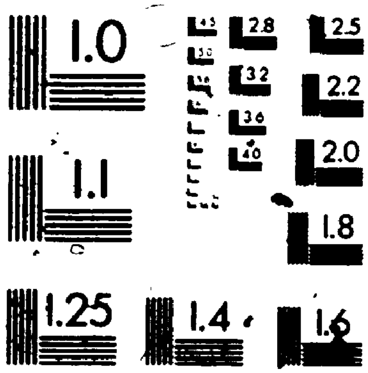

the demand function satisfies the Slutsky restrictions. None of these situations involve a priori assumptions on preferences. A unitary value for the income elasticity of demand, however, reflects a homothetic preference ordering; so too may well-behaved demand functions characterize utility in this manner.

In appendix III, it is shown that a homothetic indirect utility function, $v^*(p,y)$, can be expressed in terms of a linearly homogeneous indirect utility function, $v(p,y)$, i.e.,

(3.9) $u = v(p,y) = k(v^*(p,y))$

where: $k(°)$ is a monotonic function.

Linear homogeneity not only simplifies the welfare analysis, but also accurately captures all of the economically relevant information embodied in the larger class of homothetic preferences to which it belongs. Totally differentiating equation (3.9) and employing Roy's identity yields the following result:

(3.10) $\hat{u}y/(k'(v^*(p,y))v^*(p,y)n_y^{u^*}/k(v^*(p,y))) = y(\hat{y} - \sum_{i=1}^{n} S_i(p,y)\hat{p}_i)$

where: $n_y^{u^*}$ is the income elasticity of utility for the homothetic utility function.

The denominator of the left-hand side of this equation is simply the unitary income elasticity of utility for linearly homogeneous functions given by equations (III.9) and (III.10) in appendix III. Equation (3.10) is, therefore, identical to equation (3.8) assuming a unitary value for the income elasticity of utility in the latter. A comparison of equations (3.8) and (3.10) also confirms that linear homogeneity satisfies the Engel and Cournot aggregation conditions.

The integral of the left-hand side of equation (3.10), holding utility and income constant at either their post price-change or initial levels, yields compensating or equivalent variation, respectively.

$$(3.11)\quad CV(p',y^\circ,y') = (y'/u')\int_{u^\circ}^{u'} du = y'(1 - u^\circ/u')$$

$$(3.12)\quad EV(p^\circ,y^\circ,y') = (y^\circ/u^\circ)\int_{u^\circ}^{u'} du = y^\circ(u'/u^\circ - 1)$$

For a small country analysis which assumes a linearly homogeneous utility specification, the integral of the right-hand side of equation (3.10) yields:

$$(3.13)\quad CV(p',y^\circ,y') = \int_{y^\circ}^{y'} dy + \sum_{i=1}^{n}\int_{p_i^\circ}^{p_i'} x_i(p,e(p,u^\circ))dp_i = (y'-y^\circ) + \sum_{i=1}^{n} HCS_i(p^\circ,p',y^\circ)$$

$$(3.14)\quad EV(p^\circ,y^\circ,y') = \int_{y^\circ}^{y'} dy + \sum_{i=1}^{n}\int_{p_i^\circ}^{p_i'} x_i(p,e(p,u'))dp_i = (y'-y^\circ) + \sum_{i=1}^{n} HCS_i(p^\circ,p',y')$$

Thus, compensating and equivalent variation are composed of additive, income- and price-effect components for the multiple price-change case. The price-effect components in compensating variation are denoted as $HCS_i(p^\circ,p',y^\circ)$, $i = 1,\ldots,n$, where $p^\circ = (p_1^\circ,\ldots,p_n^\circ)$ is the initial price vector and $p' = (p_1',\ldots,p_n')$ is the post-change price vector. Each price-effect component represents the amount of income, at prices p°, necessary to compensate for a price-induced change in utility when aggregate income is held constant at its initial level y°. The price-effect components, therefore, equal Hicksian consumer's surplus in each market in which a commodity price changes. The price-effect components in equivalent variation also equal Hicksian consumer's surplus in the affected markets, $HCS_i(p^\circ,p',y')$, $i = 1,\ldots,n$, but Hicksian consumer's surplus determined by holding aggregate income constant at its post price-change level y'. They represent the reduction in income, at prices p', that would yield a welfare result equivalent to the price change. The income-effect component in both compensating and equivalent variation equals $y' - y^{\circ}$ and represents the change in aggregate income caused by the commodity price changes.[14]

If the utility specification is homothetic, compensating and equivalent variation can be calculated based on the linearly homogeneous welfare information contained in equations (3.11) and (3.12), the relationship between linearly homogeneous and homothetic indirect utility functions given by equation (3.9), and the result obtained by integrating equation (3.8) for the homothetic ordering. For example, for utility functions that are homogeneous of degree c, compensating and equivalent variation can be obtained from the additional calculations:

$$(3.15)\quad CV(p', y^{\circ}, y') = y'(1 - (1 - cz_{cv}/y')^{1/c})$$

$$(3.16)\quad EV(p^{\circ}, y^{\circ}, y') = y^{\circ}((1 + cz_{ev}/y^{\circ})^{1/c} - 1)$$

where: z_{cv} is compensating variation for the associated linearly homogeneous utility function given by equation (3.13); and

z_{ev} is equivalent variation for the associated linearly homogeneous utility function given by equation (3.14).

No assumptions on preferences were imposed in the derivation of equation (3.7). This basic approach can also be applied to non-homothetic preference orderings but, due to the wide range of possible alternative non-homothetic utility specifications, it must be considered on a case-by-case basis. In part 4(b) below, it is shown that integration of the left-hand side of equation (3.7) for the ELES functional form also yields compensating or equivalent variation, depending on the utility and supernumary income levels chosen. As in the case of the linearly homogeneous utility function, the ELES specification satisfies the Engel and Cournot aggregation conditions, and compensating and equivalent variation are composed of additive, price- and income-effect components; the former being equal to Hicksian consumer's surplus in each of the affected markets under the small country assumption.

d) Determining the Aggregate Income Change

The determination of the change in aggregate income resulting from a price change (or changes) is based on the use of "general" price elasticities of demand, i.e., price elasticities based on total derivatives. Since they are based on total derivatives, general price elasticities reflect the impact of a change on all economic variables in the same way as elasticities derived from an applied general-equilibrium analysis. Equation (3.6) captures the importance of "partial" price and income elasticities of demand (i.e., those based on partial derivatives) in the small country welfare analysis. It also provides the link between general and partial elasticities.

The relationship between general and partial elasticities of demand can be seen by rearranging equation (3.6) as:

$$(3.17)\quad N_{ij}^{d} = \hat{x}_i(p,y)/\hat{p}_j$$

$$= n_{iy}^{d}\hat{y}/\hat{p}_j + n_{ij}^{d} + \sum_{k\neq j} n_{ik}^{d}\hat{p}_k/\hat{p}_j,\quad i = 1,\ldots,n$$

where: N_{ij}^{d} is the general (own or cross) price elasticity of demand for good i;

n_{iy}^{d} is the income elasticity of demand for good i; and

n_{ij}^{d} and n_{ik}^{d} are partial (own or cross) price elasticities of demand for good i.

Equation (3.17) can also be rearranged to yield the percentage change in income as a function of the various elasticities underlying the demand system.

When the prices of all goods but one remain constant and the aggregate income level is held fixed, as in a partial-equilibrium analysis, the general own-price and cross-price elasticities of demand equal their respective partial elasticity counterparts. For example, assuming the price of only good j changes, equation (3.17) reduces to $N_{jj}^{d} = n_{jj}^{d}$, and $N_{kj}^{d} = n_{kj}^{d}$ for all $k \neq j$.

For the single price change case in a small country framework, $\hat{p}_k = 0$ in equation (3.17). The demand system, expressed in terms of elasticities, becomes:

(3.18) $N_{jj}^{d} = n_{jy}^{d}\hat{y}/\hat{p}_j + n_{jj}^{d}$

(3.19) $N_{kj}^{d} = n_{ky}^{d}\hat{y}/\hat{p}_j + n_{kj}^{d}, \; k \neq j$

Eliminating the common term $\hat{y}/\hat{p}_j$ yields:

(3.20) $N_{jj}^{d} - n_{jj}^{d} = (n_{jy}^{d}/n_{ky}^{d})(N_{kj}^{d} - n_{kj}^{d})$

Rearranging equation (3.18) yields the percentage change in income as a function of general and partial elasticities of demand for good j, and the percentage change in the price of good j:

(3.21) $\hat{y} = \hat{p}_j(N_{jj}^{d} - n_{jj}^{d})/n_{jy}^{d}$

Integration of equation (3.21), treating the elasticity values as constants, yields an approximation of the post price-change level of aggregate income. This approximation will become less valuable, the larger is the change in a commodity price, but for small price changes, can be expected to provide a reasonably good estimate of the actual income change. This point is numerically illustrated in appendix VI.

4. Applying the Approach to Particular Demand Specifications

To illustrate the practical application of the approach outlined in the previous section, the analysis proceeds within the small country framework under the assumption that the price of only one good changes. Compensating and equivalent variation formulae are derived from observable market demand information for the CES and ELES demand specifications. While the single price change assumption is relatively simple, it is not without precedent. It is often employed in empirical work and, indeed, is a fundamental premise of partial-equilibrium analyses. Its use here allows the results generated for the CES and ELES demand specifications to be compared with Willig's and Hausman's welfare formulae (as applicable), and Marshallian consumer's surplus. A numerical comparison of CES welfare indicators is provided in appendix VI.

a) The CES Functional Form

The CES demand function for good j is given by[15]:

(3.22) $x_j(p,y) = a_j^{\,r} y / p_j^{\,r} B$

where: $B = \sum_{i=1}^{n} a_i^{\,r} p_i^{(1-r)}$; and

r is the elasticity of substitution in demand.

It is assumed that all other commodity demands of the economy are also represented by CES functions.

Only the price of good j is assumed to change. In keeping with the small country assumption, the prices of all other goods remain fixed, but the aggregate income level is allowed to vary. Based on equation (3.22), the complete demand system for the economy can be expressed in percentage change terms as:

$$(3.23)\quad \hat{x}_j(p,y) = \hat{y} - (r + (1-r)S_j(p,y))\hat{p}_j$$

$$(3.24)\quad \hat{x}_k(p,y) = \hat{y} - (1-r)S_j(p,y)\hat{p}_j,\ k \neq j$$

A comparison of equations (3.23) and (3.24) to equation (3.6) yields the following information on CES uncompensated, partial elasticities:

$$(3.25)\quad n_{jy}^{d} = 1,\ j = 1,\ldots,n$$

$$(3.26)\quad n_{kj}^{d} = -(1-r)S_j(p,y),\ k \neq j$$

$$(3.27)\quad n_{jj}^{d} = -(r + (1-r)S_j(p,y))$$

Further, since the CES specification is homogeneous of degree one, the income elasticity of utility equals unity.

In order to derive compensating and equivalent variation for the small open economy, the CES elasticity results listed above are substituted into equation (3.7). This results in:

$$(3.28)\quad (y/u)du = dy - x_j(p,e(p,u))dp_j.$$

(Not surprisingly, a comparison of equation (3.28) to equation (3.8) reveals that the CES demand function satisfies the Engel and Cournot aggregation restrictions.) Holding utility and income constant at u' and y', respectively, on the left-hand side, integration of both sides of a so-modified equation (3.28) yields compensating variation for the small country:

$$(3.29)\quad CV(p',y^{\circ},y') = (y' - y^{\circ}) + HCS_j(p^{\circ},p',y^{\circ})$$

When it is assumed that $u = u^{\circ}$ and $y = y^{\circ}$, integration results in equivalent variation for the small country:

$$(3.30)\quad EV(p^{\circ},y^{\circ},y') = (y' - y^{\circ}) + HCS_j(p^{\circ},p',y')$$

The term $HCS_j(p^{\circ},p',y^{\circ})$ can be calculated exactly using either Hausman's or Willig's procedure. Since the income elasticity of demand for CES functions is constant, the price effect in compensating variation can be calculated from Marshallian consumer's surplus. Marshallian consumer's surplus for the CES demand curve for good j is given by:

(3.31) $MCS_j(p^o,p',y^o) = y^o \ln(B'/B^o)/(r-1)$

where: $B' = \sum_{i=1}^{n} a_i^{\,r}(p_i')^{1-r}$; and $B^o = \sum_{i=1}^{n} a_i^{\,r}(p_i^o)^{1-r}$.

Willig's approach yields:

(3.32) $HCS_j(p^o,p',y^o) = y^o(1 - \exp(-MCS_j(p^o,p',y^o)/y^o))$.

Since CES demands satisfy the Slutsky restrictions, Hausman's approach can also be used to obtain:

(3.33) $HCS_j(p^o,p',y^o) = y^o(1 - (B'/B^o)^{1/(1-r)})$.

In order to determine the income effect in compensating or equivalent variation, and the price effect in equivalent variation, the post price-change level of income must first be determined. Utilising the information contained in equations (3.25), (3.27) and (3.21) yields the desired relationship for the CES specification:

(3.34) $\hat{y} = (N_{jj}^{d} - n_{jj}^{d})\hat{p}_j = (N_{jj}^{d} + r + (1-r)S_j(p,y))\hat{p}_j$.

Treating the bracketed term in equation (3.34) as a constant, integration yields the following approximation:

(3.35) $y' = y^o(p_j'/p_j^o)^c$

where: $c = N_{jj}^{d} - n_{jj}^{d} = N_{jj}^{d} + r + (1-r)S_j(p,y)$.

The price effect in equivalent variation is given by:

(3.36) $HCS_j(p^o,p',y') = (y'/y^o)EV_j(p^o,p',y^o)$

where: $EV_j(p^o,p',y^o)$ essentially equals the price effect in equivalent variation under an assumption that income remains constant at its initial level y^o.[16]

Using Willig's approach,

(3.37) $EV_j(p^o,p',y^o) = y^o(\exp(MCS(p^o,p',y^o)/y^o) - 1)$.

Using Hausman's approach,

(3.38) $EV_i(p^\circ, p', y^\circ) = y^\circ((B^\circ/B')^{1/(1-r)} - 1)$.

Necessary demand information for the calculation of the aggregate income change and the price effect in equivalent variation, therefore, consists of values for the general own-price elasticity of demand, and either the partial own-price elasticity or the expenditure share for good j together with the elasticity of substitution in demand. The latter values can be determined through direct econometric estimation of the CES demand function for good j. The value for the general own-price elasticity may be obtained from a literature survey of applied general-equilibrium modelling results.

When the expenditure share for good j is small, of course, the term $(1-r)S_j(p,y)$ in equation (3.35) vanishes and the determination of the income change is simplified accordingly. In addition, Marshallian consumer's surplus provides a reasonable approximation of the price effect in compensating variation.

b) The ELES Functional Form

The ELES demand system for an economy is given by[17]:

(3.39) $x_j(p,y) = x_j{}^* + a_j{}^* w(p,y)/p_j,\ j = 1,\ldots,n+1$

where: $x_j{}^*$ is the subsistence quantity of good j;

$w(p,y) = y - \sum_{i=1}^{n+1} p_i x_i{}^*$ is utility-yielding supernumary income;

$x_j(p,y) - x_j{}^* > 0,\ j = 1,\ldots,n+1$;

$a_j{}^*$ is the portion of supernumary income spent on good j; and

$\sum_{j=1}^{n+1} a_j{}^* = 1$.

Savings is denoted as the n+1th good; its subsistence quantity is assumed equal to zero. As a result, a_{n+1}^* is interpreted as the marginal propensity to save.

Assuming a small country and a change only in the price of good j, the complete demand system can be expressed in percentage change terms as:

(3.40) $\hat{x}_j(p,y) = \hat{y}a_j^*/S_j(p,y) + \hat{p}_j((1-a_j^*)p_jx_j^*/S_j(p,y)y-1)$

(3.41) $\hat{x}_k(p,y) = \hat{y}a_k^*/S_k(p,y) - \hat{p}_j a_k^* p_j x_j^*/S_k(p,y)y, \ k \neq j$

A comparison of equations (3.40) and (3.41) to equation (3.6) yields the following information on ELES uncompensated price elasticities:

(3.42) $n_{jy}^d = a_j^*/S_j(p,y), \ j = 1,\ldots,n+1$

(3.43) $n_{kj}^d = -a_k^* p_j x_j^*/S_k(p,y)y, \ k \neq j$

(3.44) $n_{jj}^d = (1-a_j^*)p_j x_j^*/S_j(p,y)y - 1$

The ELES indirect utility function is given by:

(3.45) $v(p,y) = w(p,y)\prod_{i=1}^{n+1}(a_i^*/p_i)^{a_i^*}$

The income elasticity of utility is, therefore, equal to:

(3.46) $n_y^u = y/w(p,y)$

Substituting the partial elasticity and income elasticity of utility results into equation (3.7) yields:

(3.47) $(w(p,y)/u)du = dy - x_j(p,e(p,u))dp_j$

The integral of the left-hand side of equation (3.47) is compensating or equivalent variation for the ELES specification, depending on the utility and supernumary income levels chosen. Integration of the right-hand side of equation (3.47) yields the same price and income effects for the small country as are represented in equations (3.29) and (3.30) for the CES specification. A natural consequence of this procedure for calculating compensating and equivalent variation, it is apparent from a comparison of equations (3.47) and (3.8) that the ELES preference ordering satisfies the Engel and Cournot aggregation restrictions.

Since the income elasticity of demand is not constant for the ELES functional form, Willig's approach to the derivation of the price effect in compensating variation cannot be used. ELES demands satisfy the Slutsky restrictions, however, so that according to Hausman's approach:

$$(3.48)\quad HCS_j(p^\circ, p', y^\circ) = w(p^\circ, y^\circ)(1-(p_j'/p_j^\circ)^{aj*}) - (p_j' - p_j^\circ)x_j^*$$

The income effect in compensating and equivalent variation is given by:

$$(3.49)\quad y' = y^\circ(p_j'/p_j^\circ)^c$$

where: $c = (N^d_{jj} - n^d_{jj})/n^d_{jy}$.

The price effect in equivalent variation is given by:

$$(3.50)\quad HCS_j(p^\circ, p', y') = w(p', y')((p_j^\circ/p_j')^{aj*} - 1) - (p_j' - p_j^\circ)x_j^*$$

4. Conclusions

The procedure outlined in this chapter allows compensating and equivalent variation, as defined in a Walrasian general-equilibrium structure, to be calculated from observable market demand data. Since the demand curve for a particular good can be estimated using econometric techniques, and utility and expenditure functions derived based on this information, the approach seems potentially less biased and more flexible than applied general-equilibrium modelling which presupposes a particular utility specification.

For linearly homogeneous and ELES utility functions, both compensating and equivalent variation can be decomposed into two, additive components: a price-effect component (or components) and an income-effect component. The former is a measure of the income change that would provide the same change in utility as is caused by a price change (or changes), assuming that the price change does not affect aggregate income. The income-effect component represents the change in aggregate income that results from a price change. For homothetic utility functions, compensating and equivalent variation can be determined from the welfare information contained in the associated linearly homogeneous functions.

The work of Willig and Hausman, which essentially attempts to remove the need for the apologetic caveats that are often used together with consumer's surplus, is also put into proper perspective. Assuming that preferences can be represented by either a linearly homogeneous or an ELES utility specification, the country under consideration is small and the price of only one good changes (Hausman's analysis is essentially confined to the two latter assumptions), their procedures allow for the calculation of only one of the two components of compensating variation - the price effect or Hicksian consumer's surplus. Aggregate income is explicitly held fixed in their analyses (as in a partial-equilibrium analysis) so that a general-equilibrium measure of compensating variation cannot be attained. Further, their calculation of "equivalent variation" does not represent the price-effect component of the general-equilibrium measure of equivalent variation. To do so requires knowledge of the post price-change level of aggregate income.

A procedure is provided to approximate the income-effect component of compensating and equivalent variation, which utilizes price elasticities of demand based on total derivatives. Estimates of these general elasticities may be obtained from applied general-equilibrium modelling results.

The approach is applied to the CES and EBES demand specifications. It is thereby shown that compensating and equivalent variation can be easily obtained from observable market demand data and elasticity estimates for both homothetic and non-homothetic preference orderings. A small country assumption is employed to simplify the analysis. The single price change case is highlighted to allow comparison of the resulting formulae with those derived using either Willig's or Hausman's approaches.

The approach outlined in this essay addresses all of the major criticisms against "consumer's surplus" save one. The distributional impacts of welfare changes are, in fact, not commented on. Perhaps, as Harberger suggests, however, this is a characteristic "upon which the economist as such is not professionally qualified to pronounce"[18].

Footnotes

1. See, for example, Burns (1973), Harberger (1971), Hausman (1981), Hicks (1956), Hotelling (1938), Little (1957), Samuelson (1947) and Willig (1976).

2. Harberger (1971), p. 785.

3. Little (1957), p. 180.

4. Hicks (1946), pp. 40-41 (parentheses added).

5. Hicks (1946), p. 331.

6. The relationship between Marshallian consumer's surplus, Hicksian consumer's surplus, and compensating and equivalent variation is elaborated on in appendix IV. The ceteris paribus assumption of partial-equilibrium analyses is discussed in chapter IV.

7. Chipman and Moore (1980), pp. 933-49. They also analysze the ability of compensating and equivalent variation to rank the welfare impacts of alternative policy options.

8. Willig (1976), pp. 589-97. Willig's conditions are analyzed in appendix IV.

9. Vartia (1983), pp. 79-98.

10. Hausman (1981), pp. 662-76. Hausman's procedure is discussed in appendix IV.

11. See Shoven and Whalley (1984), table 5, pp. 1024-5, and table 8, pp.1036-7, and Mansur and Whalley (1984), table 1, pp. 88-90.

12. The Engel and Cournot aggregation restrictions are given by equations (III.13) and (III.14) in appendix III.

13. Properties of homothetic utility functions are presented in appendix III.

14. The price- and income-effect components of compensating and equivalent variation are analyzed in detail in appendix IV. In this discussion, it is assumed that the preference ordering can be represented by either linearly homogeneous or BLES utility functions, the country under consideration is small, and the price of only one good changes.

15. Underlying this CES demand specification is the assumption that only one elasticity of substitution appears in the associated utility function. This does not in any way, however, affect the validity of the procedure being demonstrated.

16. The term $EV_j(p^*,p',y^*)$ is defined in appendix IV. Its interpretation and usefulness in welfare analysis is also discussed there. It should be noted that both Willig and Hausman define $EV_j(p^*,p',y^*)$ as equivalent variation in their analyses. It should also be noted that the relationship given by equation (3.36) holds for all homothetic preference orderings.

17. See Howe (1975), pp. 305-10, for the development and interpretation of the ELES form from atemporal maximisation. Lluch et al (1977) and Lluch (1973) deal with the intertemporal approach to the ELES.

18. Harberger (1971), p. 785.

CHAPTER IV

THE ROLE OF CONSUMER'S AND PRODUCER'S SURPLUSES IN THE PARTIAL-EQUILIBRIUM APPROACH TO WELFARE ANALYSIS

A partial-equilibrium framework is intended to accurately represent the market for a single, homogeneous good. The quantity of the good demanded by consumers or supplied by perfectly competitive producers at various possible commodity prices is captured in demand and supply curves. Unless it is set exogenously through price controls or due to the dominence of world markets over a small, open economy, the market price for the good is determined through the interaction of supply and demand.

The market or Marshallian demand function for a good, $x_j(p,y)$, is dependent on all commodity prices, $p = (p_1,\ldots,p_n)$, and on aggregate income, y. For a normal good, it is negatively sloped. The competitive industry is usually assumed to operate with a constant-returns-to-scale technology. Under this assumption, the supply function is only well-behaved if the supply of at least one primary factor of production is fixed. The market supply function for the good, $x_j(p,w,R)$, is dependent on all commodity prices (assuming the existence of intermediate goods), the fixed primary factor of production, R, and the return to each variable primary factor used in its production, $w = (w_1,\ldots,w_m; m \neq R)$.

A partial-equilibrium analysis is based on three fundamental assumptions known collectively as the ceteris paribus assumption:

i) a fixed level of aggregate income;

ii) constant commodity prices other than for the good under consideration; and

iii) fixed returns for the variable primary factors.

(Component (ii) is conceptually equivalent to a single price change under the small country assumption. Assuming all goods are traded, an exogenous change in the price of one good will affect the terms of trade, but will not alter any other commodity prices facing a small, open, price-taking economy.) The ceteris paribus assumption is typically justified on the grounds that the market under consideration is independent of all other markets and is small enough that it exerts no appreciable influence on the economy in aggregate. While the ceteris paribus assumption may be a useful abstraction in certain limited circumstances, however, it cannot reasonably be expected to have general applicability. As a result, the partial-equilibrium framework is often subject to criticism as being overly simplistic and unrealistic.

In attempting to determine the welfare impact of a policy change, partial-equilibrium analyses employ the concepts of Marshallian consumer's surplus and producer's surplus. The validity of these surplus measures as welfare indicators is generally perceived to be highly suspect, however. Of the two, producer's surplus is, perhaps, the more severely criticised.

Marshallian consumer's surplus is a construct of demand theory, derived with respect to the uncompensated or market demand curve for a single good. Due to the fact that it is associated solely with the demand side of the market, the impacts of policy changes on production are excluded in its calculation. Aggregate income is determined through the interaction of supply and demand. It follows, therefore, that aggregate income is implicitly held fixed when calculating Marshallian consumer's surplus. This is, of course, the first component of the ceteris paribus assumption of partial-equilibrium analyses. An alternative way of expressing this same point is, even though consumer prices respond to policy changes, producer prices and costs remain fixed. A fixed aggregate income level is conceptually equivalent to fixed producer prices and costs; a more restrictive condition than the third component of the ceteris paribus assumption.

Further, since Marshallian consumer's surplus is determined with reference to a single market demand curve, the demands for other goods are excluded from the welfare calculation. Since aggregate income (or producer prices and costs) remains constant when calculating Marshallian consumer's surplus, the exclusion of these commodity demands amounts to an additional assumption of constant commodity prices other than for the good under consideration. But this is the second component of the ceteris paribus assumption.

The basic objective underlying the use of Marshallian consumer's surplus is to obtain a monetary measure of a change in utility. Theoretically correct monetary measures of the welfare impact of price or fiscal policy changes are Hicksian compensating and equivalent variation. Unfortunately, the Hicksian welfare measures are associated with compensated demand functions. These functions, dependent on utility, are not observable and, therefore, cannot be directly estimated.

Compensating and equivalent variation are commonly used in applied general-equilibrium welfare analyses. By its very nature, this type of analysis addresses one of the major criticisms of partial-equilibrium analyses in that it reflects the more realistic premise that the markets of an economy are fully interdependant; interactions between supply and demand resulting from policy changes affect relative prices, the aggregate income level and, therefore, all demands.

In chapter III, a procedure is developed for calculating compensating and equivalent variation from well-behaved, observable, market demand functions and elasticity estimates, thereby removing the need to resort to complex general-equilibrium models and their associated, underlying assumptions. Welfare analysis is considerably simplified. Since market demand curves can be econometrically estimated, the a priori selection of a utility function is avoided. It is not necessary to arbitrarily select a value (or values) for the elasticity of substitution in the preferences. The equilibrium status of the aggregate economy is also irrelevant. The welfare approach presented in chapter III is, therefore, potentially less biased and more flexible than a general-equilibrium approach in these respects.

For linearly homogeneous and ELES utility specifications, compensating and equivalent variation are found to consist of two components: a price effect and an income effect. The price-effect component is a measure of the income change that would provide the same change in utility as is caused by a price change, assuming the price change does not affect aggregate income. For the price effect in compensating variation, aggregate income is held constant at its initial level, y°; for the price effect in equivalent variation, it is fixed at its post price-change level, y'. The income-effect component represents the change in aggregate income that results from a price change, i.e., the difference between the post change and initial levels of aggregate income, $y' - y^\circ$.

For a small country welfare analysis of a single price change, the price-effect component of compensating variation is equivalent to what can be termed Hicksian consumer's surplus in the affected market, $HCS_j^r(p^\circ, p', y^\circ)$, where $p^\circ = (p_1^\circ, \ldots, p_n^\circ)$ is the initial price vector and $p' = (p_1^\circ, \ldots, p_{j-1}^\circ, p_j', p_{j+1}^\circ, \ldots, p_n^\circ)$ is the post change price vector. Like Marshallian consumer's surplus, Hicksian consumer's surplus is a construct of demand theory. It represents the amount of income necessary to maintain utility at its initial level, or to compensate for a policy change, when aggregate income is held constant at y°. The small-country-single-price-change case and fixed level of aggregate income correspond to the first two parts of the ceteris paribus assumption of partial-equilibrium analyses. As such, Hicksian consumer's surplus is subject to the same criticisms as the Marshallian measure, except that it is calculated with respect to the Hicksian demand curve. In effect, it is a limiting form of compensating variation. Thus, compensating variation, $CV(p', y^\circ, y')$, for linearly homogeneous or ELES utility functions can be expressed algebraically as:

(4.1). $CV(p', y^\circ, y') = (y' - y^\circ) + HCS_j(p^\circ, p', y^\circ)$.

The derivation of equivalent variation from market demand information is not dealt with in this chapter for the following reasons. The partial-equilibrium approach assumes that aggregate income is held constant at its initial level. The price effect in equivalent variation (a limiting form of equivalent variation), on the other hand, represents the change in income that would yield a welfare result equivalent to the price change, assuming aggregate income is held constant at its post-change level. Further, the procedure developed in Chapter III for calculating the post-change aggregate income level yields only an approximation. As a result, the calculation of the price effect in equivalent variation will not be exact. No approximation is involved, however, in determining the price effect in compensating variation.

The procedure for calculating compensating variation from market demand curves and elasticity estimates is undertaken in two stages. First, Hicksian consumer's surplus is derived from information embodied in the market demand curve; when preferences are homothetic, it can be calculated exactly from Marshallian consumer's surplus. Second, the policy-induced change in aggregate income is determined though the use of general price elasticities of demand which, in effect, capture the production-side impacts.

Marshallian consumer's surplus is equal to the area under a market demand curve. For a fall in the price of good j, the change in Marshallian consumer's surplus ($MCS_j(p^\circ,p',y^\circ)$) is generally given as:

$$(4.2)\quad MCS_j(p^\circ,p',y^\circ) = \int_{p_j^\circ}^{p_j'} x_j(p,y^\circ)dp_j .$$

For homothetic utility specifications, the relationship between Hicksian consumer's surplus and Marshallian consumer's surplus is as follows:

(4.3) $HCS_j(p^\circ,p',y^\circ) = y^\circ(1 - \exp(-MCS_j(p^\circ,p',y^\circ)/y^\circ))$.

The production side of the economy is captured through the use of price elasticities of demand based on total derivatives. Termed "general elasticities", they are conceptually equivalent to elasticities generated from applied general-equilibrium analyses. The use of general elasticities reflects the assumption of a fully interdependent economy; their value represents the response to a policy change that results from the full interaction of all segments of an economy.

The post-change level of aggregate income is determined through the use of both general and partial elasticities of demand. Partial price elasticities of demand are based on partial derivatives in the same way as elasticities derived from partial-equilibrium analyses. For the small-country-single-price-change case, the post change level of aggregate income is given by:

(4.4) $y' = y^\circ(p_j'/p_j^\circ)^c$

where: $c = (N_{jj}^d - n_{jj}^d)/n_{jy}^d$;

N_{jj}^d is the general own-price elasticity of demand for good j;

n_{jj}^d is the partial own-price elasticity of demand for good j; and

n_{jy}^d is the income elasticity of demand for good j.

The income elasticity of demand for homothetic functions is, of course, equal to unity. Equation (4.4) is based on the additional assumption that the general and partial elasticity estimates are constant. As a result, it yields only an approximation of the post price-change level of aggregate income. The approximation will become less valuable, the larger the price change, but for a small price change, can be expected to provide a reasonably good estimate of the post change aggregate income level.

In conjunction with Marshallian consumer's surplus, traditional partial-equilibrium welfare analyses also make use of the concept of producer's surplus which is based on the existence of a perfectly competitive supply curve for the good in question. The supply curve is determined using the second and third components of the ceteris paribus assumption. The market supply curve is assumed to equal the aggregate of the upward sloping portion of the marginal cost curve, lying above its associated average variable cost curve, for each of the individual firms in the industry. Equal to the area above the supply curve, producer's surplus is notionally interpreted as a measure of welfare, symmetric with consumer's surplus. Welfare in this context is taken to mean producer profits and/or rent accruing to the owners of fixed factors of production. But producers (or factor owners) are consumers as well. An issue of double counting arises as a result.

More importantly, utility or welfare is defined as a function only of market demand. Market demand, in turn, is a function of all prices and aggregate income. For the small-country-single-price-change case, Hicksian consumer's surplus is a theoretically correct component of compensating variation. It alone does not entirely capture the welfare impact of the price change since aggregate income (or producer prices and costs) is held constant at y^* in its calculation. The use of equation (4.4) is one method of determining the impact of the price change on aggregate income and the second component of compensating variation. The general price elasticity of demand in equation (4.4) captures the impact of the price change on production, but, in doing so, does not necessarily reflect the partial-equilibrium condition that variable factor returns remain fixed.

The theory developed in chapter III is applied to a CES demand specification in appendix VI. Marshallian and Hicksian consumer's surplus, and compensating and equivalent variation are calculated using a benchmark, general-equilibrium data set. It is found that the approach yields reasonably good estimates of compensating and equivalent variation, particularly for small price changes, as compared with the results of a corresponding general-equilibrium model.

Also included in appendix VI are welfare estimates from a partial-equilibrium analysis which utilizes the same market data. Together with the theory developed in chapter III, these numerical results yield important insights into the true meaning of producer's surplus and the value of the partial-equilibrium approach. They suggest that a change in producer's surplus approximates the change in rent, as defined in a general-equilibrium framework, accruing to owners of fixed factors of production. Together with the change in tax revenues and the change in the value of excess demands due to the small country assumption, this rent-change measure yields a good approximation to the income-effect component of compensating and equivalent variation, regardless of the size of a price change. It is not an exact measure of the income effect since the comparison general-equilibrium analysis, to which the numbers relate, assumes fixed stocks of primary factors. Had an assumption of international factor mobility been employed in the general-equilibrium analysis, it is reasonable to expect a more precise partial-equilibrium, income-effect result. The price-effect component of compensating variation is equal to Hicksian consumer's surplus and is derived from Marshallian consumer's surplus.

It is indicated above that the calculation of compensating variation from market demand curves and elasticity values removes the necessity of using all of the assumptions that are typically employed in general-equilibrium welfare analyses. The appropriate use of producer's surplus also has advantages over the use of either equation (4.4) or a general-equilibrium model to determine the welfare impacts of a price change. Equation (4.4) utilizes a general elasticity value which can only be obtained from a general-equilibrium analysis. The industry supply curve from which producer's surplus is derived can be econometrically estimated so that the need to conduct a literature survey to choose a value (or values) for the elasticity of substitution in production is avoided. The equilibrium status of the aggregate economy remains irrelevant. Further, the potential exists for non-zero economic profits to arise in the industry under consideration, possibly due to a relatively short time frame for the partial-equilibrium analysis or to market entry restrictions.

The results of chapter III suggest that producer's surplus is not a concept symmetric with Marshallian consumer's surplus, and should not be given the welfare interpretation traditionally afforded it. It does, however, have a valid place in welfare analysis. While it may not be perfectly suited to all situations, a partial-equilibrium welfare analysis which utilizes consumer's surplus together with producer's surplus cannot be dismissed out of hand as a meaningless or misleading approach to policy analysis. Under certain conditions, it can result in as valid a representation of the market for a single, homogeneous good as that achieved using the general-equilibrium modelling technique.

Five conditions under which a partial-equilibrium analysis can be expected to yield a valid representation of welfare change, i.e., compensating variation, are listed below. It should be noted that these five conditions are employed in the partial-equilibrium analyses of the welfare impacts of the NEP crude oil pricing and fiscal policies in chapters I and II. Thus, the aggregate welfare results reported there can be expected to yield a reasonably close approximation to compensating variation as defined in a general-equilibrium framework.

i) Small Country Assumption - all commodity prices are set exogenously on world markets; the large foreign sector accomodates any excess demands (positive or negative) at unchanged commodity prices.

ii) Linearly Homogeneous Preferences - compensating variation is composed of income- and price-effect components; the latter equal Hicksian consumer's surplus in each market in which a commodity price changes; Hicksian consumer's surplus can be calculated exactly from Marshallian consumer's surplus; the income effect is dependent only on price elasticities of demand.

iii) Single Price Change - due to the small country assumption, a change in the price of one good does not affect the relative prices between other goods; compensating variation is composed of an income effect and a single price effect, i.e., Hicksian consumer's surplus in the affected market; the market for a single good can be legitimately analyzed in isolation from all other commodity markets.

iv) Perfect Competition - in both the affected market as well as in associated intermediate goods-using industries; under the latter assumption, the area under the intermediate demand curve in the affected market is equal to "Marshallian consumer's surplus"; Hicksian consumer's surplus can be obtained from user's surplus.

v) Linearly Homogeneous Production Technology/One Fixed Factor/All Other Factors Internationally Mobile - an industry supply curve can be derived; in the absence of taxes, the area above the supply curve equals the rent arising from the fixed factor of production; the returns to variable factors are held constant at their world levels.

Under certain limited conditions, a partial-equilibrium welfare analysis may accurately incorporate the derived demand characteristics of crude oil, discussed in chapter I, in one of two ways: either by utilizing user's surplus or by utilizing Marshallian consumer's surplus. In the latter case, intermediate surplus is treated as a component of the income effect of compensating variation. This point is further dealt with in appendix VII in the context of removing price controls on crude oil.

To summarize, compensating variation for linearly homogeneous utility functions can be separated into two parts: a price effect and an income effect. Assuming a small country and a single price change, the price-effect component of compensating variation equals Hicksian consumer's surplus in the affected market. Hicksian consumer's surplus can be calculated exactly from Marshallian consumer's surplus. Under an assumption of perfect competition, the values of intermediate surplus in the intermediate input markets and Marshallian consumer's surplus in the corresponding final product markets are identical. Hicksian consumer's surplus can, therefore, be derived from user's surplus. Further, under perfect competition, it is demonstrated that the income effect can be approximated, with a reasonable degree of accuracy, by changes in producer's surplus and taxes together with, in an analysis of the NEP price ceiling policy, an income loss due to import price subsidization. Thus, a partial-equilibrium analysis is capable of yielding essentially the same welfare result, i.e., compensating variation, as that attained from a general-equilibrium analysis. The former is also potentially more flexible and less biased than the latter.

CHAPTER V

A SMALL COUNTRY, GENERAL-EQUILIBRIUM ANALYSIS OF CANADIAN ENERGY PRICING POLICY INCORPORATING FOREIGN OWNERSHIP OF NATURAL RESOURCES*

1. Introduction

Canadian energy policies over the period January 1, 1981, to May 31, 1985, included a complex system of controls which kept most producer and consumer prices of energy products below world levels (for both oil and natural gas).[1] Since Canada was a small net energy importer over this period, energy imports at world prices were subsidized to domestically controlled price levels, with the revenues needed raised through an additional tax on consumers.

This system of controls was introduced in the National Energy Program (NEP) and is often rationalized as having produced a "made in Canada" price system. Since both consumer and producer prices were set below world levels, however, a national welfare loss clearly resulted from overconsumption and underproduction of energy. On the other hand, a significant fraction of the leases for energy extraction in Canada are foreign owned, so that controlling producer prices at levels lower than world prices also transferred rents from foreign owners of Canadian resources to domestic residents. Thus, whether or not Canadian policies were nationally desirable depends on the net effects of the revenue (rent) transfer from foreigners, and the deadweight losses in consumption and production.

In this essay, an applied general-equilibrium model is presented for a small, open, price-taking economy which is used to evaluate the impacts of Canadian energy pricing policies, focussing specifically on international revenue transfer and domestic efficiency effects. Unlike the more multi-purpose, general-equilibrium, open economy models (recently surveyed by Shoven and Whalley (1984)), the model developed here is relatively sparse in detail. Its features are designed to highlight the key elements of the equilibrium structure relevant to the policy issues at hand; energy price controls and foreign ownership of petroleum and natural gas leases. The price-taking assumption also substantially simplifies computation.

Specifically, the basic model uses the assumption that Canada is an international price taker in both energy and other products to determine cost covering factor prices from given world goods prices.[2] Using these factor prices, full-employment conditions for factors then determine industry production levels. Once domestic demands are calculated, excess demands (imports and exports) for goods are known. Since the rest of the world is assumed sufficiently large to accommodate Canadian excess demands in goods at unchanged commodity prices (subject to Walras' law), demand-supply equalities need only hold in domestic factor markets.

The approach allows for further complicating structural elements to be introduced as required. For the purposes of this essay, these include a system of energy price controls, energy import subsidies generated by an energy consumption tax subject to a zero net revenue government constraint, and non-traded goods. The major restriction on the use of the approach is the requirement that the number of primary factors equal the number of traded goods produced domestically, but, for the policy issues analyzed here, the resulting model is not in any way unsuitable because of this.

The advantage of the approach is that it is much simpler than the traditional method of modelling the small open economy used in the applied general-equilibrium literature. The traditional approach uses an Armington formulation and allows elasticities of substitution between similar domestic and foreign commodities to become large in order to approximate a small open economy. The approach presented in this essay sharply reduces the dimension of the equilibrium problem; first, by assuming internationally homogeneous rather than heterogeneous (Armington) products and, second, by removing the need to satisfy demand-supply equalities for goods since the large foreign country accomodates any domestic imbalance. Furthermore, no fixed point or other computational algorithm is required to solve the model. The simplicity of the basic approach also allows for other complications, such as foreign ownership of factors and the complexities of differing policy regimes, to be more easily introduced than in the case of the traditional approach. Thus, as a manageable and relatively easily implementable approach to equilibrium policy evaluation modelling in the small open economy, this seems a natural route to explore.

2. The Basic Approach

To illustrate the basic approach, an n good, n factor, static general-equilibrium model of an economy is outlined in this section.

(In the actual modelling of Canadian energy pricing policies undertaken based on this approach, four goods-producing industries and three primary factors of production are specified.) The economy is treated as a taker of commodity prices on world markets.[3] To simplify the exposition of the basic approach, all complications arising from government intervention through price controls and taxes, and the existence of non-traded goods are initially ignored; these are discussed in the next two sections.

Production in each industry is described by the two-level fixed-coefficient, value-added production system:

(5.1) $Y_i = \min (v_i/a_{vi};\ H_{ki}/a_{ki},\ k=1,\ldots,n),\ i=1,\ldots,n$

where: Y_i is the gross output of industry i;

v_i is the value added in industry i;

a_{vi} is the value-added requirement per unit of gross output for industry i;

H_{ki} is the use of good k in industry i; and

a_{ki} is the fixed requirement of good k per unit of gross output of industry i.

While fixed-coefficient intermediate production is considered, substitution is allowed between primary factors in meeting the value-added requirements of each industry. Value added for industry i is given by the CES function:

(5.2) $$v_i = B_i\left(\sum_{j=1}^{n} g_{ij}(F_{ij})^{(S_i-1)/S_i}\right)^{S_i/(S_i-1)},\ i=1,\ldots,n$$

where: B_i is a units parameter for industry i;

g_{ij} are the share parameters on the factor inputs in industry i;

F_{ij} are amounts of factor j used by industry i[4]; and

S_i is the elasticity of factor substitution in industry i[5].

The use of factor j per unit of output i, (F_{ij}/Y_i), is denoted by f_{ij}.

Net output for each industry, N_i, is given by:

(5.3) $N_i = Y_i - \sum_{k=1}^{n} a_{ik}Y_k$, i=1,...,n.

On the demand side, each of Q consumers has a utility function which, for convenience, is also assumed to be represented by a CES specification:

(5.4) $U^q = \left(\sum_{i=1}^{n} a_i^q (C_i^q)^{(S^q-1)/S^q}\right)^{S^q/(S^q-1)}$, q=1,...,Q

where: C_i^q is consumption of good i by consumer q;

a_i^q are share parameters for consumer q; and

S^q is consumer q's elasticity of substitution in preferences.[5]

Commodity prices are denoted as P_i (i=1,...,n) and factor prices as w_j (j=1,...,n). These can be normalized to sum to unity if so desired, i.e., $\sum_{i=1}^{n} P_i + \sum_{j=1}^{n} w_j = 1$, since factor demands are homogeneous of degree zero in P_i and w_j. Since the f_{ij} will reflect the outcome of cost minimization, these are written as $f_{ij}(w)$ where w denotes the vector $(w_1,\ldots,w_n)$. The economy-wide endowment of each of the factor inputs is $\bar{F}_j$. If there is foreign ownership of any factor, it is denoted by $\bar{F}_j^r$. Domestic ownership of each factor, $\sum_{q=1}^{Q} \bar{F}_j^q$, equals $\bar{F}_j - \bar{F}_j^r$.[6]

Maximizing (3.4) subject to each domestic consumer's budget constraint yields the domestic commodity demands:

$$(5.5)\quad C_i^q = (a_i^q)^{s^q}\, I^q/(P_i)^{s^q} \sum_{k=1}^{n} (a_k^q)^{s^q} (P_k)^{(1-s^q)}$$

where consumer q's income I^q is given by the value of his factor endowment (i.e., $\sum_{j=1}^{n} w_j \bar{F}_j^q$).

Given fixed world goods prices, $\bar{P}_i$, a domestic equilibrium in this model is characterized by a vector $w^* = (w_1^*, \ldots, w_n^*)$ such that two sets of conditions hold:

(i) demands equal supplies for factors,

$$(5.6)\quad \sum_{i=1}^{n} f_{ij}(w^*)Y_i^* = \bar{F}_j,\ j=1,\ldots,n;\ \text{and}$$

(ii) zero profit conditions hold in domestic industries,

$$(5.7)\quad \bar{P}_i = \sum_{k=1}^{n} a_{ki}\bar{P}_k + \sum_{j=1}^{n} f_{ij}(w^*)w_j^*,\ i=1,\ldots,n.$$

At such an equilibrium, domestic commodity excess demands (foreign trades) are given by:

$$(5.8)\quad X_i^* = \sum_{q=1}^{Q} C_i^{q*} + \sum_{k=1}^{n} a_{ik}Y_k^* - Y_i^*,\ i=1,\ldots,n$$

Summing the domestic consumer's budget constraints and using the zero profit conditions, it follows that trade balance holds, i.e.,

$$(5.9)\quad \sum_{i=1}^{n} \bar{P}_i X_i^* = 0.$$

At such an equilibrium, domestic excess demands for goods are accomodated by the foreign country which is considered to be large enough that buying or selling the required quantities at the given world prices will not affect global equilibrium. Other than this willingness to buy or sell any quantities of goods at fixed world prices (subject to trade balance), no further characteristics of the foreigner's behavior need to be specified in the model.

Solving this model for an equilibrium is considerably easier than for the traditional general-equilibrium model. From the first-order conditions for cost minimisation in each industry:

$$(5.10) \quad f_{ij}(w) = \left(v_i (g_{ij})^{S_i/(1-S_i)} / Y_i B_i\right) \left(\sum_{l=1}^{n} (g_{il}/g_{ij})^{S_i} (w_l/w_j)^{(1-S_i)}\right)^{S_i/(1-S_i)}$$

Using these solutions for the $f_{ij}(w)$ in the zero profit conditions (5.7) provides a system of n equations involving n unknown factor prices. Given the commodity prices, the equilibrium factor prices $w_j{*}$ satisfying (5.7) can then be determined. If the values of $w_j{*}$ corresponding to the given goods prices $\bar{P}_i$ yield goods and factor prices which do not sum to unity, goods and factor prices can be rescaled so that they lie on a unit simplex since both demands and the solutions to cost minimization are homogeneous of degree zero in goods and factor prices. Any normalization of prices can be used, however, as only relative goods and factor prices are relevant in the model.

Given the equilibrium factor prices, the equilibrium values of gross outputs $Y_i{*}$ satisfying the full employment conditions (5.6) can be determined. Further, consumer incomes I^{q*} and hence consumer demands C_i^{q*} can also be solved for by using the equilibrium factor prices in equation (5.5). Equilibrium domestic excess demands for goods (imports and exports) are given by (5.8). Implementing this basic approach requires no computational algorithm. Provided the system of non-linear equations (5.10) can be solved for the $w_j{*}$, no fixed-point solution procedure is necessarily required in determining an equilibrium.

The key feature making the approach operational is that there are the same number of traded goods as factors so that equations (5.7) can be solved. However, it is not ruled out that specialization in production may occur in which case the model can become underdetermined unless extra goods are added. A poorly specified numerical model which has production sets that yield large supply responses when prices change (unrealistically large supply elasticities) is typically indicated if this occurs. In the modelling of Canadian energy price controls, substitution elasticity values in energy production are chosen so as to be approximately consistent with literature estimates of energy supply elasticities, such that specialization does not occur for the policy changes considered.

With the modifications described in the next section, this same basic approach can be used to evaluate the impacts of domestic price distortions such as tariffs, taxes or (as in this essay) energy price controls. Non-traded goods can also be added to the analysis, as discussed in section 4. It is important to stress, however, that it is the operational simplicity of the approach rather than general properties, such as existence of equilibrium for all possible numerical specifications, which motivates its use here.

3. Extensions to Analyse Canadian Policies Specific to Energy

Analysis of the effects of Canadian energy pricing policies involves a number of extensions to the model presented in the previous section. Producer and consumer energy price controls, and the degree of foreign ownership of energy resources must be specified. Factor and excise taxes on energy industries and products must be included. The model also needs to be generalized to incorporate the blended price mechanism actually used in Canada (a zero revenue system of taxes on domestic energy consumers and subsidies for energy imports).

a) Producer and Consumer Energy Price Controls

Under a government declared system of producer and consumer energy price controls set below world energy price levels, an approach similar to that described above can be used to determine a domestic equilibrium. Modifications to the basic approach are necessary, however. In this section, the changes needed to incorporate an arbitrary system of consumer and producer price controls on all goods is presented, even though only price controls on energy products are considered in the model of Canada used in subsequent sections. The (given) world price of any good is denoted as $\bar{P}_i$ and the controlled domestic producer and consumer prices by $\bar{P}_i^p$ and $\bar{P}_i^c$, respectively. Consumer prices are net of excise taxes.

Determining a domestic equilibrium in this case involves using $\bar{P}_i^p$ rather then $\bar{P}_i$ on the left-hand side of equation (5.7), and $\bar{P}_k^p$ rather than $\bar{P}_k$ in the summation term on the right-hand side in (5.7). The latter reflects the assumption that $\bar{P}_k^p$ is the controlled price applying to domestic intermediate users of the k^{th} good. As above, equations (5.7) and (5.10) can be used to determine equilibrium values for the factor prices w_j* which satisfy the zero profit conditions modified to include controlled producer rather than world prices. Equation (5.6) is again used to determine gross industry output Y_i*.

The major change relative to the previous section arises in the way equation (5.5) is used to generate consumer demands. Controlled consumer prices, controlled producer prices, and world prices may differ. A subsidy or tax, at a rate equalling the difference between domestic and world prices, is required if a price controlled good is imported or exported, respectively. The income of the consumer is affected in both cases. This occurs through either an income loss due to lump-sum taxes needed to finance the subsidy or an income gain as export taxes are returned to consumers through lump-sum transfers.

Denoting these transfers, T, as:

$$(5.11)\quad T = \sum_{i=p}^{n}(\bar{P}_i - \bar{P}_i^c)(\sum_{q=1}^{Q} C_i^q) - \sum_{i=1}^{n}(\bar{P}_i - \bar{P}_i^p)(Y_i - \sum_{k=1}^{n} a_{ik} Y_k),$$

the income term in the demand functions equation (5.5) must be written as:

$$(5.12)\quad I^q = \sum_{j=1}^{n} w_j \bar{F}_j^q - T^q$$

where: $T^q = a^q T$.

The terms a^q sum to unity and determine the share of consumer q in the lump-sum tax or transfer.

T plays the same role in this system as the revenue term in the analysis of general equilibrium in the presence of taxes due to Shoven and Whalley (1973). As with taxes, a simultaneity is created with price controls in the evaluation of demands. Until consumer demands are known, the revenues either created by or required to sustain the controlled prices are unknown. Equally, the size of such revenues depends on the values of demands. This simultaneity is accommmodated in the same way that Shoven and Whalley accomodate the revenue simultaneity from taxes, namely by making T endogenous to the model.

Thus, given world prices and controlled, domestic producer and consumer prices, an equilibrium is characterized by a vector $w^* = (w_1^*, \ldots, w_n^*)$ and a value T^* such that equations (5.6) and (5.7) hold. In addition, equation (5.11) holds and the equilibrium demands are given by (5.5) where the income term is modified as in equation (5.12).

Solving this version of the model for a domestic equilibrium is slightly more complex than the procedure described above because of the endogeneity of T. It is no longer possible to solve the model directly from the given world goods prices through the factor prices to the excess demands for goods since a value for T must be initially assumed in order to make the calculations. Typically this will not be the equilibrium value T* so that a fixed point or other computational algorithm will be required to solve for an equilibrium in this case. A one-dimensional simplex (T,d) can also be used where d is a scalar applying to the world goods prices $\bar{P}_i$, and controlled producer and consumer goods $\bar{P}_i^p$ and $\bar{P}_i^c$.

This same general procedure can be used, as well, where price controls apply only to a subset of goods. In the model of Canada, price controls apply only to energy products.

b) A Blended Price Mechanism for Energy Price Controls

Energy price controls in Canada from January 1, 1981, to May 31, 1985, differed slightly from the description given above in that controlled producer and consumer prices were not independent of each other. Instead, a "blended price mechanism" was used through which subsidies for oil imports and higher-cost domestic production were fully financed by a tax levied on domestic consumers. The blended consumer price was set such that world prices for oil imports and controlled prices for domestic production were averaged into a single consumer price, subject to a zero net revenue government constraint. The tax level was adjusted appropriately as oil prices and production changed to ensure the constraint was met.[7]

Introducing this system into the approach outlined above differs only in that P_e^c (the controlled consumer energy price net of excise taxes) is now endogenously determined while T becomes exogenous (set equal to zero through the federal government's zero net revenue requirement). For any given world energy price $\bar{P}_e$ and controlled producer price for energy $\bar{P}_e^p$, the consumer energy price P_e^c will be endogenously determined such that in equilibrium $\bar{T}$, given by (5.13) below, equals zero.[8]

$$(5.13) \quad \bar{T} = (\bar{P}_e - P_e^c)(\sum_{q=1}^{Q} C_e^q) - (\bar{P}_e - \bar{P}_e^p)(Y_e - \sum_{k=1}^{n} a_{ek} Y_k)$$

This blended price case bears the same relationship to the pre-specified controlled consumer and producer price case as the equal tax yield equilibria, considered by Shoven and Whalley (1977), to general equilibria under pre-specified tax rates. In the former case, tax rates are endogenous and the revenue requirement exogenous; in the latter case these are reversed.

To solve the model for a blended energy price equilibrium, both $\bar{P}_e^p$ and $\bar{P}_e$ are pre-specified. For any given consumer energy price P_e^c, the model could be solved for a domestic equilibrium using the procedures outlined in the previous section. However, a computational problem arises in that the zero revenue requirement ($T = 0$) will typically not be satisfied for an initial arbitrarily chosen value of P_e^c. Thus, as with the consumer and producer price control case described in part 3(a), a fixed point or other computational algorithm is required to find a domestic equilibrium although, once again, the dimension of the equilibrium problem is relatively small. In the case of a single controlled consumer energy price, the one dimensional simplex (P_e^c, d) can be used, where d is a scalar applying to the given world price, $\bar{P}_e$, and the controlled producer price, $\bar{P}_e^p$. In this case, P_e^c rather than T is endogenously determined.

4. Extensions to Incorporate Non-Traded Goods

The model dicussed thus far has the same number of traded goods and primary factors. While this feature is necessary in order to be able to determine equilibrium factor prices from given world goods prices, the procedure can be augmented by including an arbitrary number of non-traded goods. The extension of the basic approach to consider non-traded goods is discussed here. In the modelling of Canadian energy pricing policies, the service industry is assumed to produce a non-traded good. All other industries produce traded goods. For the purpose of determining the net welfare impact of Canadian energy policies, the inclusion of non-traded goods is probably of second order. For other applications of the basic approach, however, such as in analyzing the effects of a tariff change, the addition of non-traded goods would be an important extension.

Suppose there are G non-traded goods whose prices are denoted by P_i^N; i=1,...,G. Each non-traded goods industry has production functions as described by equations (5.1) and (5.2), and the non-traded goods appear as part of the consumer demands (equation (5.5)). Since the goods are not traded, there are no foreign demands and consequently the domestic economy is not a price taker for these commodities.

To determine a domestic equilibrium in the presence of non-traded goods, equation (5.7) can be solved both for the values of factor prices, w*, and for the values of non-traded goods prices, P^{N*}, which satisfy the zero profit conditions for the traded goods industries. With all endogenous prices calculated in this way, consumer demands for non-traded goods can be determined from (5.5) and the per unit factor demands in non-traded goods industries calculated from (5.10). This enables the total factor requirements of non-traded goods industries to be ascertained. These are then subtracted from the economy-wide endowments $\bar{F}_j$ and a so-modified version of equation (5.6) used to solve for the equilibrium domestic production of traded goods. With these modifications, the remainder of the approach can be used in the same way as described above.

5. Parameterizing a Model to Analyze the Impacts of Canadian Energy Policies

The approach outlined in the previous sections is applied to a numerical model of Canada benchmarked to a 1980 micro-consistent equilibrium data set to analyze the impacts of changes in Canadian energy pricing policies. To specify parameter values for the functions used in the model, the calibration procedure outlined in Mansur and Whalley (1984) is followed. This procedure requires exogenous specification of key substitution elasticity parameters prior to calibration to a benchmark data set.

The main features of the benchmark data are displayed in table VIII. Four goods-producing industries are specified: manufacturing, services, non-manufacturing/non-services, and energy (oil and natural gas). Three factors of production are considered: capital services,

TABLE VIII

1980 BENCHMARK EQUILIBRIUM DATA SET FOR CANADA
($1980 million)

Intermediate Transactions	Industry: Manufacturing	Industry: Services	Industry: Energy	Industry: Other	Total Intermediate Use	Value of Domestic Production Net of Intermediate Use
Commodities						
Manufacturing	62538.9	44615.1	1065.2	6141.8	114361.0	63325.2
Services	26097.0	92284.5	3665.3	9130.3	131177.1	141548.0
Energy Products	15420.4	1689.9	47.5	164.6	17322.4	(1005.7)
Other Products	20790.5	4122.6	614.4	2197.5	27725.0	8234.5
Total	124846.8	142712.1	5392.4	17634.2	290585.5	212102.0
Value Added					All Industries	
Capital Services	9150.1	24627.0	1209.8	6012.4	40999.3	
Labour Services	35723.2	88110.4	2519.7	7777.7	134131.0	
Resource	-	-	97.0	-	97.0	
Total	44873.3	112737.4	3826.5	13790.1	175227.3	
Factor Taxes					All Industries	
Capital Taxes	5951.4	13305.4	1113.0	4154.9	24524.7	
Labour Taxes	2014.7	3970.2	200.8	380.3	6566.0	
Resource Taxes[a]	-	-	5784.0	-	5784.0	
Total	7966.1	17275.6	7097.8	4535.2	36874.7	
Gross Value Added[b]	52839.4	130013.0	10924.3	18325.3	212102.0	
Gross Output	177686.2	272725.1	16316.7	35959.5	502687.5	

TABLE VIII - Continued

	Total Value of Domestic Production Net of Intermediate Use	Net of Tax Value of Domestic Consumption	Taxes on Output	Gross of Tax Value of Domestic Consumption	Value of Exports	Value of Imports	Value of Net Exports
Manufacturing	63325.2	65414.8	10335.5	75750.3	52478.6	54568.2	(2089.6)
Services	141548.0	141548.0	3651.9	145199.9	0.0	0.0	0.0
Energy Products	(1005.7)	513.6	27.3	540.9	14787.8	18164.0	(3376.2)
Other Products	8234.5	2768.7	85.8	2854.5	12188.3	6722.5	5465.8
Total Commodities	212102.0	210245.1	14100.5	224345.6	79454.7	79454.7	0.0

NOTE: All numbers are valuated at domestic prices except those relating to the value of exports, imports and net exports which are valuated at world prices.

[a] Includes royalties and land payments (both federal and provincial) net of provincial incentives.

[b] Net domestic product at factor cost; gross of factor taxes.

labour services, and resources. Domestic consumers are assumed to possess identical homothetic preferences. The data set is built from flow data so that the resource-factor input refers to the resource flow used during the year rather than to the stock of available resources in the ground. As a result, the welfare effects of energy price controls are calculated on a flow basis in dollars per year and are based on the simplifying assumption that resources are available each year at the same flow rate as that extraction which occurred in 1980. Further, the use of identical preferences means that the analysis is restricted to aggregate national impacts. A more complex calculation focussing on impacts on subgroups (such as the poor, or regions in Canada) could be performed using the same general approach.

The data set is based primarily on the 1980 Canadian micro-consistent data set reported in St. Hilaire and Whalley (1985). The data relating to the resource input in the energy industry is separated from the data pertaining to the capital input in the energy industry using statistics obtained from the Petroleum Monitoring Agency (1981). Adjustments are also made to the foreign trade data to yield zero trade balance in the benchmark data set.

In addition to the benchmark equilibrium data, a series of other parameter values are required to complete the specification of the model. The resource input in the Canadian energy industry is assumed to be 70 percent foreign owned (approximately the situation prevailing in 1980). Price controls on energy producers are treated as leaving them with a net price of 45 percent of world levels (approximately the situation prevailing in 1980). Price controls on consumers involve them also paying 45 percent of the world price for energy consumption, net of excise taxes and the tax component of the blended price mechanism. Resource taxes on value added represent actual 1980 provincial government royalties, net of associated incentives, and federal and provincial land payments.[9] Treating resource taxes separately from federal price controls, and federal and provincial taxes allows the effects of each to be individually analyzed. Income taxes, and sales and excise taxes are also incorporated. While no foreign ownership of capital services is considered in the base case specification, this is incorporated in sensitivity variations on these calculations.[10]

The elasticity of substitution for each of the CES value-added functions in the non-energy sector of the model (i.e., manufacturing, services and non-manufacturing/ non-services industries) is assumed equal to 0.1.[11] The relatively low value for these elasticities was made necessary because of a specialization problem that arose from the particular specification of the Canadian economy employed in the model. Higher substitution elasticity values, more representative of the values reported in time series and cross-sectional studies, elicit large supply responses that result in negative values for gross output in certain industries. A modification to the model to constrain output to a zero value for these industries can be incorporated to address the issue. This would, however, result in certain industries being eliminated in the counterfactual equilibrium through increasing the price of energy to world levels. Since energy prices in Canada are currently at world levels, and all major industries still in existence, this seems a rather unrealistic solution.

An alternative approach, which appears to be more reasonable, would be to incorporate a third, industry-specific, primary input in the value-added functions of the non-energy industries. Specialisation in production would be completely avoided as a result. This, therefore, seems a more appropriate route to follow in future modelling efforts. It should also be noted that the specialisation problem will manifest itself to varying degrees dependent on the particular data set employed and the magnitude of the policy changes modelled. In analyzing the impacts of Canadian energy price decontrol, a 122 percent increase in energy prices over their 1980 levels is necessary.

The substitution elasticity values used in the base case specification for the value-added function of the energy industry and the commodity demand functions have been chosen to yield short-run point estimates of the price elasticities of energy supply and demand that are roughly consistent with literature estimates. The literature estimates for these price elasticites are, however, not directly comparable to those generated by the model. The latter are general-equilibrium estimates and, as such, reflect the full impacts of policy changes on all industries and all commodity demands. Estimates reported in the literature are generally of a more partial nature. Dependent on the particular supply or demand specification employed in these studies and the type of data used, however, some general-equilibrium effects may be captured.[12]

In addition to determining appropriate general-equilibrium price elasticites of energy supply and demand, the particular elasticity value chosen for the value-added function of the energy industry may also have important implications for the model in that a low substitution elasticity value makes the constraint of the industry-specific factor more severe. The lower the value, the more difficult it is to substitute capital and labour for resources. Further, for any particular substitution elasticity values chosen, different policy changes generate different values for the price elasticities of energy supply and demand. A value of 0.5 for the substitiution elasticity of the energy industry is used in the base case specification. The substitution elasticity on the demand side is set at 0.4. Incremental increases in the controlled price of energy towards world levels result in energy supply elasticity values of between 0.3 and 0.6.[13] These same policy changes result in point estimates of the price elasticity of energy demand of between 0.5 and 0.6, in absolute value terms. Implementation of the blended price policy results in a value for the price elasticity of energy demand equal to (negative) 0.1.[14]

To apply the calibration procedures described in Mansur and Whalley (1984), the benchmark equilibrium data set is separated into price and quantity observations using a unit convention similar to that in Harberger (1962). Quantities of commodities are taken as those amounts selling on world markets for $1; domestic controlled energy prices are thus 45¢ per unit for both producers and consumers (the latter net of excise taxes and the tax associated with the blended price). Quantities of productive factors are those amounts generating factor incomes of $1 net of factor taxes.

Once specified in this way, the model reproduces or replicates the benchmark data as a domestic equilibrium using the methods described in earlier sections. The model can then be used to examine counterfactual equilibria generated by moving from the 1980 system of energy price controls to the controls imposed through the NEP, and by considering alternative pricing policies. The impacts of the NEP fiscal policies could also be analyzed using this model of Canada.

6. Model Results

In this section, model results are presented from increasing the 1980 Canadian energy price-control levels towards world levels as well as changing the system of price controls to incorporate a blended price mechanism corresponding to that introduced in the NEP. The impacts of moving to the NEP blended price system are also compared to moving to energy price decontrol, with the approximate, average level of foreign ownership of resources, based on upstream revenues, that existed over the NEP period. A base case model specification is used for the analyses around which sensitivity analyses are performed. The characteristics of the base case model for the Canadian situation described in section 5 are summarized in table IX.

Welfare and other impacts of increasing energy prices towards world price levels, and eliminating controls entirely in the counterfactual equilibrium are presented in table X. Welfare impacts are reported as Hicksian compensating and equivalent variations in the sense described by Harberger and Bruce (1976). A sign convention is employed so that, for either measure, a negative number indicates a welfare loss while a positive number indicates a welfare gain.

The main result emerging from case 1 of table X is that Canadian welfare decreases as energy prices are increased towards world levels.

TABLE IX

CHARACTERISTICS OF THE BASE CASE MODEL FOR CANADA

1. Model benchmarked to 1980 micro-consistent data set.

2. Energy policies include price controls on producers and consumers with imports subsidized down to domestic prices (1980 policy regime). The price ceiling on energy is set at 45 percent of the world price for energy.

3. Elasticity configuration:

   • Value-added substitution elasticites of:
     - 0.1 in manufacturing, services and non-manufacturing/ non-services; and
     - 0.5 in energy.

   • Substitution elasticity in demands is set equal to 0.4.

4. Degree of foreign ownership of natural resources in Canada is set at 70 percent. Degree of foreign ownership of capital in Canada is set at 0 percent.

5. Canada is a small net importer of energy under 1980 price controls.

6. The service industry in Canada is assumed to produce a non-traded good. All other industries produce goods that are traded on world markets.

TABLE X

WELFARE AND OTHER IMPACTS OF REMOVING ENERGY PRICE CONTROLS: COUNTERFACTUAL ENERGY PRICE CHANGES

(Base Case Model Variant)

Case 1: 70% Foreign Ownership of Resource Rents	Counterfactual Domestic Energy Price as Percentage of World Energy Price			
	60	75	90	100
1. Welfare Impacts on Canada ($1980 million)				
Compensating Variation	3497.1	3458.8	1136.6	-1580.9
Equivalent Variation	3607.6	3685.7	1252.8	-1784.0
2. Change in Value of Energy Rents in Canada ($1980 million)				
Accruing to Foreigners	3010.1	6634.8	10757.0	13777.8
Accruing to Canadians	1290.0	2843.5	4610.1	5904.8
Total	4300.1	9478.3	15367.1	19682.6
3. Change in Energy Industry Gross Output (%)	16.7	27.0	34.6	38.8
4. Change in Energy Demand (%)	-17.0	-34.7	-54.9	-71.1

TABLE X - Continued

Case 2: 30% Foreign Ownership of Resource Rents	Counterfactual Domestic Energy Price as Percentage of World Energy Price			
	60	75	90	100
1. Welfare Impacts on Canada ($1980 million)				
Compensating Variation	5218.3	7252.5	7286.9	6296.6
Equivalent Variation	5383.1	7728.2	8032.5	7105.6
2. Change in Value of Energy Rents in Canada ($1980 million)				
Accruing to Foreigners	1290.0	2843.5	4610.1	5904.8
Accruing to Canadians	3010.1	6634.8	10757.0	13777.8
Total	4300.1	9478.3	15367.1	19682.6
3. Change in Energy Industry Gross Output (%)	16.7	27.0	34.6	38.8
4. Change in Energy Demand (%)	-17.0	-34.7	-54.9	-71.1

Removing energy price controls entirely is a nationally welfare losing proposition since the welfare gain from reducing or removing the subsidy on energy consumption is more than offset by the loss associated with a larger transfer of rents to foreigners. The welfare loss, of between $1.5 to $2 billion, that results from eliminating energy price controls is approximately equal to 1 percent of the value of Canadian net domestic product in 1980. The rent-transfer effect in favour of foreigners in this case is around $14 billion; a larger value than the consumer-side gain for Canadians from moving to world prices. Energy output increases by 39 percent and energy demand falls by 71 percent. The net effect is to change Canada from a net importer to a net exporter of energy. While a national welfare loss does not result, qualitatively similar, but quantitatively smaller impacts occur where prices are increased closer to but still remain below world levels.

It is interesting to note that moving controlled prices incrementally towards world prices is a nationally welfare gaining change while eliminating price controls is a welfare losing change. This is because the welfare gain from reducing controls is approximately quadratic in the difference between domestic and world prices while the rent transfer effect is approximately linear. For this reason, there will be a nationally welfare neutral set of price controls where the dead-weight loss of controls and the rent transfer from foreigners offset each other for any given degree of foreign ownership. Results in case 1 of table X suggest that this occurs when domestic producer prices are between 90 and 100 percent of world levels.

Results in case 2 of table X indicate the impact of changing the crucial foreign ownership of Canadian resources parameter. In the base case model of Canada, this parameter is set equal to 70 percent. When it is set at 30 percent, however, a net Canadian welfare gain occurs when price controls are eliminated. In the latter case, the rent-transfer effect no longer dominates the consumer-side effect.

Welfare and other impacts of removing energy price controls are reported in table XI where the benchmark domestic energy price is set at different levels in relation to the world price. These cases are motivated by the feature that controlled energy prices in later years of the NEP period were much closer to world prices than was true in 1980. In 1983, for example, they averaged about 80 percent of world levels; over the full NEP period, they averaged about 60 percent. Results indicate that the effects of eliminating energy price controls, while smaller, are still negative in these cases when foreign ownership of resources is assumed to be 70 percent.

The welfare results presented in table XII reflect the impacts of modifying the base-case analysis to incorporate foreign ownership of capital services. Based on 1980 data from Statistics Canada (61-215), the capital input in manufacturing is assumed to be 46 percent foreign owned; in the energy industry, it is assumed to be 58 percent foreign owned. Employing these additional parameter values, welfare and other impacts of increasing energy prices towards world price levels, and eliminating controls entirely in the counterfactual equilibrium are generated. The results support the basic welfare findings of case 1 in table XI. Canadian welfare: (i) increases as controlled prices are moved incrementally towards world levels;

TABLE XI

WELFARE AND OTHER IMPACTS OF REMOVING ENERGY PRICE CONTROLS: BENCHMARK ENERGY PRICE CHANGES

(Base Case Model Variant)

Case 1: 70% Foreign Ownership of Resource Rents

	Benchmark Domestic Energy Price as Percentage of World Energy Price				
	45	60	75	90	100
1. Welfare Impacts on Canada ($1980 million)					
Compensating Variation	-1580.9	-2699.4	-1872.7	-746.7	0.0
Equivalent Variation	-1784.0	-2872.0	-1928.8	-753.8	0.0
2. Change in Value of Energy Rents in Canada ($1980 million)					
Accruing to Foreigners	13777.8	6634.8	3010.1	920.2	0.0
Accruing to Canadians	5904.8	2843.5	1290.0	394.4	0.0
Total	19682.6	9478.3	4300.1	1314.5	0.0
3. Change in Energy Industry Gross Output (%)	38.8	27.0	16.7	6.7	0.0
4. Change in Energy Demand (%)	-71.1	-31.1	-14.2	-4.6	0.0

TABLE XI - Continued

Case 2: 30% Foreign Ownership of Resource Rents	Benchmark Domestic Energy Price as Percentage of World Energy Price				
	45	60	75	90	100
1. Welfare Impacts on Canada ($1980 million)					
Compensating Variation	6296.6	1094.2	-151.5	-220.5	0.0
Equivalent Variation	7105.6	1164.2	-156.1	-222.6	0.0
2. Change in Value of Energy Rents in Canada ($1980 million)					
Accruing to Foreigners	5904.8	2843.5	1290.0	394.4	0.0
Accruing to Canadians	13777.8	6634.8	3010.1	920.2	0.0
Total	19682.6	9478.3	4300.1	1314.5	0.0
3. Change in Energy Industry Gross Output (%)	38.8	27.0	16.7	6.7	0.0
4. Change in Energy Demand (%)	-71.1	-31.1	-14.2	-4.6	0.0

TABLE XII

WELFARE AND OTHER IMPACTS OF REMOVING ENERGY PRICE CONTROLS: FOREIGN OWNERSHIP OF CAPITAL

(Base Case Model Variant)

	Counterfactual Domestic Energy Price as Percentage of World Energy Price			
	60	75	90	100
1. Welfare Impacts on Canada ($1980 million)				
Compensating Variation	3286.5	3340.3	1550.3	-445.7
Equivalent Variation	33[illegible]0.3	3559.4	1708.9	-503.0
2. Change in Value of Energy Rents in Canada ($1980 million)				
Accruing to Foreigners	3010.1	6634.8	10757.0	13777.8
Accruing to Canadians	1290.0	2843.5	4610.1	5904.8
Total	4300.1	9478.3	15367.1	19682.6
3. Change in Value of Capital Returns in Manufacturing and Energy ($1980 million)				
Accruing to Foreigners	60.3	-183.8	-869.7	-1694.2
Accruing to Canadians	-105.5	-566.0	-1547.4	-2635.5
Total	-45.2	-749.8	-2417.1	-4329.7
4. Change in Energy Industry Gross Output (%)	16.7	27.0	34.6	38.8
5. Change in Energy Demand (%)	-17.0	-34.7	-54.9	-71.1

(ii) decreases for larger changes in controlled prices; and (iii) becomes negative when controls are completely removed. The Canadian welfare loss that arises from removing price controls in table XII ($400-500 million) is, however, smaller than in table XI. This is due to the fact that the resource rent-transfer to foreigners is partially offset by a transfer of rents to Canadians from foreign owners of capital. The net rent-transfer effect in favour of foreigners is about $12 billion. Compared to table XI results, energy demand and output changes are unaffected by ownership considerations.

In table XIII, the results of moving from the 1980 system of producer and consumer energy price controls to the NEP blended price system are reported. Since the producer price stays unchanged in this analysis, no changes in energy rents or production occur, and there are no impacts on foreigners. A welfare gain results from the increase in consumer prices which is significant relative to the 1980 system of price controls. A sharp reaction was voiced against this policy both within Canada and abroad when it was announced in October 1980. It was generally viewed as a major departure from the previous policy. Results in table XIII clearly suggest that this was the case, at least in its effect.

The impacts of moving from the 1980 Canadian energy pricing regime to the NEP blended price regime are compared in table XIV to those from moving instead to energy price decontrol. Foreign ownership of resources in the counterfactual equilibria is set at 62 percent for this purpose. This level approximates the average level of foreign ownership that existed over the period of the NEP. The results indicate that both the movement to world energy price levels

TABLE XIII

IMPACTS OF MOVING FROM 1980 ENERGY PRICING REGIME
TO 1981 NEP BLENDED PRICE POLICY
(Base Case Model Variant)

	Base Case	Foreign Ownership of Resource Rents = 30%
1. Welfare Impacts on Canada ($1980 million)		
Compensating Variation	1909.3	1909.3
Equivalent Variation	1908.9	1908.9
2. Change in Value of Energy Rents in Canada ($1980 million)		
Accruing to Foreigners	0.0	0.0
Accruing to Canadians	0.0	0.0
3. Change in Energy Industry Gross Output (%)	0.0	0.0
4. Change in Energy Demand (%)	-1.0	-1.0

TABLE XIV

WELFARE AND OTHER IMPACTS OF MOVING TO NEP PRICING REGIME VERSUS ENERGY PRICE DECONTROL: 62% FOREIGN OWNERSHIP OF NATURAL RESOURCES

(Base Case Model Variant)

	Energy Price Decontrol	NEP Pricing Regime	Column 2 Minus Column 1
1. Welfare Impacts on Canada ($1980 million)			
Compensating Variation	1.5	1917.1	1915.6
Equivalent Variation	1.7	1916.7	1915.0
2. Change in Value of Energy Rents in Canada ($1980 million)			
Accruing to Foreigners	12203.2	0.0	-12203.2
Accruing to Canadians	7479.4	0.0	-7479.4
Total	19682.6	0.0	-19682.6
3. Change in Energy Industry Gross Output (%)	38.8	0.0	-38.8
4. Change in Energy Demand (%)	-71.1	-1.0	70.1

and the implementation of the NEP pricing regime are welfare improving changes for Canada. Since the benefits from the NEP pricing regime outweigh those from energy price decontrol, however, the results suggest that Canada was better off under the former.

Sensitivity results are reported in table XV from varying substitution elasticities from their base case values in analysing the impacts of removing energy price controls. The elasticity of substitution in consumer demands, S, is varied between 0.2 and 1.5, and the elasticity of substitution in the value-added function in energy, S_e, is varied between 0.1 and 0.5. The symbols CV and EV denote compensating and equivalent variation, respectively; the symbols C and F, Canadians and foreigners. The results indicate substantial sensitivity of welfare impacts with respect to elasticity values on the supply side, but more limited sensitivity effects with respect to the demand-side elasticity variations. Energy output is not affected for demand-side elasticity changes but does show substantial variation for supply-side elasticity changes. The net domestic welfare effect reflects the consumer surplus gain and the rent transfer to foreigners; the former is affected by the demand-side elasticity while the latter is left unchanged as this parameter varies. The important point for policy making is that the sign of the welfare effect is robust to both sensitivity analyses.

TABLE XV

SENSITIVITY ANALYSIS FOR THE BASE CASE ANALYSIS
OF THE IMPACTS OF REMOVING ENERGY PRICE CONTROLS
(70% Foreign Ownership)

S_e \ S		0.2	0.4	0.6	0.8	0.99	1.5
	Welfare Impacts on Canada ($1980 million)						
0.1	CV:	-4007.7	-4027.1	-4052.6	-4083.1	-4115.7	-4215.6
	EV:	-4517.2	-4544.5	-4578.6	-4618.2	-4659.9	-4785.6
0.3	CV:	-3028.1	-3050.6	-3079.2	-3112.8	-3148.2	-3255.6
	EV:	-3413.0	-3442.6	-3478.9	-3520.7	-3564.5	-3695.9
0.5	CV:	-1553.7	-1580.9	-1614.1	-1652.1	-1691.8	-1810.3
	EV:	-1751.3	-1784.0	-1823.6	-1868.6	-1915.5	-2055.1
	Change in Value of Energy Rents in Canada ($1980 million)						
0.1	C:	4324.4	4324.4	4324.4	4324.4	4324.4	4324.4
	F:	10090.2	10090.2	10090.2	10090.2	10090.2	10090.2
0.3	C:	4967.4	4967.4	4967.4	4967.4	4967.4	4967.4
	F:	11590.5	11590.5	11590.5	11590.5	11590.5	11590.5
0.5	C:	5904.8	5904.8	5904.8	5904.8	5904.8	5904.8
	F:	13777.8	13777.8	13777.8	13777.8	13777.8	13777.8
	Change in Energy Industry Gross Output (%)						
0.1		4.9	4.9	4.9	4.9	4.9	4.9
0.3		18.1	18.1	18.1	18.1	18.1	18.1
0.5		38.8	38.8	38.8	38.8	38.8	38.8
	Change in Energy Demand (%)						
0.1		-50.6	-52.7	-54.7	-56.7	-58.4	-62.9
0.3		-57.0	-59.1	-61.2	-63.1	-64.9	-69.4
0.5		-69.0	-71.1	-73.2	-75.2	-77.0	-81.6

7. Conclusions

An applied general-equilibrium model for policy evaluation in the small, open, price-taking economy case is presented in this essay which is considerably simpler than the model currently in wide use in the literature. Provided that there are as many primary factors as traded goods, and no difficulties with specialization occur, it is possible to use the zero profit conditions to determine factor prices from the given world prices for commodities. In this way, the whole model can be solved for a domestic equilibrium in which factor markets clear and zero-profit conditions hold. Demand-supply equalities in markets for traded goods are not needed since the large foreign sector accommodates any excess demands (subject to trade balance). Computation is dramatically simplified as a result. Extensions of the basic model to incorporate the distorting effects of price controls, taxes, tariffs and other policy interventions are relatively straightforward, as are extensions to incorporate non-traded goods.

The approach is used to analyze the effects of Canadian energy pricing policies of the NEP period. The net outcome in terms of national welfare depends on two separate effects. On the one hand, consumer and producer prices set below world prices result in overconsumption and underproduction of energy, and a welfare loss. On the other hand, producer energy prices set below world price levels reduce the factor returns accruing to owners of resources in Canada, many of whom are foreigners.

The numerical results portray the rent transfer effect against foreigners as significant in the net welfare calculation. Depending on the level of foreign ownership of resources, the increased rents transferred to foreigners may outweigh the welfare gain from energy price decontrol. Removing energy price controls in the base case specification is a nationally welfare worsening change; the combined effects of increased energy consumption, reduced domestic energy supply and rent transfer from foreigners under controlled energy prices are relatively more beneficial.

The blended price policy of the NEP regime caused the energy price for consumers to move closer to world levels through an additional tax on consumers. As a result, the welfare loss in consumption was smaller than the loss that would have arisen had only a ceiling price for energy been effective. Producer energy prices and, therefore, foreign rents were not affected by this policy. Results indicate that the imposition of the blended price increased Canadian welfare to a greater degree than the elimination of energy price controls, given the average level of foreign ownership that existed over the NEP period.

Footnotes

* This essay is based on an earlier paper prepared jointly with John Whalley. See Lenjosek and Whalley (1986).

1. See the description of these policies by Lenjosek in Trebilcock et al (1983) and in appendix I to this dissertation.

2. Fama and Laffer (1972) show that, under certain reasonable conditions, the Cournovian relationship between the number of firms and the degree of competition in an industry disappears in a general-equilibrium analysis. In particular, a general equilibrium with two of more noncolluding firms per industry is perfectly competitive. The general-equilibrium model that is developed in this essay meets the conditions that Fama and Laffer specify. Under these conditions, the actual market structure of the particular industries under consideration can be effectively approximated by the assumption of perfect competition.

3. A more complex dynamic formulation in which the country involved is a taker of a price path for all goods (with energy prices obeying Hotelling's rule) could also be used. Dynamic issues are ignored here both to simplify the presentation and to keep the numerical model more manageable.

4. In the modelling of Canadian energy pricing policies, the resource-factor input only enters the energy industry (i.e., $F_{ij} = 0;\ i=1,2,4;\ j=3$).

5. A more general multi-staged CES function could be used in which more than one elasticity appears.

6. In the modelling of Canadian energy pricing policies, there is foreign ownership of resources, but no foreign ownership of either capital or labour (i.e., $\sum_{q=1}^{Q} \bar{F}_j^q = \bar{F}_j;\ j=1,2$).

7. This specification was in accordance with the provisions of the 1981 Canada-Alberta energy pricing and taxation agreement. When the tax (the Petroleum Compensation Charge) was eliminated on June 1, 1985, however, a deficit of over $1 billion existed in the compensation account.

8. The existence of a general equilibrium in the presence of a blended price-ceiling policy is only assured for the case of the small country analysis. This point is discussed further in appendix VIII.

9. See Economic Council of Canada (1982), pp. 37-44, for a discussion of the measurement of economic rent from oil and gas production.

10. The absence of foreign ownership of capital services in the base case analysis can be considered as a crude attempt to model international capital mobility since this capital market specification would result in a fixed rate of return to capital in Canada (equal to the international rate). Foreigners would, therefore, realise no benefit or loss from this source. The importance of capital market specifications in welfare analyses which incorporate foreign ownership of factors of production is elaborated on in appendix IX.

11. See Mansur and Whalley (1984) for a discussion of literature values.

12. The relationship between elasticities of demand based on partial and total derivatives for the small country case is established in the first essay of this dissertation.

13. These price elasticities of energy supply are towards the bottom of the range of energy supply elasticities used by Thirsk and Wright (1977).

14. See Kouris (1982), Scarfe (1981), McRae (1979), Hogan and Manne (1977), Thirsk and Wright (1977), and Berndt and Wood (1975) for estimates of the price elasticity of energy demand.

CONCLUSIONS

The traditional partial-equilibrium approach to welfare analysis utilizes the Marshallian consumer's surplus and producer's surplus measures. These two constructs, however, have been severely criticized from a variety of perspectives and have, consequently, fallen out of general favour in the economics profession. Compensating and equivalent variation are theoretically correct monetary measures of a change in utility. These Hicksian measures are typically used in applied general-equilibrium analyses which attempt to measure the welfare impact of price or fiscal policy changes.

A procedure is developed in chapter III for calculating compensating and equivalent variation from market demand information. Compared to the general-equilibrium approach to welfare analysis, this technique is relatively simple, and potentially less biased and more flexible. It is neither constrained to a particular class of utility functions nor functional forms that are convenient. It is neither restricted to single price changes nor assumptions concerning the ability of a country to influence the world terms of trade. The methodology outlined here has relevance to any economic analysis which attempts to discern the welfare implications of fiscal or pricing policies.

For linearly homogeneous and ELES utility functions, compensating and equivalent variation are found to consist of two components: a price effect and an income effect. The former is a measure of the income change that would provide the same change in utility as is caused by a price change (or changes) assuming that the price change does not affect aggregate income. The income-effect component represents the change in aggregate income that results from the price change (or changes).

Assuming that the country under consideration is small (i.e., a taker of prices on world markets) and that the price of only one good changes, the price-effect component of compensating variation is equivalent to Hicksian consumer's surplus in the affected market. Hicksian consumer's surplus is a measure of welfare change associated with the compensated or Hicksian demand curve. It can be determined from a partial-equilibrium analysis in which, by definition, the aggregate income level is held constant at its initial level (and the prices of all other goods remain fixed). The price-effect component of equivalent variation is also equivalent to Hicksian consumer's surplus under these conditions, but Hicksian consumer's surplus calculated under the assumption that aggregate income is held constant at its post-change level.

The change in aggregate income that results from a price change is the same for both compensating and equivalent variation. The post change level of aggregate income can be approximated by utilizing "general" price elasticities of demand. General elasticities reflect the impact of a price change on all economic variables, in the same way as elastitities derived from general-equilibrium analyses, and so capture production-side effects. Since the elasticity values are held constant in determining the post price-change level of aggregate income, however, only an approximation results. Using this income approximation, the price effect of equivalent variation and the income-effect components of both compensating and equivalent variation can be solved for. Thus, compensating and equivalent variation can be determined.

Previous attempts to calculate compensating and equivalent variation have only succeeded in capturing one of the two components of compensating variation - the price effect or Hicksian consumer's surplus. This is due to the fact that aggregate income changes have not been considered. As such, a general-equilibrium measure of compensating variation cannot be obtained. Further, the calculation of "equivalent variation" which other authors purport to present does not represent the price-effect component of the general-equilibrium measure of equivalent variation. To do so requires knowledge of the post price-change level of aggregate income which, as indicated above, is held constant in their studies. As a result, their "equivalent variation" measure is at best only an approximation to the price-effect component of compensating variation, but an approximation of less value than Marshallian consumer's surplus.

The approach presented in chapter III is applied to CES and ELES demand specifications. It is thereby shown that compensating and equivalent variation can be easily obtained from observable market demand data and elasticity estimates for both homothetic and non-homothetic preference orderings. The former type of utility specification is widely used in the economic literature. The small country assumption and the single price change case are highlighted to allow comparison of the resulting welfare formulae with those derived by other authors. Using a benchmark general-equilibrium data set, the welfare equations that are generated by applying the procedure to the CES demand specification are verified by comparing the numerical results with corresponding general-equilibrium results. Not surprisingly, these results indicate that using Marshallian or Hicksian consumer's surplus as opposed to compensating or equivalent variation to measure welfare changes can lead to inappropriate, if not erroneous, policy conclusions.

The methodology developed in chapter III and the numerical calculations based on it also yield important insights into the true meaning of producer's surplus and the value of the partial-equilibrium approach to welfare analysis. Utilizing the same benchmark, general-equilibrium data set, it was shown that a partial-equilibrium analysis is capable of yielding a good approximation of compensating variation regardless of the size of a price change. (The income-effect approximation developed in the third chapter is most valuable for small price changes.) Producer's surplus appears to have a valid place in welfare analysis as a measure of the change in rent, as defined in a general-equilibirum structure, accruing to the owners of fixed factors of production. This rent-change approximation is one element of the income-effect component of compensating and equivalent variation. Together with fiscal changes and the change in the value of excess demands due to the small country assumption, this rent-change measure yields a good approximation to the income-effect component of compensating and equivalent variation. For a small country welfare analysis of a single price change where the underlying utility function is linearly homogeneous, the price-effect component in compensating variation is equivalent to Hicksian consumer's surplus.

Five conditions are outlined in chapter IV under which a partial-equilibrium analysis can be expected to yield compensating variation. They are as follows:

i) the small country, price-taking assumption;

ii) linearly homogeneous preferences;

iii) the single price change case;

iv) perfect competition; and

v) linearly homogeneous production technology with one fixed factor of production and all other factors internationally mobile.

It should be noted that, since aggregate income is, by definition, fixed at its initial level in a partial-equilibrium framework, the determination of equivalent variation (although possible) does not logically follow.

Chapters I and II, and a portion of chapter V deal with evaluating the welfare implications of the NEP for Canada within both partial- and general-equilibrium frameworks, respectively. The assumptions underlying the partial-equilibrium analyses are consistent with the five conditions noted above. The welfare impacts of both the NEP pricing and fiscal policies on crude oil are addressed within this framework. A unique approach to general-equilibrium modelling for the small country is also developed in chapter V. It is used to analyze the impact of the NEP pricing policies on crude oil and natural gas. These pricing policies consisted of a system of petroleum price controls and a "blended price mechanism" through which subsidies for oil imports and higher-cost domestic production were financed by a tax levied on domestic consumers. Foreign participation in the Canadian economy is explicitly incorporated into both empirical investigations so as to address the welfare consequences of the transfer of energy rents between foreigners and Canadians. In doing so, a more complete treatment is provided of the Canadian welfare costs and benefits of the NEP than was previously available.

The demand for crude oil consists of two components: the demand for a final consumption good and the demand for an intermediate factor of production. The area under the demand curve for crude oil is referred to as user's surplus. In recognition of its final and intermediate demand components, user's surplus is also composed of two parts: Marshallian consumer's surplus or the surplus corresponding to a final demand curve; and intermediate surplus or the surplus corresponding to a derived demand curve. Where an intermediate good is used by a perfectly competitive industry to produce a consumer good, the values of intermediate surplus in the intermediate input market and Marshallian consumer's surplus in the corresponding final product markets are identical. Under perfect competition, therefore, the welfare impact (as measured by Marshallian consumer's surplus) of ceteris paribus output changes is reflected in input market demand functions and can be detected through an analysis of input markets.

The demand for crude oil used in the partial-equilibrium analysis is assumed to reflect the demand by refiners. Since estimates of the income elasticity of demand for crude oil are close to unity, it is further assumed that the underlying preferences for petroleum products are homothetic. Consequently, Hicksian consumer's surplus in the market for crude oil can be calculated exactly from Marshallian consumer's surplus. (Had a non-homothetic utility specification been employed, Marshallian consumer's surplus could have been used as a reasonable proxy for, or to obtain an estimate of the Hicksian welfare measure. Alternatively, Hicksian consumer's surplus could have been calculated exactly from an estimate of the market demand curve.)

The supply curve used in the partial-equilibrium analysis is assumed to represent the before-tax aggregate of the relevant portion of the marginal cost curves for each of the individual firms in the industry. It is also assumed that this function represents some "average", linearly homogeneous technology for oil extraction. The existence of the fixed factor of production (i.e., crude oil) allows the industry supply curve to be determined under these conditions. In the absence of taxes, the area above the supply curve equals the rent (or revenue) arising from the fixed factor; the returns to variable factors are held constant at their world levels.

The applied general-equilibrium model for policy evaluation in the small, open, price-taking economy case presented in chapter V is considerably simpler than the model currently is wide use in the literature. Provided that there are as many primary factors as traded goods, and no difficulties with specialization occur, it is possible to use the zero profit conditions to determine factor prices from given world prices for commodities. In this way, the whole model can be solved for a domestic equilibrium in which factor markets clear and zero-profit conditions hold. Demand-supply equalities in markets for traded goods are not needed since the large foreign sector accomodates any excess demands (subject to trade balance). Computation is dramatically simplified as a result. Extensions of the basic model to incorporate the distorting effects of price controls and taxes are relatively simple, as are extensions to incorporate non-traded goods; each is undertaken in chapter V.

The ceiling price and fiscal policies of the NEP resulted in overconsumption and underproduction of petroleum in Canada compared to the levels of consumption and production that would have resulted from market-determined petroleum pricing (i.e., world prices) and in the absence of the NEP fiscal policies. While allocational inefficiencies reflect a Canadian welfare loss, petroleum rents were also redistributed between foreigners and Canadians. The results of both empirical analysis suggest that the transfer of rents from foreign producers to Canadians, reflected in a Canadian welfare gain, was not insignificant; indeed it is found to have dominated the efficiency losses in consumption and production.

Petroleum revenues were redistributed intranationally as well as internationally. As shown in the partial-equilibrium analysis, oil users were the major winners; in fact, the gain to consumers, primarily due to price controls, is found to be larger than the sum of the losses to the other participants in the Canadian economy. The petroleum industry in Canada, both foreign-owned and Canadian-owned segments, was made worse off under the NEP; the foreign-owned industry being affected more adversely. The federal government, and the governments of the producing and consuming provinces also lost through foregone tax revenues. It should be noted that the total welfare impact, equal to the sum of these individual impacts, both Canadian and foreign, is negative. While the policies of the NEP resulted in a deterioration of global welfare, however, aggregate Canadian welfare was enhanced.

The blended price policy of the NEP regime caused the energy price for consumers to move closer to world levels through an additional tax on consumers. As a result, the welfare loss in consumption was smaller than the loss that would have arisen had only a ceiling price for energy been effective. Producer energy prices and, therefore, foreign rents were not affected by this policy. General-equilibrium results indicate that the imposition of the blended price increased Canadian welfare to a greater degree than the elimination of energy price controls, given the average level of foreign ownership that existed over the NEP period.

The aggregate Canadian welfare result that stems from the two empirical investigations is subject to qualification, however. Crude oil is a non-renewable natural resource. It is conceivable that a dynamic analysis could reveal that, while Canadian welfare was higher than it otherwise might have been during the NEP period, a Canadian welfare loss will be incurred over the longer term as a result of the NEP policies. It is also noted that the crude oil market is not entirely consistent with the concept of perfect competition which underlies the two analyses. Further, neither risk nor exploration and development activities are adequately treated in the analyses. The distributional results can also be considered only as a first approximation; they will need to be modified to the extent that revenues are redistributed through secondary mechanisms such as equalization payments.

The majority of economists favour the view that the NEP resulted in a substantial welfare loss for Canada. A minority viewpoint holds that the transfer of revenues from foreigners to Canadians outweighed the efficiency losses in production and consumption, and resulted in a net Canadian welfare improvement. The results of the two empirical analyses support the latter view. While it is true that the NEP introduced further distortions into the Canadian economy and dramatically redistributed revenues intranationally as well as internationally, the net welfare effect for Canada was positive. Canadians as a whole benefitted at the expense of foreigners. This is not to suggest that a similar or even larger welfare gain could not have been accomodated through a less distortionary set of policies (given federal-provincial cooperation) or that the NEP was particularly desirable considering the frictions and divisions it caused both within the country and internationally. The findings contained in this dissertation do, however, raise some important policy issues that must be addressed, not only relating to domestic policies but, more generally, international relations including the establishment of freer trade agreements.

APPENDIX I

EVOLUTION OF THE CANADIAN PRICING AND FISCAL REGIMES APPLICABLE TO CRUDE OIL AND NATURAL GAS: 1961-86

1. Introduction

Pricing and fiscal policy applicable to crude oil and natural gas in Canada has been subject to numerous and substantial revisions over the past 25 years. To a large extent, these changes were predicated by events which occurred outside of Canada and over which Canada had no control. The particular policies adopted in response to these external stimuli, however, reflected the philosophies, objectives and constitutional authority of elected Canadian governments. The purpose of this paper is to outline the major, petroleum pricing and fiscal policies that have been implemented since 1961, and to provide a brief rationale for their adoption.

2. Petroleum Pricing Policy

Two basic views have been advanced to attempt to explain the quadrupling of world oil prices in 1973-74.[1] The one most widely accepted by economists is that the Organization of Petroleum Exporting Countries (OPEC) formed a cartel which was able to effectively control world oil prices by restricting crude oil production. Saudi Arabia acted as the "swing" producer, adjusting its production levels as necessary to ensure the overall OPEC production quota was met. The dramatic world oil price fall of early 1986 lends credence to this view. Over the 1970s and early 1980s, Saudi Arabia's crude oil market share feld significantly as other OPEC members continuously violated their agreed upon production ceilings. In order to reassert its position in the world oil market, Saudi Arabia substantially increased its crude oil production. Shortly thereafter, the world price for crude oil fell by over 60 percent.

The alternative view suggests that the oil price increase in 1973-74 merely reflected a shift in underlying market conditions that had been underway since the late 1960s. The role of OPEC in this scenario is largely irrelevant. The members of the cartel are seen to have acted competitively and the price increase, while in favour of OPEC, was not brought about by the organization. Regardless of its underlying rationale, however, the world oil price shock of 1973-74 had a fundamental impact on the pricing of crude oil and natural gas in Canada over the following decade.

The evolution of Canadian oil and gas pricing can be divided into four distinct periods separated by: the quadrupling of world oil prices in 1973-74; the introduction of the federal National Energy Program (NEP), effective in 1981; and the implementation of the provisions of the Western Accord between the governments of Canada, Alberta, British Columbia and Saskatchewan in 1985.

The pre-1961 period for crude oil and pre-1975 period for natural gas were essentially characterized by market-determined prices.. Domestic market access for foreign oil was restricted between 1961 and 1973 enabling domestic oil to be sold at higher than world prices. This form of price control was designed to enhance the competitive position of the Canadian petroleum industry.

When world oil prices rose sharply in 1973-74 and again in 1979-80, most countries, particularly those wholly or largely dependent on imported oil, allowed their domestic oil prices to adjust to world levels. In Canada, however, price ceilings were established on the wellhead price of oil in 1974 and on natural gas (both for domestic use and for export) in 1975. Subsidies were also provided to reduce the cost of oil imports to domestic levels, and a tax levied on oil exports. Over the period 1974-80, increases in oil and gas price levels were provided through periodic federal-provincial negotiations.

Explicit price schedules for oil and gas were formally established in the NEP and subsequent federal-provincial energy agreements. World oil prices were made available to certain types of domestic oil production. A self-financing or blended price mechanism was also instituted under which subsidies to higher cost domestic production and crude oil imports were fully financed through a new tax on oil users.

Crude oil price controls and the blended price mechanism were eliminated on June 1, 1985, as a result of the Western Accord. Oil prices are now deregulated. Through the 1985 Agreement on Natural Gas Markets and Prices, domestic natural gas prices were deregulated on November 1, 1986.

Reasons for the imposition of price controls on crude oil in 1974 included a widespread belief that Canadians should not be subject to the vagaries of the "fragile" world oil market, the fact that western Canada was self-sufficient in oil and gas while eastern Canada was dependent on crude oil imports (the Canadian dichotomy argument), and the fact that the majority of Canadian oil reserves were discovered prior to 1974 and, therefore, economic at lower-than-world prices. Oil price increases were viewed as resulting in unnecessary windfall gains to western producers at the expense of eastern consumers. Price controls were imposed on natural gas due to the belief that the commodity was priced below its true market value, and that there should be some explicit relationship between the selling prices of crude oil and natural gas. Gradual increases in domestic oil and gas prices were provided, however, to foster the development of new supplies of oil and gas, and to encourage conservation while, at the same time, to allow Canadian consumers and energy-using industries sufficient time to adjust and, thereby, minimize their impact. In this way, governments attempted to balance the interests of consumers and producers.

Export restrictions were also put in place. From the late 1960s to 1975, Canada was a net oil exporter, i.e., the volume of oil exports from western Canada to the United States exceeded the volume of oil imports into eastern Canada from foreign sources. In 1975, the federal government initiated a policy designed to phase-out most crude oil exports by 1981 in order to achieve self-sufficiency in oil and to effectively maintain Canadian prices below world levels. Only that oil deemed to be in excess of Canadian needs or which was unable to be refined in Canada was allowed to be exported. This policy was particularly directed towards exports of light crude oil; sufficient domestic refining capacity does not exist, even today, for heavy crude oil. Natural gas exports were allowed where they were determined to be in excess of reasonably foreseeable domestic requirements.

Canadian pricing policy effectively controlled domestic oil prices over the period of 1974 to mid-1985. As shown in table XVI, the average price of Canadian crude oil delivered to Montreal (column 3) exceeded the average price of crude oil imports (column 7), both adjusted for quality, in 1971 and 1972. The reverse is true from 1974-85. Natural gas prices were successfully controlled over the period 1975-86. Table XVII provides information on historical natural gas prices. While the wholesale price of gas at Toronto (column 3) exceeded the export price for gas (column 8) from 1971-74, the opposite held true from 1975 to 1985.[2]

a) Crude Oil Pricing

To better appreciate the crude oil pricing developments that took place in Canada over the period 1961-85, it is useful to provide a simplified characterization of the Canadian crude oil market. In excess of 95 percent of the crude oil production in the country is centered in the three western provinces of Alberta, British Columbia, and Saskatchewan; of the three, Alberta alone accounts for about 85 percent. The crude oil industry is also of vital importance to the economies of those provinces in terms of employment, investment and revenues. A large portion of heavy crude oil production is exported due to a lack of adequate, domestic refining capacity. Light crude oil is either exported to foreign markets or transported by pipeline to domestic markets as far east as Ontario. Quebec and the Maritime Provinces derive most of their crude oil requirements from foreign-sourced oil.

TABLE XVI

AVERAGE CRUDE OIL PRICES: 1971-85

(Dollars per Barrel)

	Wellhead Price	Gathering and Transportation	Adjusted Price	Petroleum Compensation Charge	Special Compensation Charge	Blended Price	World Price	Column(3)/ Column(7)	Column(6)/ Column(7)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(%)	(%)
1971	2.84	0.82	3.66	-	-	3.66	3.39	108	108
1972	2.85	0.81	3.66	-	-	3.66	3.35	109	109
1973	3.48	0.81	4.29	-	-	4.29	4.75	90	90
1974	5.83	0.75	6.58	-	-	6.58	11.27	58	58
1975	7.25	0.94	8.19	-	-	8.19	12.72	64	64
1976	8.53	0.91	9.44	-	-	9.44	12.98	73	73
1977	10.25	0.97	11.22	-	-	11.22	15.19	74	74
1978	12.25	1.05	13.30	0.05	-	13.35	16.36	81	82
1979	13.25	1.16	14.41	0.44	-	14.85	22.88	63	65
1980	15.58	1.22	16.80	1.47	-	18.27	37.57	45	49
1981	18.88	1.42	20.30	6.14	0.75	27.19	43.28	47	63
1982	24.62	1.69	26.31	6.30	-	32.61	42.29	62	77
1983	29.75	1.84	31.59	3.76	-	35.35	38.06	83	93
1984	29.75	1.92	31.67	4.15	-	35.82	39.70	80	90
1985	33.49	1.95	35.44	2.72	-	38.16	40.62	87	94

TABLE XVI - Continued

SOURCES: Energy Statistics Division, Energy Statistics Handbook (Ottawa: Energy, Mines and Resources Canada, 1984-87)

Petroleum Monitoring Agency Canada, Canadian Petroleum Industry Monitoring Survey (Ottawa: Supply and Services Canada, 1985)

[1] Based on average quality prices for 1971-80; "old oil" reference price schedules contained in the NEP, energy agreements and amending agreements from 1981 to May 31, 1985; and the Edmonton purchase price less estimated gathering costs of 57 cents per barrel for the remainder of 1985.

[2] To Montreal. For 1971-79, actual average costs to Toronto are adjusted upwards by the proportionate difference in 1980 actual average pipeline tariffs between Toronto and Montreal.

[3] Not to exceed a maximum of 75 percent of the world price under the 1981 Canada-Alberta Memorandum of Agreement (MOA).

[4] Includes the Syncrude Levy from July 1, 1978, to July 11, 1980.

[5] Effective from May 3 to September 21, 1981.

[6] Not to exceed a maximum of 85 percent of the world price under the NEP.

[7] Based on the value of Saudi Arabian light crude oil for 1971-73; and the actual average cost of oil imports at Montreal, adjusted for quality differentials, for 1974-85.

TABLE XVII

AVERAGE NATURAL GAS PRICES: 1971-85

(Dollars per Gigajoule)

	Alberta Border Price	Transportation	Toronto City-Gate Price	Transportation Assistance Program	Canadian Ownership Charge	Natural Gas Tax	Toronto Wholesale Price	Export Price	Toronto Refinery Cost	Column 7/ Column 9
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(%)
1971	0.18	0.21	0.39	-	-	-	0.39	0.26	0.57	68
1972	0.21	0.23	0.44	-	-	-	0.44	0.29	0.57	77
1973	0.21	0.24	0.45	-	-	-	0.45	0.33	0.67	67
1974	0.28	0.27	0.55	-	-	-	0.55	0.51	1.04	53
1975	0.53	0.29	0.82	-	-	-	0.82	1.12	1.29	64
1976	0.84	0.40	1.24	-	-	-	1.24	1.55	1.50	83
1977	1.04	0.43	1.47	-	-	-	1.47	1.92	1.78	83
1978	1.28	0.49	1.77	-	-	-	1.77	2.30	2.12	83
1979	1.36	0.56	1.92	-	-	-	1.92	2.79	2.36	81
1980	1.61	0.62	2.23	-	-	0.05	2.28	4.74	2.91	78
1981	1.75	0.67	2.42	-	0.09	0.35	2.86	5.38	4.47	64
1982	2.01	0.79	2.80	-	0.14	0.61	3.55	5.68	5.39	66
1983	2.48	0.90	3.38	-	0.14	0.34	3.86	5.22	5.83	66
1984	2.78	0.93	3.71	(0.03)	0.14	0.01	3.83	5.31	5.90	65
1985	2.80	0.96	3.76	(0.02)	0.06	0.00	3.80	4.09	6.15	62

TABLE XVII - Continued

SOURCES: Energy Statistics Division, Energy Statistics Handbook (Ottawa: Energy, Mines and Resources Canada, 1984-87)

Petroleum Monitoring Agency Canada, Canadian Petroleum Industry Monitoring Survey (Ottawa: Supply and Services Canada, 1985)

[1] Reference price for gas from September 1, 1981, to October 31, 1986.

[2] Average TransCanada PipeLines transmission tolls from the Alberta-Saskatchewan border to Toronto.

[3] Reference price for gas from November 1, 1975, to August 31, 1981. Until January 1, 1981, its level was set so as to attain a gas-oil price equivalency ratio of 85 percent at Toronto.

[4] Transmission tolls in excess of 5 percent of June 30, 1983, levels were reduced through revenues generated from the Canadian Ownership Special Charge.

[5] The Canadian Ownership Special Charge (COSC) on natural gas was a component of the Toronto Wholesale Price (TWP), from September 1, 1981, to May 31, 1985.

[6] The Natural Gas and Gas Liquids Tax (NGGLT) was a component of the TWP, from September 1, 1981, to January 31, 1984.

[7] Used to attain a gas-oil price equivalency ratio of 65 percent at Toronto over the period September 1, 1981, to May 31, 1985.

[9] The comparison price which, together with the Toroto City-Gate Price (TCGP) or the TWP, as applicable, was used to attain the desired gas-oil price equivalency ratio. Equal to the blended price of table XVI, adjusted to reflect transportation costs to Toronto instead of Montreal, plus the COSC on crude oil.

i) 1961 - 1973

A form of crude oil price control was first introduced by the federal government through the National Oil Policy in 1961. Two discrete, Canadian oil markets were established, separated by the "Borden or Ottawa Valley Line". Oil was imported into the eastern market from foreign sources. The western market was supplied by, what was at the time, more expensive, domestically produced oil. Price control through restricted market access was, therefore, first introduced to the benefit of Canadian oil producers. The policy was designed to foster the development of a viable Canadian industry. It was implemented in response to international developments which occurred in the late 1950s: low world oil prices brought about by oil discoveries in the Middle East and Venezuela; and the imposition of oil import quotas in the United States.

ii) 1974 - 1980

From 1974 to 1980, the price of crude oil produced in Canada was controlled through a series of federal-provincial agreements, primarily to the benefit of Canadian energy users. In March 1974, the two levels of government established a single domestic wellhead price for Canadian oil, subject to the cost of transportation, that was significantly below the price prevailing in world markets. It was also agreed that this wellhead price should rise in stages over time towards world levels. Commencing July 1, 1977, official policy was to raise crude prices at the rate of $1.00 per barrel ($6.30 per cubic metre) every six months.[3] In the event that the cost of crude oil to Canadian refineries exceeded the cost of crude to refineries located in the northern United States, Canadian oil price levels were to be reviewed.

The pre-NEP price control system for oil was somewhat ad hoc in nature despite the federal-provincial agreements that were concluded. The extent and timing of oil price increases could not always be agreed upon even though it was generally acknowledged that an increase in prevailing domestic oil and gas prices was essential to ensure the development of new petroleum supplies. Uncertainty over future levels of world oil prices and the inability of the two levels of government to reach an agreement on the sharing of oil revenues remained important factors preventing the establishment of a comprehensive oil pricing agreement. Prior to 1979, for example, the world market was characterised by an excess supply of oil and real prices were being eroded as oil exporters offered discounts to maintain their market share. It was only with the Iranian revolution in 1978 and the resulting cuts in oil supplies that OPEC was able to accelerate oil price increases in 1979 well beyond those anticipated. Despite the difficulties inherent in the pre-NEP pricing system, however, annual wellhead oil price increases in Canada averaged approximately $2.00 per barrel ($12.60 per cubic metre) over the seven-year period from August 1973 to August 1980.

The price of imported oil was beyond Canadian control. Although domestic oil prices were controlled, eastern Canada continued to be supplied by higher cost, foreign oil. The Oil Import Compensation Program (OICP) was, therefore, introduced by the federal government in the autumn of 1973. The purpose of this complementary policy was to reduce the price of oil for consumers in eastern Canada to domestically controlled levels. This was accomplished through federal subsidies paid to refiners to reduce the average cost of imported oil to the same level as oil produced in Canada.

The third component of the 1974-80 pricing system was a tax levied on exports of crude oil and oil products. The tax essentially equalled the difference between domestic oil prices, inclusive of transportation costs to the export market, and prices prevailing in markets in the United States. The Oil Export Tax was introduced on October 1, 1973, under the Excise Tax Act. The tax was repealed under this legislation on April 1, 1974, however, and reintroduced as the Oil Export Charge under the Petroleum Administration Act[4]. Proceeds from the Oil Export Tax were shared equally between the producing provinces and the federal government. This revenue sharing was terminated coincident with the repeal of the Oil Export Tax. Oil Export Charge revenues were used by the federal government to subsidize eastern oil imports until November 1, 1980.

Even before the doubling of world oil prices after the 1978 Iranian revolution, the revenues collected from the Oil Export Charge were not sufficient to fully offset the costs of oil import compensation. While Oil Export Tax revenues of $511 million initially exceeded the $157 million subsidy to imported oil in fiscal year 1973-74, they began to lag behind only two years later.[5] Proceeds from the Oil Export Charge amounted to only $979 million in fiscal year 1975-76 (primarily due to export controls on light crude oil) compared to oil import compensation requirements of $1.6 billion. For fiscal year 1977-78, Oil Export Charge revenues accounted for only 47% of the import subsidy of $923 million. As a result, an increasing portion of import compensation had to be financed from general federal revenues. The discrepancy between Oil Export Charge revenues and oil import compensation became even more pronounced with the substantial oil price increases that occurred in the aftermath of the Iranian revolution.

To promote the development of synthetic crude oil, production from oil sands mining operations was allowed to be sold at world prices in the late 1970s.[6] As with imported oil, this higher cost domestic production was subsidized by the federal government. The subsidy was paid to domestic refiners to reduce the average cost of synthetic oil to the average cost of other types of domestic production. Unlike oil import compensation, however, the subsidy was fully financed by the Syncrude Levy which was imposed on all oil refined in Canada. This self-financing system was the predecessor of the NEP blended price system through which both higher cost domestic production and imported oil were fully subsidized by means of revenues generated from a tax on oil users.

iii) NEP Period

In 1979, the federal Clark government conducted a major review of energy policy in consultation with the producing provinces and the petroleum industry. The proposed elements of a national energy strategy were outlined at a First Minister's conference in November of that year. A second attempt was made by the Trudeau government in the spring of 1980. An agreement between the federal government and the producing provinces on oil and gas pricing and revenue sharing was, however, not attained. This stalemate led to the unilateral introduction of the NEP by the federal government on October 28, 1980.

The NEP included a new pricing regime for oil and gas. This regime represented a major departure from the system of price controls that had existed from 1974 to 1980. It was comprised of two components: a reference price and price schedule, and a "blended" price.

Canadian oil production was separated into three categories distinguished by the method of recovery employed: oil recovery through conventional methods; oil recovery by means of tertiary oil recovery techniques; and oil recovery from oil sands mining operations.[7] A reference price and price schedule was established for each type of production, effective January 1, 1981.

The Oil Sands Reference Price (OSRP) was essentially set equal to world prices, adjusted for quality.[8] The price for tertiary oil production was increased to approximately 80% of OSRP levels. The conventional oil price, which applied to the vast majority of oil produced in Canada, was to rise in regular stages towards world levels much more quickly than in the pre-NEP period, and was to equal the OSRP by 1990.[9]

The second component of the NEP pricing system was the blended price. The Petroleum Compensation Charge (PCC), which incorporated the Syncrude Levy, was imposed, under the Energy Administration Act, on all oil refined in Canada. The PCC had retroactive effect from July 12, 1980.[10] Revenues from the charge were used to subsidize Canadian refiners by an amount sufficient to reduce the average cost of both crude oil imports and higher cost domestic production to the average cost of domestic, conventional oil. Refiners, therefore, effectively paid a weighted average or blended price for oil where the weights corresponded to quantities of imported oil and various streams of domestic oil. The blended price was not to exceed 85 percent of the lesser of the price of imported oil or the average price of oil in the United States (i.e., at Chicago). Through the blended price mechanism, the burden of financing oil import compensation was shifted from the general taxpayer to the oil user.

Together, the reference price and price schedule, and the blended price were designed to foster the development of new oil supplies, to encourage conservation, to allow Canadian consumers time to adjust gradually and predictably to higher world prices, to raise revenues for the federal government (potentially in excess of those required to fully subsidize higher cost oil), and to give the Canadian oil-using industry a competitive advantage.

Oil export charge revenues were able to be used for purposes other than financing the OICP. Effective November 1, 1980, they were again shared equally between the federal government and the producing provinces. It is interesting to note that in fiscal year 1980-81, proceeds from the oil export charge amounted to only about 25% of oil import compensation payments of $3.2 billion.

Provincial reaction to the NEP was concrete and negative; the NEP was perceived to be a federal intrusion in provincial jurisdiction. The Government of Alberta responded by cutting back provincial oil production in early 1981 (by 5 percent every three months). The resulting decrease in domestic supply could only be offset through increased imports of higher cost, foreign oil. To address, and draw attention, to the siutuation, the federal government imposed the Special Compensation Charge (SCC) on all oil refined in Canada, instead of increasing the PCC to cover the extra cost of the additional imports. The SCC was in effect over the period May 3, 1981, to September 21, 1981.

These energy developments led directly to the announcement of bilateral energy pricing and taxation agreements in the latter half of 1981 between the federal government, on one hand, and each of the provinces of Alberta, British Columbia and Saskatchewan, on the other.[11] These energy agreements modified the basic pricing system already established in the NEP in favour of the petroleum industry. The term of the energy agreements extended from September 1, 1981, to December 31, 1986.

Canadian oil production was now classified as either old oil or new oil for pricing purposes. Old oil was defined as oil recovered from a pool initially discovered prior to January 1, 1981, other than oil recovered through tertiary recovery projects commencing operation after December 31, 1980. New oil included oil from pools initially discovered after December 31, 1980, incremental oil from tertiary recovery schemes commencing operation after December 31, 1980, synthetic oil from oil sands mining operations, and oil from the frontier areas of Canada.

As under the NEP, reference prices and price schedules were established for old and new oil. Both reference prices were increased above the NEP reference price levels, effective January 1, 1982. The Conventional Old Oil Price (COOP), applicable to old oil, was to move more rapidly towards world price levels than under the NEP. It was agreed, however, that the COOP, adjusted for quality and transportation costs to Montreal, would not exceed 75 percent of the average cost of imported crude at Montreal. The New Oil Reference Price (NORP), applicable to new oil, was to equal but not exceed the average cost of imported crude at Montreal, adjusted for quality and transportation costs. The federal government also agreed to set and to adjust, as necessary, the level of the PCC so as not to generate any revenues in excess of those required, over the period 1981-86, to fully finance oil import compensation and the NORP.

Subsequent international events proved the oil price schedules established in the energy agreements to be, at best, overly optimistic. During 1981-82, downward pressure was being exerted on world oil prices due to a number of factors. These included poor economic growth in the industrialized countries, reduced consumer demand for oil, oil production increases in non-OPEC countries, and in-fighting and price-cutting, partly as a result of market realities, between members of the OPEC cartel itself. Constant, nominal world oil prices, and lower Canadian oil demand resulting from recession and conservation impacted adversely on the Canadian energy industry.

The federal government responded, in part, by offering various forms of pricing relief to the oil and gas industry in the NEP Update of May 31, 1982. A new category of oil, with a new reference price applicable to it, was introduced. The reference price was called the Special Old Oil Price (SOOP) and was set, effective July 1, 1982, at 75 percent of the average cost of imported oil at Montreal, adjusted for quality and transportation costs. It applied to oil discovered after March 31, 1974, and before January 1, 1981, that was subject to reduced provincial oil royalty rates. The NORP was also extended, on

January 1, 1983, to all tertiary oil recovery projects and to various other sources of domestic production.

The fall in world oil prices in 1982-83, from U.S. $34.00 to U.S. $29.00 per barrel for reference-quality, Saudi Arabian light oil, caused the COOP to exceed its agreed maximum of 75 percent of the international price by about 5 percent. Consequently, the federal and provincial governments were forced to amend the original energy agreements prior to their scheduled expiration dates. The energy amending agreements of 1983 and 1984, effective for the eighteen month period July 1, 1983, to December 31, 1984, included a number of changes to the oil pricing regime.[12] The COOP was frozen at its June 30, 1983, level of $29.75 per barrel subject to it neither exceeding, nor falling below 75 percent of, the world price level. The NORP was also extended to oil that had previously qualified for the SOOP as well as to various other types of domestic oil production.

iv) <u>Western Accord</u>

World oil prices remained essentially unchanged at the end of the term of the amending agreements. New energy agreements were, therefore, needed. As a result of the transition of power following the 1984 federal election, however, the final date for completing the energy negotiations was postponed to March 31, 1985. The term and provisions of the 1983 amending agreements were extended to cover this interim period. On March 28, 1985, the Western Accord was announced. The bilateral agreements which had characterized the NEP period were replaced with one comprehensive energy pricing and taxation agreement between the four governments of Canada, Alberta, British Columbia and

Saskatchewan.

As provided in the Western Accord, Canadian crude oil prices were deregulated on June 1, 1985. Oil can now be purchased from either domestic or foreign sources, at prices determined by the market. Should international oil market disturbances result in sharp price changes or supply disruptions, however, provisions are included in the Western Accord to allow the federal government, following consultations with the western provincial governments, to take measures necessary to protect Canadian interests.

Consistent with the move to market-determined pricing, crude oil export restrictions were relaxed. The oil export charge on oil and oil products was eliminated. The OICP and the PCC were also removed. These changes became effective on June 1, 1985, with the commencement of oil price deregulation.

In 1981, only about 10 percent of the oil produced in Canada was priced at world levels. By 1985, this had risen to over 50 percent with the creation of the SOOP and the later extension of the NORP to various types of Canadian production. Including imports, approximately 80 percent of the oil refined in Canada in 1985 would have received the world price in the absence of deregulation.

As stated in the 1981 Canada-Alberta Memorandum of Agreement (MOA), the PCC could not be used by the federal government to generate revenues in excess of those required to fully finance oil import compensation and higher cost domestic production. No constraints had been put in place, however, as to the actual level of the charge at any particular time over the period of the MOA. At the time of its elimination, insufficient revenues had been generated by the PCC to fully finance higher cost oil. The Western Accord further provided that this deficit of approximately $1 billion could not be recovered through the implementation of any special tax on the oil and gas industry.

b) Natural Gas Pricing Within Canada

The characterization of the natural gas market in Canada differs in certain key respects from that for crude oil. The three western provinces again account for over 95 pecent of Canadian gas production; Alberta is responsible for about 85 percent of the Canadian total. The vast majority of natural gas exports and virtually all natural gas moving in interprovincial trade, however, originates in Alberta. Saskatchewan supplies most of its own gas requirements, but has not yet achieved self-sufficiency. Excess supplies of natural gas in British Columbia are exported. Today, natural gas is transported by pipeline from the Alberta-Saskatchewan border to domestic markets as far east as Ontario and parts of Quebec. The development of the Quebec market was accomplished in the early 1980s. Natural gas is not yet available in the Maritime Provinces.

Prior to November 1, 1975, the wellhead or field price of natural gas produced and consumed in Canada was market-determined. In the early 1970s, various studies conducted by the Alberta Energy Resources Conservation Board (AERCB) each determined that the average field price of gas within Alberta was below the value for gas based on the price of competing fuels at the point of sale (i.e., the deemed true market value). It was this finding together with the 1973-74 world oil price shock that led to the eventual implementation of natural gas price controls.

i) 1975 - 1980

The Government of Alberta initially intended to regulate interprovincial natural gas prices at the equivalent value of competing fuels (by adjusting field prices), but did not possess the legislative authority to do so. The federal government responded to the situation by passing the Petroleum Administration Act in 1975. This Act gave the federal government the authority to prescribe prices for gas sold in interprovincial trade. Due to their joint interest in this area, the Natural Gas Pricing Agreement between the governments of Canada and Alberta was signed on October 17, 1975. The agreement pertained to natural gas transported across provincial boundaries for Canadian consumption. The price of natural gas produced and consumed within any province (i.e., Alberta, British Columbia, Ontario and Saskatchewan) was not included and remains provincially regulated. Gas export pricing is discussed in the next section.

Effective November 1, 1975, the interprovincial reference price for gas, the Toronto City Gate Price (TCGP), was set at $1.25 per thousand cubic feet ($1.17 per gigajoule[13]) to equal 85 percent of the energy equivalent cost of crude oil at Toronto. Successive Canada-Alberta gas pricing agreements maintained the relationship between the interprovincial price of natural gas and the price of crude oil according to the 85 percent rule over the period November 1, 1975, to October 30, 1980. The final gas price increase prior to the NEP occurred on September 1, 1980, one month after a corresponding increase in the wellhead price of crude oil. The price level was set

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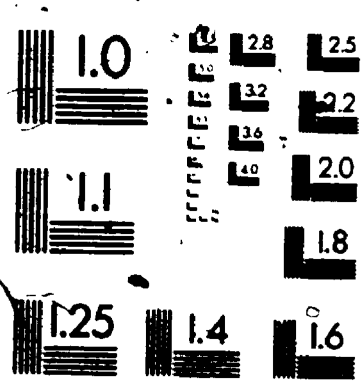


at $2.60 per thousand cubic feet ($2.42 per gigajoule) at that time.

ii) NEP Period

The federal government sought to implement a number of changes to the interprovincial natural gas pricing system through the NEP. As in the pre-NEP period, the reference price for gas was to be the TCGP. Increases in the natural gas price, however, were to be prescribed so as to encourage the substitution of natural gas for oil both to realise oil conservation objectives and to promote the expansion of gas into markets east of Ontario. For this reason, city-gate prices were also to be established for Montreal, Quebec and Halifax and set at the same level as the TCGP. City gate prices west of Toronto were to be less than the TCGP by an amount reflecting lower transportation costs. Commencing November 1, 1980, natural gas prices were to rise by $0.45 per thousand cubic feet ($0.42 per gigajoule) each year for three years. The former 85 percent gas-oil equivalency rule was to be abandoned in favour of specified gas price increases which led to a gas-oil equivalency ratio of approximately 67 percent in 1983.[14] Regardless of federal intentions, however, the interprovincial natural gas price remained at its September 1, 1980, level until the announcement of the 1981 MOA.

Under the MOA and the subsequent Canada-Alberta Natural Gas Sub-Agreement of December 10, 1981, interprovincial natural gas pricing reverted to a system of price controls different from the pre-NEP system in two major aspects.[15] First, the reference price became the Alberta Border Price (ABP) for gas instead of the TCGP. Interprovincial transportation costs thus ceased to affect the netback to producers. The ABP in effect on September 1, 1981, was to increase by $0.25 per thousand cubic feet ($0.23 per gigajoule) every six months, commencing February 1, 1982, with the last increase effective on August 1, 1986. These gas price increases were timed to occur one month after the oil price increases provided for in the 1981 energy agreements.

Second, the gas-oil equivalency ratio at Toronto was lowered from 85 percent to 65 percent. The gas price increases, by themselves, however, were not designed to maintain this relationship. Commencing September 1, 1981, the price of gas for purposes of maintaining the 65 percent ratio was also to include the Canadian Ownership Special Charge (COSC) applicable to gas, and the Natural Gas and Gas Liquids Tax (NGGLT).

The COSC was levied, under the Energy Administration Act, on all domestically consumed natural gas, natural gas liquids (ethane, propane and butane) and crude oil, from May 1, 1981, to May 31, 1985. Introduced in the NEP, its rate was fixed at 15 cents per thousand cubic feet (14 cents per gigajoule) for gas and $1.15 per barrel ($7.25 per cubic metre) for oil. Revenues from the charge went towards financing PetroCanada's acquisiton of Petrofina, which was completed in March 1983.

Also introduced in the NEP, the NGGLT was imposed, under the Excise Tax Act, on natural gas and natural gas liquids consumed in Canada, commencing November 1, 1980, and on exports of those products, effective February 1, 1981. The tax was, however, effectively removed from exports of natural gas and ethane originating from Alberta and British Columbia, on October 1, 1981, under the 1981 energy agreements. As outlined in the 1981 MOA, the rate of the NGGLT was set at the level necessary to ensure that the parity relationship between the Toronto Wholesale Price (TWP) for gas and the Toronto Refinery Acquisition Cost (TRAC) for crude oil, remained at approximately 65 percent over the term of the agreement. The TRAC of crude oil was defined as the blended price for oil at Toronto instead of Montreal, plus the COSC applicable to oil.

The COSC was originally intended to be used to increase the level of Canadian ownership of the petroleum industry; the NGGLT was designed solely as a federal revenue raising device. Under the 1981 MOA, however, both the charge and the tax became integral parts of the natural gas pricing system as well.

As indicated previously, one of the goals of the NEP was to promote the expansion of eastern Canadian gas markets. It is significant to note that, under the 1981 MOA, Alberta agreed to provide the federal government with Market Development Incentive Payments (MDIP) for this purpose. These payments were dedicated to assist in the financing of the extension of gas transmission and distribution systems into new domestic gas markets east of Alberta, for Alberta-produced gas.[16]

The fall in world oil prices in 1982-83 made it increasingly clear that adherence to the original schedule of ABP increases would soon preclude the maintenance of the 65 percent gas-oil price equivalency ratio, even with the rate of NGGLT reduced to zero. The 1983 Canada-Alberta energy amending agreement, therefore, contained provisions designed to rectify the situation. The ABP increase scheduled for August 1, 1983, would be implemented, as planned.

Subsequent price increases would essentially be determined, however, as a netback from 65 percent of the TRAC of crude oil. The ABP would increase only to the extent that a higher ABP, together with the relevant transportation charge and the fixed COSC, did not violate the 65 percent gas-oil price equivalency ratio. The NGGLT would make up any difference.

This amendment to the method of determining gas price increases resulted in a zero rate of NGGLT on February 1, 1984. Further, in order to cushion the impact of rising transportation costs, over the period August 1, 1983, to January 31, 1985, on the price of natural gas, the 1983 amending agreement provided that increases in TransCanada PipeLines (TCPL) transmission tolls in excess of 5 percent of June 30, 1983, levels would be offset, through the federal Transportation Assistance Program (TAP), by revenues generated from the COSC.

iii) Western Accord

The 1985 Western Accord provided for the implementation of a more flexible and market-oriented regime for the domestic pricing of natural gas, by November 1, 1985. In the interim, the ABP for gas remained essentially unchanged from its February 1, 1984, level of $2.99 per thousand cubic feet ($2.79 per gigajoule). The TAP, the term of which had previously been extended to March 31, 1985, the COSC and the NGGLT were eliminated on June 1, 1985. These pricing and tax changes resulted in the formal abandonment of the 65 percent gas-oil price equivalency objective, also effective June 1, 1985. The MDIP was to be terminated by May 1, 1986, at the latest. Finally, the

Natural Gas Market Incentive Plan, which was introduced in early 1984 by the governments of Canada and Alberta and under which Alberta producers provided a gas price discount to industrial users in eastern Canada, was terminated on May 1, 1986.

The Agreement on Natural Gas Markets and Prices between the governments of Canada, Alberta, British Columbia and Saskachewan was announced on October 31, 1985. Its basic objective was to foster a competitive market for natural gas in Canada, consistent with the regulated character of the transmission and distribution sectors of the industry. A two-stage implementation process was established for the deregulation of interprovincial natural gas prices by November 1, 1986.

During the twelve-month transition period from November 1, 1985, to October 31, 1986, the ABP remained essentially unchanged from its February 1, 1984, level. In order to subsidize a November 1, 1985, increase in TCPL transmission tolls and, thereby, maintain the TWP constant over the transition period, a second TAP was created by the federal government, financed by a further extension of the MDIP to October 31, 1986.

A limited amount of natural gas price negotiation was also allowed during the transition period. Under specified conditions, direct sales were allowed between producers and consumers; system sales by distributors to end users with special marketing requirements; and sales between producers and distributors under new contracts. As of November 1, 1986, the purchase and sale of all natural gas in interprovincial trade is negotiated between buyers and sellers, and wholesale prices are no longer prescribed by governments.

c) Natural Gas Export Pricing

As with the pricing of crude oil and natural gas consumed in Canada, world oil price changes have influenced domestic pricing policies for natural gas exports. Perhaps a more important factor, and certainly one of longer duration, however, stems from the nature of the natural gas export market itself. The province of Alberta is the predominant supplier of gas for export; the remaining portion originates from British Columbia. All gas exports are to the United States. As such, the U.S. has had a profound impact, directly and indirectly, on export pricing policy.

Prior to 1975, prices for natural gas exports were determined in an essentially competitive manner between buyers and sellers, subject to their ultimate approval by the federal National Energy Board (NEB). The NEB regulates the operation of interprovincial and international pipelines, including the establishment of tolls and tariffs. From 1959, when it was created, to 1982, the NEB was required to satisfy itself that export prices were "just and equitable" in relation to the public interest. For these purposes, three tests, first introduced in 1967, were employed: the gas export price must cover production costs; the export price should not be less than the price of gas to Canadians in the same general geographic area; and the export price should not be significantly less than the price of the least cost, alternative energy source in the market area in the United States in which the gas is sold. Where prices of competing gas supplies or alternative energy sources changed significantly, the NEB reported its findings and recommendations to the federal government.

i) 1975 - 1977

Similar to the AERCB findings concerning the relative market value of natural gas in Alberta, the price of natural gas exports was determined by the NEB to be significantly below the equivalent average value of designated alternative fuels in markets in the United States after the 1973-74 world oil price shock. Price controls for natural gas exports were implemented on January 1, 1975, as a result.[17] A uniform border price was established and the gas export price was raised by 82% to $1.00 per thousand cubic feet ($0.93 per gigajoule) at that time.[18] This initial border price remained below the NEB-determined equivalent value of alternative fuels, however, in order to allow consumers sufficient time to adjust. Subsequent increases moved the gas export price closer to the weighted average value of prices of competing fuels.

ii) 1977 - 1983

In 1977, Canada adopted a substitution-value concept for setting the uniform border price[19] which linked the gas export price to the price of crude oil imported into Canada, modified to the extent necessary by an assessment of the export market situation. This policy change reflected, in part, the fact that energy price controls in the United States were undervaluing Canadian gas exports but, more importantly the notion that gas exports could be used to replace Canadian crude oil imports into Canada.

The substitution-value approach was subsequently formalised in the March 25, 1980, Canada-United States Understanding on Natural Gas Export Pricing, through, what is commonly referred to as, the

Duncan-Lalonde formula. In essence, the border price was to equal the price of Canadian crude oil imports at Toronto, minus natural gas transportation costs from the Alberta-Saskatchewan border to Toronto, plus the average natural gas transmission cost to the Canada-United States border, commencing April 1, 1980. Further, only if the export price, which was to be calculated monthly, changed by more than U.S. $0.15 per thousand cubic feet would it be adjusted and then only after 90 days. The purpose of the lag was to ensure that Canadian gas remained competitive with alternative fuels in the United States. The U.S. $0.15 trigger was for administrative simplicity.

Two long-standing government policies were reaffirmed in the 1981 MOA. First, both governments agreed in principle to the continued use of the revenue flowback system whereby the difference between the higher gas export price and the ABP, net of transportation costs and MDIP, was redistributed to Alberta producers on a pro-rata basis.[20] Regardless of the destination of a particular producer's natural gas, an export flowback was received on each unit of production. Competition based on market destination, but not production volumes, was thereby eliminated. Second, the federal government restated its intention, first announced in 1959, to authorise additional exports of gas that were determined, by the NEB, to be surplus to "reasonably foreseeable" domestic requirements.

The border price for gas was lowered on April 11, 1983, following the 1982-83 fall in world oil prices, to U.S. $4.40 per thousand cubic feet (U.S. $4.10 per gigajoule) according to the Duncan-Lalonde formula. Gas prices in the United States, however, remained below the Canadian export price level due to a surplus of natural gas in the United States. As a result, large quantities of Canadian gas were shut in.

In response to the decline in the Canadian share of the export market, the federal government established the Volume Related Incentives Program (VRIP), initially to be in effect for the period July 6, 1983, to November 1, 1984. Under this program, exported gas volumes in excess of an established base quantity were allowed to be priced below the border price for gas. The incentive price was set at U.S. $3.40 per thousand cubic feet (U.S. $3.17 per gigajoule). The base quantity equalled the lesser of 50% of annual licenced quantity for export, or actual sales over the period November 1, 1981, to October 31, 1982. On November 1, 1983, the VRIP was modified to allow a portion of natural gas exports to qualify for the incentive price each month.

iii) <u>1984 - 1986</u>

A new gas export pricing policy was announced on July 13, 1984, as a result of the recommendations of a task force, consisting of representatives of the federal government, Alberta and British Columbia, established to review the issue. Exporters were essentially offered a choice. Effective November 1, 1984, the gas export price could be either determined under the provisions of the VRIP or negotiated between buyer and seller subject to the approval of the NEB.

Where the gas export price was negotiated, seven established criteria (three of which were price-related and four of which were contract-related) had to be met for NEB approval. One such criterion was an enhanced economic return for the gas exports relative to the return realized under the VRIP. The negotiated price had to be a cost-covering price; not less than the TWP of gas; and result in prices in the United States at least equal to the price of major competing energy sources.

The November 1984 change in Canadian export pricing policy was implemented due to increased competition resulting from the gas surplus existing in the United States, and to allow large Canadian shut-in natural gas reserves to be freed up for export. In effect, the new policy reflected elements of both pre-1975 and post 1974 gas export pricing policy, and reintroduced a certain degree of price competition into the natural gas export market. The 1984 policy actually represented the first step towards the eventual deregulation of natural gas export prices.

The next step came with the 1985 Agreement on Natural Gas Markets and Prices. While it dealt largely with domestic gas pricing, provisions were also included relating to the deregulation of gas export prices.

The NEB criteria for approving export agreements were modified. The enhanced economic return requirement and the competing fuels test were eliminated. The TWP rule was also replaced by the 1967 restriction that the export price not be less than the price of gas to Canadians in the same general geographic area. Unlike the 1967 policy, however, verification that the export price does not favour U.S. consumers is to be accomplished through ex post monitoring of gas prices. The results of this monitoring activity are to be released on a semi-annual basis.

It was further indicated in the 1985 Agreement that the NEB's procedures for determining whether on not gas to be exported is surplus to reasonably foreseeable domestic requirements would be made less rigid, thereby enhancing domestic access to export markets. Effective November 1, 1985, volume limitations were removed from short-term contracts of up to two years in duration. In the spring of 1986, a more flexible surplus test, based on a reserves-to-production ratio, was outlined for long-term export contracts. The NEB is currently conducting a public review of surplus determination methodologies which is expected to be completed in the summer of 1987.

Provision was also made, for the first time, in the 1985 Agreement for the possible import of natural gas into Canada. Finally, the export flowback system in Alberta was eliminated, effective November 1, 1986.

3. Petroleum Fiscal Regime

Responsibility for the taxation and management of non-renewable natural resources in Canada is shared between the federal and provincial governments. The division of legislative powers is set out in sections 91, 92 and 92A of the Constitution Act, 1867 (formerly called the British North America Act, 1867).

Section 91 of the Constitution Act, 1867 establishes the legislative authority of the federal government. As they apply to the oil and gas industry, these powers include all matters relating to: the raising of money by any mode or system of taxation; federal public property; and the regulation of trade and commerce.

The legislative authority of the provincial governments is contained in sections 92 and 92A of the Constitution Act, 1867. It extends to the following matters: direct taxation within the province to raise revenues for provincial purposes; the management and sale of public lands belonging to the province; the raising of money by any mode or system of taxation in respect of non-renewable natural resources and the primary production therefrom; and the exploration for, and development, conservation and management of non-renewable natural resources in the province, including the regulation of the rate of upstream oil and gas production.

The legislative powers of the two levels of government are reflected in a broad array of fiscal and regulatory instruments. The governments of the producing provinces regulate the production of oil and gas; collect land bonus and rental payments on the sale of Crown leases; provide incentives to exploration and development; levy royalties and freehold taxes on upstream production; impose income taxes on corporations and individuals engaged in oil and gas activities; and, generally, exact motive fuel taxes on refined oil products. Major federal fiscal instruments applicable to oil and gas currently consist of income, sales and excise taxes. Production from the frontier areas of Canada under federal jurisdiction is also subject to federal royalties. Other federal instruments utilized over the period 1974-85 have included, as well, oil export charges; a quasi-royalty called the Petroleum and Gas Revenue Tax (PGRT); a "windfall" profits tax termed the Incremental Oil Revenue Tax (IORT); a grant-based incentive for exploration and development named the Petroleum Incentives Program (PIP); and various downstream taxes such as the PCC, the COSC, and the NGGLT.

It is not the purpose of this section to describe these individual taxes, royalties and charges in detail. This is accomplished satisfactorily elsewhere.[21] The focus here is, rather, on how petroleum fiscal policy has evolved over the period 1961 to 1986, and has been used by Canadian governments to attempt to realise economic and social objectives. Included in the latter are revenue generating, rent sharing and financing goals; regional development considerations; energy security objectives; and Canadianization targets.

a) 1961 - 1973

The oil and gas industry in Canada has traditionally been allowed special incentives to encourage certain types of investment because of the perceived riskiness inherent in the industry and the depleting nature of the resource base. Generally delivered through the Income Tax Act prior to 1973, examples of such incentives included the automatic or percentage depletion allowance, and accelerated rates of write-off for intangible exploration, development and land acquisition costs.

In September 1962, the Diefenbaker government appointed a Royal Commission on Taxation (RCT) to study the Canadian tax system and to provide recommendations for its eventual reform. After a rather lengthy process which included the release of the RCT report in February 1967 (Pearson government) and a White Paper on tax reform in November 1969 (Trudeau government), tax reform commenced in 1972.

b) 1974 - 1980

Major tax reform changes affecting oil and gas were contained in the federal budgets of 1974. In May of that year, the nature of the depletion allowance was changed from an extra deduction calculated as a percentage of income (automatic depletion) to an extra deduction earned in proportion to eligible expenditures undertaken (earned depletion). Eligible expenditures included expenditures on exploration, development and tangible capital assets.

Since the vast majority of petroleum production is centered in the three western provinces, the earned depletion allowance was, in effect, a regional incentive. As energy security concerns increased in the aftermath of the 1973-74 world oil price shock, enhanced depletion allowances were provided to promote both the search for oil and gas in other areas of Canada and the development of higher cost, non-conventional sources of supply. To assist frontier exploration activity, the frontier exploration allowance (superdepletion) was available from April 1, 1977, to March 31, 1980. The supplementary depletion allowance was provided over the period April 11, 1978, to December 31, 1980, to encourage investment in tertiary oil recovery and oil sands projects.

Write-off rates for development and land acquisition costs were also modified as a result of tax reform. Formerly fully deductible in the year incurred, write-off rates for these expenditures were lowered to 30 percent on a declining balance basis in May 1974. As proposed by the Clark government, the rate of amortisation for oil and gas land acquisition costs was reduced to 10 percent per year in December 1979. Exploration expenditures were not affected by tax reform and remain fully deductible in the calculation of income tax.

At about the same time that tax reform was altering the income tax system for oil and gas, other fiscal changes were being made in response to the 1973-74 world oil price shock. Prior to 1974, the Government of Alberta levied a single-rate, gross royalty on oil and gas production. The royalty system became both price and productivity sensitive in 1974, and differentiated between types of production based on the date of discovery. Oil and gas discovered after 1973 were subject to lower rates than oil and gas discovered before 1974. Overall royalty rates for both pre-1974 and post 1973 oil and gas were increased significantly, however, in an attempt to capture a much larger share of the windfall revenues resulting from the rapid increase in world oil prices. For example, average royalty rates for pre-1974 oil more than doubled from 16 2/3 percent in 1972 to approximately 38 percent in 1974.

In response to the rapid escalation in provincial royalty rates, the federal government disallowed the deductibility of provincial royalties for federal income tax purposes in 1974. Had provincial royalties remained deductible, the increase would have severely eroded federal tax collections. (It should be noted that provincial royalties remain fully deductible for provincial income tax purposes.) In 1976, the federal government introduced the resource allowance as a substitute for royalty deductibility. The 25 percent rate of the allowance reflects the federal government's position as to the appropriate, average Crown royalty rate.

Another important incentive, designed to be regionally discriminatory, was introduced in 1975. While it did not apply exclusively to oil and gas, the Investment Tax Credit (ITC), nonetheless had an important impact on the industry. The ITC equals a specified percentage of the acquisition cost of an eligible asset; the percentage is dependent on the region in Canada in which the expenditure occurs and the type of expenditure undertaken.

Over the period 1974-80, the domestic price of oil, set through federal-provincial agreement, rose continually but was maintained below world levels. The need for a comprehensive fiscal regime for the oil and gas industry was recognized, but agreement between the two levels of government was not able to be attained due to their respective positions on revenue sharing and to uncertainty over future world oil price levels. As a result of their inability to reach agreement, modifications to the fiscal regime continued to be made unilaterally by each. The federal government derived revenues from oil export taxes or charges, corporate income taxes, and sales and excise taxes; and subsidized the price of crude oil imports. Provincial government revenues came from land bonus and rental payments, Crown royalties and freehold taxes, corporate income taxes, and, from October 1, 1973 to March 31, 1974, oil export taxes, but were reduced by various incentives offered for oil and gas exploration and development.[22]

Revenue sharing statistics are provided in table XVIII. The definition of revenue shares is consistent with that used in the 1981 energy agreements: revenue available for sharing is defined as upstream, gross industry revenues minus operating costs; sales and excise taxes, levied on downstream production, are excluded from the government statistics. The federal share of industry revenues fell

TABLE XVIII

OIL AND GAS REVENUE SHARING: 1975-85

	Total Revenue	Federal Share		Provincial Share		Industry Share	
	($ billion)	($ billion)	(%)	($ billion)	(%)	($ billion)	(%)
1975	5.0	0.3	6	1.9	38	2.8	56
1976	6.0	0.3	5	2.6	43	3.1	52
1977	7.5	0.3	4	3.8	51	3.4	45
1978	9.0	0.7	8	4.2	47	4.1	45
1979	10.6	0.1	1	5.5	52	5.0	47
1980	11.9	(1.0)	(8)	6.0	50	6.9	58
1981	16.1	3.4	21	5.6	35	7.1	44
1982	20.4	5.3	26	5.7	28	9.4	46
1983	22.1	4.5	21	6.5	29	11.1	50
1984	23.1	3.4	15	7.3	32	12.4	53
1985	24.4	4.0	16	7.3	30	13.1	54
1975-80	50.0	0.7	1	24.0	48	25.3	51
1981-85	106.1	20.6	19	32.4	31	53.1	50
1975-85	156.1	21.3	14	56.4	36	78.4	50

SOURCES: Energy, Mines and Resources Canada.
Petroleum Monitoring Agency Canada. <u>Canadian Petroleum Industry Monitoring Survey</u>
(Ottawa: Supply and Services Canada, 1980-5).

almost continuously over the period 1975-80, averaging about 1 percent per year. By 1980, the federal share actually became negative due to the level of oil import compensation relative to the level of upstream fiscal levies. The provincial share increased from 1975-77, after which time it remained relatively constant, at about 50 percent of annual industry revenues, for the remainder of the decade. The industry revenue share fell from 1975 to 1978, and then rose to a high of 58 percent in 1980; the average for the period 1975-80 was 51 percent of revenues available for sharing.

c) NEP Period

In late 1979 and early 1980, federal and provincial governments made two unsuccessful attempts to reach an agreement on oil and gas pricing and revenue sharing. This stalemate led directly to the unilateral introduction of the NEP by the federal government on October 28, 1980. Along with a pricing regime for oil and gas, the NEP included a fiscal regime for the management of Canada's oil and gas resources. The Program was designed to achieve three major objectives: fairness (equitable revenue sharing), security (incentives to promote oil and gas investment), and opportunity (Canadianization of the energy industry). These objectives were reflected in the fiscal measures introduced as part of the NEP; taxes and incentives included the PGRT, the NGGLT, the COSC, the PCC, and the PIP. A new frontier fiscal regime was also implemented.

The PGRT was a federal tax levied, under the PGRT Act, on the net operating revenues of oil and gas producers. It was not deductible for federal income tax purposes. The PGRT can be characterized as lying somewhere between a royalty, levied on gross revenues, and an income tax, levied on revenues after deductions for, among other things, operating costs, the resource allowance, and tangible and intangible capital costs. When it was originally introduced on January 1, 1981, the PGRT essentially equalled 8 percent of the difference between gross revenues and operating costs. As the period of the NEP progressed, however, the tax evolved to resemble, more closely, an income tax as various additional incentives were incorporated into the tax calculation. These included the federal resource allowance, the deductibility of capital expenditures on tertiary oil recovery projects that were subject to reduced provincial royalties, the small producers' credit, and a special rate reduction for synthetic crude oil. The basic PGRT rate was also varied between 16 percent and 14.67 percent. Certain changes to the PGRT were introduced in response to lower than expected world oil prices in 1982-83; others were designed to provide assistance to higher cost sources of supply for energy security reasons; still others were implemented to assist smaller, typically Canadian producers, to help achieve Canadianization targets.

The PIP was introduced in the NEP as a general replacement for the former income tax-based depletion allowance. (Earned depletion remained available, at a lower rate, for eligible expenditures on high-cost, non-conventional tertiary oil recovery projects and oil sands projects, and was extended to crude oil upgrading assets in the NEP.) Grants were provided, under the PIP Act, for qualifying exploration and development expenditures, and certain expenditures on tangible capital assets used in tertiary oil recovery projects.[23]

The size of the grant depended on the degree of Canadian ownership and control of the investor, the location of the investment, and the type of investment made. The largest grants were available to Canadian companies exploring in the frontier areas of Canada. The PIP was made deliberately discriminatory in order to assist the Canadianization of the petroleum industry and to stimulate frontier exploration activity. As stated in the NEP, part of the funding for the PIP was obtained from revenues generated by the PGRT. The Government of Alberta, in the 1981 MOA, agreed to fund and administer the PIP within its own province.

The frontier lands fiscal regime outlined in the NEP included a number of elements: a 10 percent basic royalty, a 40 percent Progressive Incremental Royalty (PIR), the Crown share interest and Crown share incentive, and ex gratia payments. The concepts of the basic royalty and the PIR were originally outlined in 1976[24], but were not enacted until the passage of the Canada Oil and Gas Act (COGA) on March 5, 1982. Their basic structure was, therefore, determined prior to the NEP.

Prior to March 5, 1982, royalties were levied on frontier lands production under the provisions of the 1961 Canada Oil and Gas Land Regulations (COGLR), made pursuant to the Public Lands Grants Act and the Territorial Lands Act. The COGLR royalty essentially equalled 5 or 10 percent of gross production revenue, dependent on the location of the production in the frontier lands and the length of time that the production had been underway. Under the 1961 Regulations, holders of exploration permits were also required to remit at least 50 percent of the lands under permit to the federal government when applying for an oil and gas lease to conduct development and production activities.

The federal government reserved a 25 percent carried or Crown share interest, subsequently convertible to a working interest, in all production from the frontier lands under the COGA. This interest can be considered, in part, a replacement for the method of land issuance under permit and reversion under oil and gas lease that had existed under the COGLR, as well as an extra royalty. In turn, the federal government contributed 25 percent of post-1980 frontier exploration expenses in the form of grants under the PIP. These grants were called the Crown share incentive and were not dependent on the degree of Canadian ownership and control of a firm. For pre-1981 exploration expenditures, an ex gratia payment, financed from revenues accruing to the Crown share interest, was to be made in lieu of the Crown share incentive.

The NEP provided the impetus which led to the signing of the bilateral energy agreements in late 1981. The energy agreements did not result in major changes to the fiscal regime of the NEP: some fiscal elements, such as the PCC, the NGGLT and the PGRT were modified; and a new federal tax, the Incremental Oil Revenue Tax (IORT), was introduced.

The IORT was designed to capture a portion of the "windfall" profits accruing to producers from the higher old oil prices provided for in the 1981 MOA relative to those in the NEP. To do so, the tax was imposed, under the PGRT Act, at a rate of 50 percent on the difference between the COOP of the MOA and the lower conventional oil price of the NEP. Revenue subject to the IORT was not subject to income tax. Except for production from the Suncor oil sands plant, the IORT was only in effect for the five-month period, January 1 to May 31, 1982. As outlined in the 1981 MOA, Suncor continued to pay the tax in return for it receiving the NORP for its production.

In early 1982, the oil and gas industry began to suffer from short-term, cash flow constraints and shut-in, oil and gas production. The Government of Alberta responded by reducing its oil and gas royalty rates. The newly elected Devine government in Saskatchewan introduced royalty holidays for exploration and development wells. The federal government provided a number of pricing incentives, outlined in the previous section, and fiscal incentives. The latter included the general suspension of the IORT in June 1982; PGRT rate reductions; and the small producers' PGRT credit.

As with the 1981 energy agreements, the main thrust of the NEP also remained intact with the introduction of the NEP Update in 1982, the federal budgets of April 19, 1983, and February 15, 1984, the amendments to the federal-provincial energy agreements in 1983 and 1984, and the November 8, 1984, Economic and Fiscal Statement. Changes to the fiscal regime at these times essentially constituted a fine tuning of the NEP fiscal regime.

Revenue sharing statistics for the period 1981-85 are contained in table XVIII. While it declined by about 10 percent from 1982 to 1984, the federal share for the entire NEP period averaged 19 percent of revenues available for sharing. The provincial share for the period fell, relative to its 1975-80 average, to 31 percent. The industry revenue share increased steadily from 44 percent in 1981 to 54 percent in 1985, but did not regain its 1980 level. Compared to the pre-NEP period, the 1981-85, average industry share remained essentially unchanged at 50 percent.

Security concerns under the NEP centered on freedom from uncertain world oil markets. (This was later extended to threats by any province to restrict oil supplies as Alberta did in 1981 in reaction to the NEP.) The PCC was one fiscal instrument used to achieve this goal. Other pricing and fiscal incentives, including the PIP and higher reference prices for oil sands and tertiary oil production, were introduced to promote the development of higher cost supply sources. Higher domestic oil prices and the MDIP also served to encourage oil conservation and oil substitution initiatives.

The fiscal burden was also restructured to encourage the Canadianisation of the petroleum industry and, thereby, to attain the third objective of opportunity. The NEP target was 50 percent Canadian ownership of oil and gas production by 1990. PIP grants, which favoured companies with a high degree of Canadian ownership and control, were one mechanism employed. The Crown Share Interest, which elicited a negative international reaction, and the COSC were more direct methods used to increase Canadian participation.

d) Western Accord

Major changes to the petroleum fiscal regime were contained in the 1985 Western Accord. The Accord provided for the elimination or phase-out of all the federal taxes and incentives introduced in the NEP and the 1981 MOA. The IORT was terminated on January 1, 1985. The Oil Export Charge, the PCC and the COSC were eliminated on June 1, 1985. Legislation implementing the NGGLT, the rate of which had been set to zero on February 1, 1984, was repealed. The PIP was generally terminated on April 1, 1986; grandfathering provisions were added for certain activities in Alberta until December 31, 1986, and for frontier lands exploration expenditures until December 31, 1987. The PGRT was scheduled to be phased out by January 1, 1989. PGRT exemptions were provided for post March 1985 oil and gas production and for major new energy projects. A new PGRT credit was also introduced to allow non-income-taxpaying companies (typically smaller Canadian firms) to utilise exploration and development write-offs, not immediately usable for income tax purposes, to reduce their PGRT liability. Further, the Western Accord provided that any new tax-based incentives designed to stimulate petroleum investment could not be discriminatory as to either the location of the activity or the ownership and control of the investor.

A new frontier lands fiscal regime was announced on October 31, 1985, to replace the COGA regime.[25] A 1/5/30 percent royalty is to apply, under the Canada Petroleum Resources Act, to production from the frontier lands where the responsibility for establishing royalties has not been transferred to a province. The proposed royalty is similar to royalties levied in Alberta on high-cost oil sands and tertiary oil recovery projects. Two new frontier lands exploration incentives were also introduced: the Investment Royalty Credit and the Exploration Tax Credit. It should be noted that the responsibility for establishing and collecting resource revenues and provincial taxes of general application as if those petroleum-related activities were on land within the province, was transferred to the Government of Newfoundland and Labrador on February 11, 1985, through the Atlantic Accord, and to the Government of Nova Scotia on

August 26, 1986, through the Canada-Nova Scotia Offshore Petroleum Resources Act.

In early 1986, world oil prices fell by over 60 percent from their 1985 levels and remain at depressed levels today. The Canadian petroleum industry was severely affected in terms of profitability, investment activity, and employment. The governments of the producing provinces responded by reducing royalty rates and enhancing royalty holiday provisions. The federal government accelerated the elimination of the PGRT to October 1, 1986. Further, a grant-based federal incentive program, called the Canadian Exploration and Development Program, was introduced, effective April 1, 1987, to promote conventional exploration and development activity in Canada.

A second reform of the federal tax system, announced in the May 1985 federal budget, is currently underway. Taxes subject to reform consist of the income and sales taxes. Objectives of tax reform include stabilizing federal revenue generation, enhancing horizontal equity, shifting the tax burden from individuals to corporations, maintaining international competitiveness and meeting Canadian priorities such as regional needs. These goals are to be accomplished through a reduction in tax rates combined with the elimination or reduction of tax incentives and exemptions. Phase 1 of corporate tax reform commenced in May 1985 with a phase-down of corporate income tax rates offset by the general phase-out of the ITC by 1990 and the elimination of the 3 percent inventory allowance. A White Paper on tax reform is to be released on June 18, 1987, which contains a detailed federal proposal.

4. Summary

A form of price controls on crude oil was first established in 1961 to enhance the ability of the Canadian oil industry to compete with foreign-sourced oil. In September 1962, a Royal Commission was appointed to study the Canadian tax system and to make recommendations for its eventual reform. The impacts of this first tax reform process were felt almost 10 years later. Within two years of the commencement of tax reform, world oil prices escalated dramatically. As a result of this first oil price shock, the nature of crude oil price controls was altered in favour of consumers; price controls were imposed on natural gas, at least partially in response to the international situation, and linked to the price of crude oil; and the fiscal regime for oil and gas was significantly modified.

In their attempts to balance the interests of producers and consumers, conflict increased between the federal government and the governments of the producing provinces. The NEP was announced by the federal government partly as a consequence of the second world oil price shock in 1979 and partly due to the inability of the two levels of government to reach a comprehensive agreement on oil and gas pricing and revenue sharing. The NEP contained a revised pricing and fiscal regime for oil and natural gas. Pricing and fiscal policies also became interdependent in certain respects. Subsequent federal-provincial agreements did not alter the basic tenets of the NEP.

The Western Accord was announced in 1985 following the election of a Conservative government in 1984 and in an environment of falling world oil prices. Crude oil prices were deregulated; provision was made for the later deregulation of interprovincial natural gas prices by November 1, 1986; and all federal fiscal provisions implemented over the period 1973-85 were either eliminated or phased out.

World oil prices fell by over 60 percent in early 1986 and remain at relatively low levels today. Once again, governments responded by modifying the petroleum fiscal regime, but this time in a manner so as to assist the industry in coping with the adverse effects of depressed price levels. At the same time, the federal government is involved in a second, comprehensive reform of its income and sales tax systems. The federal tax reform proposal is to be released on June 18, 1987.

Footnotes

1. Gately (1984), pp. 1100-14. See also Griffen (1985), pp. 954-63.

2. It should be noted that the export price of gas is not analogous to the world price of gas. For example, from 1977 to 1983, the gas export price was set according to an oil substitution concept which linked the price of gas exports to the price of oil imported into Canada.

3. The $1.00 per barrel price increase scheduled for January 1, 1979, was, however, deferred.

4. The Energy Administration Act, S.C. 1980-81-82-83, c. 114 amends and renames the Petroleum Administration Act, S.C. 1974-75-76, c. 47, as amended.

5. This can be explained, in part, as a consequence of the federal policy to phase-out oil exports on which the oil export charge was levied.

6. This pricing incentive was made available to Syncrude from the start-up of plant production in August 1978, and, temporarily, to Suncor (formerly Great Canadian Oil Sands) from April 4, 1979, to October 27, 1980.

7. Conventional or primary methods are generally defined to include secondary enhanced recovery techniques such as waterflooding. Tertiary oil recovery techniques include thermal processes such as in-situ combustion and steam injection, chemical processes such as polymer or caustic flooding, and miscible and immiscible displacement processes such as carbon dioxide or hydrocarbon flooding.

8. While production from the Suncor oil sands plant was not initially eligible to receive the OSRP, this incentive price was effectively extended to it on April 1, 1981, through the 1981 MOA.

9. The reference price for conventional oil under the NEP, and for conventional old oil under the 1981 MOA, represented the price of average quality oil delivered by pipeline to Montreal. This average quality was 38° API and 0.5 percent sulphur.

10. The legislation implementing the Syncrude Levy restricted it to a maximum of $1.00 per barrel. Making the Petroleum Compensation Charge retroactive to July 12, 1980, allowed this ceiling to be exceeded.

11. The Memorandum of Agreement relating to energy pricing and taxation between the governments of Canada and Alberta was announced on September 1, 1981; the Letter of Agreement relating to oil and gas pricing and related fiscal measures between the governments of Canada and British Columbia on September 24, 1981; and the Letter of Understanding relating to energy pricing and taxation between the governments of Canada and Saskatchewan on October 26, 1981.

12. The Agreement to Amend the Memorandum of Agreement relating to energy pricing and taxation between the governments of Canada and Alberta was announced on June 30, 1983; the Agreement to Amend the Letter of Understanding relating to energy pricing and taxation between the governments of Canada and Saskatchewan on August 23, 1983; and the Agreement to Amend the Letter of Agreement relating to oil and gas pricing and related fiscal matters between the governments of Canada and British Columbia on April 13, 1984.

13. Since one thousand cubic feet of natural gas equals one million British Thermal Units (BTU) based on the heat content of wet gas, the November 1, 1975, gas price may also be expressed as $1.25 per million BTU.

14. From a different point of view, it could be argued that the 85 percent gas-oil price equivalency ratio was not completely abandoned. Since oil prices were to increase by a total of $13.50 per barrel over the three-year period January 1, 1981, to December 31, 1983 (composed of a $2.00 per barrel wellhead price and a $2.50 per barrel Petroleum Compensation Charge increase per year), gas prices would have increased by $2.03 per thousand cubic feet ($0.15 per thousand cubic feet for every $1.00 per barrel increase in the price of oil) in the pre-NEP period to maintain the 85% ratio. Under the NEP, on the other hand, gas prices were to rise by $1.35 per thousand cubic feet over the three-year period November 1, 1980, to October 31, 1983, ($0.45 per thousand cubic feet on November 1 of each year). But the Natural Gas and Gas Liquids Tax (NGGLT) was also to rise by $0.75 per thousand cubic feet over the same period ($0.30 per thousand cubic feet on November 1, 1980, and $0.15 per thousand cubic feet on each of July 1, 1981, January 1, 1982, and January 1, 1983). Combining the specified NEP gas price and NGGLT increases yields a three-year increase of $2.10 per thousand cubic feet.

15. The December 10, 1981, sub-agreement is titled the Memorandum of Agreement between the Government of Canada and the Government of Alberta respecting Gas Pricing and Market Development Incentive Payments.

16. The incentive payments essentially equalled the product of 30 percent of the ABP, and the amount by which eligible gas, defined as gas transported across the Alberta-Saskatchewan border destined for use in provinces east of Alberta, in a year commencing after November 1, 1980, exceeded 97.5 percent of the eligible gas of the immediately preceeding year.

17. Export price controls were implemented on natural gas originating in British Columbia on November 1, 1974.

18. While a differentiated border price approach, based on the price of competing fuels in various distinct markets in the United States, was proposed by Canada in 1976, the United States initially opposed the idea on the grounds that it would represent a form of Canadian extraterritoriality, and would be discriminatory. In 1979, however, the United States argued for a policy of discount pricing based on the value of competing fuels in each export market. With the 1979-80 oil price increase and the change to the substitution-value concept for pricing natural gas exports in 1977, Canada felt that the discount pricing concept would be politically unviable.

19. Since September 21, 1977, the Canadian export price for natural gas has been set in United States dollars due to the relative decline in the value of the Canadian dollar.

20. British Columbia used a similar system for redistributing gas export revenues to producers based on their relative provincial production shares.

21. Those fiscal instruments which played a dual role in oil and gas pricing policies over the period 1974-85 have already been briefly dealt with in the preceding section. For a detailed description of federal and provincial fiscal instruments, see the Department of Energy, Mines and Resources publications, Petroleum Fiscal Systems in Canada (1986) and Petroleum Fiscal Systems in Canada: A Summary (1983); the Price Waterhouse publications, Oil and Gas Taxation (1986 and 1983); and Lenjosek (1983). A detailed chronology of federal fiscal changes for oil and gas from 1972 to 1984 is contained in Lenjosek (1984).

22. In Alberta, for example, incentive programs included the Exploration and Development Incentive System and the Geophysical Incentives System. Under the former, cash grants and royalty holidays were offered to promote exploration and development activities. Under the latter, cash grants were provided to encourage seismic studies to locate potential oil and gas reserves.

23. One of the main reasons for structuring the PIP incentive as a grant was that non-taxpaying firms, generally viewed to be Canadian companies, could not make use of existing tax-based incentives. Further, by not including a comparable incentive in the Income Tax Act, favourable treatment could be afforded Canadian firms without negative tax treaty implications.

24. Department of Energy, Mines and Resources and Department of Indian and Northern Affairs, Statement of Policy: Proposed Petroleum and Natural Gas Act, and New Canada Oil and Gas Land Regulations, May 1976.

25. Department of Energy, Mines and Resources, Canada's Energy Frontiers: A Framework for Investment and Jobs, 1985.

APPENDIX II

BACKGROUND STATISTICS FOR THE PARTIAL-EQUILIBRIUM WELFARE ANALYSES

This appendix is composed entirely of tables of statistics which underlie the partial-equilibrium welfare analyses of chapters I and II. The period to which the tables apply generally extends from January 1, 1981, to May 31, 1985. Statistics are included on Canadian petroleum industry revenues, exploration expenditures, assets, crude oil production and prices, upstream and downstream fiscal instruments, and crude oil trade.

TABLE XIX

PETROLEUM INDUSTRY REVENUES, ASSETS
AND EXPLORATION EXPENDITURES
($ Billion)

	1981	1982	1983	1984	1985	1981-85
Revenues						
°Crude Oil[a]	10.14	10.20	12.03	14.17	13.64	60.18
°Natural Gas[a]	7.42	6.25	5.75	7.46	7.09	33.97
°Upstream	17.56	16.45	17.78	21.63	20.73	94.15
°Downstream[a]	34.46	29.92	26.70	23.85	24.20	139.13
°Total	52.02	46.37	44.48	45.48	44.93	233.28
Exploration Expenditures	3.85	3.26	3.68	4.17	3.98	18.94
Assers	2.12	73.33	74.03	77.62	78.21	375.31

SOURCES: Petroleum Monitoring Agency Canada, Canadian Petroleum Industry Monitoring Survey (Ottawa: Supply and Services Canada, 1981-85)

Statistics Canada, Consumer Prices and Price Indexes (62-010)

Statistics Canada, Industry Price Indexes (62-011)

Statistics Canada, National Income and Expenditure Accounts (13-001)

NOTE: Crude oil and natural gas revenues are discounted by the Raw Materials Price Index for those products; downstream revenues by the Energy Price Index; and assets and exploration expenditures by the GNE Implicit Price Deflator.

[a] PMA revenue statistics are grossed up to reflect industry aggregates. For upstream revenues, the gross up equals 1.15 for 1981 and 1984; 1.05 for 1982 and 1983; and 1.12 for 1985. For downstream revenues, it equals 1.02.

TABLE XX

CANADIAN CRUDE OIL PRODUCTION
(Million Barrels)

TYPE OF OIL	1981	1982	1983	1984	1985[a]	1981-85
COOP Oil						
•Pentanes Plus	36.1	29.9	25.5	24.6	9.9	126.0
•Light and Medium	369.3	297.0	277.5	252.9	93.7	1290.4
•Heavy	54.9	19.5	17.0	17.5	6.4	115.3
	460.3	346.4	320.0	295.0	110.0	1531.7
SOOP Oil[b]						
•Pentanes Plus	-	2.5	3.0	-	-	5.5
•Light and Medium	-	23.4	19.3	-	-	42.7
•Heavy	-	13.8	12.9	-	-	26.7
	-	39.7	35.2	-	-	74.9
NORP Oil						
•Pentanes Plus	-	0.7	4.8	9.6	4.4	19.5
•Light and Medium	-	11.5	48.2	102.9	53.3	215.9
•Heavy	-	6.4	29.4	53.7	26.9	116.4
•Experimental	-	1.1	9.2	12.2	8.7	31.2
•Synthetic	40.7	43.9	58.3	48.7	26.9	218.5
•Enhanced Recovery						
-Light and Medium	-	2.3	19.8	32.2	16.8	71.1
-Heavy	-	-	4.1	5.1	-	9.2
	40.7	65.9	173.8	264.4	137.0	681.8
SOOP and NORP Oil	40.7	105.6	209.0	264.4	137.0	756.7

SOURCE: Energy, Mines and Resources Canada

[a] First five months.

[b] For the period July 1, 1982, to June 30, 1983.

TABLE XXI

DISCOUNTED CRUDE OIL PRICES IN ALBERTA

(Dollars per Barrel)

PRICE BY OIL TYPE	1981	1982	1983	1984	1985[a]	1981-85[b]
COOP						
°Pentanes Plus	19.17	20.74	23.25	22.93	21.49	21.28
°Light and Medium	18.88	20.42	22.88	22.57	21.16	20.98
°Heavy	17.98	18.96	20.54	20.26	18.99	18.93
	18.80	20.37	22.79	22.46	21.06	20.85
SOOP						
°Pentanes Plus	-	25.62	24.06	-	-	24.77
°Light and Medium	-	25.03	23.51	-	-	24.34
°Heavy	-	23.28	19.33	-	-	21.37
	-	24.46	22.03	-	-	23.31
NORP						
°Pentanes Plus	-	36.55	31.11	30.37	29.12	30.49
°Light and Medium	-	34.87	29.16	29.58	28.50	29.50
°Heavy	-	30.49	25.26	25.23	24.83	25.43
°Experimental	-	27.10	23.11	21.93	22.26	22.55
°Synthetic	18.91	36.15	30.55	31.07	29.45	29.49
°Enhanced Recovery						
-Light and Medium	-	36.54	31.15	30.33	28.79	30.40
-Heavy	-	-	23.63	23.78	-	23.71
	18.91	35.24	28.80	28.63	27.63	28.53

SOURCES: Energy, Mines and Resources Canada
Statistics Canada, Industry Price Indexes (62-011)

NOTE: Discounted using the Raw Materials Price Index for crude oil.

[a] First five months.

[b] Weighted average based on quantities in table XX.

TABLE XXII

CRUDE OIL REVENUE AS A PROPORTION OF UPSTREAM INDUSTRY REVENUE

YEAR	CRUDE OIL REVENUE ($ Billion)	UPSTREAM INDUSTRY REVENUE ($ Billion)	RATIO (%)
1981	10.14	17.56	58
1982	10.20	16.45	62
1983	12.03	17.78	68
1984	14.17	21.63	66
1985	13.64	20.73	66

SOURCE: Based on table XIX.

TABLE XXIII

PETROLEUM COMPENSATION CHARGE REVENUES

($ Million)

	1981	1982	1983	1984	1985	1981-85
Price Subsidy[a]						
°Domestic Oil	40	1035	1268	1796	1183	5322
°Imported Oil	3190	1284	335	369	200	5378
	3230	2319	1603	2165	1383	10700
PCC Revenues[b]	3098	2605	1435	1330	1166	9634
Net PCA	(132)	286	(168)	(835)	(217)	(1066)

SOURCES: Energy, Mines and Resources Canada

Petroleum Monitoring Agency Canada, Canadian Petroleum Industry Monitoring Survey (Ottawa: Supply and Services Canada, 1981-85)

Statistics Canada, Consumer Prices and Price Indexes (62-010)

Statistics Canada, Industry Price Indexes (62-011)

[a] Discounted using the Raw Materials Price Index for crude oil.

[b] Discounted using the Energy Price Index. Includes revenues from the Special Compensation Charge for the period May 3 to September 21, 1981.

TABLE XXIV

NEP UPSTREAM OIL INDUSTRY NET INCOME

(C$ Billion)

	1981	1982	1983	1984	1985[a]	1981-85
Revenue[b]	10.14	10.20	12.03	14.17	5.68	52.22
Operating Costs	1.94	1.92	2.06	2.46	1.05	9.43
Capital Costs[c]	1.66	1.30	1.42	1.65	0.73	6.76
Royalties	2.68	2.75	2.98	2.98	1.12	12.51
PGRT	0.61	0.93	1.06	1.20	0.44	4.24
IORT	-	0.22	0.06	0.04	-	0.32
Land Payments	0.48	0.28	0.37	0.47	0.26	1.86
CIT	0.84	0.93	1.36	1.49	0.61	5.23
PIP	(0.54)	(0.83)	(0.93)	(0.96)	(0.35)	(3.61)
Net Income	2.47	2.70	3.65	4.84	1.82	15.48

SOURCES: Petroleum Monitoring Agency Canada, Canadian Petroleum Industry Monitoring Survey (Ottawa: Supply and Services Canada, 1981-85)

Statistics Canada, Industry Price Indexes (62-010)

NOTE: Discounted using the Raw Materials Price Index for crude oil. PMA data adjusted by percentages in tables XIX and XXII.

[a] First five months.

[b] Includes the price subsidy for higher cost domestic production; excludes OEC revenues.

[c] Accounting write-offs for exploration, development and capital expenditures.

TABLE XXV

NEP UPSTREAM CRUDE OIL REVENUE SHARING
($ Billion)

	1981	1982	1983	1984	1985[a]	1981-85
Federal Government						
°CIT	0.73	0.87	1.18	1.20	0.50	4.48
°PGRT and IORT	0.61	1.15	1.12	1.24	0.44	4.56
°OEC	0.36	0.19	0.10	0.19	0.12	0.96
°Land Payments	0.01	0.01	0.01	0.01	-	0.04
°PIP	(0.30)	(0.56)	(0.71)	(0.76)	(0.25)	(2.58)
°Price Subsidy[b]	(0.04)	(1.03)	(1.27)	(1.80)	(1.18)	(5.32)
	1.37	0.63	0.43	0.08	(0.37)	2.14
Provincial Governments						
°CIT	0.11	0.06	0.18	0.29	0.11	0.75
°Royalties[c]	2.68	2.75	2.98	2.98	1.12	12.51
°OEC	0.36	0.19	0.10	0.19	0.12	0.96
°Land Payments	0.47	0.27	0.36	0.46	0.26	1.82
°PIP	(0.24)	(0.27)	(0.22)	(0.20)	(0.10)	(1.03)
	3.38	3.00	3.40	3.72	1.51	15.01
Government Revenues	4.75	3.63	3.83	3.80	1.14	17.15
Industry Net Income	2.47	2.70	3.65	4.84	1.82	15.48
Total Revenues	7.22	6.33	7.48	8.64	2.96	32.63

SOURCES: Energy, Mines and Resources Canada

Petroleum Monitoring Agency Canada, Canadian Petroleum Industry Monitoring Survey (Ottawa: Supply and Services Canada, 1981-85)

Statistics Canada, Industry Price Indexes (62-011)

NOTE: Discounted using the Raw Materials Price Index for crude oil. PMA tax data adjusted by percentages in table XXII.

[a] First five months.

[b] For high cost domestic production (excludes imports).

[c] Includes freehold taxes; net of provincial incentives.

TABLE XXVI

NEP DOWNSTREAM OIL REVENUE SHARING
($ Billion)

	1981	1982	1983	1984	1985[a]	1981-85
Federal Government						
•PCC and SCC	3.10	2.60	1.43	1.33	1.17	9.63
•COSC on Oil	0.41	0.54	0.46	0.43	0.23	2.07
•Sales Tax	1.29	1.21	1.22	1.27	0.50	5.49
•Excise Tax	0.41	0.32	0.28	0.27	0.15	1.43
	5.21	4.67	3.39	3.30	2.05	18.62
Provincial Governments						
•Sales Tax	2.26	2.53	2.56	2.33	0.92	10.60
Government Revenues	7.47	7.20	5.95	5.63	2.97	29.22

SOURCES: Energy, Mines and Resources Canada

Petroleum Monitoring Agency Canada, Canadian Petroleum Industry Monitoring Survey (Ottawa: Supply and Services Canada, 1981-85)

Statistics Canada, Consumer Prices and Price Indexes (62-010)

Statistics Canada, National Income and Expenditure Accounts: The Annual Estimates 1970-84 (13-201)

NOTE: Discounted using the Energy Price Index.

[a] First five months.

TABLE XXVII

CANADIAN CRUDE OIL PRODUCTION AND TRADE

(Million Barrels)

	1981	1982	1983	1984	1985[a]	1981-85
Domestic Supply	501.0	452.0	529.0	559.4	247.0	2288.4
Exports[b]	34.9	57.0	94.6	111.2	63.6	361.3
Adjusted Supply	466.1	395.0	434.4	448.2	183.4	1927.1
Imports	142.9	89.3	73.7	62.9	26.6	395.4
Domestic Demand	609.0	484.3	508.1	511.1	210.0	2322.5
Net Exports	(108.0)	(32.3)	20.9	48.3	37.0	(34.1)

SOURCE: Energy, Mines and Resources Canada

[a] First five months.

[b] Over 75 percent comprised of heavy crude oil.

TABLE XXVIII

CEILING AND WORLD OIL PRICES

(Dollars per Barrel)

	1981	1982	1983	1984	1985[a]	1981-85
Average SOOP/NORP	18.91	31.19	27.66	28.63	27.63	28.01
PCC Price Subsidy to Domestic Oil[b]	0.98	9.80	6.07	6.79	8.64	7.03
Ceiling Price[c]						
SOOP/NORP	17.93	21.39	21.59	21.84	18.99	20.98
COOP	18.80	20.37	22.79	22.46	21.06	20.85
Average	18.73	20.61	22.32	22.17	19.91	20.89
Transportation[d,e]	1.43	1.40	1.42	1.46	1.39	1.42
PCC Price Subsidy to Imported Oil[e,f]	22.32	14.38	4.55	5.87	7.52	13.60
World Oil Price	42.48	36.39	28.29	29.50	28.82	35.91

SOURCES: Based on tables XX, XXI, XXIII, XXVI and XXVII. Energy Statistics Division, Energy Statistics Handbook (Ottawa: Energy, Mines and Resources Canada, 1985-87)

[a] First five months.

[b] Per barrel conversion based on SOOP and NORP oil production volumes.

[c] Based on quantities in table XX.

[d] To Montreal.

[e] Assumes the average quality of domestic oil delivered to Montreal is equivalent to that of imported oil.

[f] Per barrel conversion based on imported quantities.

TABLE XXIX

NEP PRODUCER AND CONSUMER OIL PRICES

(Dollars per Barrel)

	1981	1982	1983	1984	1985[a]	1981-85
Producer Price	8.54	11.42	13.50	13.69	13.69	11.99
Net Upstream Tax Rate[b]	10.19	9.19	8.82	8.48	6.22	8.90
Ceiling Price[c]	20.16	22.01	23.74	23.63	21.30	22.31
Downstream Tax Rate[d]	12.27	14.87	11.71	11.02	14.14	12.58
Consumer Price	32.43	36.88	35.45	34.65	35.44	34.89

SOURCES: Based on tables XXV, XXVI, XXVII and XXVIII.

[a] First five months.
[b] Per barrel conversion based on adjusted supply.
[c] At Montreal; transportation costs included.
[d] Per barrel conversion based on domestic demand.

TABLE XXX

TAX RATES UNDER THE ALTERNATIVE REGIME

	1981	1982	1983	1984	1985[a]	1981-85
Upstream Tax Revenues ($ Billion)						
•Federal	0.74	0.88	1.19	1.21	0.50	4.52
•Provincial	3.26	3.08	3.52	3.73	1.49	15.08
•Total	4.00	3.96	4.71	4.94	1.99	19.60
•Grossed Up[b]	9.07	6.99	5.97	6.57	2.88	33.69
•Tax Rate ($/B)[c]	19.46	17.70	13.74	14.67	15.71	17.48
Downstream Tax Revenues ($ Billion)						
•Federal Sales	1.29	1.21	1.22	1.27	0.50	5.49
•Provincial Sales	2.26	2.53	2.56	2.33	0.92	10.60
•Sub-Total	3.55	3.74	3.78	3.60	1.42	16.09
•Grossed Up[d]	7.48	6.18	4.50	4.49	1.92	25.90
•Federal Excise	0.41	0.32	0.28	0.27	0.15	1.43
•Total	7.89	6.50	4.78	4.76	2.07	27.33
•Tax Rate ($/B)[e]	12.96	13.43	9.42	9.32	9.86	11.77

SOURCES: Based on tables XXV, XXVI, XXVII, and XXVIII.

[a] First five months.

[b] Using world-ceiling (excluding transportation) oil price ratio.

[c] Per barrel conversion based on adjusted supply.

[d] Using world-ceiling (including transportation) oil price ratio.

[e] Per barrel conversion based on domestic demand.

TABLE XXXI

PRODUCER AND CONSUMER OIL PRICES
UNDER THE ALTERNATIVE REGIME
(Dollars per Barrel)

	1981	1982	1983	1984	1985[a]	1981-85
Producer Price	23.02	18.69	14.55	14.83	13.11	18.43
Net Upstream Tax Rate	19.46	17.70	13.74	14.67	15.71	17.48
World Oil Price	42.48	36.39	28.29	29.50	28.82	35.91
Downstream Tax Rate	12.96	13.43	9.42	9.32	9.86	11.77
Consumer Price	55.44	49.82	37.71	38.82	38.68	47.68

SOURCES: Based on tables XXVIII and XXX.

[a] First five months.

TABLE XXXII

GOVERNMENT TAX REVENUE SHARING

(Percentages)

	1981	1982	1983	1984	1985[a]	1981-85
A. NEP REGIME						
1. Upstream Revenues						
Federal	29	17	11	2	-32	12
Provincial[b]	71	83	89	98	132	88
	100	100	100	100	100	100
2. Downstream Revenues						
Federal	70	65	57	59	69	64
Provincial[c]	30	35	43	41	31	36
	100	100	100	100	100	100
B. ALTERNATIVE REGIME						
1. Upstream Revenues						
Federal	18	22	25	24	25	23
Provincial[b]	82	78	75	76	75	77
	100	100	100	100	100	100
2. Downstream Revenues						
Federal	40	36	36	39	40	38
Provincial[c]	60	64	64	61	60	62
	100	100	100	100	100	100

NOTE: Based on tables XXV, XXVI and XXX.

[a] First five months.

[b] Three western producing provinces.

[c] Excludes Alberta and Saskatchewan.

APPENDIX III

PROPERTIES OF HOMOTHETIC UTILITY FUNCTIONS

A demand function which satisfies the Slutsky restrictions can, in theory, be integrated to determine its associated utility function. Consequently, a particular demand specification embodies economic assumptions imposed on the underlying utility specification. The form of a utility function can have important ramifications for the evaluation of economic policy, but its justification is often given second priority in applied analyses. For example, the assumption of a homothetic preference ordering is widely-used in the literature, although usually for purposes of simplification as opposed to economic relevancy. It is, therefore, useful to draw attention to this particular class of functional forms. For this reason, a number of properties of homothetic-to-the-origin utility functions are established below.

A homothetic utility function, $u^*(x)$, is defined as:

(III.1) $u^* = u^*(x) = h(u(x))$

where: $h(\cdot)$ is a monotonic function; and

$u(x)$ is a linearly homogeneous utility function in x.

Since $h(\cdot)$ is monotonic, it has an inverse function

(III.2) $u = u(x) = h^{-1}(u^*(x)) = k(u^*(x))$.

As a result, all homothetic functions can be expressed in terms of linearly homogeneous functions.

Associatied with the utility functions of equations (III.1) and (III.2) are indirect utility functions and expenditure functions. The former yield the maximum utility attainable for a given price vector, $p = (p_1, \ldots, p_n)$, and level of income, y. The latter, the solution to the dual problem of consumer theory, yield the minimum expenditure necessary to reach a given level of utility, u, at prices p. For the purpose of this appendix, the indirect utility and expenditure functions corresponding to equation (III.1) are denoted as $v^*(p,y)$ and $e(p,u^*)$, respectively; the indirect utility and expenditure functions associated with equation (III.2), as $v(p,y)$ and $e(p,u)$. By using Euler's Theorem together with the first-order conditions for expenditure minimization, it can be shown that the indirect utility and expenditure functions for linearly homogeneous utility functions can be expressed as:

(III.3) $v(p,y) = k(v^*(p,y)) = yv(p)$

(III.4) $e(p,u) = e(p,u^*) = u/v(p) = ue(p) = y$

Using the relationships given in equations (III.3) and (III.4), compensating variation, $CV(p',y^\circ,y')$, and equivalent variation, $EV(p^\circ,y^\circ,y')$, for any homothetic preference ordering can be expressed as a function of a linearly homogeneous preference ordering in the following way:

(III.5) $CV(p',y^\circ,y') = e(p',(u^*)') - e(p',(u^*)^\circ)$

$= y' - y^\circ v(p^\circ)/v(p') = y'(1 - u^\circ/u')$

(III.6) $EV(p^\circ,y^\circ,y') = e(p^\circ,(u^*)') - e(p^\circ,(u^*)^\circ)$

$= y'v(p')/v(p^\circ) - y^\circ = y^\circ(u'/u^\circ - 1)$

Homogeneous functions are a special class of homothetic functions. Denoted as:

(III.7) $v^*(p,y) = (yv(p))^c$,

they are characterized by a constant income elasticity of utility, n_y^{u*},

(III.8) $n_y^{u*} = (\partial v^*(p,y)/\partial y)(y/v^*(p,y)) = c$

where: $\partial v^*(p,y)/\partial y$ is the marginal utility of income; and

c is a constant equal to the degree of homogeneity.

The income elasticity of utility for linearly homogeneous utility functions, n_y^u, equals unity.

(III.9) $n_y^u = 1$

The general form of the income elasticity of utility for homothetic functions is given by:

(III.10) $n_y^{u*} = yv(p)h'(yv(p))/h(yv(p))$

$= k(v^*(p,y))/k'(v^*(p,y))v^*(p,y)$.

Utilizing what is commonly referred to as Roy's identity[1], the Marshallian demand function for some good j, $x_j(p,y)$, corresponding to a homothetic preference ordering, can be expressed as:

(III.11) $x_j(p,y) = -(\partial v^*(p,y)/\partial p_j)/(\partial v^*(p,y)/\partial y)$

$= -(\partial v(p,y)/\partial p_j)/(\partial v(p,y)/\partial y)$

$= -(y/v(p))(\partial v(p)/\partial p_j)$

$= yx_j(p)$.

Since, by definition, $y = e(p,u^*) = e(p,u)$, equation (III.11) can also be used to derive the associated Hicksian demand function for good j, $h_j(p,u)$.

(III.12) $h_j(p,u) = x_j(p,e(p,u))$

$= -(e(p,u)/v(p))(\partial v(p)/\partial p_j)$

$= -(u/v^2(p))(\partial v(p)/\partial p_j)$

$= uh_j(p)$

If a function is homothetic then, graphically, a straight line from the origin must cut all indifference surfaces at points of equal slope. Equivalently, the income expansion path is a straight line from the origin. As can be seen from equation (III.11), the income elasticity of demand, η_{jy}^{d}, for such functions is equal to unity. An important corollary follows from this characteristic of homothetic functions and satisfaction of the budget condition. A system of homothetic demand functions satisfies the Engel aggregation restrictions and, consequently, the Cournot aggregation restrictions as well.

(III.13) $\sum_{i=1}^{n} S_i(p,y)\eta_{iy}^{d} = 1$

(III.14) $\sum_{i=1}^{n} S_i(p,y)\eta_{ij}^{d} = -S_j(p,y),\ j = 1,\ldots,n$

where: $S_i(p,y) = p_i x_i(p,y)/y$ is the expenditure share for good i; and

η_{ij}^{d} is the uncompensated (own or cross) price elasticity of demand for good i.

Footnote

1. According to Chipman and Moore (1980), p. 934, Roy's identity is actually a second rediscovery. This relationship was originally discovered by G.B. Antonelli (1886) and rediscovered by R.G.D. Allen (1933).

APPENDIX IV

THE RELATIONSHIP BETWEEN CONSUMER'S SURPLUS, AND COMPENSATING AND EQUIVALENT VARIATION

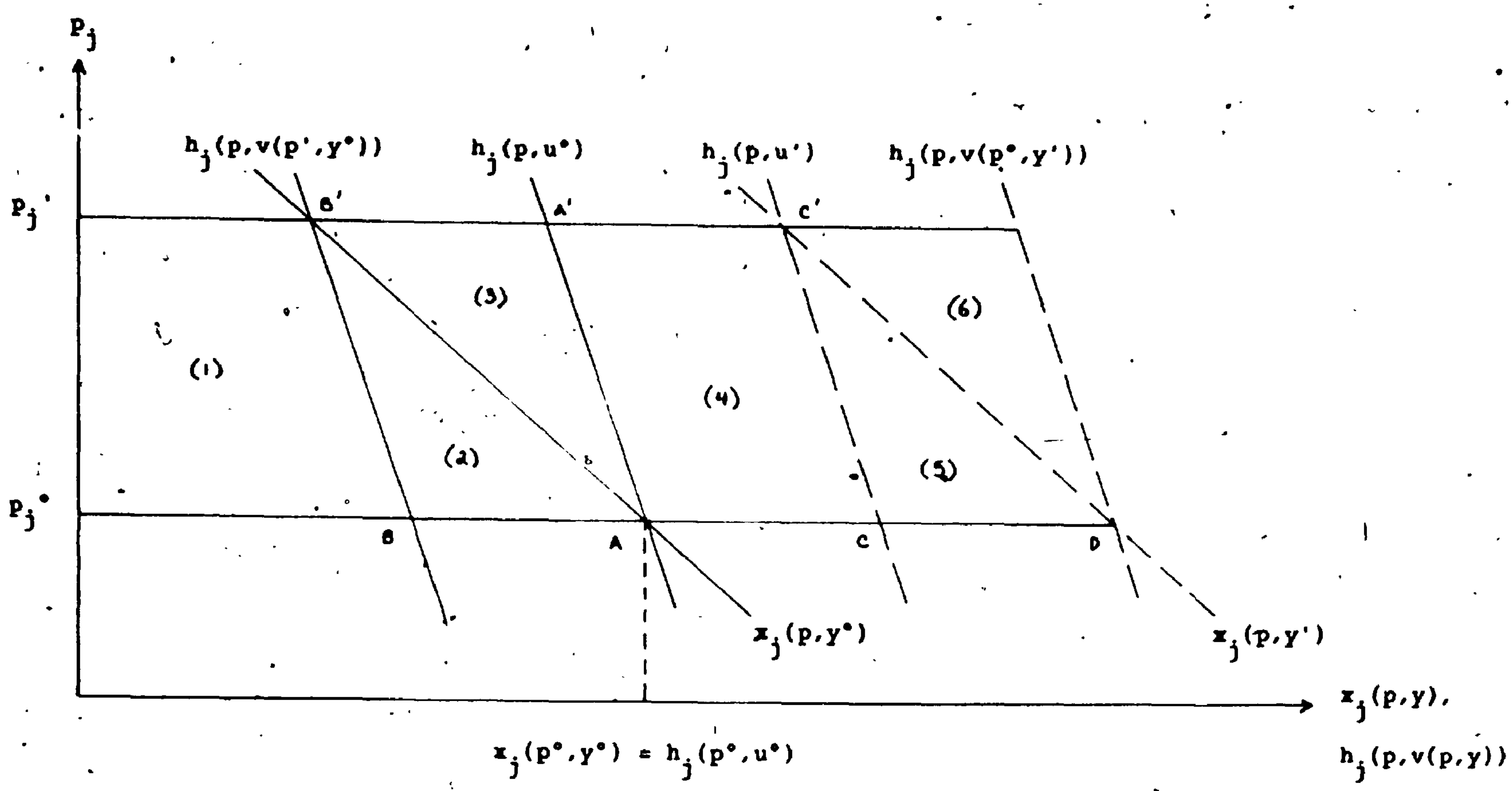
1. Marshallian and Hicksian Consumer's Surpluses

Marshallian and Hicksian consumer's surpluses are illustrated in figure V. In this diagram, the demand for good j is drawn as a function of its price. It is assumed that good j is a normal good. The complete demand system for the economy consists of n consumer goods. The price of good j, p_j, is assumed to increase from $p_j{}^\circ$ to $p_j{}'$. The prices of all other goods and the income level are held constant, as is the case in a partial-equilibrium framework.

The market demand curve for good j, corresponding to income level y°, is denoted as $x_j(p, y^\circ)$ where p is a vector of n consumer prices associated with the n consumer goods. The initial price vector is $p^\circ = (p_1{}^\circ, \ldots, p_n{}^\circ)$; the post change price vector is $p' = (p_1{}^\circ, \ldots, p_{j-1}{}^\circ, p_j{}', p_{j+1}{}^\circ, \ldots, p_n{}^\circ)$. Two compensated demand curves for good j are represented by $h_j(p, v(p^\circ, y^\circ))$ and $h_j(p, v(p', y^\circ))$ where p is the same consumer price vector relevant to the uncompensated demand curve, and $v(p^\circ, y^\circ) = u^\circ$ and $v(p', y^\circ)$ are two levels of utility. Due to the ceteris paribus assumption employed here, an increase in the price of good j unambiguously reduces the budget set such that $u^\circ > v(p', y^\circ)$. For simplicity, the Marshallian and Hicksian demand curves are depicted as linear.

FIGURE V

WELFARE MEASURES IN A PARTIAL-EQUILIBRIUM FRAMEWORK



$MCS_j(p^\circ,p',y^\circ) = (1) + (2)$

$HCS_j(p^\circ,p',y^\circ) = (1) + (2) + (3) = A'B'$

$CV(p',y^\circ,y') = C'B' - A'B' = C'A'$

$EV(p^\circ,y^\circ,y') = DA - DC = CA$

From the dual approach to consumer theory, it is clear that, regardless of prices, if the consumer is given the minimal income $e(p,u^\circ)$ necessary to realize utility u° at those prices, then the Hicksian demand at utility u° is the same as the Marshallian demand at income $e(p,u^\circ)$, i.e.,

(IV.1) $x_j(p,e(p,u^\circ)) = h_j(p,u^\circ)$.

Similarly, the following identity also holds:

(IV.2) $x_j(p,y^\circ) = h_j(p,v(p,y^\circ))$,

i.e., for a given price vector, the Marshallian demand at income y° equals the Hicksian demand at utility $v(p,y^\circ)$. At prices p°, $x_j(p^\circ,y^\circ) = h_j(p^\circ,u^\circ)$. At prices p', $x_j(p',y^\circ) = h_j(p',v(p',y^\circ))$.

The relationship between the slopes of the Marshallian and Hicksian demand curves is given by the Slutsky equation:

(IV.3) $\partial x_j(p,y^\circ)/\partial p_j = \partial h_j(p,v(p,y^\circ))/\partial p_j - x_j(p,y^\circ)(\partial x_j(p,y^\circ)/\partial y)$

The term $\partial x_j(p,y^\circ)/\partial y$ is positive for a normal good. Consequently, it follows from equation (IV.3) that the slope of the Hicksian demand curve for good j is everywhere steeper than the slope of the Marshallian demand curve for good j.

In general, the change in Marshallian consumer's surplus, $MCS_j(p^\circ,p',y^\circ)$, resulting from the price increase is given by:

(IV.4) $MCS_j(p^\circ,p',y^\circ) = -\int_{p_j^\circ}^{p_j'} x_j(p,y^\circ)dp_j$.

For homothetic preferences, it may also be expressed as:

(IV.5) $MCS_j(p^\circ,p',y^\circ) = y^\circ\int_{p_j^\circ}^{p_j'} (\partial v(p)/\partial p_j)(1/v(p))dp_j$

$= y^\circ \ln(v(p')/v(p^\circ))$.

Marshallian consumer's surplus is represented by the sum of areas (1) and (2) in figure V.

Hicksian consumer's surplus can be defined with respect to either the Hicksian demand curve or the expenditure function. As noted in chapter III, it is, in effect, compensating variation calculated under the ceteris paribus assumption; the amount of "extra" income, valuated at prices p', needed to maintain utility at its initial level (or to compensate for a price change) given a constant aggregate income level. Hicksian consumer's surplus, $HCS_j(p^\circ,p',y^\circ)$, equals:

$$(IV.6)\quad HCS_j(p^\circ,p',y^\circ) = -\int_{p_j^\circ}^{p_j'} h_j(p,u^\circ)dp_j = -\int_{p_j^\circ}^{p_j'} (\partial e(p,u^\circ)/\partial p_j)dp_j$$
$$= e(p^\circ,u^\circ) - e(p',u^\circ).$$

For homothetic utility functions, it can also be expressed as:

$$(IV.7)\quad HCS_j(p^\circ,p',y^\circ) = -\int_{p_j^\circ}^{p_j'} x_j(p,e(p,u^\circ))dp_j$$
$$= y^\circ(1 - v(p^\circ)/v(p')),\ \text{or}$$

$$(IV.8)\quad HCS_j(p^\circ,p',y^\circ) = y^\circ - e(p',u^\circ)$$
$$= y^\circ(1 - \exp(-MCS_j(p^\circ,p',y^\circ)/y^\circ)).$$

Hicksian consumer's surplus is equal to the sum of areas (1) to (3) in figure V. It is the amount of income at prices p' necessary to shift the Marshallian demand curve out from point B' to intersect the Hicksian demand curve at point A'.

Due to the assumption of a normal good[1], it is always the case that the Marshallian and Hicksian consumer's surplus measures are related in the following way:

$$(IV.9)\quad MCS_j(p^\circ,p',y^\circ) \geq HCS_j(p^\circ,p',y^\circ)$$

a) The Constant Marginal Utility of Income Case

The concept of consumer's surplus is generally attributable to Jules Dupuit.[2] Alfred Marshall, who popularized the measure, conditioned its use on the assumption of a constant marginal utility of income justified on the grounds that the expenditure on a commodity comprises only a small part of an individual's total expenditure. Under this constraint, Marshallian consumer's surplus yields exactly the same welfare result as Hicksian consumer's surplus.

To demonstrate this equivalence, total differentiation of the indirect utility function $u = v(p,y)$, holding utility constant, yields:

(IV.10) $\sum_{i=1}^{n} (\partial v(p,y)/\partial p_i)dp_i + (\partial v(p,y)/\partial y)dy = 0$

For the case of a change only in the price of good j, $(\partial v(p,y)/\partial p_i)dp_i = 0$ for all $i \neq j$. Incorporating this result into equation (IV.10) and employing Roy's identity yields the following relationship when aggregate income and the marginal utility of income are held constant at y° and m, respectively:

(IV.11) $-(\partial v(p,y^\circ)/\partial p_j)/(\partial v(p,y^\circ)/\partial y) = -(\partial v(p,y^\circ)/\partial p_j)/m$

$= x_j(p,y^\circ)$

A constant marginal utility of income implies that $\partial^2 v(p,y^\circ)/\partial y^2 = \partial^2 v(p,y^\circ)/\partial y \partial p_j = 0$.[3] Partially differentiating equation (IV.11) with respect to income gives the result that $\partial x_j(p,y^\circ)/\partial y = 0$, or, equivalently, the income effect of a price change is nil. Thus, equation (IV.3) reduces to:

(IV.12) $\partial x_j(p,y^\circ)/\partial p_j = \partial h_j(p,u^\circ)/\partial p_j$,

which implies that the Marshallian and Hicksian demand curves are one in the same, i.e., $x_j(p,y^\circ) = h_j(p,u^\circ)$. As a result, so too are the Marshallian and Hicksian welfare measures.

b) General Suitability of Marshallian Consumer's Surplus as a Proxy for Hicksian Consumer's Surplus

Can Marshallian consumer's surplus be realistically used to approximate Hicksian consumer's surplus when the marginal utility of income is not constant? For the case of a single price change, Robert Willig derives error bounds for using the Marshallian measure to approximate the Hicksian welfare measure; the calculation is not dependent on any special assumptions on preferences.[4] In most practical applications, these bounds will be very small. They can also be calculated explicitly from observable demand data.

The validity of Willig's finding can be justified intuitively with reference to figure V. In applied work, area (3), which represents the difference between Marshallian and Hicksian consumer's surplus, will generally be very small relative to the value of Marshallian consumer's surplus given by the sum of areas (1) and (2).

The bounds that Willig develops for the single price change case can be approximated using the following rule of thumb:

$$\text{(IV.13)} \quad \underline{n}^{d}_{jy}|MCS_j(p^\circ,p',y^\circ)|/2y^\circ \leq (HCS_j(p^\circ,p',y^\circ) - MCS_j(p^\circ,p',y^\circ))/|MCS_j(p^\circ,p',y^\circ)| \leq \overline{n}^{d}_{jy}|MCS_j(p^\circ,p',y^\circ)|/2y^\circ$$

where $\underline{n}^{d}_{jy}$ is the smallest and $\overline{n}^{d}_{jy}$, the largest, value of the income elasticity of demand in the region of the demand curve under consideration. When the term $n^{d}_{jy}|MCS_j(p^\circ,p',y^\circ)|/2y^\circ$ is small, the bounds calculated using equation (IV.13) are generally small enough to allow Marshallian consumer's surplus to serve as a reasonable proxy for Hicksian consumer's surplus.[5] If the error bounds, calculated using either the rule of thumb or Willig's precise formula, become too large for Marshallian consumer's surplus to usefully approximate the Hicksian measure, an estimate of the latter can be made. It should also be noted that for the special case of a constant income elasticity of demand, Willig shows that Hicksian consumer's surplus can be calculated exactly using Marshallian consumer's surplus.[6]

Willig's approximation may be inadequate if the expenditure share for the good under consideration is large or the income elasticity of demand is large. Harold Hotelling wrote that consumer's surplus is a useful measure of social value unless "the variations under consideration are too large a part of the total economy of a person"[7]. According to John Hicks, in order that Marshallian consumer's surplus "be a good measure, one thing alone is needful - that the income effect should be small"[8].

To illustrate these points, consider the Slutsky equation expressed in terms of elasticities and expenditure shares for a price induced change in demand:

(IV.14) $$n_{jj}^{d}\hat{p}_j = n_{jj}^{cd}\hat{p}_j - n_{jy}^{d}S_j(p,y)\hat{p}_j$$

where: n_{jj}^{d} is the uncompensated own-price elasticity of demand;

n_{jj}^{cd} is the compensated own-price elasticity of demand;

$S_j(p,y) = p_j x_j(p,y)/y$ is the expenditure share for good j; and

$\hat{p}_j = dp_j/p_j$ is the percentage change in the price of good j.

The term $|MCS_j(p^*,p',y^*)|/y^*$ in equation (IV.13) is approximately equal to the product of the expenditure share and the percentage change in the price of good j. It may be interpreted as the relative size of the variation or as the proportional change in income resulting from the price change. Thus, large values for either the income elasticity of demand or the expenditure share may invalidate Willig's consumer's surplus approximation. (The usefulness of the Marshallian measure as a proxy for Hicksian consumer's surplus when preferences are homothetic essentially depends on the size of the expenditure share of the good under consideration. The smaller the expenditure share, the more useful the approximation.) It is also evident from equation (IV.14) that the compensated price elasticity tends to equal its uncompensated counterpart when the expenditure share or the income elasticity for good j is small.

Of greater importance for partial-equilibrium welfare analyses are the implications of Willig's approach for the calculation of deadweight loss. While the error in using Marshallian consumer's surplus to approximate Hicksian consumer's surplus may generally be quite small in practice, it does not follow that the corresponding deadweight loss calculation will necessarily be so accurate. Indeed, in most cases, it can be expected that the Marshallian and Hicksian consumer's surplus deadweight losses will differ significantly. This point has been made before.[9] Willig's approximation can, therefore, be expected to be much less useful in most applied welfare analyses which evaluate the efficiency or deadweight loss resulting from a policy change.

2. The Relationship Between Hicksian Consumer's Surplus, and Compensating and Equivalent Variation

Using expenditure functions, compensating and equivalent variation are, respectively, defined as:

$$(IV.15)\quad CV(p',y^{\circ},y') = e(p',u') - e(p',u^{\circ})$$
$$= e(p',v(p',y')) - e(p',v(p^{\circ},y^{\circ}))$$

$$(IV.16)\quad EV(p^{\circ},y^{\circ},y') = e(p^{\circ},u') - e(p^{\circ},u^{\circ})$$
$$= e(p^{\circ},v(p',y')) - e(p^{\circ},v(p^{\circ},y^{\circ}))$$

For homothetic preference orderings, they can also be expressed as[10]:

$$(IV.17)\quad CV(p',y^{\circ},y') = y' - y^{\circ}v(p^{\circ})/v(p') = y'(1 - u^{\circ}/u')$$

$$(IV.18)\quad EV(p^{\circ},y^{\circ},y') = y'v(p')/v(p^{\circ}) - y^{\circ} = y^{\circ}(u'/u^{\circ} - 1)$$

where: u° and u' are homogeneous of degree one.

For a welfare-deteriorating change, compensating variation is positive while equivalent variation is negative. The common sign convention is adopted in equations (IV.15) through (IV.18), however, that compensating and equivalent variation are both negative for a welfare-deteriorating change. Hicksian consumer's surplus given by equations (IV.6), (IV.7) and (IV.8) also reflects this sign convention.

As shown in chapter III, compensating and equivalent variation can be separated into income- and price-effect components when preferences can be characterized by either linearly homogeneous or ELES utility specifications. Consider the single price-change case outlined in section 1. For compensating variation, these components can be expressed algebraically as:

$$(IV.19)\quad CV(p',y^{\circ},y') = (e(p',u')-e(p^{\circ},u^{\circ})) + (e(p^{\circ},u^{\circ})-e(p',u^{\circ}))$$
$$= (y' - y^{\circ}) + HCS_j(p^{\circ},p',y^{\circ})$$

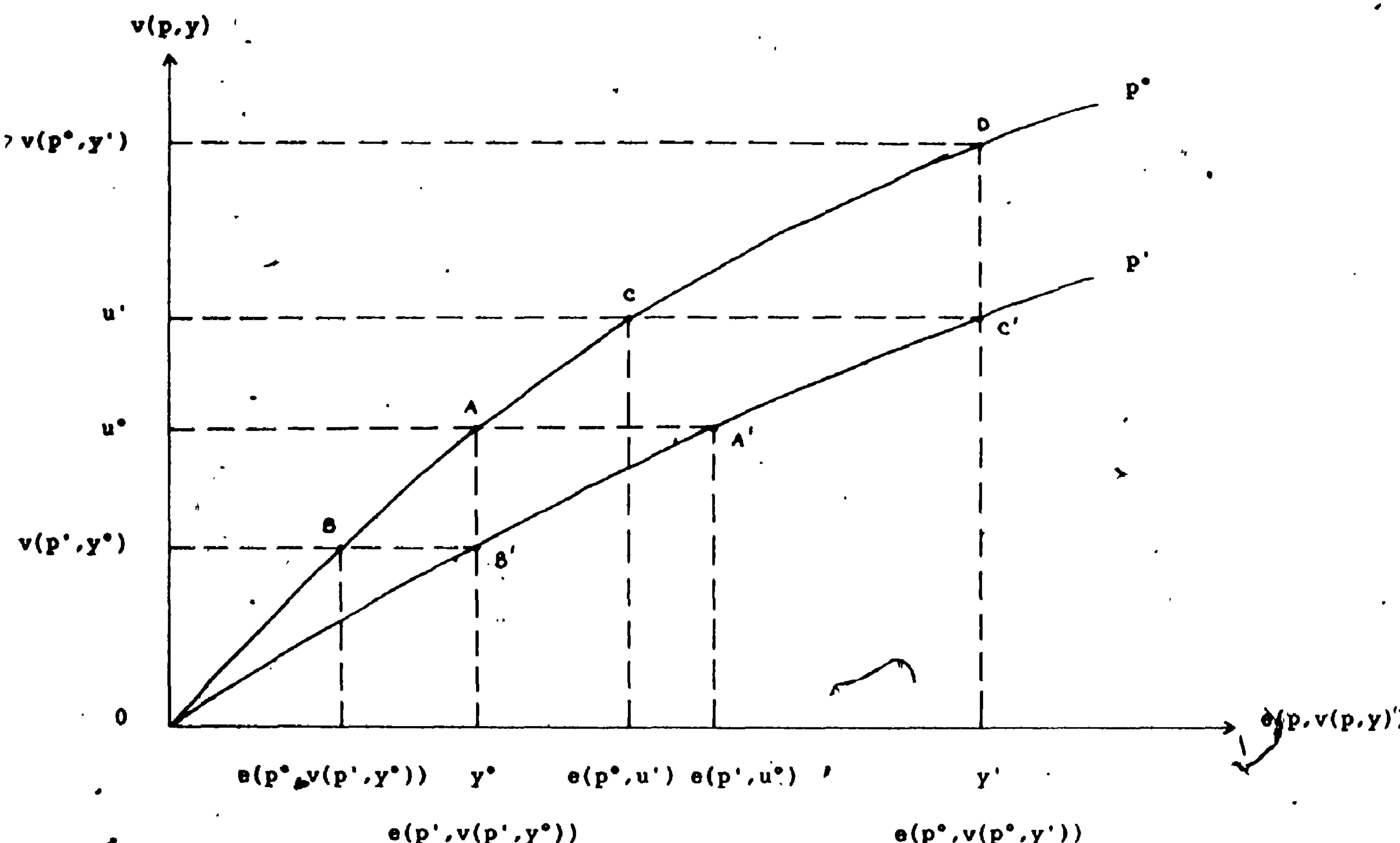
The second term in equation (IV.19) is the price effect in compensating variation. It represents the amount of income at prices p' necessary to compensate for the price-induced change in utility when aggregate income is held constant at y°. But this is just Hicksian consumer's surplus, as is evident from equation (IV.6). With respect to figure VI, an increase in the price of good j, holding income and other commodity prices constant, results in a movement from point A to point B'. Hicksian consumer's surplus represents the further movement along curve p' from point B' to point A', such that utility is unchanged from its initial level u°. Due to the sign convention adopted above, the price effect in compensating variation is negative for an increase in the price of good j.

The income effect in compensating variation equals $y' - y^{\circ}$. It represents the change in aggregate income caused by the change in the price of good j. For a welfare improving price increase, the income effect is positive and larger than the (negative) price effect. In figure VI, it is assumed that the price of good j is initially held below its opportunity level due to the existence of an effective price ceiling policy.[11] The income effect in compensating variation represents a movement along curve p' from point B' to point C'; utility increases from $v(p',y^{\circ})$ to u'.

The price and income effect components of compensating variation, corresponding to the relaxation of a price ceiling policy on good j, are also illustrated in figure VII in output space. As in figure VI, the price effect or Hicksian consumer's surplus is (the negative of) A'B'; the income effect, C'B'. Compensating variation is, therefore, C'A'. The notation in figure V is also consistent with the notation used in figures VI and VII.

FIGURE VI

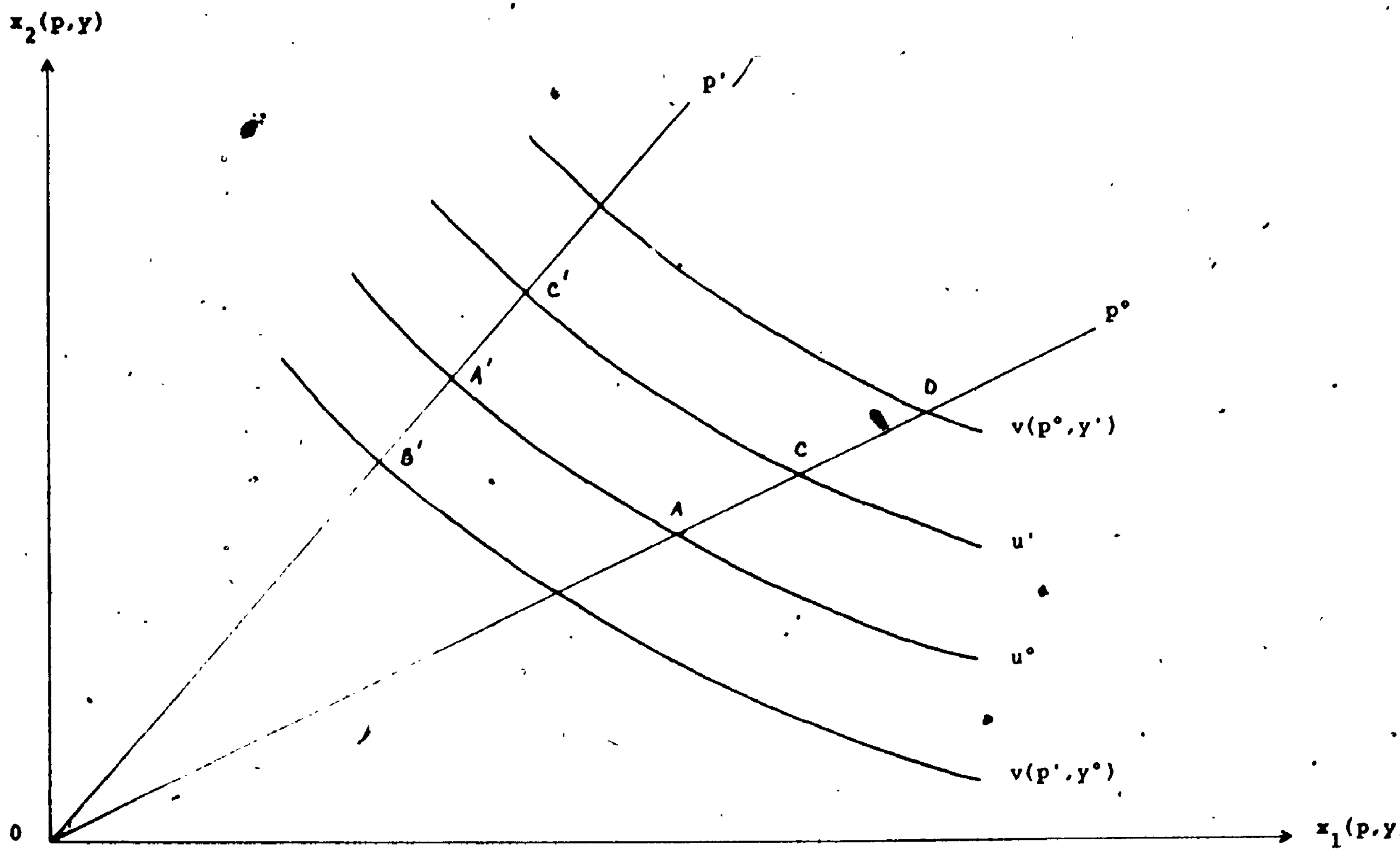
COMPENSATING AND EQUIVALENT VARIATION IN UTILITY-INCOME SPACE



$CV(p', y°, y') = C'B' - A'B' = C'A'$ $EV(p°, y°, y') = DA - DC = CA$

FIGURE VII

COMPENSATING AND EQUIVALENT VARIATION IN OUTPUT SPACE



$CV(p',y°,y') = C'B' - A'B' = C'A'$ $EV(p°,y°,y') = DA - DC = CA$

Using initial prices p°, the income and price effects in equivalent variation can similarly be expressed in terms of the expenditure function for linearly homogeneous and ELES utility functions.

$$\text{(IV.20)} \quad EV(p^{\circ},y^{\circ},y') = (e(p',u') - e(p^{\circ},u^{\circ})) + (e(p^{\circ},u') - e(p',u'))$$
$$= (y' - y^{\circ}) + HCS_j(p^{\circ},p',y')$$

As in equation (IV.19), the term $y' - y^{\circ}$ is the income effect of an increase in the price of good j. In figure VI, the income effect in equivalent variation is represented by a movement along curve p° from point A to point D; utility increases from u° to $v(p^{\circ},y')$.

The term $HCS_j(p^{\circ},p',y')$ in equation (IV.20) is the price effect in equivalent variation, determined by holding aggregate income constant at its post price-change level, y'. An increase in the price of good j reduces utility from $v(p^{\circ},y')$ at point D in figure VI to u' at point C'. The price effect in equivalent variation represents the reduction in income at prices p° that would yield a welfare result equivalent to the price increase. Analogous to the relationship between Hicksian consumer's surplus and compensating variation, the price effect in equation (IV.20) is a limiting form of equivalent variation. It is, in effect, Hicksian consumer's surplus calculated with respect to the Hicksian demand curve $h_j(p,u')$. In figure V, it is the reduction in income, equal to the sum of areas (1) through (4), sufficient to shift the Marshallian demand curve $x_j(p,y')$ from point D to point C.

It should be noted that the post price-change level of utility in a general-equilibrium analysis is different from that applicable to a partial-equilibrium analysis. In the former case, this utility level is $v(p',y') = u'$, while in the latter case, it is $v(p',y^{\circ})$. This distinction reflects the differing treatment of income in the two analyses. Since income is held constant in a partial-equilibrium analysis, it is also the case that the expenditure function evaluated at prices p' and utility level $v(p',y^{\circ})$ equals the value of the expenditure function at prices p° and utility level u°, i.e.,

(IV.21) $e(p',v(p',y^{\circ})) = e(p^{\circ},u^{\circ}) = y^{\circ}$.

Both Willig and Hausman implicitly use this identity in defining their "compensating variation" measure as[12]:

(IV.22) $CV_j(p^{\circ},p',y^{\circ}) = e(p',u^{\circ}) - e(p^{\circ},u^{\circ})$.

A comparison of equations (IV.22) and (IV.6), however, reveals that this is just Hicksian consumer's surplus, without the sign convention adopted above. Recognizing that the post price-change level of utility in a partial-equilibrium analysis is $v(p',y^{\circ})$, equation (IV.22) can also be derived by substituting $e(p^{\circ},u^{\circ})$ for $e(p',v(p',y^{\circ}))$ in a so-modified equation (IV.15). As shown in equation (IV.19), this results in the price effect in compensating variation, not compensating variation per se. The relationship given by equation (IV.21) is not generally valid, nor is it particularly realistic. Policy evaluation under the assumption of a constant aggregate income level effectively ignores the production-side of an economy.

Willig and Hausman define "equivalent variation" as[12]:

(IV.23) $EV_j(p^{\circ},p',y^{\circ}) = e(p',v(p',y^{\circ})) - e(p^{\circ},v(p',y^{\circ}))$.

This is not (the negative of) the price effect in equivalent variation given by equation (IV.20). Rather, it is equal to area (1) in figure V, derived with reference to the Hicksian demand curve

$h_j(p, v(p', y^\circ))$. This area represents the reduction in income necessary to yield a utility reduction equivalent to that caused by the increase in the price of good j, when the relationship in equation (IV.21) holds. At prices p°, it represents an inward shift of the Marshallian demand curve from point A to point B. As shown in figures V through VII, utility decreases from u° to $v(p', y^\circ)$. From figure VI, it is evident, however, that this equivalent variation measure lies outside the range of expenditure function values relevant for the determination of the true equivalent variation given by equation (IV.16). Unlike Hicksian consumer's surplus in compensating variation, equation (IV.23) is not a valid component of equivalent variation.

It would seem that the equivalent variation calculation based on equation (IV.23) is an attempt to estimate the price effect in equivalent variation in the same way that Hicksian consumer's surplus is an attempt to estimate the price effect in compensating variation. But in doing so, the wrong Hicksian demand curve is utilized. This is a common occurrence in the literature. At best, equation (IV.23) can be considered an approximation to Hicksian consumer's surplus, but an approximation of less value than Marshallian consumer's surplus. Alternatively, it can be considered as the price effect in equivalent variation calculated under the assumption that aggregate income is held fixed at its initial level y°. In order to calculate the price effect in equivalent variation as defined in equation (IV.20), however, the post price change level of income needs to be ascertained. But since income is held constant in a partial-equilibrium analysis, this is a non-sequitur. Again recognising that the post price-change level of utility in a partial-equilibrium analysis is $v(p',y^{\circ})$, Willig's and Hausman's definition of "equivalent variation" can be derived by substituting $e(p',v(p',y^{\circ}))$ for $e(p^{\circ},u^{\circ})$ in equation (IV.16).

3. The Derivation of Hicksian Consumer's Surplus From Observable Market Demand Data

Using the dual approach to consumer theory, Jerry Hausman derives Hicksian consumer's surplus, as defined in equation (IV.22) or (IV.6), from the market demand curve for a single good when the price of that good changes. Hausman's technique requires the strong assumption that aggregate income is unaffected by a price change or, alternatively, that producer prices and costs remain fixed. Further, the price ratios of all other goods are held constant. His approach is not, however, limited by requiring special assumptions concerning, for example, the marginal utility of income or the income elasticity of demand. Exact measures of deadweight loss associated with Hicksian consumer's surplus can be determined thereby overcoming the major deficiency in Willig's approach.

Consider the following identity:

(IV.24) $u^{\circ} = v(p,e(p,u^{\circ})) = v(p,y)$

Totally differentiating equation (IV.24), holding utility and all but one commodity price constant, and employing Roy's identity yields:

(IV.25) $dy/dp_j = de(p,u^{\circ})/dp_j = x_j(p,y)$

This is the basic equation underlying Hausman's analysis. He seeks to determine the compensating income change that yields the same utility level $v(p',y^{\circ})$ as resulted from the single price change. Substitution and integration of a well-behaved, market demand function allows Hicksian consumer's surplus to be obtained.

For the two-good case, the expenditure function is derived from the market demand curve and the Hicksian welfare measures determined accordingly. For the many good case, only a "quasi" expenditure function is able to be ascertained since derivation of the actual function would require knowledge of the complete demand system. Hicks' composite commodity theorem is employed to demonstrate that the quasi function corresponding to a two-good world can be used to yield the same measure of welfare as the actual function.[13] The key assumption that ensures the success of Hausman's approach is that the market demand function under consideration satisfy the Slutsky restrictions so that an indirect utility function and, therefore, an expenditure function can be derived through integration.

Footnotes

1. For an inferior good, the relationship in equation (IV.9) would be reversed.

2. Dupuit (1844), pp. 255-83.

3. It is assumed here that the second order partial derivatives of the indirect utility function are continuous so that via Young's Theorem:

$$\partial^2 v(p,y)/\partial y \partial p_j = \partial^2 v(p,y)/\partial p_j \partial y$$

4. See equation 20, Willig (1976), p. 594. Formulae for multiple price changes are provided in Willig (1973a) and (1973b).

5. For example, if the uncompensated income elasticity of demand is 0.8 and Marshallian consumer's surplus, as defined in figure V, equals 5 percent of income, then Hicksian consumer's surplus is within 2 percent of the Marshallian measure according to equation (IV.13). It should be noted that the inequality

$$1 \pm (1-n_{jy}^{d})MCS_j(p^\circ \text{[illegible]}, y^\circ)/y^\circ > 0$$

must be satisfied for Willig's approximation to hold.

6. The constant income elasticity case is used in chapter III for the purpose of comparing welfare-measurement approaches. Willig's approach for calculating Hicksian consumer's surplus for the case of a constant income elasticity of demand is reproduced in Varian (1978), pp. 211-12.

7. Hotelling (1938), p. 289.

8. Hicks (1956), p. 177.

9. Hausman (1981), p. 663.

10. These formulae are discussed in appendix III.

11. This is the situation analyzed in a general-equilibrium framework by Lenjosek and Whalley (1986), pp. 89-110. The issue of foreign ownership of petroleum resources that they address is, however, ignored here.

12. Willig (1976), p. 591, and Hausman (1980), p. 665. Varian (1978), p. 209, also uses these definitions of compensating and equivalent variation. In a partial-equilibrium framework, however, the relationship given by equation (IV.21) holds so that compensating and equivalent variation can be defined in this way.

13. Hicks' composite commodity theorem is comparable to the small country assumption, employed in chapter III, since, in both cases, a change in the price of one good is assumed not to affect the price ratios of any other goods.

APPENDIX V

COMPARATIVE STATIC EQUATIONS FOR THE PARTIAL-EQUILIBRIUM WELFARE ANALYSES

This appendix contains the equations underlying the comparative static results of chapters I and II.

1. Variable Names

p_w, world price of crude oil

p^*, NEP ceiling price of crude oil

p_c^{NEP}, NEP consumer price of crude oil

p_p^{NEP}, NEP producer price of crude oil

p_c, consumer price of crude oil under the alternative regime

p_p, producer price of crude oil under the alternative regime

$(Q_c^D)^{NEP}$, quantity demanded under the NEP regime

$(Q_p^S)^{NEP}$, quantity supplied under the NEP regime

Q_c^D, quantity demanded under the alternative regime

Q_p^S, quantity supplied under the alternative regime

n^D, price elasticity of demand

n^S, price elasticity of supply

i, rate of Canadian ownership of the petroleum industry

c, Canadian share of user's surplus

t_c^{NEP}, downstream tax rate under the NEP

t_p^{NEP}, upstream tax rate under the NEP

CWI, Canadian welfare impact from imposing the NEP

$US(p^*,p',y^*)$, user's surplus

$PS(p^*;p',w^*,R)$, producer's surplus

y^*, initial level of aggregate income

w^*, constant returns to the variable factors of production

R, fixed supply of the resource input

2. Definitions

Arc elasticity specifications are given as:

$$n^S = (Q_p^S - (Q_p^S)^{NEP})(p_p + p_p^{NEP})/((Q_p^S + (Q_p^S)^{NEP})(p_p - p_p^{NEP})) > 0$$

$$n^D = (Q_c^D - (Q_c^D)^{NEP})(p_c + p_c^{NEP})/((Q_c^D + (Q_c^D)^{NEP})(p_c - p_c^{NEP})) < 0$$

NEP tax rates are defined as follows:

$$t_c^{NEP} = (p_c^{NEP} - p^*)/(p_w - p^*) > 0 \text{ for } p_c^{NEP} > p^*$$

$$t_p^{NEP} = (p^* - p_p^{NEP})/(p_w - p^*) > 0 \text{ for } p_p^{NEP} < p^*$$

Under these definitions, $t_c^{NEP} = 1$ when $p_c^{NEP} = p_w$, $t_c^{NEP} = 0$ when $p_c^{NEP} = p^*$ and $t_p^{NEP} = 0$ when $p_p^{NEP} = p^*$.

The impact of the NEP on Canadian welfare is taken as the sum of the Canadian portion of user's and producer's surpluses, upstream and downstream tax changes and oil import compensation payments. It is denoted as:

$$\begin{aligned} CWI = {} & c(Q_c^D)^{NEP}(p_c + p_c^{NEP})(p_c - p_c^{NEP})/((p_c + p_c^{NEP}) - n^D(p_c - p_c^{NEP})) \\ & - i(Q_p^S)^{NEP}(p_p + p_p^{NEP})(p_p - p_p^{NEP})/((p_p + p_p^{NEP}) - n^S(p_p - p_p^{NEP})) \\ & + (Q_p^S)^{NEP}((p_w - p_p^{NEP}) - (p_w - p_p) \\ & \qquad (((p_p + p_p^{NEP}) + n^S(p_p - p_p^{NEP}))/((p_p + p_p^{NEP}) - n^S(p_p - p_p^{NEP})))) \\ & + (Q_c^D)^{NEP}((p_c^{NEP} - p_w) - (p_c - p_w) \\ & \qquad (((p_c + p_c^{NEP}) + n^D(p_c - p_c^{NEP}))/((p_c + p_c^{NEP}) - n^D(p_c - p_c^{NEP})))) \end{aligned}$$

User's surplus as opposed to Hicksian consumer's surplus is used here only for purposes of simplification. The relationship between user's and Hicksian consumer's surpluses for homothetic preference orderings is given in equation (1.1).

3. Comparative Statics

Given the base-case parameter values listed in table II, the impact of the NEP on Canadian welfare varies:

a) directly with the Canadian share of user's surplus:

$$\partial(CWI)/\partial c = US(p^{\circ},p',y^{\circ}) > 0, \text{ for } p_c > p_c^{NEP}$$

b) inversely with the degree of Canadian ownership of the petroleum industry:

$$\partial(CWI)/\partial i = PS(p^{\circ},p',w^{\circ},R) < 0, \text{ for } p_p > p_p^{NEP}$$

c) inversely with the price elasticity of demand:

$$\partial(CWI)/\partial n^D = (Q_c^D)^{NEP}(p_c+p_c^{NEP})(p_c-p_c^{NEP})(c(p_c-p_c^{NEP})-2(p_c-p_w)) / ((p_c+p_c^{NEP})-n^D(p_c-p_c^{NEP}))^2$$

$$< 0, \text{ for } p_c > p_w > p_c^{NEP}$$

d) inversely with the price elasticity of supply:

$$\partial(CWI)/\partial n^S = (Q_p^S)^{NEP}(p_p+p_p^{NEP})(p_p-p_p^{NEP})(i(p_p-p_p^{NEP})-2(p_w-p_p)) / ((p_p+p_p^{NEP})+n^S(p_p-p_p^{NEP}))^2$$

$$< 0, \text{ for } p_w > p_p > p_p^{NEP}$$

e) directly with the upstream tax rate under the NEP:

$$\partial(p_p^{NEP})/\partial(t_p^{NEP}) = -(p_w-p^*) < 0, \text{ for } p_w > p^*$$

$$\partial(CWI)/\partial(p_p^{NEP}) = (Q_p^S)^{NEP}((i-1)(p_p+p_p^{NEP})^2+n^S(i-n^S)(p_p-p_p^{NEP})^2 +2n^S(p_p^2-(p_p^{NEP})^2+2p_p(p_w-p_p))) / ((p_p+p_p^{NEP})-n^S(p_p-p_p^{NEP}))^2$$

$$< 0, \text{ for } p_w > p_p > p_p^{NEP} \text{ and } i < 0.45$$

f) directly with the downstream tax rate under the NEP:

$$\partial(p_c^{NEP})/\partial(t_c^{NEP}) = p_w - p^* > 0 \text{ for } p_w > p^*$$

$$\partial(CWI)/\partial(p_c^{NEP}) = (Q_c^D)^{NEP}((1-c)(p_c + p_c^{NEP})^2 - n^D(c-n^D)(p_c - p_c^{NEP})^2 - 2n^D(p_c^2 - (p_c^{NEP})^2 - 2p_c(p_c - p_w))) / ((p_c + p_c^{NEP}) - n^D(p_c - p_c^{NEP}))^2$$

$$> 0, \text{ for } p_c > p_w > p_c^{NEP}$$

APPENDIX VI

A NUMERICAL COMPARISON OF WELFARE INDICATORS

Welfare impacts of removing energy price controls in Canada are reported in Lenjosek and Whalley (1986). CES demand functions are specified for the small, open, price-taking economy. The data underlying the welfare results are used here for the purpose of comparing the Marshallian and Hicksian consumer's surplus, and compensating and equivalent variation welfare measures given by equations (3.29) to (3.38). Due to its inherent characteristics, the CES demand specification is well suited for this comparison. The issue of foreign ownership of petroleum resources dealt with by Lenjosek and Whalley is ignored.

Benchmark data set values used by Lenjosek and Whalley that are relevant to the welfare comparison are listed in table XXXIII. Two counterfactual equilibria are considered. The first concerns a rise in the domestic energy price to 60 percent of the world price from its benchmark level of 45 percent of the world price. In the second, the domestic energy price is increased to the world energy price level.

For the purpose of determing the post price-change level of aggregate income given in equation (3.35), the general own-price elasticity of demand for good j is calculated as:

$$(VI.1)\quad N_{jj}^{d} = (x_j(p',y')-x_j(p^{\circ},y^{\circ}))(p_j^{\circ}+p_j') \\ /((x_j(p^{\circ},y^{\circ})+x_j(p',y'))(p_j'-p_j^{\circ}))$$

TABLE XXXIII

BENCHMARK AND COUNTERFACTUAL DATA

1. BENCHMARK DATA

	Domestic-World Energy Price Ratio 45%
Aggregate income (y^*) ($1980 million)	239,737.9
Energy Price (p_j^*) ($1980/energy unit)	0.4644
Energy Demand ($x_j(p^*,y^*)$) (energy units)	27,917.2
CES Parameters	
- r	0.6
- B^*	1.4137

2. COUNTERFACTUAL DATA

	Domestic-World Energy Price Ratio	
	60%	100%
Energy Price (p_j') ($1980 million)	0.6192	1.0320
Expenditure Share for Energy ($S_j(p,y)$)	0.0541	0.0541
CES Parameters		
- B'	1.4230	1.4424
- N_{jj}^d	-0.5358	-0.5669

Values for this elasticity, generated from the applied general-equilibrium analysis in Lenjosek and Whalley, are also reported in table XXXIII. The expenditure share for good j is assumed remain fixed at its 5 percent benchmark level for both counterfactual comparisons.

Except for the general own-price elasticity, the benchmark and counterfactual data in table XXXIII could have been generated from observable demand data by means other than the general-equilibrium modelling actually used. The welfare results from applying the general-equilibrium benchmark data and counterfactual results to equations (3.29) through (3.38) are listed in table XXXIV. For this purpose, the approach outlined in chapter III is referred to as Lenjosek's approach.

Also reported in table XXXIV are welfare results from a partial-equilibrium analysis of the market for energy. Such an analysis of a price ceiling policy includes four components: Hicksian consumer's surplus, producer's surplus, tax changes and an income loss from energy import price-subsidization due to the domestic energy price being held below the world price level.

Lenjosek and Whalley use a two-level, fixed-coefficient, value-added production system in their paper. While the model assumes fixed-coefficient intermediate production, substitution is allowed between primary factors in meeting each industry's value-added requirements. Value added for each industry is given by a CES specification. Three industries are modelled. Energy value added is dependent on three primary factor inputs; capital, labour and resources. The flow of the resource input is assumed fixed in supply

TABLE XXXIV

A COMPARISON OF WELFARE RESULTS

		Counterfactual Energy Price Level			
		60% of World Price		100% of World Price	
		CV	EV	CV	EV
		($1980 million)		($1980 million)	
Price Effect	- Marshallian Consumer's Surplus	-3,939.8	-	-12,074.3	-
	- Hicksian Consumer's Surplus				
	• Lenjosek and Whalley	-3,972.4	-4,009.7	-12,383.5	-12,533.5
	• Lenjosek	-3,972.4	-4,005.3	-12,383.5	-12,301.8
	• Hausman/Willig	-3,972.4	-3,907.6	-12,383.5	-11,775.3
Income Effect	- Lenjosek and Whalley	6,262.7	6,262.7	15,437.6	15,437.6
	- Lenjosek	5,991.0	5,991.0	10,718.7	10,718.7
Welfare Impact	- Lenjosek and Whalley	2,290.3	2,252.9	3,054.0	2,904.0
	- Lenjosek	2,018.6	1,985.7	-1,664.8	-1,583.1
	- Partial-Equilibrium Analysis[a]	2,140.9	-	2,912.1	-

[a] Price effect equals Hicksian consumer's surplus adjusted to include the intermediate demand for energy; income effect approximated by producer's surplus, tax changes and reduced oil import compensation. (See appendix VII.)

and specific to the energy-producing industry. The parameter values established in the benchmark equilibrium are used here for the purpose of calculating producer's surplus. The gross supply function for energy is given by:

$$\text{(VI.2)}\quad x_j(p,w,\bar{R}) = (B_j\bar{R}/a_{vj})a_j^{r/(r-1)}$$
$$(1-(B_j/a_{vj})^{r-1}(p_j(1-a_{jj})-\sum_{i\neq j}p_ia_{ij})^{r-1}(\sum_{i\neq j}a_i^r w_i^{1-r}))^{r/(1-r)}$$

where: $x_j(p,w,R)$ is gross energy output;

a_{ij}, a_{jj} are fixed requirements for intermediate goods;

a_{vj} is the fixed requirement of value-added in energy production;

B_j is a units parameter in the value-added function;

r is the elasticity of factor substitution;

a_i are the share parameters for the variable primary-factor inputs;

w_i are non-resource-factor input prices;

p_i, p_j are commodity prices; and

$\bar{R}$ is the fixed resource-factor input.

Producer's surplus results from integration of equation (A.2) between initial and post change producer price levels, assuming constant commodity prices for non-energy intermediate goods and fixed factor returns for the variable primary factors. The reduction in oil import compensation is determined as the difference between the product of the excess demand for energy and the world-domestic energy price differential in the benchmark equilibrium and both of the counterfactual equilibria. Upstream and downstream tax revenue changes are also included in estimating the income-effect component of compensating variation.

The major conclusions resulting from a comparison of the various welfare calculations in table XXXIV are as follows:

i) The results generated using Lenjosek's approach are significantly different than the Marshallian and Hicksian consumer's surplus calculations, due to the inclusion of the income change in the former; in fact, the sign of the welfare measures are reversed for the 60 percent counterfactual case. The positive income effect reflects the fact that the domestic energy price is held below the opportunity or world price of energy as a result of the price ceiling policy adopted by Canada.

ii) The differences in the values of the welfare calculations using Lenjosek and Whalley's general-equilibrium model and Lenjosek's approach are due to the simplifying assumptions used in the latter, i.e., the constant elasticity and expenditure share assumptions. Of the two, the constant expenditure share assumption accounts for most of the discrepancy.

iii) The value of the income-change approximation outlined in chapter III varies inversely with the size of the price change. Producer's surplus, on the other hand, recognizing as well tax revenue changes and the income savings from reduced subsidies to imported oil as the domestic energy price rises, yields a reasonable approximation of the income effect in compensating and equivalent variation regardless of the size of the energy price change.

iv) The use of Marshallian or Hicksian consumer's surplus as opposed to compensating or equivalent variation in welfare analyses can lead to inappropriate, if not erroneous, policy conclusions.

APPENDIX VII

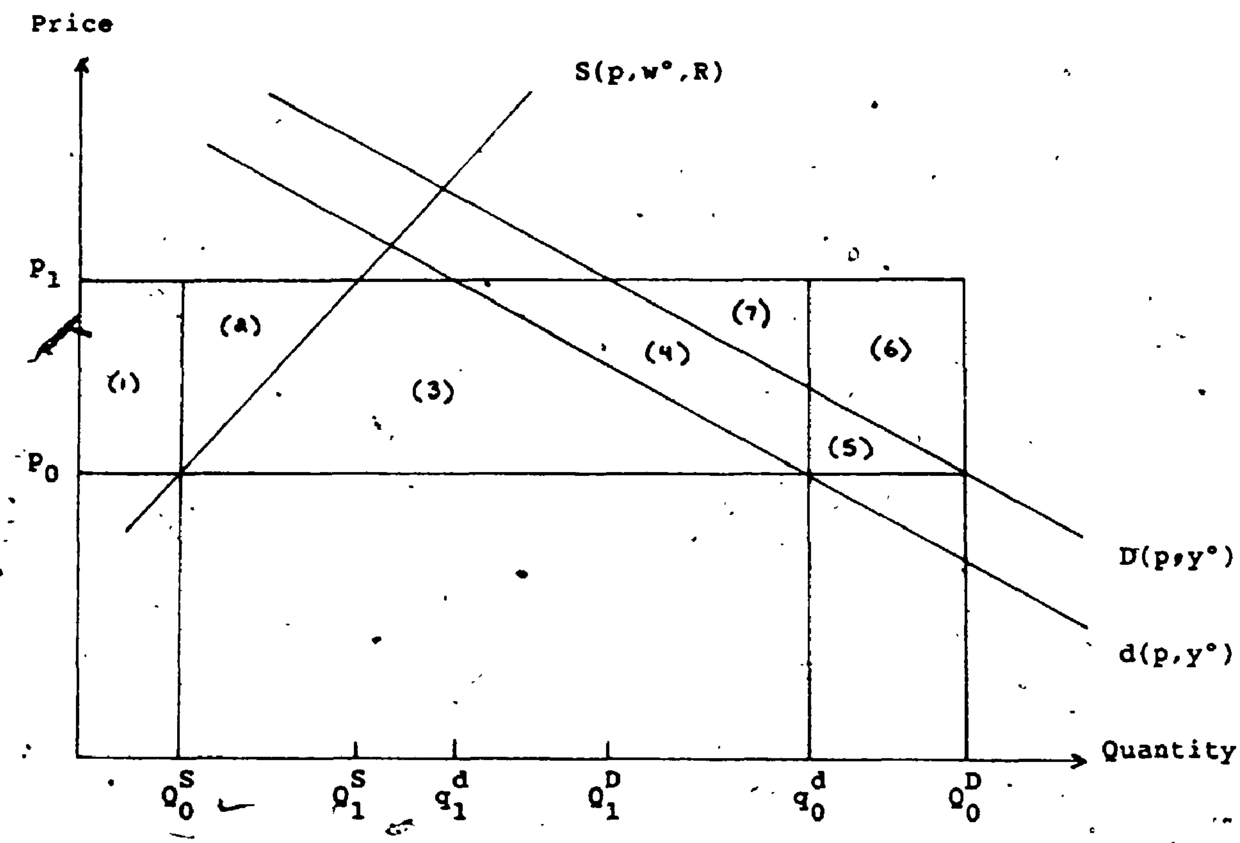
THE USE OF FINAL VERSUS TOTAL DEMAND CURVES IN PARTIAL-EQUILIBRIUM WELFARE ANALYSES

The demand curve for crude oil is an aggregate of a final demand curve for petroleum products per se and a derived demand curve for petroleum products to be used as intermediate factors of production. Under certain assumptions, a partial-equilibrium welfare analysis may accurately incorporate the derived demand characteristics in one of two ways: either through an analysis utilizing user's surplus or through an analysis utilizing Marshallian consumer's surplus. In the analysis of a price ceiling policy presented here, for example, the difference between the two approaches is captured through an adjustment to the income loss that arises from import price-subsidization. These alternative methods for determining the welfare impact of a policy change cannot, however, generally be expected to be equally valid. Of the two, the analysis incorporating user's surplus is superior.

The welfare impact of removing a price ceiling on crude oil is analyzed with reference to figure VIII. The five conditions listed in chapter IV are assumed to hold. The intermediate demand for crude oil is assumed to be based on fixed coefficients of production. The total demand curve, $D(p,y^{*})$, is, consequently, parallel to the final demand curve, $d(p,y^{*})$. It is further assumed that the expenditure

FIGURE VIII

ALTERNATIVE APPROACHES TO PARTIAL-EQUILIBRIUM WELFARE ANALYSIS ASSUMING FIXED COEFFICIENTS OF PRODUCTION



<u>Case 1</u>: MCS(p°,p',y°) = -((1)+(2)+(3))

PS(p°,p',w°,R) = (1)+(2)

Reduced Import Subsidies = (2)+(3)+(4)+(7)

Welfare Change = (2)+(4)+(7)

<u>Case 2</u>: US(p°,p',y°) = -((1)+(2)+(3)+(4)+(5))

PS(p°,p',w°,R) = (1)+(2)

Reduced Import Subsidies = (2)+(3)+(4)+(5)+(6)+(7)

Welfare Change = (2)+(6)+(7)

<u>Difference</u> = ((4)+(7)) - ((6)+(7)) = 0

share for crude oil is small so that Marshallian consumer's surplus and user's surplus serve as good approximations to their corresponding Hicksian consumer's surplus counterparts. The price increase from p* to p' causes the final demand to fall from q_0^d to q_1^d; total demand decreases from Q_0^D to Q_1^D; and supply rises from Q_0^s to Q_1^S. The market is characterized by excess demand under both price controls and world prices. Imports of the commodity are initially subsidized to domestically controlled levels.

Under these assumptions, the loss in Marshallian consumer's surplus is equal to the sum of areas (1) to (3) in figure VIII; user's surplus is given by the sum of areas (1) to (5). The gain in producer's surplus is equal to areas (1) plus (2). Using the final demand curve, the income gain through reduced import compensation is equal to the sum of areas (2), (3), (4), and (7); using the total demand curve, it includes areas (5) and (6) as well. The difference between the aggregate welfare impacts using the final and total demand curves, DIFF, is given by:

(VII.1) DIFF = ((4)+(7))-((6)+(7)) = 0 since $Q_0^D - Q_1^D = q_0^d - q_1^d$

Thus, either of the two approaches can be used in this particular case.

It is generally not possible to identify Marshallian consumer's surplus and intermediate surplus, however, given only the total demand curve. This is able to be accomplished in the above example due to the assumption of fixed coefficients of production. Since aggregate income, or producer prices and costs remain fixed when calculating consumer's surplus, so too does an intermediate or derived demand which is based on production. Typically, the market demand functions and production technology of that part of the economy in which the good is used as an intermediate factor would be needed to separate the demand for the commodity ~~into final~~ and intermediate components. Such a determination would necessitate the extension of the analysis into a general-equilibrium framework.

The change in user's surplus in figure VIII can be approximated by the following formula:

$$\text{(VII.2)}\quad US(p^\circ, p', y^\circ) = -\int_{p^\circ}^{p'} D(p, y^\circ)\,dp$$

$$\approx (p^\circ - p')(p^\circ + p')Q_0^D/(p^\circ(1+n^D) + p'(1-n^D))$$

where: n^D is the price elasticity of demand for the total demand curve.

The change in Marshallian consumer's surplus can be derived from the user's surplus calculation:

$$\text{(VII.3)}\quad MCS(p^\circ, p', y^\circ) = -\int_{p^\circ}^{p'} d(p, y^\circ)\,dp$$

$$\approx US(p^\circ, p', y^\circ)q_0^d(p^\circ(1+n^D) + p'(1-n^D))/Q_0^D(p^\circ(1+n^d) + p'(1-n^d))$$

where: n^d is the price elasticity of demand for the final demand curve.

Using arc elasticity specifications, the price elasticities of demand underlying the final and total demand curves are related in the following way:

$$\text{(VII.4)}\quad n^d = n^D(q_0^d - q_1^d)(Q_0^D + Q_1^D)/((q_0^d + q_1^d)(Q_0^D - Q_1^D))$$

Fixed coefficients of production specify a particular relationship between the final and total demands so that the associated elasticity values are related in a well-defined manner. Other demand assumptions are also capable of yielding similar outcomes. For example, when the ratio of initial and post change total demands are held equal to the corresponding ratio for final demands, i.e., $Q_0^D/Q_1^D = q_0^d/q_1^d$, then $n^d = n^D$ and the relationship between Marshallian consumer's surplus and user's surplus is established.

For linearly homogeneous utility functions, Hicksian consumer's surplus can be determined from Marshallian consumer's surplus or user's surplus according to equation (IV.8) or equation (1.1), respectively. Intermediate surplus, however, should properly be treated as a component of user's surplus rather than as an adjustment to excess demand. By calculating Hicksian consumer's surplus based on Marshallian consumer's surplus, the appropriate adjustment to intermediate surplus is not made. A failure to include intermediate surplus is also compounded by the fact that equations (IV.8) and (1.1) are non-linear. While Marshallian consumer's surplus and user's surplus may be used interchangeably in a welfare analysis where the expenditure share for the good under consideration is small, the calculation of Hicksian consumer's surplus should employ user's surplus.

Welfare results from partial-equilibrium analyses employing Marshallian consumer's surplus and user's surplus are reported in table XXXV. Compensating variation from the general-equilibrium welfare analysis of removing energy price controls in Canada as reported in Lenjosek and Whalley (1986) is included to serve as a reference against which to evaluate the two approaches. The basic structure of their model is outlined in appendix VI. The main characteristics of relevance here are as follows: the derived demand for energy is based on fixed coefficients of production; CES demand and value-added functions are specified for the small, open, price-taking economy; the production of energy is dependent on an energy-specific, fixed resource input; the supply of capital and

TABLE XXXV

ALTERNATIVE PARTIAL-EQUILIBRIUM WELFARE RESULTS

	Counterfactual Energy Price Level			
	60% of World Price		100% of World Price	
	Final Demand	Total Demand	Final Demand	Total Demand
	(1980$ Million)		(1980$ Million)	
Price Effect				
Partial-Equilibrium Analysis				
- Marshallian Consumer's Surplus (MCS)	-3,939.8	-	-12,074.3	-
- User's Surplus (US)	-	-5,352.5	-	-17,254.2
- Hicksian Consumer's Surplus - from MCS	-3,972.4	-	-12,383.5	-
- from US	-	-5,412.7	-	-17,890.3
Lenjosek and Whalley	-3,972.4	-3,972.4	-12,383.5	-12,383.5
Income Effect				
Partial-Equilibrium Analysis	6,140.9	7,553.6	15,622.5	20,80[illegible].4
Lenjosek and Whalley	6,262.7	6,262.7	15,437.6	15,437.6
Compensating Variation				
Partial-Equilibrium Analysis				
- based on Final Demand	2,168.5	-	3,239.0	-
- based on Total Demand	-	2,140.9	-	2,912.1
Lenjosek and Whalley	2,290.3	2,290.3	3,054.0	3,054.0

labour is assumed to be fixed; and factor demand-supply equalities and zero profit conditions hold. Under these assumptions, Hicksian consumer's surplus can be calculated directly from Marshallian consumer's surplus and from user's surplus. The income-effect component of compensating variation is approximated by changes in producer's surplus and taxes together with the reduction in import compensation due to the elimination of price controls which hold domestic energy prices below world price levels.

The results indicate that using either user's surplus or Marshallian consumer's surplus together with their associated income-effect components yield identical welfare conclusions. The use of Hicksian consumer's surplus based on user's surplus yields only a slightly different welfare result than the use of Hicksian consumer's surplus based on Marshallian consumer's surplus due to the relatively small expenditure share for energy.

APPENDIX VIII

MODELLING A SELF-FINANCING PRICE-CEILING POLICY IN A GENERAL-EQUILIBRIUM FRAMEWORK

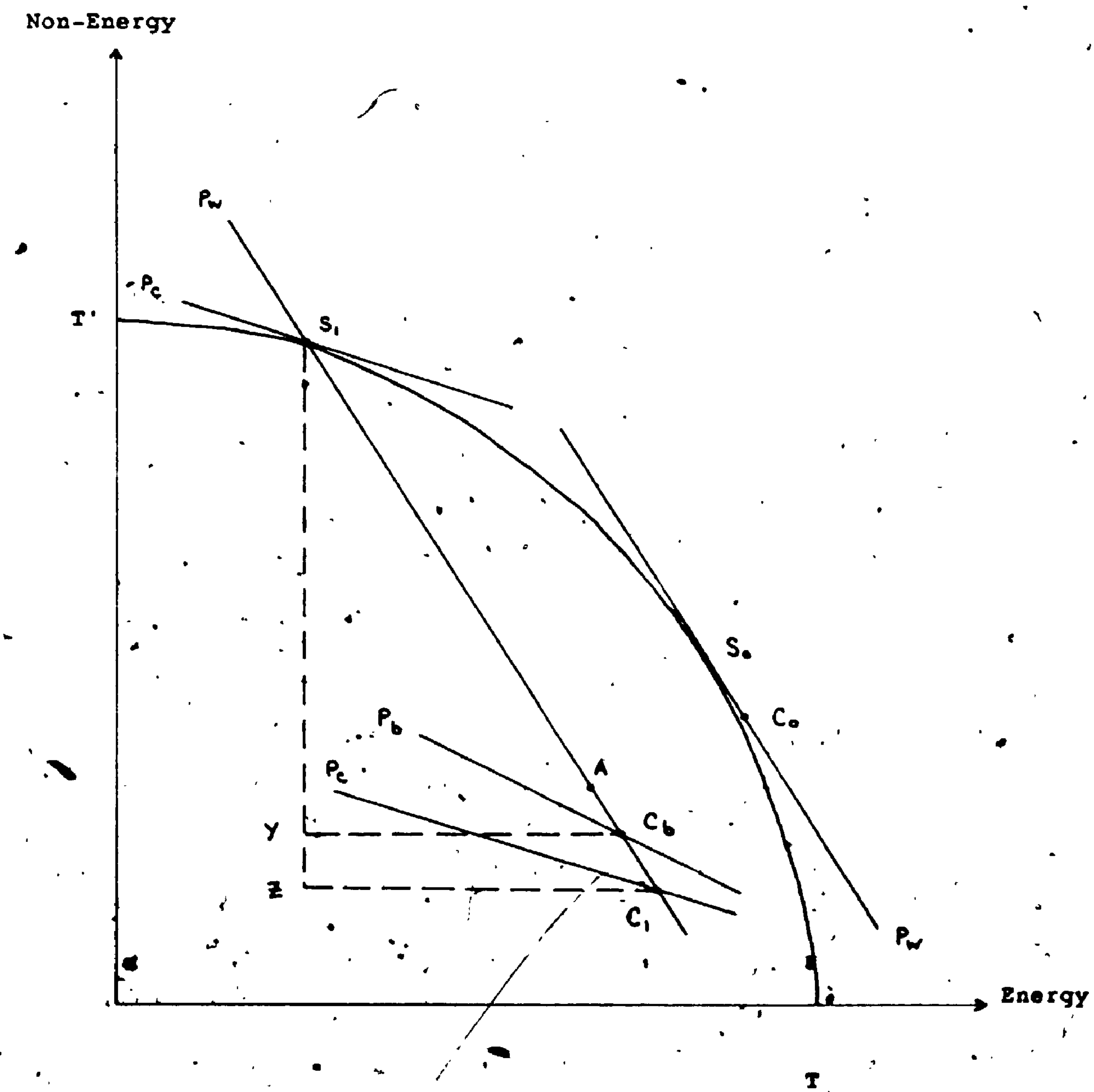
Modifications to the usual modelling of ceiling prices in a general-equilibrium framework need to be made to appropriately analyze the consequences of the self-financing or blended energy price-ceiling policy peculiar to the NEP. Of particular concern is the compatibility of such a price-ceiling policy with the simultaneous existence of an equilibrium. It is shown here that the issue hinges crucially on an initial assumption concerning Canada's ability to influence world prices, i.e., the small versus large country assumption.

The issue is illustrated in figure IX. In this simple case, two goods are produced labelled energy, E, and non-energy, NE. Each good can be thought of as being used both for final demand and as an intermediate input for the other industry. The transformation curve, TT', therefore represents the net output of the two goods available for final consumption.[1] For the purpose of analyzing the effects of a self-financing price ceiling on energy, however, the specific consequences of intermediate goods are ignored.

Canada is assumed to be small and, therefore, unable to influence the world terms of trade through domestic policy changes. Further, it is assumed for simplicity that consumer preferences can be

FIGURE IX

A SELF-FINANCING PRICE CEILING POLICY
AND THE SMALL-COUNTRY ASSUMPTION



represented by a set of homothetic community indifference curves. With free trade, production occurs at S_0 and consumption at C_0. Energy is initially imported. The world terms of trade is represented by P_w.

The effect of a price ceiling on energy is to reduce the domestic price of energy for producers and consumers by equivalent amounts such that the domestic terms of trade becomes P_c.[2] Production will shift to S_1 and consumption to C_1 such that the value of domestic production equals the value of domestic consumption, valuated at world prices. Canadian welfare will fall as evidenced by the movement of the consumption point to a point within the transformation curve.

Conceptually, the self-financing price-ceiling policy is intended to generate revenues, through a consumer tax on energy, sufficient to fully subsidize imports of that commodity to domestic price levels. The existence of the consumer tax affects neither the controlled producer price nor the domestic supply of the good. The imposition of a consumer tax on energy, in addition to the ceiling price, increases the price of energy for consumers to P_b in figure IX and shifts the consumption point to C_b. The domestic trade triangle becomes S_1YC_b and, due to the small country assumption, equals the foreign trade triangle. The domestic economy is in equilibrium.

As long as there is positive production of both goods, the consumption point resulting from the imposition of the blended price policy will be located along P_w between points A and C_1. Point A represents the consumption of energy and non-energy that would be realised from a consumption tax set at a level such that the domestic relative-price line equals the world terms of trade. Due to the constraint that zero net government revenues were to be realised from the blended price policy, the blended consumer price would only be set equal to the world price of energy if Canadian consumption consisted entirely of imported energy, i.e., only if Canada specialised in the production of non-energy.[3] Specialization in non-energy implies that the price ceiling for energy was set so low that economic domestic energy production was prohibited. Since the purpose of the self-financing, energy price-ceiling policy was to achieve a degree of autonomy from world energy markets and not to adversely affect domestic energy production, consumption points along P_w between A and S_1 would never be realized. Such combinations of energy and non-energy consumption are not consistent with an effective blended price policy.

Under the small country assumption, Canadian excess demands for goods are fully accomodated at given world prices by a large foreign sector without affecting global equilibrium. If Canada was assumed to be large enough to be able to influence the world terms of trade, on the other hand, the consumption point corresponding to the self-financing energy price-ceiling policy could not generally be expected to represent an equilibrium. Only if the non-linear foreign offer curve associated with the large country assumption happened to intersect the consumption point resulting from the blended price policy would an equilibrium be achieved. It is likely, however, that the zero net revenue constraint of the blended price policy would be violated since the level of the consumer tax would have to reflect foreign excess demands in addition to domestic excess demands. The concept of a self-financing price-ceiling policy together with the simultaneous existence of an equilibrium are, therefore, not generally compatible when the large country assumption is involked. Foreign excess demands become the deciding factor.

Footnotes

1. A description of such an intermediate good model is found in Warne (1971). The welfare effects from the introduction of intermediate goods in simple trade models is discussed in Melvin (1969).

2. The impacts of the ceiling price policy on energy in figure IX are equivalent to those of an appropriate tax on producers combined with an equal subsidy to consumers.

3. To see this, let P* represent the price ceiling (exclusive of the consumer tax) on energy, P_b represent the blended consumer energy price, and P_w represent the world energy price. If total energy consumption is denoted as E and energy imports as I, then the blended price is given by:

$$P_b = P^*(1 - I/E) + P_w(I/E).$$

When energy consumption consists entirely of imported energy (i.e., I = E), the blended price equals the world price. This implies that energy is no longer produced domestically.

APPENDIX IX

ALTERNATIVE CAPITAL MARKET SPECIFICATIONS

The general-equilibrium model developed in chapter V is based on the traditional trade theory assumption of fixed factor endowments. This assumption implies that the domestic capital market is separate and distinct from the international capital market. Changes in the domestic return to capital resulting from domestic policy initiatives, therefore, do not give rise to corresponding capital flows between the domestic economy and international markets. Similarly, domestic capital markets are sheltered from events which affect international capital markets.

It is clearly the case, however, that international capital flows do arise in response to domestic and foreign policies. It is also clear that barriers exist to impede perfect capital mobility between countries. Consider, for example, the market for capital in the form of drilling rigs in the oil and gas industry. Canadian well completions in 1981 declined sharply from 1980 levels with the introduction of the NEP.[1] Drilling rigs were moved south of the border into the United States. With the effective dismantling of the NEP through the Western Accord, on the other hand, restrictions were effectively imposed on the movement of foreign-built, offshore drilling rigs into Canada by disallowing their automatic eligibility for Petroleum Incentive Program grants during that program's phase-out period.[2]

The adoption of a particular capital market specification in a general-equilibrium framework which incorporates foreign ownership of factors of production may significantly affect the conclusions that are reached concerning the welfare impacts of policy changes. A priori assumption of a single international capital market or of a separate national market, therefore, could become an important consideration. The former implies a fixed return to capital when impediments to international capital flows do not exist. The latter implies a fixed capital stock. While the implications of the choice of one capital market specification over another are not fully explored here, a situation is outlined which indicates the potential ramifications of the selection.

Consider the general-equilibrium analysis contained in chapter V and the analysis in Lenjosek and Whalley (1986). In the former, three traded goods, one non-traded good and three primary factors of production are modelled. A modified 1980 data set, based on data reported in St. Hilaire and Whalley (1985), is utilized. In the latter analysis, three traded goods and three primary factors of production are considered, and the 1972 data set in St. Hilaire and Whalley (1983) is updated to reflect 1980 values. In both cases, energy is an intermediate factor of production in the small, open economy and the primary inputs are assumed to be in fixed supply. Foreigners are also assumed to own 70 percent of the resource-factor input in the base-case specifications.

The imposition of a price ceiling on energy, approximately equivalent to that which existed in 1980, has similar welfare effects in the two analyses. Efficiency losses arise in energy consumption and production, but are more than compensated for by the rent transfer against foreign owners of resources. Canadian welfare improves in both cases.

An important discrepancy arises between the two analyses, however, with respect to the impact of the price-ceiling policy on the return to capital in the economy. In chapter V, the return to capital falls under energy price controls; in Lenjosek and Whalley (1986), it rises. Had foreign ownership of capital been included in the base-case specification along with foreign ownership of resources, these differing capital-return impacts could significantly alter the basic welfare result of these investigations.

The decreased return to capital arising in chapter V would tend to reinforce the conclusion that Canadian welfare improves due to the price ceiling on energy, as revenues would be transferred not only from foreign owners of resources but also from foreign owners of capital. The increased return to capital in Lenjosek and Whalley (1986), however, would have the opposite effect. Part of the increase would accrue to the foreign owners of capital. The welfare of the domestic economy would decrease not only due to the efficiency losses in consumption and production resulting from the price ceiling on energy, but also due to the revenue transfer to foreigners through the increased return to capital. A welfare gain would arise from the transfer of rents from foreign owners of resources to Canadian consumers. The net welfare impact would depend on the relative magnitudes of these offsetting effects.

Under the alternative assumption of an international capital market with no restrictions on capital mobility, the return to capital would remain constant under energy price controls. International capital flows would arise to relieve any pressure on the price of capital in Canada and maintain it at a level equal to the price set on international markets. No benefit or loss would accrue to foreign owners of capital in Canada and domestic welfare would, therefore, not be affected through the capital market. The net domestic welfare impact resulting from the imposition of price controls on energy would depend only on the relative magnitude of the efficiency losses in consumption and production, and the rent transfer from foreigner owners of resources. The results presented in chapter V suggest that, in 1980, the latter effect dominated the former. A 10 percentage point decrease in the foreign ownership of resources, however, would be sufficient to reverse this outcome.

Footnotes

1. See Petroleum Monitoring Agency Canada, Canadian Petroleum Industry Monitoring Survey (1981), p. 31.

2. See Petroleum Incentive Program Regulations, SOR/82-666, 1982 Canada Gazette Part II, as amended.

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