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THE CRUDE PETROLEUM INDUSTRY
AND CANADIAN POST-WAR
ECONOMIC DEVELOPMENT

by

GARRY E. VOLLANS

A thesis submitted to the Faculty
of Graduate Studies in partial fulfilment
of the requirements for the
degree of Master of Arts

Carleton University
Ottawa, Ontario.

December, 1974 (i.e. 1975)

The undersigned recommend to the Faculty of
Graduate Studies acceptance of the thesis "The Crude
Petroleum Industry and Canadian Post-War Economic
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ABSTRACT

The study examines the post-war development of the Canadian crude petroleum and natural gas industry in the context of the overall growth in the Canadian economy. A framework is developed for analysing the interaction between the growth processes at the industry level and the economy as a whole.

Essentially, the Canadian demand for crude petroleum and natural gas is tied to the growth in the economy with provision made for substitution over time relating to relative price and quality movements. This domestic demand, when combined with external demand evokes an industry supply response which may involve investments to expand the capacity to produce and/or imports, depending on their relative costs. An attempt is made to trace through any externalities associated with activities at the industry level which could have an impact on the growth of the economy as a whole. The distribution of incomes associated with the production of crude petroleum and natural gas in Canada is discussed, with particular emphasis on the price received by Canadians for this non-renewable resource, and the impact of special corporation income tax provisions for this industry on the distribution of incomes.

The study concludes the framework developed and applied to this particular case could be extended to other industries existing in Canada. The information so developed provides a starting point for the evaluation of existing or potential policies which could have the effect of allocating resources in a manner that is judged to be superior to that dictated by market forces.

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A. Introduction and Historical Perspective.

The crude petroleum and natural gas industry has enjoyed a longer existence in Canada than is normally recognized. In fact, the first successful oil well on the North American continent was established in 1858 in Lambton County in southwestern Ontario.¹ Refineries were constructed to distill the crude oil produced employing the techniques in use in the coal oil industry.² Natural gas was also produced quite early in southwestern Ontario, attaining an annual value of \$150,000 as early as 1892.³ Production of crude petroleum and natural gas was reported as far back as 1910, and 1912 respectively in New Brunswick, although the amounts have consistently been quite small. Similarly, for Alberta, production of natural gas and crude petroleum was reported as early as 1903 and 1914 respectively. Even the Northwest Territories, which are normally thought of as a frontier area for petroleum and gas exploration, have a record of production at Norman Wells which dates back to 1932 for gas and 1936 for petroleum.

Production of crude petroleum and natural gas remained at a fairly constant level in Ontario up to and including World War II. In Alberta, however, production began to increase in the mid-1930's reflecting the establishment of Turner Valley in 1936 as the first major oil field in the British Commonwealth.⁴

1. J. Davis, Canadian Energy Prospects for the Royal Commission on Canada's Economic Prospects, Ottawa: The Queen's Printer, 1957. p.99..

2. G.A. Purdy, Petroleum. Toronto: Copp Clark Publishing Company, 1957. p.26.

3. See appendices A1 and A2 for the data sources in this paragraph.

4. J. Davis, op cit, p.99.

In the present perspective, the volumes involved over the six decades under discussion do not loom very large. Total cumulated production of crude oil in Canada to 1945 inclusive was less than one quarter of the 1971 production of 461.2 million barrels⁵ while the similar production total for natural gas to 1945 closely approximated the exports of natural gas for the year 1971 of 900 billion cubic feet (bcf).⁶

The end of world war II is commonly recognized as the take-off point for the development of the crude petroleum and natural gas industry in Canada.⁷ The Lloydminster field on the Saskatchewan-Alberta border started production in 1945 and then the Leduc discovery was made near Edmonton in 1947.⁸ By almost any indicator one might wish to employ, the industry's development in Canada has been rapidly increasing ever since. Crude petroleum production has increased at a compound annual rate of 18.2% between 1946 and 1971 (see appendix A3) for Canada as a whole to reach 500 million barrels in 1971. The amounts produced in Ontario and the Northwest Territories, however, were relatively small by comparison. While their production levels gradually increased throughout the post-war period, the more rapid growth in the western provinces reduced the Ontario and NWT share of total output from 4% in 1946 to 0.4% in 1971.

5. Statistics Canada. Canada's Mineral Production 1971. Cat. no. 26-202. Ottawa: Information Canada, 1972.

6. Appendix A9.

7. J.P. Lounsbury. The Canadian Petroleum Industry, Achievements and Prospects. Toronto, The Toronto-Dominion Bank, 1960. p.1.

8. J. Davis, op cit, p.99.

Manitoba started production in the early fifties with annual output soon running at about 5 million barrels. However, this output has remained relatively steady with the result that Manitoba's share of total output dropped from 3.4% in 1956 to 1.1% in 1971. Thus, the three western-most provinces accounted for the bulk of this spectacular growth. Table A1 portrays the compound annual growth rates in output for the three provinces and the Canada total for five year intervals.

TABLE A1

Compound Annual Growth Rates of Canadian Crude Oil Production

Years	Total Canada	British Columbia	Alberta	Saskatchewan
1946-51	44.5%	-	51.5%	65%
1951-56	29.3%	-	25.6%	78%
1956-61	5.7%	60%	2.3%	21.5%
1961-66	7.4%	75%	4.8%	10.8%
1966-71	9.3%	8.7%	13.2%	-0.7%

Source: Appendix A3

It is interesting to note that while output in Saskatchewan increased quite rapidly over the first four intervals, it was held fairly constant at approximately 90 million barrels a year since the mid-60's. Even in British Columbia, where production did not commence until the mid-50's, the output level has remained constant at 25 million barrels for the past three years. Therefore, while Alberta's

share of total output fell from 92% in 1946 to 75% in 1971, the bulk of the industry's growth in output may be attributed to Alberta. Output in Alberta increased at a compound annual rate of 17.2% over the post-war period, reaching a production level of 377 million barrels in 1971.

The picture for natural gas production is quite similar. Production for Canada as a whole grew at a compound annual rate of 16.8% over the 25 year post-war period attaining 2,298 bcf in 1971. With Ontario's production growing at an average rate of 4.3% rate, however, its share of total output dropped from 14.8% in 1946 to 0.7% in 1971. Saskatchewan, starting from a 0.3% share of output in 1946, increased production quite rapidly at first but then levelled off during the last decade to a rate about half that for Canada to arrive at a 3% share of output in 1971. Production did not start in British Columbia until 1956; however, during the 60's, growth rates approached those for Canada as a whole so that by 1971, the province's share of output was 14.4%. Alberta's relative position changed little throughout the post-war period dropping from 83.7% of total output in 1946 to 81.9% in 1971. The bulk of the growth was accounted for by Alberta and it is interesting to note how closely the growth rates for Alberta and Canada approximate one another both over-all and over five year periods in Table A2.

TABLE A2

Compound Annual Growth Rates of Canadian Natural Gas Production

Years	Total Canada	British Columbia	Alberta	Saskatchewan	Ontario
1946-51	10.5%	-	11.8%	35%	3.4%
1951-56	16.3%	-	15.9%	61%	8.8%
1956-61	30.3%	35%	26.8%	30%	2.5%
1961-66	16.2%	12.6%	17.8%	6.4%	1.3%
1966-71	11.4%	12.2%	11.5%	6.7%	1.4%
1946-71	16.8%		16.7%		4.3%

Source: Appendix A4

Despite the fact that Canada had become a significant crude oil producer in the post-war period, crude imports into eastern Canada continued to increase (see Appendix A8). Table A3 portrays the five year compound annual growth rates for crude imports and exports. It is interesting to note that the lowest rate of growth in crude imports coincided with the introduction of the National Oil Policy which reserved the markets west of the Ottawa valley to products refined from Canadian crude.

TABLE A3

Compound Annual Growth Rates of Canadian Crude Oil and Natural Gas Trade (volumes)

Year	Crude Oil		Natural Gas	
	Imports	Exports	Imports	Exports
1946-51	5.8%	-	-	-
1951-56	4.8%	-	2.7%*	7.4%*
1956-61	4.6%	7.2%	-22%	73.2%
1961-66	1.9%	13.6%	51%	20.5%
1966-71	10.9%	16.9%	-21%	16.2%

Source: Appendixes A8 and A9

* growth rates calculated from 1952 - 1956 (4 years).

Exports of crude oil, going almost entirely to the United States started rising in the early 50's at a slow rate then increased rapidly during the Suez crisis after which they fell off slightly and then continued increasing quite rapidly so that by 1969 Canada was exporting more crude than she was importing in volumetric terms. However, when trade in refined petroleum products are taken into account (see appendix A8a), Canada was still importing more than she exported in 1971.⁹

9. The values do not reflect a true balance of trade since import values do not include transport costs from the country of origin to Canada.

Canadian exports of natural gas to the United States started in 1950 and except during the Suez crisis, have consistently exceeded imports since 1952 (see appendix A9). The growth in exports has proceeded in a step-wise manner as pipeline capacity was added in stages; however, taken over five year periods, (see Table A3) the growth rates have been quite high. Imports of natural gas have remained at relatively low levels throughout the post-war period except during the mid 50's and 60's when short-term imports into southern Ontario were increased in order to build up markets in anticipation of large increases in pipeline capacity from Alberta. It should be pointed out that the trade figures are understated to the extent that petrochemicals are excluded.

Because of a basic change in concepts in the Standard Industrial Classification (SIC) employed by DBS in 1961, the principal statistics for the industry are not strictly comparable over the entire post-war period. However, one may discern certain highlights from the available data (see appendixes A5, A5a, and A6). The number of production employees peaked in 1956 at 8,000 then declined to a level slightly over 3,000 which was maintained throughout the 1960's. Employment for "total activity"¹⁰ of the industry was reported at 11 thousand in 1961 and had increased to 14 thousand in 1969. Salaries and wages amounted to approximately 10 per cent of value added.

10.

"Total activity" is defined by DBS to include management, professional, and other administrative personnel.

Both the gross value of production and value added increased regularly throughout the post-war period to over a billion dollars annually in 1966.

The cost of material and energy inputs amounted to 25 million in 1961 or approximately four per cent of the value of marketable production. By 1969, the proportion of intermediate inputs to output was the same but the amount had increased to over 57 million.

From an examination of the provincial breakdown of the principal statistics of the industry, it is evident that the industry was centred in Alberta. Alberta maintained a fairly constant share of approximately 75 per cent of the value of marketable production. It is interesting to note that while Alberta had about 70 per cent of the production workers during this period, its share of employees of the "total activity" of the industry was 82 per cent in 1961 and increased regularly throughout the decade to almost 90 per cent in 1969 reflecting head offices moving to Alberta.

Capital expenditures made by the petroleum and natural gas industry have increased considerably since the Leduc discovery in 1947 so that by 1971, the industry was investing over a billion dollars annually (see appendix A7). Investment expenditures for petroleum and natural gas extraction increased quite regularly throughout the post-war period except in 1956 and 1966 when expenditures peaked corresponding to the Suez crisis and the Rainbow field discovery in Alberta respectively. Investment in pipeline transportation facilities has been bunched as large expenditures were made during the initial construction stage. In 1951, there was considerable work done on the Interprovincial oil pipeline and in 1952 on the Trans Northern and Transmountain oil pipelines. In 1957 and 1958 large amounts were expended on the Alberta Gas Trunk Plains Division and the Trans Canada gas pipelines. Again in 1961, the Alberta Gas Trunk Foothills Division line was installed. In the latter half of the 1960's, the investment expenditures were much more regular as a result in large part of the considerable expansion which took place to the existing pipelines to increase capacity for both domestic and export markets.

In summary, a new and dynamic industry has developed within Canada's borders over the post-war period. At the same time, the Canadian economy, along with the rest of the developed nations, gradually switched to petroleum and natural gas as the predominate energy inputs for production and consumption, displacing coal to a large extent and wood. Census value added in the industry increased from nearly 0.5% of GDP in 1949 to about 2% in 1969.¹¹ While a share of this increase in relative importance may be attributed to the favourable tax treatment accorded to the industry during this period, and the shift in demand mentioned above, a necessary condition for the development of the industry was the existence of the natural resource within Canadian boundaries. In general terms, the remainder of this paper will examine the benefits which have accrued to Canadians from the development of this resource and how net benefits might have been increased, under alternative policies, in an effort to suggest improvements that might be made in industry-orientated policies for the benefit of Canadians in the future.

11.

See appendixes A5, A6, and B3.

B. Outline of the Study Plan

The purpose of the foregoing is to sketch the post-war growth of the petroleum and natural gas industry in Canada. By themselves, the statistics do not do much more than indicate that there was some economic activity in western Canada involved in the production and transportation of crude petroleum and natural gas. They certainly do not represent a reply to the interesting questions that are being posed currently about the future role of the industry. For example, if there is an energy "crisis" developing in the United States, should we be exporting our oil and gas as fast possible before they develop alternative supplies within their borders or new energy substitutes; trying to get the best possible price for our exports in the short-term at the risk of losing the market over the longer term; meeting our domestic requirements and exporting the surplus; conserving our natural gas for our own use because of its environmental advantage in use; or conserving both our oil and gas for future generations? Before an adequate reply may be given to these and many other questions about the future, it would appear that it is necessary to take a careful look at the current situation as it pertains to the oil and gas industry, how we arrived there, and what were the consequences of past policies and the ensuing development of the industry.

The first question to be examined will be the role the industry has played in the post-war economic growth of the economy. More specifically, an attempt will be made to determine whether the industry was a leading sector in the economy, stimulated largely by foreign demand, as in the case of the staple theory of economic growth, or whether the growth of the industry was in response to the traditional or "neoclassical" demand forces within the

domestic economy. To a certain extent the question resembles that of the chicken and the egg since the two relationships are so closely intertwined but an attempt will be made to explain the factors at work. A macro model of the economy will be estimated in order to identify the structural parameters of the growth process. Within this context, demand curves for crude oil and natural gas will be estimated in an effort to isolate the causal forces in play. Several shocks will be applied to the system in order to demonstrate the adaptability of the economy to external forces and the extent to which the petroleum industry might have contributed to post-war development.

In addition to its impact at the national level, the industry may also have contributed in a significant manner to the development of the of the western region and Alberta in particular. By means of the Canadian input-output model, inter-industry linkages emanating from the industry will be estimated. An attempt will be made to identify the externalities arising from these indirect effects and their relation to the regional development aspirations of western Canada.

The last section of the paper will discuss the incomes and employment that may be directly or indirectly attributed to the industry as well as the overall balance of payments impact. These benefits will be compared with opportunity costs associated with the inputs employed in the industry in order to determine the net benefits - in effect, a long-run social benefit - cost approach applied to a single industry. The peculiar fiscal environment within which the industry developed over this period will be analyzed with respect to its impact on the distribution of incomes arising from the production of oil and gas. The purpose of this paper then is not so much to "push back the frontiers of science", but to establish a conceptual framework for the evaluation of a single industry's contribution

to Canada's economic development.¹² It is hoped that this framework might then be amenable to comparable studies of other industries with a view towards the establishment of a long-term industrial strategy.

12 The term "economic development" was deliberately chosen in this context to indicate a concept wider than "economic growth" which is usually measured in terms of per capita output. It follows T.M. Brown's definition (Canada's Economic Growth, 1964, pp. 4-5), "...we define development in an economy to mean the infusion and the incorporation of science and technology into its methods of production, accompanied or followed by 'major changes in the pattern of its industry', with a consequent rising and more variegated standard of living. "This standard of living should also encompass qualitative improvements as well as quantitative increase and thus has greater significance than the usual definition of economic growth.

C. Post-War Economic Growth and the Development of the Canadian Petroleum Industry

Over the post-war period (1946-1970), the Canadian economy has grown in real terms at a compound annual rate of almost 5 per cent.¹ Within this period, the Canadian petroleum and natural gas industry has grown considerably as evidenced in the preceding section. Some industry spokesmen would have the Canadian people and their political leaders believe, however, that without the growth and expansion of the petroleum industry, the growth of the Canadian economy would have been considerably reduced.

"Since the discovery of oil at Leduc, Alberta, in 1947, the petroleum industry has grown into a dynamic force in the Canadian economy. It has contributed to a sound economic base for a major expansion of the nation's population, wealth and productivity... It is estimated that without the petroleum industry western Canada would have one million fewer people and the gross national product would be approximately \$3 billion smaller."²

In order to place statements such as the above in their proper perspective and to better understand the post-war growth of the Canadian economy, it was decided to develop a highly aggregated macro-economic model of the Canadian economy. This model could serve as a framework both for a better understanding of the growth process in the economy and as a generator of demand for the output of the crude petroleum and natural gas industry. The petroleum industry will be treated as peripheral to the aggregate economy i.e. the output and investment of the industry will not feedback to the rest of the economy. In addition to avoiding the considerable statistical problems involved in developing industry data on a national accounting basis, such a procedure would lend itself to comparable treatment of any other industry.

¹ Canadian Statistical Review, Historical Summary, 1970. Ottawa: Statistics Canada, cat. no. 11-505, Table 1.3. p.16.

² Canadian Petroleum Association. Report to the Federal Cabinet. March, 1969.p.7.

A model of the Canadian economy already exists which highlights economic growth and development.³ The government sector was treated as endogenous and since our purpose does not concentrate on fiscal policy alternatives, this was appropriate. In addition, the model was kept in real terms which resulted in a model of manageable size and eliminated the need to concentrate a great deal of effort on the monetary and financial side of the economy. The goal was to develop a long-run growth model of the Canadian economy which would "explain the growth in potential aggregate supply in the economy, and at the same time to analyse the growth in aggregate demand."⁴ Rather than devoting a great deal of time and effort in specifying and estimating another macro-model of the economy, it was felt that a more fruitful exercise would be to employ Brown's model. Its structural weakness could be corrected based on his experience in simulations.

Brown's model used observed data from 1927 to 1941 and 1946 to 1961 to specify the behavioural relationships of the Canadian economy. The petroleum industry in Canada, as mentioned above, is primarily a post-war phenomenon. In addition, pre-war data was influenced by the effects of the depression. For these reasons, it was felt more appropriate to re-specify Brown's equations using post-war data, i.e. 1946 to 1970 which provides 25 data points. The basic structure of Brown's model was adhered to as closely as possible but some differences were occasioned either for statistical or practical reasons. The following is an equation-by-equation description of the model as respecified including reasons for divergence from Brown where applicable.

³ T.M. Brown. Canadian Economic Growth. Ottawa: Royal Commission on Health Services, 1965. pp.139-151.

⁴ Ibid., p.142.

I. Demand for Final Goods

A. Consumption

1. Personal Consumption

The largest portion of aggregate demand is accounted for by personal expenditures on goods and services. Brown hypothesized that personal consumption (CONP) was a function of private sector income (YDISP), total population (NPOP), consumption expenditures of the previous year (CONP-1) reflecting the "habit persistence hypothesis", and a variable reflecting the Pigou effect.

This last variable proved to be statistically insignificant in Brown's work and was accordingly not tested here.⁵ Since there is considerable multicollinearity,

$$\text{CONP}_b = .335,829 \text{ YDISP} + .250,711 \text{ NPOP} + .485,050 (\text{CONP}_{-1}) - 1.371,625$$

(6.6) (2.6) (5.5)

T.L. C.V. = 1.8% R = .999 vN = 1.88

$$\text{CONP}_v = .310,795 \text{ dYDISP} + .244,633 \text{ NPOP} + .953,254 (\text{CONP}_{-1}) - 1.414,693$$

(2.82) [.01] (1.54) [.17] (16.7) [.91] (1.63)

T.L. C.V. = 1.5% R = .998 D.W. = 1.86

(estimation period 1947 to 1970 = 24 obs.)

YDISP had the wrong sign so the first difference was used. This gave improved results statistically, but (CONP₁₋) is now the principal explanatory variable.

This could result in cumulative errors in simulation exercises.

⁵ For brevity in the description of the equations, Brown's left-hand variable is subscripted with a b and the corresponding variable estimated by the author with a v. The figures in parenthesis under the regression coefficients represent the t statistics; the number in square brackets under the independent variables is an elasticity coefficient calculated at the mean ($E = \beta_x (\bar{X} + \bar{Y})$); c.v. the coefficient of variation; R the coefficient of correlation; v.N. the von Neumann ratio; and D.W. the Durbin-Watson statistic. The method of estimation is represented as follows: OLS, ordinary least squares; T.L., two stage least squares; 3PLS, three-pass least squares; and SWLS, step-wise least squares.

2. Public or Government Consumption (including military)

In Brown's formulation of this equation, government expenditures for military and defence needs were excluded. Since it was not possible to derive estimates for military expenditures from Statistics Canada for the post-war period, they were left in the data. Two dummy variables, however, were employed to remove higher military expenditures in selected years: DWAR equal to one in 1946, 1952 through 1956; DSUEZ equal to zero in 1956 and 1957.

Both were set equal to zero elsewhere. In Brown's specification, government consumption expenditures (CONGb) were a function of GDP; however, he felt that graphical analysis indicated a change in the relationship beginning in 1954. Therefore, his equation has two GDP variables, the one with zero's after 1953 and the second with zero's before 1954. Since government spending has been employed as a counter-cyclical instrument in the post-war period, it was felt that an additional variable should be added to reflect this influence on government spending. The unemployment rate (NUNPER) was employed to this end. The writer's specification implicitly

$$\text{CONGb} = .048,7478 \text{ GDP}_1 + .0789585 \text{ GDP}_2 + .383,987$$

(5.7) (16.8)

T.L. C.V. = 13.3% R = .965 v.N. = .847

$$\text{CONGv} = .147,174 \text{ GDP} + 934.023 \text{ DWAR} + 482.647 \text{ DSUEZ} + 62.4148 \text{ NUNPER}$$

-382,204

(43,21) [.979] (3.38) [.032] (8.82) [.005] (2.11) [.048] (2.38)

T.L. C.V. = 3.28% R = .990 D.W. 1.99

(estimation period 1946 to 1970 = 25 obs.)

assumes that government military expenditures have become institutionalized (except in periods of war activity) much like any other government current expenditure. The 1954 inflection point did not appear warranted by graphical analysis.

B. Investment

3. Government Gross Investment in Fixed Capital (non-military)

In Brown's formulation of this equation, government investment expenditures (GGFCFb) are a function of population. He had tested for an acceleration effect using the change from the previous year in government consumption expenditures but it was insignificant. The writer also tested for this effect using

$$GGFCFb = .158,744 \text{ NPOP} - 1.415,862$$

(5.7)

$$\text{T.L. C.V.} = 23.3\% \quad R = .945$$

$$GGFCFv1 = .248,419 \text{ NPOP} - 2.807,602$$

(36.0) [1.02] (23.73)

$$\text{T.L. C.V.} = 7.0\% \quad R = .983 \quad \text{D.W.} = .37$$

(estimation period 1946 to 1970 = 25 obs.)

both a change and a lagged government consumption expenditure variable, but both proved to be insignificant. The very low Durbin-Watson statistics indicates that an explanatory variable may be missing. On the hypothesis that government investment expenditures may also have been employed as a counter-cyclical tool, the unemployment rate was added as an explanatory variable but it had the wrong sign. Since the slope of the curve has increased relative to Brown's estimation, this might indicate an increased propensity for governments to invest in social infrastructure.

Based upon the hypothesis that one ought to expect a carry-over of government investment expenditures from one year to the next, lagged government investment expenditures of one year were used as an independent variable. Since the

co-efficient of variation was reduced somewhat and the Durbin-Watson statistic improved considerably, it was decided to retain this specification.

$$GGFCF_{v2} = .089,555 \text{ NPOP} + .644,905 \text{ GGFCF}_{-1} - 0.961,819$$

(3.26) [1.09] (5.86) [.603] (2.97)

T.L. C.V. = 4.47 R = .993 D.W. = 1.43

(estimation period 1946 to 1970 = 25 obs.)

4. Private Gross Investment in Fixed Capital

In Brown's specification of this equation, the explanatory variables are the change in GDP to explain the acceleration effect, gross profits and depreciation flows of the previous year which could represent both the profitability factor in the investment process and the availability of liquidity with which to effect the investment, and investment expenditures of the previous year to explain the multiplier mechanism. It would appear that the curve

$$BGFCG_{\beta} = .135,794 \text{ dGDP} + .248,011 (\text{PIE} + \text{DEP})_{-1} + .616,650 \text{ BGFCF}_{-1} - .536,716$$

(1.5) (4.3) (7.3)

T.L. C.V. = 9.0% R = .991 v.N. = 1.06

$$BGFCF_v = .264,552 \text{ dGDP} + .150,156 (\text{PIE} + \text{DEP})_{-1} + .707,370 \text{ BGFCF}_{-1} - .191,394$$

(3.30) [.07] (2.20) [.29] (7.65) [.67] (0.53)

OLS C.V. = 4.9% R = .985 D.W. = .90

(estimation period 1946 to 1970 = 25 obss.)

has shifted upwards to a higher level but that the basic relationship has not changed appreciably. Because the Durbin-Watson statistic was low and business investment lagged one year was entering the equation as an explanatory variable, it was felt that the three pass least squares procedures might be more appropriate with an additional variable for serial correlation.⁶

$$BGFCF_v = .365,519dGDP + .186,926(PIE+DEP)_{-1} + .571,958BGFCF_{-1} + .711,057R\Delta BGFCF_{-1}$$

-.366,848

(4.9) [.09] (3.0) [-.36] (5.79) [.52] (3.08) [.04]

(1.29)

3PLS C.V. = 3.97% R = .989 D.W. = 1.81

(estimation period 1947 to 1970 = 24 obs.)

The variable for autocorrelation was statistically significant and the Durbin-Watson statistic improved; therefore, it was decided to utilize this specification for simulation purposes.

5. Private Sector Demand for Inventory Stocks

Brown postulated that the demand for inventory stocks was a function of GDP but that over time, the level of inventories relative to GDP might change. He felt that the negative sign on the time variable might reflect a general decrease in the need for inventories because of improved communications and inventory management techniques. The negative sign was maintained with post-war data and the magnitude increased considerably which seems to reflect the drop of approximately 10% between the late forties and the late sixties of the inventory

⁶ L. Taylor and T. Wilson, "Three-Pass Least Squares: A Method for Estimating Models with a Lagged Dependent Variable, Review of Economics and Statistics, vol. 46, 4 (Nov. 1964) pp. 329-346.

stock as a percent of GDP. Even though the correlation is quite high, the Durbin-Watson statistic indicates that an explanatory variable has been excluded; however, it was not possible to isolate the influence. Interest rates are an untested possibility.

$$HJ_b = -.044 \text{ TIME} + .36187 \text{ GDP} + 1.6217$$

(1.2) (7.9)

SWLS C.V. = 7.2% R = .977

$$HJ_v = -33.921 \text{ TIME} + .242,974 \text{ GDP} + 4.749,682$$

(0.87) [0.095] (11.09) [0.736] (2.59)

T.L. C.V. = 2.13% R = .993 D.W. = .59

(estimation period 1946 to 1970 = 25 obs.)

C. Foreign Trade

In Brown's formulation, exports were treated exogenously as growing with time. Because of the interest of this paper, and the fact that both graphical analysis and trade agreements would lead one to expect exports to the U.S. to move differently than exports to the rest of the world, the two variables were estimated separately.

6. Exports to Other Countries

Similar to Brown, this variable was treated as an exogenous function of time to reflect the myriad of factors which would affect exports to other countries and in addition, as a function of the logarithm of time to reflect the decline in the growth rate. The curve was estimated in the following format.

$$\ln XOTH = a + \beta_1 \ln \text{TIME} + \beta_2 \text{TIME}$$

$$\ln XOTH_v = .062,735 - 42.9084 \ln \text{TIME} + .359,290 \text{ TIME}$$

(5.76) (5.20) [9.35] (5.75) [2.59]

OLS C.V. = 1.57% R = .852 D.W. = 1.24

(estimation period 1946 to 1970 = 25 obs.)

This function was then projected and treated as an exogenous variable.

7. Exports to the United States

Because almost 100% of Canadian exports of crude petroleum and natural gas go to the United States, it was felt desirable to estimate this variable separately. In addition, the growth rates diverged somewhat in the latter years because of the influence of the auto-pact in particular. Even after a logarithmic transformation to linearize a constant growth rate, there appeared to be an increase in the slope about 1962 which coincides with the Bladen plan regarding automobile parts. Consequently, this equation was estimated in two portions, from 1946 to 1962 and from 1962 to 1970.

(1946 to 1962)

$$\ln XUS = .006,613 + .003,612 USGNP$$

(52.48) (11.95) [.183]

T.L. C.V. = 1.03% R = .91 D.W. = .95

(1962 to 1970)

$$\ln XU.S. = .005,915 + .004,315 USGNP$$

(25.04) (12.63) [.334]

T.L. C.V. = 0.86% R = .96 D.W. = .87

As expected, the slope in the latter portion was higher than the earlier portion. The two curves were then combined algebraically to cover the entire period for simulation purposes. The resulting equation contains an additional intercept and slope term after 1962.

$$\ln XU.S. = .006,613 a_1 - .001,02 a_2 + .003,612 USGNP + .001,02 USGNP$$

(T>62) (T>62)

The resultant equation after transformation of the dependent variable (anti-log) yields an R of .982 and D.W. of 1.03.

8. Imports

In Brown's formulation of this equation, imports were a function of output (GDP), the change in inventories (dHJ), the number unemployed (NUNEM), gross private investment (BGFCF) and a capacity variable $(3.5 - \text{NUNPER} \geq 0)$.

When the unemployment rate is above 3.5 per cent, this variable takes on a zero value; however, at rates less than 3.5, imports will increase in order to alleviate bottlenecks arising at various points in the economy as it reaches full employment.

$$\text{IMP}_b = .115,885\text{GDP} + .241,471(3.5 - \text{NUNEM}\%) + .78,616\text{dHJ} - .348,942\text{NUNEM} = .256,350\text{BGFCF} + .043,368$$

(9.4) (2.3) (2.1) (1.8) (4.6)

O.L.S. C.V. = 3.9% $R^2 = .998$

$$\text{IMP}_v = .200,663\text{GDP} + .191,694\text{BGFCF}_{-1} + 191,069(3.5 - \text{NUNPER}) + 1,483.427\text{DUS6470} - .724,652$$

(6.15) [.97] (1.13) [.13] (1.62) [.02] (3.08) [.04] (1.04)

T.L. C.V. = 6.08% $R^2 = .979$ D.W. = 1.01

(estimation period 1946 to 1970 = 25 obs.)

A re-estimation of Brown's formulation yielded very unsatisfactory results from a statistical point of view. Even after adding a dummy variable (DUS6470) to take account of the increase in imports attributable to the auto-pact, dHJ and NUNEM were statistically insignificant in explaining the variation in imports. BGFCF was only somewhat significant with a one year lag. Perhaps the greater variability and reduced significance of "real" variables can be attributed to the floating exchange rate during part of the period; however, this possibility was not tested.

D. Aggregate Supply and Income Determination

9. Technical Progress Factor

Brown estimated his technical progress factor (A) on the basis of a production function framework, factor shares, and changes in output and labour inputs. For the projection period, he assumed an average annual rate of 1.7 per cent which he subsequently found to be too high in his simulation exercises.

The writer decided to try and measure A in a production function framework but simplifying the approach somewhat to get an average technical progress factor that might be used for projection purposes. Assuming an aggregate production function of the form expressed as equation 1, this can be transformed to yield 2 by dividing both sides by L. Since the labour and capital coefficients

$$GDP = \alpha \cdot K^{\beta} \cdot L^{(1-\beta)} \cdot e^{\lambda T} \quad (1)$$

$$\ln (GDP/L) = \alpha + \beta \ln (K/L) + \lambda T \quad (2)$$

were constrained to sum to one, we are in effect assuming constant returns to scale. Any increases in factor productivity should be incorporated into the coefficient λ on the Time variable since labour was measured in units of man-hours and capital in constant dollars without any adjustments for qualitative changes. Thus increases in labour productivity attributable to investments in human capital should show up as technical progress. On the other hand, since capital is measured in constant dollars rather than physical units, part of the capital price deflator may be picking up qualitative changes in the capital equipment i.e. embodied technical progress. Thus the technical progress factor λ might be understated to a certain extent. It might also be picking up increasing returns

to scale attributable to such factors as a more efficient use of social infrastructure. In any event, λ reflects not only technical progress but a whole host of factors which might yield a greater output with the same inputs. The specification as estimated was:

$$\ln (\text{GDP/L}) = -.000,045 + .649,327 \ln (\text{K/L}) + .003,967 \text{ TIME}$$

(9.98) (6.52) [1.21] (1.01) [.218]

O.L.S. C.C. = 2.01% $R^2 = .991$ D.W. = 1.10

where L = NEMP.HRS (man-hours)

K = KP (KDCPM adj'd for utilization plus inventory stocks)

(estimation period 1946 to 1970 = 25 obs.)

While this equation could be improved considerably the coefficient on T was adopted as a plausible estimate for technical progress for simulation purposes i.e. 0.4%/year.

10. Implied Demand for Labour

Brown estimated an aggregate production function from which the demand for labour (NE) could be derived given prior estimates for aggregate demand, (GDP), capital stock (KP) and average hours worked (h). Aggregate demand was adjusted for technical progress (A) and the capital stock was adjusted for utilization, based upon the utilization of the labour force as reflected in the unemployment rate.

$$\text{GDP/Ab} = 1.084,027 \text{ Neh} + .111,949 \text{ KP} - 5.596,308$$

(8.4) (13.0) (5.0)

T.L. C.V. = 3.2% $R = .992$ v.N. = .723

$$\text{GDP/A}_v = .708,640(\text{NEMPLHRS}) + .283,299 \text{ KP} - 1.577,356$$

(1.65) [.23] (14.93) [.80] (0.46)

T.L. C.V. = 1.40% $R^2 = .998$ D.W. = 1.30

(Estimation period 1946 to 1970 = 25 obs.)

Brown suggested that the negative constant term in his equation might indicate that the Canadian economy is subject to increasing returns to labour and capital because the economy had not yet reached the optimum proportions of labour and capital relative to land and natural resources. To the extent that this interpretation is correct, the reduced size of the constant in the re-estimated version might indicate that the economies of scale had been captured to a large degree; however, the low value of the t statistic might preclude attaching much significance to its magnitude.

E. Miscellaneous Equations to Complete Model

11. Depreciation

This variable comprises the Capital consumption allowances and miscellaneous valuation adjustments in the National Accounts and the accounting identities. The poor Durbin-Watson statistic could indicate the lack of an

$$DEP_b = .0702889GDP + .0294291KDCPM_{-1} - .684,650$$

(11.9) (8.1)

T.L. C.V. = 6.5% R = .989 v.f. = .808

$$DEP_v = .082,190GDP + .014,630KDCPM_{-1} + .057,443$$

(4.49) [.69] (2.52) [.30] (0.27)

T.L. C.V. = 5.6% R = .980 D.W. = .46

(estimation period 1946 to 1970 = 25 obs.)

explanatory variable but more probably reflects the quality of the National Accounts data.

12. Real Depreciation

This equation is meant to estimate real depreciation which is assumed to take place only with respect to the fixed capital stock (as opposed to the accounting-identify above). Brown postulated that the time trend in the hypothesis would reflect changing composition of the capital stock and/or changing life expectancies of the capital stock. The strong degree of multicollinearity

$$\text{DNR}_D = .05671\text{KDPCM}_{-1} + .002,706\text{TIME} - .4179$$

(139.1) (5.2)

SWLS C.V. = 0.8% R = .999

$$\text{DNR}_V = .02590\text{KDPCM}_{-1} + 30.332\text{TIME} - 1.34867$$

(12.95) [.85] (2.73) [.33] (2.94)

T.L. C.V. = 1.8% R = .998 D.W. = .95

(estimation period 1947 to 1970 = 24 obs.)

makes it difficult to interpret the significance of the coefficients, but the large increase in the size of the time coefficient may reflect an increasing share of machinery and equipment in the capital stock with a corresponding increase in the average rate of depreciation.

13. Average Hourly Earnings

This equation is important in the determination of the civilian wage bill along with the average hours of work and provides an indication of the change in labour income consequent upon productivity changes as represented by PL, the output/labour ratio.

$$\text{WHRb} = .50505\text{PL}_{-1} + .35029$$

(35.3)

SWLS C.V. = 3.8% R = .989

$$\text{WHRv} = .282,682 \text{ PL}_{-1} + .000,151$$

(40.84) [.84] (7.41)

OLS C.V. = 2.02% R = .987 D.W. = .83

(estimation period 1947 to 1970 = 24 obs.)

14. Average Hours of Work per Worker Per Year

$$\text{HRSb} = -.0082595\text{TIME} - .2550\text{PL}_{-1} - .006648\text{NUNPER} + 3.1107$$

(1.8) (2.8) (2.5)

SWLS C.V. = 2.7% R = .955

$$\text{HRSv} = .262,958\text{TIME} - 3.858,004 \text{ PL}_{-1} - .002,618\text{NUNEM} + .037,499$$

(3.21) [2.74] (3.86) [.27] (3.16) [.02] (18.93)

OLS C.V. = .70% R = .879 D.W. = .861

(estimation period 1947 to 1970 = 24 obs.)

Brown had some difficulty with this equation in his simulations since the average hours of work declined linearly. In the writer's specification, the sign for the time variable is positive so that this problem should not be as aggravated. However, the fit could be improved and the Durbin-Watson statistics would indicate the lack of an explanatory variable. The variable PL should reflect the movement towards leisure as output relative to labour inputs increase. Over the business cycle, the unemployment variable should reflect increased average hours worked in a boom and a decreased work week recessions.

15. Indirect Taxes Less Subsidies

This variable is required in the identity which determines non-wage incomes. The change in sign on the time variable may be

$$\text{ITLSb} = .017\text{TIME} + .09745\text{GDP} + .1009$$

(2.0) (9.3)

$$\text{SWLS} \quad \text{C.V.} = 5.6\% \quad R = .992$$

$$\text{ITLSv} = -56.65\text{TIME} + .171,335\text{GDP} + 1.463,709$$

(3.52) [.69] (19.68) [.14] (2.40)

$$\text{TL} \quad \text{C.V.} = 2.21\% \quad R = .997 \quad \text{D.W.} = 1.36$$

(estimation period 1946 to 1970 = 25 obs.)

capturing the declining importance of indirect taxes as a source of government revenues in the post-war period.

16. Government Disposable Income

This variable is required in order to derive the government surplus (deficit). Even though TIME and GDP are quite correlated, it was felt that the addition of the former variable would separate out the influence of growth

in the economy on government revenues from that caused by a progressive tax structure. Even a logarithmic transformation of YG portrayed an increasing growth rate; therefore, the variable TIME was employed to capture the influence of increasing average level of money incomes on income tax revenues.

$$YGB = .210,813GDP - .693,238NUNEM - .927,618$$

(26.5) (2.3) (2.21)

T.L. C.V. = 11.5% R = .983 v.N. = 1.33

$$\ln YGv = .000,017GDP - .000,611NUNEM + .51,499TIME + .005,495$$

(3.48) [.07] (3.67) [.02] (4.98) [.04] (14.24)

T.L. C.V. = .57% R = .993 D.W. = 1.72

(estimation period 1946 to 1970 = 25 obs.)

The identities for the model are listed in appendix B1. The structure of model is basically quite straightforward. The various components of aggregate demand are pushed forward by the exogenous variables and lagged values for some of the endogenous values. After having supplied a portion of the demand from imports, the remainder is supplied domestically. This generates the demand for labour and the incomes for the next round of expenditures. Since the labour force is exogenous, the excess labour supply determines the unemployment rate which serves as a proxy for excess capacity in the economy. Increases in the unemployment rate lead to increases in government expenditures, reduced hours of work, and reduced imports all of which tend to increase the demand for labour and thereby reduce the unemployment rate. On the external side, imports are determined endogenously but exports and service payments are exogenous in effect if not in fact. Therefore, the capital account is assumed to balance the current account via an identity i.e. there is no exchange rate equilibrating mechanism.

Without a financial sector, the level of unemployment, government surpluses (deficits), and current account deficits (surpluses) serve as the equilibrating mechanisms. This is an over-simplified version of the interrelationships in the economy but it emphasizes the real side of the economy which is the primary concern of this paper.

The model as specified has been solved over the estimation period using an iterative procedure to solve the set of equations. The endogenous variables are calculated on the basis of the exogenous variables, the lagged endogenous variables and the value for the current year endogenous variables calculated in the last iteration. For each year, the endogenous variables are calculated over several iterations until the change from the previous iteration falls below a specified level. Early attempts to solve the model using this procedure for the estimation period were not entirely successful and it was necessary to make a few modifications. While the system eventually converged to an equilibrium for each year, it approached this final value in a cyclical manner, gradually diminishing in amplitude. Equation 10, the implied demand for labour, seemed to be contributing to the volatility by alternatively substituting capital for labour (causing a high unemployment rate) and then the reverse in the next iteration because of the high unemployment rate. The following specification was employed which greatly improved the

stability of the system. With this modification, the model

$$\ln \text{NEMPL} = .629467 \ln \text{GDP} + .060261 \text{TIME} - .075157 \ln \text{HRS} - 1.23548 \ln \text{KP} + 12.8702$$

(1.53) [.99] (1.88)[.54] (.93)[.01] (1.49) [2.13] (2.41)

T.L. C.V. = .34% R = .96 D.W. = 2.05

(estimation period 1950 to 1970 = 21 obs.)

performed fairly well in simulations over the sample period. The results are portrayed in Appendix B4.

F. The Crude Petroleum and Natural Gas Industry

17. Petroleum Production for Domestic Use

Petroleum production for domestic markets has been affected by two extraordinary events, the Suez war and the National Oil Policy. The former resulted in increased crude oil production for both domestic and exports markets in 1956 and 1957. The latter reserved the Ontario market for crude oil to that produced in western Canada. In the post-war period, petroleum products have displaced certain other energy sources to a large extent, especially wood and coal. In addition, there has been an import displacement in western Canada in the 1950's and to a large extent in Ontario. By 1958, virtually all of the western market and approximately 60 per cent of the Ontario market were supplied out of Canadian product.⁷ The import displacement in Ontario continued in the 1960's re-inforced by the National Oil Policy but at a much slower rate.

⁷ Royal Commission on Energy, Second Report. Ottawa: 1959. pp. 75-79.

The demand for a product such as oil which has become established as a part of the basket of final goods demanded by society can be expected to grow at the same rate as population and/or real incomes. Over the post-war period, one might expect the growth in domestic demand for Canadian petroleum to follow a sigmoid time profile (i.e. an S curve tilted to the right⁸), superimposed on the growth in GNP (reflecting rising incomes and population). Initially, the growth in demand for a new product might be expected to be lower than the growth in GNP. Then, as consumer tastes shift toward the new product and new uses are developed, because of relative price shifts and/or a quality differential (oil is easier to handle and store than coal), the growth in demand for the new product will be faster than the growth of GNP reflecting rapid substitution toward the new product. Eventually, the growth in demand would slow down and approach that for GNP as the possibility for further substitution decreases. Over the longer run, the new product may also in turn be displaced by substitutes, either new products or by relative price changes in existing substitutes, but this process has probably not yet started for petroleum.

In order to capture this substitution process statistically in the demand for oil over time, the term I/N^2 was employed along with GNP which should reflect changes in both income and population. The term I/N^2 intersects the y-axis at one when N equals one, then decreases at a decreasing rate as N increases to become asymptotic to the x-axis. With GNP increasing at a constant rate, a positive sign on I/N^2 would indicate that demand is increasing at an increasing rate (the early stages of the substitution process). This curve would be convex to the x-axis (Time). A negative sign on I/N^2 would indicate that the growth in demand is increasing at a decreasing rate, approaching the growth rate of GNP as a limit. This curve would be concave to the x-axis and indicate the latter stages of the substitution process.

⁸ T.M. Brown, op. cit., p. 8

The following curve was estimated for the domestic demand for Canadian petroleum. The two GDP's were employed - pre 1961 and post 1960 - to

$$PPDD = .000,664(GDP_{46-60}) + .000,419(GDP_{61-70}) + 7.086DSUEZ - 883.287(1/N^2) + .374,193$$

(1.57) [.08] (1.20) [.07] (1.54) [.005] (14.97) [2.0] (11.81)

O.L.S. C.V. = 4.30% R = .992 D.W. = 1.77

(estimation period 1948 - 1970 = 23 obs.)

capture the diminished role of import displacement in the 1960's.

The smaller coefficient on the latter GDP reflects the reduced influence of import displacement as a factor in demand. The negative sign on $1/N^2$ indicates that the growth rate was greater than GDP in the early part of the estimation period, reflecting the substitution towards petroleum from alternative products. It may also have captured some of the import displacement. Since the term $1/N^2$ will gradually decrease, the predominate influence on the demand for petroleum will be GDP in the projection period.

18. Natural Gas Production for Domestic Markets

In the early post-war period, natural gas was often discovered as a co-product in the search for crude petroleum. Without a ready market, it was often just flared into the atmosphere if it could not be used locally. Advances in long distance gas pipeline transportation technology led to the development of a market for the gas as well as oil.⁹ While there was some room for import displacement, the bulk of the increased demand resulted from new uses such as petrochemicals, or substitution in existing markets.

The estimated demand equation for Canadian natural gas in domestic markets was:

$$\text{NGDD} = .047,173\text{GDP} + 2,631.09(1/N^2) - 2.185,552$$

(10.38) [3.72] (2.79) [1.43] (4.81)

O.L.S. C.V. = 14.01% R = .973 D.W. = 0.74

(estimation period 1950-1970 = 21 obs.)

The positive sign on the term $(1/N^2)$ would indicate that demand was growing slower than GDP during the early part of the estimation period as would be expected with the hypothesis that natural gas was a new product just entering its new product cycle. Further, without a large existing market served by imports, a somewhat longer period was required for natural gas to gain a strong foothold in the market. Part of the low value for the Durbin-Watson statistic might be explained by the fact that domestic consumption of gas expanded in a step-wise fashion as new pipeline capacity was added. However, it also appears that the equation was underestimating domestic demand in the last few years. Between 1965

⁹ Royal Commission on Energy, First Report. Ottawa: 1958. p.1.

and 1970, domestic gas consumption was increasing at an average rate of over 16 per cent a year, considerably faster than GDP. This may indicate that natural gas has already entered the period of rapid increases in its market. One would not expect this rate of increase to continue indefinitely if natural gas demand follows the sigmoid growth profile as hypothesized: either the market will become saturated or prices will increase to slow down incremental demand. In either event, the demand growth should be approaching the growth rate of GDP some time in the future.

19. Petroleum and Natural Gas Export Demand

Both of these time series exhibit discrete breaks as pipeline capacity was added in large chunks. Further, the United States has for years imposed quantitative restrictions on imports of crude oil from Canada. More recently, export constraints have been imposed on natural gas by the NEB refusal to grant new export permits. Once the Americans lifted their import restrictions on crude oil, the Canadian government moved in to control the exports. Rather than try to sort out all these forces, it was decided to try and estimate export demand as a simple function of U.S. GNP, although it is recognized that this approach is inadequate. For the future, this amounts to the assumption that the Canadian authorities will permit increased exports of oil and gas to the United States in order to meet normal increases in demand in the market already served by Canadian production.

$$\text{PPXD} = .595,204 \text{U.S.GNP} + 21.528 \text{DSUEZ} - 239,623$$

$$(16.90) [4.03] \quad (1.62) [.03] \quad (12.33)$$

$$\text{O.L.S.} \quad \text{C.V.} = 22.14\% \quad R = .938 \quad \text{D.W.} = .82$$

(estimation period 1951 - 1970 = 20 obs.)

$$\text{NGXD} = 2.115,696 \text{U.S. GNP} - 878,335$$

$$(11.72) [1.59] \quad (7.86)$$

$$\text{O.L.S.} \quad \text{C.V.} = 17.41\% \quad R = .914 \quad \text{D.W.} = 1.28$$

(estimation period 1958 - 1970 = 13 obs.)

20. Investment in Petroleum and Natural Gas Extraction

In line with the hypothesis on the demand, one would expect investment to increase faster than the average for the economy during the period of rapid growth in demand. Eventually, however, investment would be related to overall growth in the economy once the industry has passed the initial stage of rapid expansion. Commodities such as oil which are exported will also be affected by demand conditions in the foreign market(s). Investment expenditures to meet foreign demands may lead, coincide with, or lag behind the developments for the domestic markets. Canada did not export any oil and gas to the United States to speak of until the early 1950's while exploration and development expenditures had commenced somewhat earlier primarily to serve the domestic market.¹⁰ Thus, in the early period (late 1940's), the investment expenditures were related primarily to domestic demand, then to foreign demand in the mid 1950's superimposed upon continued expansion for domestic markets. With such rapid year-to-year increases in the early period, one would expect some slowdown as the industry grew to meet incremental demands in the domestic and foreign market in the 1960's arising primarily out of growth in incomes and population.

The following equation was estimated for investment in petroleum and natural gas extraction:

$$IPNGX = .187,398U.S.GNP + .015,031dGDP + 59.017DSUEZ - 959.388(1/N^2) + 384.442$$

$$(1.64) [.44] \quad (2.55) [.12] \quad (3.27)[.02] \quad (5.20)[1.34] \quad (3.46)$$

$$O.L.S. \quad C.V. = 11.30\% \quad R^2 = .966 \quad D.W. = 1.32$$

(estimation period 1946 to 1970 = 25 obs.)

¹⁰ Royal Commission on Energy, Second Report. op. cit. p.38.

Since I/N^2 gradually diminishes in value, its influence will diminish in the future to leave investment predominately influenced by U.S. GNP and Canadian GDP. On the basis of this equation, one would predict a quite orderly development of the industry on the basis of rising incomes and population. ¹¹

21. Investment in Petroleum and Natural Gas Transportation

Practically all Canadian crude oil and natural gas is moved to markets by pipeline. Since there are economies of scale involved in pipeline transportation, both export and domestic markets are often served by the same pipeline. Additions to capacity are quite lumpy which makes their estimation more difficult. The following equation was estimated:

$$IPNGTR = .084,979VALPNGP + .360,104(IPNGTR-1) + 152.938DSUEZ + 21.194$$

(2.86) 1.371

(2.60) 1.341

(4.60) 1.111 (1.23)

O.L.S. C.V. = 38.17% R = .691 D.W. 2.67

(estimation period 1947 to 1970 = 24 obs.)

The first variable is the value of petroleum and natural gas production in constant dollars, which is mean to reflect the demand for the pipeline transportation service. Investment in pipeline transportation lagged one period was also used as an explanatory variable to reflect the fact that construction is normally spread over several years. The Suez dummy was inserted to account for the extraordinary activity in petroleum transportation which took place in those years as a result of the market disruption.

¹¹ Ideally, this equation would also incorporate some of the institutional arrangements in Alberta (market prorationing, and multiple ownership and access to oilfields) which would tend to encourage overinvestment once a discovery is made. See A.E. Kahn, "The Depletion Allowance in the Context of Cartilization", "The American Economic Review", July, 1964. p.307. Unfortunately, it was not possible to isolate a proxy variable which would account for this behaviour.

On the basis of this highly simplified statistical analysis, it appears that demand for indigenous crude petroleum in Canada grew rapidly in the early part of the post-war period as it displaced both imports and close substitutes. Natural gas followed the same route a few years later but without an import market of the same proportions to displace. Once these initial periods of rapid growth relented, export markets were the main stimulus to expansion over and above that which would be required by an economy growing at a normal rate. Investment in the industry, of course, responded to the demands generated for the total output of the industry.

It seems apparent from the parameters estimated for the model of the economy that there are some fairly strong underlying forces now at work in the economy which would tend to push the economy along without the external impetuses to growth caused by staple developments as in the past. There is a fairly large domestic market for goods and services which is growing both absolutely in terms of population and relatively as average incomes increase. The large stock of reproducible capital provides both a source of demand for investment goods for replacement purposes and a source of domestic financing (capital consumption allowances) out of current income. Rising incomes provide an additional source for domestic financing of net new investment out of current savings. The economy thus appears to be adequately equipped for future economic growth of a neo-classical nature i.e. increasing quantity and quality of the factors of production which, when combined with corresponding increases in aggregate demand (which might involve short-term stabilization measures by the government), set the pace for continued economic growth.

It is within this context that developments in the petroleum industry must be examined. While there is excellent potential for another period of rapid expansion in the industry to meet strong foreign demand, the factors of

production which must be allocated to the industry have a substantial opportunity cost in other areas of economic activity. In addition, there may be substantial opportunity cost in other areas of economic activity. In addition, there may be substantial social costs involved in developing new petroleum reserves which should also be taken into account. These social costs might involve ecological and sociological disruption in the northern areas as well as the disruptive impact on traditional markets as resources are diverted into expanded construction activities in the petroleum industry. The petroleum reserves themselves may no longer be treated as having a zero or very low social opportunity cost. While this may have been true in the past with other "surplus" staples, substantial effort and cost must now be expended in finding and developing new reserves for future expansion of the industry. In fact, it is doubtful if the staple model of economic growth is or ever was applicable to the Canadian petroleum industry. As mentioned above, the first decade of rapid development of the industry in western Canada was primarily related to the domestic market and "exportable surpluses" were developed subsequently. This is the opposite pattern to that spelled out in the staple theory.¹¹

On the other hand, there may be positive externalities involved in the rapid expansion of the Canadian petroleum industry which would more than offset the costs mentioned above. The next section addresses itself to that topic.

¹¹ M.H. Watkins, "A Staple Theory of Economic Growth", Canadian Journal of Economics and Political Science, vol. 29, May, 1963.p.144.

D. Inter-Industry Linkages Emanating from the Canada Petroleum and Natural Gas Industry

The last section presented a highly aggregated growth model of the Canadian economy based on the structure of the National Accounts. In the process of supplying the final demand expenditures, however, there is a complex production, exchange and distribution process which finally determines the incomes accruing to the factors of production and other participants in the income stream. An empirical methodology to trace the system of production from final demand through to factor incomes by industry has been developed and is normally referred to as an Input/Output system.¹ Many assumptions are made which abstract from the multi-market general equilibrium analysis; however, it is a system which permits the user to quantify several interesting inter-relationships in the production process.

In order to evaluate the interdependence of the Canadian crude oil and natural gas industry, use will be made of the latest Canadian input-output system.² Since there are a number of differences between this system and the "classical" input-output system, a brief description of the conceptual framework of the Canadian system is provided in appendix D1.

The input/output model is just a tool, however, which requires both inputs and a conceptual framework for the interpretation of the outputs

¹ W.W. Leontief, The Structure of the American Economy, 1919-1939 (second ed.; New York: Oxford University Press, 1951).

² Dominion Bureau of Statistics, The Input Output Structure of the Canadian Economy 1961 Ottawa: The Queen's Printer, 1969.

if they are to represent more than numbers. The staple model of economic growth³ would appear to be one possible framework for the evaluation of the crude petroleum and natural gas industry's role in the post-war development of the Canadian economy. The use of this framework deserves to be qualified. The staple theory has been criticized as unduly simplistic as a theory of economic growth applicable to the new country (empty land) since it does not necessarily lead to higher per capita incomes even though there has been an expansion of economic activity.⁴ Further, even if higher incomes do ensue, it relies too heavily on the emergence of successive staples over time as the dynamic factor in the growth process.⁵ These points appear to have considerable validity particularly when one recalls the strong neo-classical growth forces evident in post-war growth of the economy as depicted in the previous section. To a certain extent, however the theory has been reformulated to reflect among other things that staple developments are not necessarily the prime movers but one component of a more generalized growth process with slightly different constraints.

"The model so far makes the rate of growth in the aggregate income in region II (and also in world total income and income per capita) depend solely on the timing of resource discoveries and the feasible rate of factor migration and absorption. This process, can be visualized as superimposed upon an underlying steady swell of neo-classical growth occurring in I, II, or both ... Thus, export-based growth may explain a large part of the variation in the aggregate growth rate in region II, whether or not it explains a large part of the average level of that growth rate."⁶

³ M.H. Watkins, op. cit., pp.141-158.

⁴ P.A. Samuelson and A. Scott, Economics, An Introductory Analysis, Toronto: McGraw-Hill Company of Canada Limited, 1966. p.781.

⁵ K. Buckley. "The Role of Staple Industries in Canada's Economic Development". The Journal of Economic History. vol.18, no.4, 1958.p:443.

⁶ R.E. Caves. "Vent for Surplus Models of Trade and Growth", in Trade, Growth, and the Balance of Payments, R.E. Baldwin et. al. Amsterdam: North-Holland Publishing Company, 1966. p.102.

The essential point then is that staple-induced growth is not necessarily the leading sector in an economy's development but more probably one of several, each contributing in its own fashion to the overall growth process.

As new industries develop based on new products or technical processes, or as existing industries expand rapidly based perhaps on new external conditions, each will leave its particular imprint on the economy. In the process of expanding its output, there may arise certain externalities in other sectors of the economy. For example, these may involve certain economies of scale in the production of some commodities on the positive side, or perhaps, considerable social cost in terms of required public goods such as social infrastructure on the negative side. The location of a new or expanded industry may also be considered relevant from a regional development point of view. The staple model incorporates a framework for evaluating some of these externalities, namely the effect of expanding output in the staple industry upon outputs, factor supplies, and capital formation in other industries in the economy. These spread effects have been classified into backward, forward and final demand linkages.⁷ It would appear that this framework for the evaluation of these externalities would be generally applicable across most sectors of the economy of which staples are only prototypes. Of course, there may be other externalities associated with the expansion of a particular industry which this framework does not encompass.

An attempt will be made to quantify these linkages emanating from the crude petroleum and natural gas industry by means of the input/output model.

⁷ M.H. Watkins, op. cit. p.145.

The extent to which these linkages may be considered as benefits or costs depend upon the setting of the economy in which they occur. However, once these externalities have been classified, quantified and evaluated in the context of the stage of development of the economy, one may have moved closer to an evaluation of the "social profitability" of a particular industry. In this manner, we may be able to eventually define a desirable industrial strategy.

Backward Linkages

The backward linkages have been described as "a measure of the inducement to invest in the home-production of inputs, including capital goods, for the expanding export sector."⁸ The production function for the industry will determine its intermediate input requirements. Whether these inputs are produced domestically or imported depend on a great many factors which may change over time. For example, initially perhaps only those inputs which are costly to transport will be produced domestically. Those inputs which are supplied domestically will in turn require inputs which may be supplied from domestic production or imported. In order to quantify the backward linkages emanating from current production, a one million dollar of final demand for natural gas and crude oil was imposed on the "open" version of the I/O model. It was assumed that the final demand would be met entirely from domestic production but that any indirect demand generated for it or any other commodity would be supplied out of domestic production and/or imports in the 1961 proportions.

⁸ Ibid. p.145

Total demand was increased by an additional \$441,166 of which imports contributed \$26,824 or 6 per cent. (This compares to 6.6% for the total economy). Table C1 portrays the commodities demanded from domestic production in descending order, their per cent of the total, and their import coefficients. The bulk of the commodities fall into the service category and have a very low import content. This would tend to indicate that even in 1961, the backward linkages out of current production were still primarily restricted to those commodities which are strongly market orientated, i.e. those commodities which do not normally move in international trade to any extent and are normally produced close to the location where they are demanded.

Table C1

Commodities Demanded from Domestic Sources as a result of
Crude Oil and National Gas Production

<u>Commodity</u>		<u>Domestic</u>	<u>% of</u>	<u>Import</u>
<u>No.</u>	<u>Name</u>	<u>Output (Gross)</u>	<u>Total</u>	<u>Coefficient</u>
186	Real Estate Rent	88,264	21.3	0.0
19	Products Related to Mining	41,448	10.0	0.0413
189	Business Services	37,114	9.0	0.097
197	Operating Supplies	32,692	7.9	0.0
179	Wholesale Retail Trade	22,467	5.4	0.0
184	Electric Power	20,651	5.0	0.0013
178	Construction	19,377	4.7	0.00
187	Finance and Insurance	17,500	4.2	0.0346
180	Transportation and Storage	14,505	3.5	0.0268
195	Travel and Entertainment	12,841	3.1	0.0
193	Office Supplies	7,754	1.9	0.0
191	Personal Services	7,133	1.7	0.0846
190	Accommodation and Meals	7,009	1.7	0.0
182	Telephone and Telegraph	5,834	1.4	0.0098
89	Printed Matter	4,971	1.2	0.1856
116	Industrial Machinery	4,381	1.1	0.5374
194	Advertising	3,971	1.0	0.0
198	Non-competitive Imports	3,707	0.9	1.0000
152	Gasoline	3,631	0.9	0.0247
192	Rent Excl. Real Estate	2,945	0.7	0.0386
	Other	56,147	13.6	
	Total	414,342	100.0	

Table C2 portrays indirect industry outputs and value added by industry for the total economy consequent upon one million crude oil and natural gas production (excluding the output of the oil and gas itself). It is evident that the bulk of the backward impetus is given to the service industry which accounts for more than 50 per cent of the indirect impact. Further the bulk of the construction industry activity is repair construction while a large portion of the primary industries activities are attributable to "services incidental to mining". Both of these industries are quite analogous to service activities and if they had been classified to that sector, more than two-thirds of the output generated would have been services. While services are normally labour-intensive, they are not generally considered to be of the high growth (productivity) type industries. Further, one would expect service industries to develop as a result of almost any productive activity. By their very nature, they tend to cluster in the vicinity of goods producing industries, require little social infrastructure, and normally do not exhibit economies of scale. Thus, even though the petroleum industry requires considerable services as inputs, it seems intuitively likely that, if the productive factors employed in the petroleum industry were utilized in any other goods producing activity, the service industry would be stimulated accordingly. Of course this does not imply that the same services would be demanded or even the same level but simply that services are stimulated by most producing activities.

The last column in table C2 portrays the incomes accruing to labour divided by the returns to capital (gross) in order to develop a measure of the relative labour intensity of the industries stimulated by the petroleum industry output. On average, the industries stimulated were slightly more capital intensive than the average for the total economy.

Indirect Industry Outputs and Value Added as a Result of Crude Oil
and Natural Gas Production of One Million dollars³

I/O Industry Numbers	Sector Name	Output (gross)		Value Added		Total		Labour/ Capital Ratio
		\$	%	\$	%	\$	%	
00100-01700	Primary Industries	50,076	12.1	16,224	12.3	10,407	14.7	13.2
01800-14700	Manufacturing	69,270	16.7	16,789	12.7	9,134	11.5	12.3
01800-03800	Food and Tobacco	4,143	1.0	668	0.5	306	0.4	0.5
03900-06300	Rubber, Leather and Textiles	2,900	0.7	793	0.6	328	0.5	2.41
06400-07900	Wood, Paper, Farm Painting	16,411	3.9	4,811	3.7	1,814	2.6	2.65
08001-09500	Metal and Fabri- cating Industries	13,609	3.3	2,812	2.1	1,171	1.7	2.40
09600-14700	Finished Manufactured Goods	32,207	7.8	7,705	5.8	4,515	6.4	1.70
14810-14890	Construction Industries	21,405	5.2	10,957	8.3	1,066	1.5	10.27
14900-16200	Trans. and Communica- tions	24,291	5.9	9,987	7.6	6,660	9.4	1.49
16300-16500	Utilities	22,677	5.5	4,032	3.1	11,060	15.7	0.36
16600-19100	Services	226,305	54.6	73,873	56.0	33,277	47.1	2.21
	Total	414,024	100.0	131,862	100.0	70,604	100.0	1.86
							Total Economy	(2.30)

¹ Includes salaries, wages, supplementary labour income and net income of unincorporated business.

² Surplus including capital consumption allowances.

³ These numbers exclude the one million of crude oil and natural gas itself from primary industries output.

An additional potential source of backward linkages emanating from the petroleum industry could result from the stimulus provided to domestic producers of capital goods used in the construction of oil and gas production facilities and pipelines, the primary means of transport for this industry. These backward linkages would be strongest where the investment activity of the industry is steady and sustained, the capital goods are expensive to transport, and the same capital goods can be used in other activities so as to take advantage of scale economies.

In order to portray the possible backward linkages, a 100 million expenditure was imposed on the I/O model corresponding to capital formation for both the petroleum industry and the pipeline transportation industry.⁹ Since the input-output system is strictly linear, these results can be scaled up or down as required in line with the estimates derived from the investment equations estimated above (pp. 35-36) to derive an approximation of annual investment expenditure impacts. Table C3 portrays the bulk of the specific commodity outputs in descending order. Indirect imports as a proportion of indirect demand (gross) amounted to 11.1 per cent in the case of the pipeline and 14.3 per cent in the case of oil and gas investments. This compares with 6.6 per cent for the economy as a whole in 1961; however, one might expect investment expenditures to generate more imports than other categories of final demand. The commodity output figures by themselves do not take us very far except to highlight those commodities which are affected by a given final demand. In addition there is considerable double-counting in gross output figures as some commodities serve as inputs.

⁹ The capital expenditures for the petroleum industry were simply derived from spreading 100 million over the final demand coefficients in the capital formation vector for the crude petroleum and mining industry. The assumptions for the investment goods components of 100 million in the pipeline industry are portrayed in appendix C.

Table C3

Commodity Outputs Resulting from a 100 Million
Investment Expenditure in Both Pipelines and the Crude Petroleum
and Natural Gas Industry

A. Pipelines

Commodity		Direct and Indirect Commodity Outputs(Gross)		Indirect Commodity Outputs(Gross)		Import Coefficient
No.	Name	(mil. \$)	%	(mil. \$)	%	
097	Pipes and Tubes	44.4	20.4	6.4	4.8	.2001
091	Pig Iron	27.8	12.8	27.8	21.1	.1506
178	Construction	26.8	12.3	1.8	1.4	.0000
197	Operating Supplies	21.7	10.0	21.7	16.4	.0000
093	Steel Sheet, Plate	20.2	9.3	20.2	15.3	.0790
180	Trans. and Storage	11.4	5.2	5.4	4.1	.0268
179	Whol. & Ret. Trade	5.7	2.6	5.7	4.3	.0000
116	Whol. & Ret. Trade	4.8	2.2	0.8	0.6	.5374
198	Non-Camp. Imports	3.8	1.7	3.8	2.9	1.0000
113	Forg. & Plub. Equip.	3.1	1.4	1.1	0.8	.3712
078	Millwork (Wood)	3.0	1.4	3.0	2.3	.0267
187	Fin. and Insur.	2.6	1.2	1.6	1.2	.0346
136	Elect. Ind. Equip.	2.3	1.1	0.3	0.2	.2914
103	Plate, Tank, Boilers	2.1	1.0	0.1	0.1	.1043
185	Other Utilities	1.7	0.8	1.7	1.3	.0827
184	Elect. Power	1.6	0.7	1.6	1.2	.0013
192	Rent excl. Real Estate	1.6	0.7	1.6	1.2	.0386
166	Organic Chemicals	1.6	0.7	0.1	0.1	.4460
019	Prod. Rel. to Mines	1.4	0.6	1.4	1.1	.0413
099	Met. Prim. Form.	1.3	0.6	1.3	1.0	.1209
	Other	29.1	13.3	24.6	18.6	.0660
	Total	218.0	100.0	132.0	100.0	

B. Crude Petroleum and Natural Gas Industry

178	Construction	68.4	34.2	1.1	1.1	.0000
019	Prod. Related To Mines	18.7	9.3	2.6	2.5	.0413
197	Operating Supplies	11.3	5.7	11.3	10.7	.0000
179	Whol. and Retail Trade	10.4	5.2	8.3	7.8	.0000
097	Pipes and Tubes	9.4	4.7	9.4	8.9	.2001
091	Pig iron, Steel	8.0	4.0	8.0	7.5	.1506
180	Trans. and Storage	6.7	3.3	6.7	6.3	.0268
093	Sheet steel, plate	5.0	2.5	5.0	4.7	.0790
116	Industrial Mach.	4.8	2.4	1.5	1.4	.5374
198	Non-comp. Imports	4.0	2.0	3.7	3.5	1.0000
192	Rent excl. Real Estate	3.0	1.5	3.0	2.8	.0386
189	Business Services	2.1	1.1	2.1	2.0	.0970
144	Concrete Products	2.1	1.1	2.1	2.0	.0061
113	Forg. and Plumbing Equip.	1.9	1.0	1.9	1.8	.3712
187	Fin. Insur. and Real Estate	1.9	0.9	1.9	1.8	.0346
195	Travel and Entertainment	1.7	0.9	1.7	1.6	.0000
122	Commercial Vehicles	1.5	0.7	0.0	0.0	.1471
186	Real Estate Rent	1.4	0.7	1.4	1.4	.0000
098	Iron Castings	1.3	0.7	1.3	1.3	.1817
184	Electric Power	1.2	0.6	1.2	1.2	.0013
	Other	35.3	17.5	31.7	29.7	
	Total	200.2	100.0	106.0	100.0	

to others. They might be used, however, to indicate potential bottlenecks (given capacity constraints) or possible markets arising from a hypothetical or forecasted final demand configuration. In this case, 14 of the top 20 commodities demanded by the two investment projects were common to both; however, given the nature of most capital goods, one would expect demands for steel, iron, transportation, and similar goods. Without comparable information for investment expenditures in other industries, it is difficult to identify potential economies of scale arising from various patterns of investment expenditures.

Tables C5 and C6 portray value added by industry resulting from investment expenditures on a pipeline and petroleum extraction facilities. As would be expected, value added in the construction industry is a large portion of total value added in both cases. Manufacturing is also considerable representing more than half of the value added in the case of this pipeline. This results from the line pipe input, amounting to about one-third of the total investment. This also accounts for the fact that pipeline investment expenditures generate activity in the economy which is more capital intensive than average even though construction projects are normally considered to be fairly labour intensive.

One potential diseconomy may arise out of the fact that such a large portion of the value added in pipeline construction represents line-pipe. The mills which produce this pipe are very specialized so that in periods when pipeline construction activity diminishes, these factories cannot be readily switched to the production of alternative goods. This amounts to structural unemployment of capital. Only in the event that

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TABLE C6

INDUSTRY OUTPUTS AND VALUE ADDED AS A RESULT OF AN INVESTMENT IN PETROLEUM INDUSTRY

T/O Industry Numbers	Sector Name	Output		Value Added		
		Gross (000 \$)	%	Labour (000 \$)	%	(000 \$)
00100 - 01700	Primary Industries	22,817	11.4	7,653	14.4	5,30
01800 - 14700	Manufacturing	67,014	33.4	13,748	25.8	6,60
01800 - 03800	Food and Tobacco	818	0.4	128	0.2	
03900 - 06300	Rubber, Leather and Textiles	1,406	0.7	384	0.7	
05400 - 07900	Wood, Paper, Furn., Printing	4,681	2.3	1,252	2.4	
08001 - 09500	Metal and Fabricating Industries	39,404	19.7	6,389	12.0	
09600 - 14700	Finished Manufactured Goods	20,705	10.3	5,595	10.5	
14810 - 14890	Construction Industries	68,729	34.3	18,735	35.2	2,60
14900 - 16200	Trans. and Communications	8,543	4.3	3,674	6.9	1,90
16300 - 16500	Utilities	1,411	0.7	250	0.5	60
16400 - 19100	Services	32,060	16.0	9,142	17.2	2,80
Total		200,175		53,201		20,00

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TABLE C5

INDUSTRY OUTPUTS AND VALUE ADDED AS A RESULT OF AN INVESTMENT IN PIPELINES OF 1

I/O Industry Numbers	Sector Name	Output		Value Added		
		Gross (000 \$)	%	Labour (000 \$)	%	(000)
00100 - 01700	Primary Industries	5,909	2.7	1,870	4.2	1.7
01800 - 14700	Manufacturing	146,350	67.1	22,934	51.3	15.0
01800 - 03800	Food and Tobacco	515	0.2	80	0.2	
03900 - 06300	Rubber, Leather and Textiles	841	0.4	229	0.5	
06400 - 07900	Wood, Paper, Furn., Printing	6,499	3.0	1,954	4.4	
08001 - 09500	Metal and Fabricating Industries	122,174	56.0	16,097	36.0	
09600 - 14700	Finished Manufactured Goods	16,321	7.5	4,573	10.2	
14810 - 14890	Construction Industries	27,008	12.4	7,785	17.4	1.30
14900 - 16200	Trans. and Communications	12,724	5.8	5,922	13.2	2.70
16300 - 16500	Utilities	1,908	0.9	343	0.8	94
16600 - 19100	Services	24,112	11.1	5,874	13.1	1.90
	Total	218,011	100.0	44,728	100.0	23.51

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400 \$

Output		Value Added				Total		Labour/ Capital Ratio
	%	Labour (000 \$)	%	Capital (000 \$)	\$	(000 \$)	%	
1,770	2.7	1,870	4.2	1,770	7.5	3,640	5.3	1.06
5,030	67.1	22,934	51.3	15,030	63.9	37,964	55.7	1.53
515	0.2	80	0.2	36	0.1	116	0.2	2.22
841	0.4	229	0.5	104	0.4	333	0.5	2.20
6,499	3.0	1,954	4.4	552	2.4	2,506	3.7	3.54
22,174	36.0	16,097	36.0	12,206	61.9	28,303	41.5	1.32
16,321	7.5	4,573	10.2	2,132	9.1	6,705	9.8	2.14
12.4		7,785	17.4	1,304	4.4	9,819	12.9	7.53
5.8		5,922	13.2	2,760	11.8	9,682	12.7	2.15
0.9		343	0.8	941	4.0	1,284	1.9	0.36
11.1		5,874	13.1	1,979	8.4	7,853	11.5	2.97
100.0		44,728	100.0	23,514	100.0	63,242	100.0	1.90
Total Economy (2.30)								

the pipe were entirely imported or that pipeline construction activity were steady and sustained could this eventuality be avoided.

Potential economies of scale in the production of capital goods for pipeline and petroleum extraction are not immediately obvious. While the production of iron and steel was stimulated, this would be expected as a result of most investment expenditures.

Forward Linkages

These are defined as "a measure of the inducement to invest in industries using the output of the export industry as an input".¹⁰ In the case of petroleum, this amounts to refineries; for natural gas, it might be petrochemicals and fertilizers but the bulk is consumed for its thermal rather than its chemical properties in Canada. In order to demonstrate the potential linkages that might stem from refining crude petroleum prior to export, a one million expenditure for refined petroleum products was imposed on the I/O (open) model. Total output increased by an additional \$700,000 and \$62,500 was generated in indirect imports. The top ten commodities demanded as intermediate inputs are portrayed in Table C7. As expected, crude oil was the prime commodity affected.

¹⁰

M.H. Watkins, op. cit. p.145

Table C7

Intermediate Inputs Demanded As a Result of a One Million
Dollar Expenditure on Refined Petroleum Products

#	Commodity Name	Amount	Per Cent
017	Crude Mineral Oil	303,420	43.1
180	Trans. and Storage	84,013	11.9
186	Real Estate Rent	33,603	4.8
197	Operating Supplies	30,902	4.4
178	Construction	30,141	4.3
179	Whole. and Retail Trade	22,794	3.2
184	Electric Power	16,626	2.4
167	Industrial Chemical Products	15,144	2.1
187	Finance and Insurance	14,235	2.0
189	Business Services	13,170	1.9
	Other	140,076	19.9
	Total	704,124	100.0

A country may enjoy (or suffer) the linkages emanating from petroleum refining without necessarily having a crude petroleum industry. Montreal is an excellent example of a large refining complex based upon imported supplies. In order to derive an estimate of the refining value added above, that portion attributable to the crude oil production was subtracted. The results are portrayed in Table C8. The largest portion of value added is in the transportation industry reflecting primarily the pipeline transportation of crude oil to the refineries. Similar to the crude oil production, a considerable portion of the value added is attributable to the service industry, 26 per cent including the repair construction activity. Nevertheless, the value added stimulated indirectly by the petroleum refining process is overwhelmingly capital intensive as a result largely of the pipeline transportation but also the utility requirements. The value added in petroleum refining itself and the associated crude oil production are excluded from this table, but if they were included, it would push the capital intensity even higher.¹¹

¹¹ The corresponding labour/capital ratio for petroleum refining is 0.49 and for crude petroleum production 0.20

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TABLE C8

INDIRECT INDUSTRY OUTPUTS AND VALUE ADDED AS A RESULT OF REFINERY PRODUCTION OF OIL

I/O Industry Number	Sector Name	Output		Value Added		
		Gross \$	%	Labour ⁽¹⁾ \$	%	
00100 - 01700	Primary Industries	4,609	1.6	2,729	4.1	1.1
01800 - 14700	Manufacturing	78,575	28.1	19,082	28.6	11.1
01800 - 03800	Food and Tobacco	1,564	0.6	243	0.4	
03900 - 06300	Rubber, Leather and Textiles	1,748	0.6	469	0.7	
06400 - 7900	Wood, Paper, Furn., Printing	10,901	3.9	2,851	4.3	
08001 - 09500	Metal and Fabricating	21,769	7.8	4,146	6.2	
09600 - 14700	Finished Manufactured Goods	42,593	15.2	11,373	17.0	
14810 - 14890	Construction Industries	24,606	8.8	13,175	19.7	
14900 - 16200	Trans. and Communication	87,256	31.2	12,939	19.4	51.1
16300 - 16500	Utilities	11,785	4.2	2,111	3.2	5.1
16600 - 19100	Services	73,096	26.1	15,699	25.0	7.1
Total		279,927	100.0	66,735	100.0	77.1

- (1) Includes salaries, wages, supplementary labour income and net income of unincorporated business.
- (2) Surplus including capital consumption allowances.
- (3) These numbers exclude the one million of refined products themselves and the corresponding \$300,000 of crude oil and its associated indirect outputs.

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TABLE C8

OUTPUTS AND VALUE ADDED AS A RESULT OF REFINERY PRODUCTION OF ONE MILLION DOLLARS⁽³⁾

d	Output		Value Added						Labour/ Capital Ratio	
			Labour (1)		Capital (2)		Total			
			\$	%	\$	%	\$	%		
1,4	09	1.6	2,729	4.1	1,428	1.8	4,157	2.9	1.91	
11,5	75	28.1	19,082	28.6	11,568	14.9	30,650	21.2	1.65	
		1,564	0.6	243	0.4	113	0.1	356	0.2	2.15
		1,748	0.6	469	0.7	201	0.3	670	0.5	2.33
		10,901	3.9	2,851	4.3	1,104	1.4	3,955	2.7	2.58
		21,769	7.8	4,146	6.2	1,911	2.5	6,057	4.2	2.17
		42,593	15.2	11,373	17.0	8,239	10.6	19,612	13.6	1.38
7	06	8.8	13,175	19.7	715	0.9	13,890	9.6	18.43	
51,1	56	31.2	12,939	19.4	51,190	65.8	64,129	44.4	0.25	
5,8	85	4.2	2,111	3.2	5,818	7.5	7,929	5.5	0.36	
7,0	96	26.1	15,699	25.0	7,046	9.1	23,745	16.4	2.37	
77,7	27	100.0	66,735	100.0	77,765	100.0	144,500	100.0	0.86	
Total Economy (2.30)										

net income of unincorporated business.

themselves and the corresponding \$300,000 of

Once again, it is difficult to evaluate these forward linkages without comparative tables for alternative industries. It is evident, however, that any expansion of the industry to perhaps refine Canadian crude prior to export or to refine imported crude for export would involve large capital expenditures both in refineries and supporting industries. Further, although there are some forward linkages in petroleum refining based upon Canadian crude, these cannot be considered as net benefits to the economy; even without any domestic crude oil production, it is certain that petroleum refineries would have been located in Canada since they are traditionally market orientated. Just as Montreal is now served by imported crude oil, refineries in the rest of Canada would also have been based upon imported crude.

Final Demand Linkages

These are a measure of the inducement to invest in domestic industries producing consumer goods for factors in the export sector.¹² While it would be possible to make an estimate of these linkages by subtracting the estimates derived from the open version of the I/O model from the closed version consequent upon the same expenditures for crude petroleum, very little would be gained by such an exercise. The consumption expenditures generated are directly proportional to the size, of the primary inputs required and a dollar of wages in the petroleum industry would be spent on the same bundle of consumer goods as a dollar earned in any other industry.

¹² M.H. Watkins, op. cit. p.145.

From table C2, it was evident that the value added generated in other industries out of crude oil production was more capital intensive than the average for the economy. Further, the crude petroleum industry itself is one of the most capital intensive industries in the economy - a labour/capital ratio of 0.2 vs. 2.3 for the whole economy.¹³ Thus if there is a net contribution to final demand linkages emanating from the petroleum industry, it arises from the fact that labour incomes in the industry are higher than the average for the economy. This may be offset, however by the reputed relatively high proportion of foreign workers engaged by the industry.

In summary there do not appear to be any strong positive externalities from the crude petroleum industry. While there are backward linkages which have undoubtedly led to the development of "satellite industries",¹⁴ they are primarily services which would be associated with any major producing activity although not necessarily the same service industries.¹⁵ The linkages from investment expenditures would not appear to be significantly different from capital expenditures in most industries. The forward linkages from petroleum refining ought to be largely discounted since the economy would have had this activity even without a domestic crude petroleum industry. Any expansion of the refining industry for the export

¹³ Wages plus supplementary labour income divided by surplus calculated from I/O table.

¹⁴ A.O. Hirschman, The Strategy of Economic Development, New Haven, Yale University Press, 1958, p.102.

¹⁵ From a regional point of view however, the expanded level of activity in the western provinces may have been viewed favourably by policy-makers who wished to see development of the economy less concentrated in the two central provinces.

market would appear to be very capital intensive, both in the refining industry itself and in those industries which could be expected to expand correspondingly. The final demand linkages, because of the capital intensive nature of the crude petroleum industry, cannot be significant and may be subject to higher than average leakages to foreign labour.

Because of the higher than average capital intensity of the petroleum industry itself and those induced to expand out of increased petroleum production, any rapid development of the industry to meet potentially higher export markets will involve large amounts of capital. This utilization of scarce savings must be evaluated in terms of possible alternative uses for these funds. The following section addresses itself to the returns to the productive factors in the petroleum industry and the corresponding distribution of incomes evolving out of the production process, including the price received for the oil and gas resources.

E. The Discovery, Development and Production of Petroleum in Canada,
Their Associated Incomes and Distribution.

In the process of searching for and producing crude petroleum and natural gas, incomes are generated. The industry is largely controlled by a few multi-national corporations and has received preferential tax treatment throughout the post-war period. Large sums have been invested in this industry with prospects for further large investment expenditures in the future. This latter eventuality has both been welcomed and severely criticized. One suspects that much of the criticism may be based upon the fact that the industry is largely foreign owned and/or has special tax treatment. By themselves, neither is cause for alarm but if they lead to either an inefficient allocation of resources or an inequitable distribution of incomes, or both, corrective action may be required. Of course, there may be extenuating circumstances which would justify such a state of affairs. This section will attempt to estimate the factor incomes in the crude petroleum industry and to discuss some of the justifications which have occasionally been put forward for preferential tax treatment.

Labour

In general, labour incomes in the petroleum industry are approximately 30 to 40 percent higher than incomes for an industrial composite (as portrayed in Table E1). This spread in incomes might be explained in large part by the

Table E1

Year	<u>Average Incomes</u>		Percent Dif.
	Petroleum Industry	Industrial Composite	
1961	5,293.88	4,068.48	30.1
1963	5,707.51	4,330.04	33.5
1965	6,717.96	4,732.52	41.9
1967	7,307.51	5,347.16	36.6
1969	8,576.70	6,116.76	40.2

Source: Statistics Canada cat. no. 72-201 and 26-213.

the skilled nature of the work performed in the petroleum industry (human capital) and the high capital/labour ratio.

Normally, such high productivity industries could be considered a spur to development as labour shifts from less productive employment to the high productivity industry. In the case of petroleum however, labour is a very small proportion of value added (10 to 12 percent), so that very large output increases would be required in order to have a significant impact on productivity for the total economy. As portrayed in table E2, labour employed in the petroleum industry is a small proportion of the total labour force (0.17%). Even in terms of the economies of the four western provinces, labour employed in the petroleum industry is less than one percent. The petroleum industry, however, would have the Canadian people believe that without the industry, population and incomes would be considerably reduced (see page 12 above). These statements do not stand up under critical evaluation. On the basis of the I/O model, it was estimated that for each million dollars of output in the crude petroleum industry, \$131,862 in labour income would be generated elsewhere in the economy indirectly in order to produce the intermediate inputs required by the industry (see Table C2, page 45). On the basis of 1961 output of

\$608.8 million, this would amount to \$78 million in wages, salaries and supplementary income elsewhere in the economy.¹ At an average income of \$ four thousand, this amounts to 19,500 man-years. Further, on the basis of a comparison of the "closed" and "open" versions of the I/O model, it appears that a million dollar output of crude oil results in an additional \$304,320 of labour incomes arising from the respending of incomes (consumption multiplier). On the basis of 1961 output, this amounts to \$185 million in labour income or 46,300 man-years of employment at \$4,000 per man-year. Thus the combined total employment attributable to the output of the crude petroleum industry was approximately 77 thousand man-years or 1.18 per cent of 1961 labour force (4.4 per cent of the labour force in the four western provinces).² These figures are not meant to imply, of course, that without a crude petroleum industry in Canada that employment would be reduced by one per cent. If petroleum had never been discovered, in Canada, these people would have been employed in other areas of activity, although at lower incomes in all probability.³

¹ In the National Accounts (cat. no.13-502, 1926-56, p.42) geological and geophysical expenditures made by mining and petroleum companies are treated as current expenditures since they do not result in tangible assets (industry normally treats them as investment expenditures). Since the I/O model is based upon the national accounting system, the production of crude oil and natural gas generates an input requirement for geological and geophysical exploration expenditures. While the level of these expenditures are quite likely related to variables in addition to output, it may be argued these indirect labour requirements already include the geologists and geophysicists etc. required by the industry.

² While it might be argued that the labour requirements involved in moving the crude oil and natural gas to market could also be included as a long-run contribution to the labour force, only that portion related to the export market may be included. In the absence of a domestic petroleum industry, pipelines or other means of transportation to move imported crude and products to markets in Canada would be required or even alternative energy sources which might be more labour-intensive. In any case, because of the capital intensity of pipeline transportation, even the addition of that portion of pipeline employment related to export markets would not raise the maximum net contribution of the industry above 1.2%.

³ To the extent that immigration was increased by higher average incomes in Canada (or emmigration decreased) it might be argued that the higher incomes in petroleum employment contributed to a slightly greater population. However, given the small weight of the highly paid incomes (0.17% of labour force), this factor may be disregarded.

Table E2

Employees and Wages of the Crude Petroleum and Natural Gas Industry, Selected Years

Year	Canada		Four Western Provinces	
	No. of Employees*	% of Total Labour Force	No. of Employees*	% of Total Labour Force
1961	11,184	0.17	10,760	0.60
1965	11,817	0.17	11,386	0.59
1969	14,153	0.17	13,771	0.62

	Wages and Salaries*		Wages and Salaries*	
	(mil. \$)	% of Total	(mil. \$)	% of Total
1961	71.2	0.32	69.4	1.23
1965	84.7	0.30	81.8	1.07
1969	138.2	0.32	134.8	1.16

Source: Statistics Canada, cat. no.26-213, 11-505, and 13,-201,

*Total Activity, which includes managerial, professional and other administrative personnel.

**Wages and salaries calculated according to proportions of personal disposable income to total on a regional basis.

Similarly, to argue that those involved in the construction and installation of the capital goods required by the industry would be unemployed without a petroleum industry in Canada, is unrealistic, since investment or other types of economic activity in the economy would have been required. Thus while labour incomes in the petroleum industry are considerably higher than the average, this factor would not seem to warrant any special tax treatment because of the very few people directly employed in the industry.

Capital

The petroleum industry is normally associated with capital-intensive production and this was supported by the I/O analysis reported above. This state of affairs is not to be deplored, necessarily. As long as the marginal efficiency of capital in petroleum production exceeds the interest rate, one would expect investment to occur and production to subsequently increase until a new equilibrium is reached. If savings and current depreciation are insufficient to finance the investment demand for funds, either interest rates would be bid up or capital could be imported from abroad, or some of both, depending upon the domestic and foreign interest rate differentials. There is a danger, however, that if these capital flows are not matched by a real transfer of resources, or sterilized by the monetary authorities, they could result in increases in the exchange rate and/or inflation which in turn contribute to excessive imports.⁴

Problems may arise, however, when there are barriers to the entry of new firms which could lead to greater than normal profits being earned in an industry. This could be compounded, by a non-neutral taxation system favouring the industry in question for particular reasons which would reduce

⁴ T.M. Brown, op. cit., p.72.

the public share of these excess profits. On the other hand, if there is an element of risk in the particular line of activity, the normal rate of return on capital should be adjusted upwards somewhat in order to compensate for the risk premium.

Table E3 portrays the petroleum industry's investments (gross) as a proportion of investment in the total economy for five year periods to smooth out annual fluctuations. As might have been expected, the industry's investments

Table E3

Gross Fixed Capital Formation (GFCF)
(current \$)

	Petroleum*	As a % of Business GFCF (incl. resid. const.)	As a % of Total GFCF
1946-1950	218.1	1.8	1.5
1951-1955	910.1	3.9	3.3
1956-1960	2,085.3	5.9	4.9
1961-1965	2,395.9	5.8	4.7
1966-1970	3,698.0	5.5	4.5
1971	1,105.2	6.7	5.5

* Includes petroleum and natural gas extraction capital expenditure and investment in transportation facilities.

Source: Appendix A7 and Statistics Canada, cat. no. 11-505, 1970 Historical Summary, p. 15.

as a share of the total grew in the immediate post-war period and peaked at about 5 percent in the latter half of the 1950's, declining only slightly during the 1960's. On an annual basis, however, this share does not appear so stable. Between 1957 and 1959, the industry's share of total investment was halved, - from 7.7 percent of gross business investment to 3.8 percent and from 6.7 to 3.2 in the case of total investment. Such sudden shifts may be very destabilizing to an economy.

Published data on rates of return for the industry are beset with many complicating factors which make interpretation of the data difficult and at best ambiguous. In order to overcome these problems and yet derive an estimate on returns to capital in the industry, Table E4 was prepared from industry compiled and published data.⁵ These data relate only to the exploration, development, and production to the well-head of the petroleum industry.⁶ All the expenses incurred in the 1947 to 1971 period in the four western provinces to find and "prove-up" reserves were charged to the category "reserves inventories", an asset class which may be depreciated for income tax purposes whether the expenditures were successful in finding reserves or not. Similarly, those expenditures made for production facilities were charged to another asset class which may be depreciated for tax purposes. The two remaining expenditure categories are operating expenses and royalties.⁷ Thus, sales revenues less royalties, operating expenditures, and depreciation on production facilities and "reserves inventories" yield a calculated net income (columns 6, 7, and 8). Since all of the exploration and development expenditures may be recovered out of the depreciation of the "reserves inventories" asset class, depletion allowances are ignored for the moment. The undepreciated portion of the expenditures made for reserves and production facilities are summed into the K stock category (columns 3, 4, and 5). This represents the financial capital upon which the rate of return is calculated; it does not represent the actual capital stock in use.

⁵ Canadian Petroleum Association, Statistical Yearbook, various issues. Calgary, Data from table "Net Cash Expenditures of the Petroleum Industry".

⁶ In order to determine the initial capital stock in the industry at the beginning of 1947, it was assumed that the industry purchased all of the then existing proven reserves in Saskatchewan and Alberta at one-third of the average well-head price in 1946. Production facilities were valued at three times the value of 1946 production (a capital/output ratio of three to one).

⁷ In 1971, for example (pg. 58 "Net Cash Expenditures of the Petroleum Industry", C.P.A. Statistical Yearbook), the royalties and operating expenditures were taken as given. Production facilities included (a) field equipment, (b) natural gas plants, and (c) other development expenditures. The category "reserves inventories" includes (a) all the exploration expenditures, (b) development drilling and (c) secondary recovery and pressure maintenance. Exploration expenditures include the costs of land acquisition.

Table E4

Operations of the Crude Petroleum and Natural Gas Industry in Western Canada

Year	Revenues (mil. \$) (1)	Cash Flow (mil. \$) (2)	K Stock ¹ (mil. \$) (3)	K Stock ² (mil. \$) (4)	K Stock ³ (mil. \$) (5)	Income ¹ (mil. \$) (6)	Income ² (mil. \$) (7)	Income ³ (mil. \$) (8)	Rate of Return (6/3).100 (9)	Rate of Return (7/4).100 (10)	Rate of Return (8/5).10 (11)
1947	20.8	-10.5	48.8	58.6	227.3	-26.8	-17.0	-8.1	-54.9	-29.1	-3.6
1948	38.5	-31.6	43.8	59.4	265.0	-36.6	-30.8	6.1	-83.6	-51.8	2.3
1949	62.4	-74.2	49.8	69.6	354.3	-68.3	-64.0	15.1	-137.2	-92.0	4.3
1950	86.4	-109.8	62.0	86.4	488.1	-97.6	-93.1	24.0	-157.3	-107.8	4.9
1951	122.9	-123.4	69.8	99.8	646.5	-115.6	-109.9	35.0	-165.5	-110.1	5.4
1952	150.3	-180.7	81.1	117.0	864.2	-170.4	-164.4	36.1	-210.2	-140.5	4.2
1953	208.0	-140.1	87.4	130.1	1,061.0	-133.8	-127.0	56.7	-153.2	-97.6	5.3
1954	253.0	-152.7	95.9	145.4	1,284.5	-144.1	-137.4	70.8	-150.2	-94.5	5.5
1955	316.9	-174.4	118.9	175.3	1,555.9	-151.5	-144.6	97.0	-127.5	-82.5	6.2
1956	421.2	-187.2	166.0	231.8	1,888.9	-142.0	-132.6	143.8	-85.5	-57.6	7.6
1957	474.3	-142.3	206.6	287.4	2,178.4	-101.7	-86.6	147.3	-49.2	-30.1	6.8
1958	429.8	-156.8	221.2	320.9	2,396.7	-142.2	-123.3	61.5	-64.3	-38.4	2.6
1959	466.0	-118.4	218.3	336.2	2,579.8	-121.4	-103.2	64.6	-55.6	-30.7	2.5
1960	491.7	-112.4	221.4	354.3	2,747.3	-109.3	-94.2	55.1	-49.4	-26.6	2.0
1961	596.1	-97.0	260.8	407.0	2,948.6	-57.6	-44.4	104.4	-22.1	-10.9	3.5
1962	690.4	18.8	248.4	411.8	3,069.6	6.5	23.7	139.8	2.6	5.8	4.6
1963	805.0	48.6	267.9	444.1	3,229.7	68.1	80.9	208.7	25.4	18.2	6.5
1964	893.9	48.8	294.8	484.8	3,446.5	75.8	89.5	265.7	25.7	18.5	7.7
1965	970.8	15.7	315.0	520.6	3,734.2	35.9	51.6	303.4	11.4	9.9	8.1
1966	1,082.0	94.2	335.9	557.9	3,988.4	115.1	131.5	348.4	34.3	23.6	8.7
1967	1,215.4	86.4	427.4	666.6	4,324.8	178.0	195.0	422.9	41.6	29.6	9.8
1968	1,321.7	174.2	481.0	748.4	4,606.5	227.8	256.1	455.9	47.4	34.2	9.9
1969	1,417.2	200.4	548.0	847.4	4,887.3	267.4	299.4	481.2	48.8	35.3	9.8
1970	1,588.4	353.9	663.2	999.9	5,104.3	469.1	506.4	570.9	70.7	50.6	11.2
1971	1,828.5	445.8	821.0	1,206.7	5,348.9	603.6	652.6	690.4	73.5	54.1	12.9

¹ Production Facilities depreciated at a rate of 30% of the declining balance after investment for current year; inventory expenditures at a rate of 100%.

² Production Facilities depreciated at a rate of 15% of the declining balance after investment for current year; inventory expenditures at a rate of 100%.

³ Production Facilities depreciated at a rate of 15% of the declining balance after investment for current year; inventory expenditures at a rate of 10%.

On a cash flow basis (pre-income tax), the industry had not yet recovered all of its expenditures in western Canada by the end of 1971 (column 2).

This might be expected as long as an industry keeps growing since capital expenditures are normally recovered over a period of time. Column six of Table E4 represents pre-tax income on a basis roughly comparable to the post-war period whereby exploration and development expenditures were expensed in the year incurred.⁸ On this basis, the industry remained "in the red" until 1962. Assuming that accumulated losses were used to offset current income from oil and gas production (rather than income from other sources in the year incurred), income taxes would not have been payable until 1971. The calculated rate of return⁹ (column 9) swings from very large losses to very large profits once the industry moved out of the red as a result of the peculiar treatment for taxation purposes of the exploration and development expenditures. In 1971, the industry was earning better than a 70 per cent rate of return. Only two-thirds of this profit would be subject to taxation as a result of the depletion allowance (33 1/3 per cent of net income was non-taxable). Under these assumptions, however, the depletion allowance would have been inoperative until 1971. Although the pre-tax profits appear quite high in column nine in the latter years, company reports would not portray such returns since exploration and development expenditures outside of western Canada would be deducted from this income.

⁸ Prior to 1962, not all land acquisition expenditures made by the industry were eligible for deduction from income for taxation purposes. From the industry's point of view, however, they are expenditures of a capital nature; so they were treated as such, see J. Barbeau, "Federal Taxation in Canada" in Oil and Gas Production and Taxes, Tax Paper 33, ed. J. Barbeau. Toronto. Canadian Tax Foundation, 1963. p. 166.

⁹ This is a calculated or book value annual rate of return. Using column 2 cash flows to 1971 from Table E4 and the assumptions regarding the value and rate of extraction of remaining reserves in Table E7 (p. 76) would yield an inherent internal rate of return of 12%. An alternative methodology has been developed by C. Watkins and K. Sharp in "The Long-Term Cost of Alberta Conventional Crude Oil," The Journal of Canadian Petroleum Technology, January 1 March 1970, pp. 22-27.

Nevertheless, on the basis of these assumptions, very high rates of return will be earned out of income from oil and gas production in western Canada from existing reserves and the rate appears to be increasing.

One of the reasons for this eventuality is that capital expenditures for production facilities are eligible for accelerated depreciation (30 per cent of the declining balance of the asset class). The producing life of this equipment is typically much longer than that implicit in this depreciation rate for tax purposes. In order to show the impact of a slightly less rapid depreciation, a 15 per cent rate was employed to calculate pre-tax income (column 7). As a consequence, income taxes would have become payable in 1970 as opposed to 1971. Once the income for tax purposes moved into the black in 1962, the rate of return (column 10) was slightly lower even though absolute profits were higher because there was a larger undepreciated capital investment (column 4).

Another reason for the unusual profit pattern for this industry is the special treatment given exploration and development expenditures. These are deductible in the year incurred providing that there is sufficient income or may be carried forward indefinitely. They could also be treated as a normal capital expenditure which would be depreciated for tax purposes over a period of years, since they are made in anticipation of a future stream of revenues as are most capital expenditures. Although exploration expenditures have a certain degree of risk attached, if losses are deductible from income, they will eventually be recovered. Ideally, one would like to try and attribute wear and tear of capital assets in the production process to the income they generate; however, this has proved to be very difficult to administer in practice. Consequently, arbitrary capital consumption allowances have been established for income tax purposes. In order to demonstrate the effect on taxable income of a somewhat altered treatment of exploration and development expenditures, column eight in Table D4 was calculated.

Exploration and development expenditures were placed in an asset class which was depreciated at a rate of 10 percent of the declining balance.⁹ Under these assumptions, the industry would have made profits as early as 1948 and commenced paying taxes in 1949 after allowing for accumulated losses. The pre-tax rate of return (col. 11) on the undepreciated capital was fairly steady, gradually increasing over the period, and not excessively high. It is interesting to note that the lowest rate of return would have been earned in 1960, the year before the National Oil Policy was introduced. (This policy reserved most of the Ontario market for petroleum to western Canada and helped relieve the "glut" of western oil). By 1970, the rate of return is approaching what one might consider to be a normal rate although it still appears somewhat low considering the "risk" involved in petroleum exploration and production. Of course, there are still profits to be made from the known inventory of reserves which have not yet been accounted for.

Assuming a tax rate of 50 percent, and leaving aside the depletion allowances, the system of current year write-off of exploration and development expenditures and 30 percent depreciation rate would have yielded 214 million, in taxes commencing in 1971 as opposed to about 2.4 billion (a 10 fold increase) in a system where this production equipment would be depreciated at a rate of 15 percent and exploration expenditures at 10 percent. Of course, under these assumptions the depletion allowance would have been operable as early as 1949 and would have reduced the taxable income by one-third.

It is interesting to note the difference in net investment among

⁹ The 10 percent rate is completely arbitrary but it was selected on the basis of the present treatment of foreign exploration and development expenditures made by a Canadian corporation, see Summary of 1971 Tax Reform Legislation, Ottawa: Minister of Finance, 1971. p.46.

the alternative depreciation examples (see Table E5). Rapid write-offs permit a greater internal generation of funds for investment in the next period if so desired. Even if they are re-invested in the same industry, the owners would have a lower net investment the more rapidly capital may be recovered (compare columns 3 and 5 in Table E4). Other things remaining equal, income taxes will be paid later with more rapid capital recovery so the government has lost the opportunity of having funds earlier rather than later. Discounted to present values, the future income tax revenues have been reduced. Thus, while the industry was investing considerable sums in gross terms throughout the post-war period, the net investment was considerably reduced by the special tax provisions since depreciation allowances were being "rolled over" year after year. In terms, the capital equipment in use is the same in any of the three assumed cases. In financial terms, however, its book value may have been considerably reduced so that the capital/output ratio is much lower than one would expect for the industry.

Until the last few years, the returns on the investment in the petroleum industry were not "super-normal" or even particularly attractive. Even after trying to compensate for the tax treatment, the returns were not outstanding. One might question why, when the returns were so low, firms in the industry continued to invest. It has been suggested that one reason may be that the Alberta pro-rationing system for crude oil production encouraged firms to install excess capacity in the form of wells in order to qualify for a larger production quota.¹⁰ In the early sixties, Alberta revised its system of prorating and conservation to try and reduce the capital waste inherent in the earlier system. It is noteworthy that in the latter half of the sixties, the rate of return improved under either taxation scheme.

¹⁰ M.W. Bucovestsky, The Taxation of Mineral Extraction, Study no.8 for the Royal Commission on Taxation, Ottawa: Queen's Printer, 1964. p.77.

Table E5

Gross vs Net Investment in the Crude Petroleum
and Natural Gas Industry

(mil. \$)

Year	Gross Investment	Net Investment		
1947	28.1	-16.4 ¹	-6.6 ²	2.3 ³
1948	63.3	-5.1	0.8	37.6
1949	118.8	6.0	10.2	89.3
1950	172.7	12.3	16.8	133.8
1951	211.5	7.8	13.4	158.3
1952	287.4	11.3	17.2	217.7
1953	289.0	6.3	13.0	196.7
1954	336.1	8.6	15.3	223.5
1955	407.2	22.9	29.9	271.5
1956	497.3	47.1	56.5	332.9
1957	490.0	40.6	55.6	288.5
1958	450.5	14.6	33.5	218.3
1959	438.8	-3.0	15.3	183.1
1960	462.3	23.1	18.2	167.5
1961	493.8	39.4	52.6	201.3
1962	436.2	-12.3	4.9	121.0
1963	487.6	19.5	32.2	160.0
1964	562.0	26.9	40.7	216.8
1965	756.6	120.1	35.9	287.7
1966	653.6	20.9	37.3	254.1
1967	763.2	91.5	108.6	336.5
1968	747.5	53.6	81.8	281.7
1969	778.9	67.0	99.0	280.8
1970	748.1	115.2	152.5	217.0
1971	805.0	156.9	206.8	244.6

¹ Production facilities depreciated at 30% and exploration expenditures at 100%.

² Production facilities depreciated at 15% and exploration expenditures at 100%.

³ Production facilities depreciated at 15% and exploration expenditures at 10%.

Other possible explanations might be that either the investors have very long time horizons and are willing to wait for the very high returns or that the "majors", which dominate the petroleum industry, are interested in maintaining their market shares or control and have not been profit maximizers. While both explanations are possible, they are not very probable. A more likely explanation lies in the fact that not all the money to be made in the petroleum

industry shows up in profit and loss statements. Those who hold the stock of the petroleum companies also stand to make capital gains (and losses) just by holding the stock. While this is true in any industry, there are reasons peculiar to industries dealing with non-renewable natural resources which would accentuate this possibility. The next section discusses this and the reasons for it.

Land or Natural Resources

Land is often considered as given, neither expanding nor contracting over time. This is undoubtedly true from a global context and the assumption is very helpful in simplifying complex interrelationships. However, when dealing with the production of a commodity which draws upon a non-renewable natural resource as one of its inputs, this assumption appears somewhat limiting. Another framework which appears much more appropriate is to consider the stock of natural resources as part of the stock of social capital.¹¹ Just as reproducible capital in the form of machines are used up in the process of producing a good, so some of the stock of a resource is used up in producing the commodity derived from the resource. The reason a natural asset has any value is that the value of the capital and labour involved in extracting the resource from its environment is less than the value of the product once extracted. If the cost of extracting or transforming the resource were greater than or equal to the value of the output, then the natural resource would have no value for that purpose at least. The value of the asset will be maximized

¹¹ A. Scott, Natural Resources, The Economics of Conservation, Toronto: McClelland and Stewart Limited, 1973, p.3.

when the net revenue derived from its transformation or extraction is maximized. This involves producing the good not only at the most appropriate rate but also at the most appropriate point in time, i.e. minimizing the "user cost" associated with producing a non-renewable resource.¹²

A direct comparison may be made between land used for its renewable resource content and land employed for its non-renewable resource content. The extraction of minerals compares with agricultural production in that capital and labour are employed to produce a product; moreover, just as a farmer must make investment decisions with respect to his methods of production so as to maintain the productivity of his land, so an oil-well operator must adjust his rate of extraction and production methods as to take advantage of the natural characteristics of the deposit in order to maximize the long-run producibility of the pool. Further, investments may be made to improve the productivity of a piece of agricultural land or oil-pool such as tile drainage or pressure maintenance facilities. The fundamental difference between renewable and non-renewable resources appears to lie in the search for and discovery of mineral deposits which would appear to be more comparable to technological changes.¹³ If a discovery is not commercially viable, it is

12 P. Davidson "Public Policy Problems of the Domestic Crude Oil Industry". American Economic Review, 1963, vol.52, p.91. A barrel of oil can only be produced once: producing a barrel today when the price is expected to increase has an opportunity cost attached to it; similarly, foregoing production today when costs of production are expected to increase implies an opportunity cost of the foregone profit.

13 Report of the Royal Commission on Taxation, vol. 4, Ottawa: Queen's Printer, 1967. p.300.

irrelevant for the moment at least; if it is commercially viable, it has pushed out the production possibility frontier curve since a greater output may be achieved with the same capital and labour inputs.¹⁴

The process of discovery of non-renewable resources in the past has been somewhat haphazard: mineralization was discovered at Sudbury during the construction of the railway; oil and gas deposits have been noted on the basis of tar-pools and farmers wells; and the discoveries made by the old time prospectors were more often a case of good luck than good management. Those who made the discovery would often sell their claim, enjoy a capital gain and move on to new areas. The development and extraction of the deposit would be undertaken by someone else with more capital at his disposal. Even though firms making the discoveries today are much more likely to develop and extract resources they have located, there are still large capital gains involved as in the past. Once the announcement of a discovery is made, the share price of the company involved typically moves up as well as those companies who have any claims in the area.

Between 1947 and 1971 inclusive in the four western provinces, approximately 41 billion barrels of crude oil, 107 trillion cubic feet of natural gas, 2 billion barrels of natural gas liquids, and 174 million tons of sulphur have been discovered.¹⁵ However, only one-third of the oil

¹⁴ Consider a production possibility curve for a two commodity (wheat and oil) economy. The intersection point of the curve with the oil axis is determined by the output of oil that could be produced if all labour and capital were devoted to its production. The discovery of a commercially viable oil deposit implies that more oil can be produced with the same inputs so that the intersection point of the production possibility curve with the oil axis would shift out. The wheat point would not change so that the shift outwards is not equidistant at each point on the curve.

¹⁵ The Canadian Petroleum Association. The 1971 Statistical Yearbook, Calgary, 1972. pp. 39-45. This includes original proved reserves for crude oil and gas, and ultimate recoverable for natural gas liquids and sulphur.

(13 bil.) and two-thirds of the gas (71 trillion) are considered to be ultimately recoverable under existing economic and operating conditions. After converting the natural gas and sulphur to crude oil equivalents, this amounts to 49 billion barrels of reserves discovered and 20 billion recoverable.¹⁶ Over the same period, the petroleum industry spent 3.9 billion dollars on exploration activities in the four western provinces (3.7 billion 1961 dollars) or the equivalent of 19.5 cents (18.5 in 1961 dollars) per barrel of exploitable oil under existing economic and operating conditions.¹⁷ Obviously, with price increases, some of those known reserves now considered out of economic reach would become exploitable; so, their discovery costs will be zero, having already been expensed.

In the perfectly competitive model, one would not expect a firm to undertake research expenditures since the assumption of perfect knowledge would ensure that all other firms in the industry would have access to the knowledge gained. Only if the firm could have some type of monopoly control over the new knowledge such as a patent, would one expect a firm to undertake research and development. Similarly, one would not expect a firm to explore for petroleum unless it could exclude others from any deposit so discovered - a function served by exploration and production leases issued by governments. Since these leases enable firms to exact monopoly profits, the governments should be able to exact a price for these rights to the extent of the economic

¹⁶ Assumptions for conversion were 25,000 cubic feet of gas equals one barrel of oil and one ton of sulphur equals 10 barrels of oil, based upon Oilweek 19 Feb., 1973 p. 41. These assumptions are quite arbitrary but yield an order-of-magnitude estimate of the quantities of reserves in a common unit.

¹⁷ Canadian Petroleum Association, Statistical Yearbook for 1960 and 1971, Table entitled "Net Cash Expenditures of the Petroleum Industry" for the four western provinces. Exploration expenditures include (a) geological and geophysical expenditures, (b) exploratory drilling and (c) overhead. The current dollar expenditures were converted to 1961 dollars with the GNE implicit price index (Canadian Statistical Review, Historical Summary, 1970) Statistics Canada, cat. no. 11-505, p. 29.

rent accruing the holder of the right or permit under a situation of competitive bidding for those rights. At the time firms would be bidding for exploration permits to a geologically promising tract of land, however, they do not know to what extent, if any, there might be future possibilities for monopoly profits. Therefore, unless the exploration permit contains an element of exclusion either during the exploration process or in the event of a discovery, firms would be unwilling to pay anything for an exploration permit.¹⁸ In the western provinces, a firm pays a bonus at a lease sale and normally receives the exclusive right to explore a given piece of land for a specified period as well as the production rights. In some cases (reservations), a share, normally 50 per cent, reverts to the Crown at the end of the permit, and the production rights are auctioned as well. In this manner, the governments do collect some of the economic rent accruing to the holders of the monopoly rights. Between 1947 and 1971, the industry paid approximately \$3.4 billion for land acquisition and rentals in the western provinces.¹⁹ The extent to which the provincial governments have appropriated the economic rents accruing to the monopolistic operators is difficult to determine but the fact that the industry was willing to make these payments indicates that the bulk of the firms at least anticipated making more than a normal return. An important question that ought to be answered is whether the economic rents arising in this industry are a result of its monopolistic structure, a true Ricardian rent with only the marginal deposits earning a normal return, or preferential tax treatment reflecting the judgement that the social opportunity costs incurred in producing the marginal unit of the "surplus" natural resource

¹⁸ If competitors were excluded from a tract of land as long as the firm held an exploration permit, it might be willing to pay a price for the permit to maintain control over potential supplies either to maintain its share of the market or to maintain the price for the product or both.

¹⁹ The bulk of these payments were made to the provincial governments but they also include payments made to private owners of freehold mineral rights.

is less than the private opportunity costs.¹⁹

A direct comparison can be made between those reserves described above as ultimately recoverable and working inventories.²⁰ Just as manufacturing firms require inventories of raw materials and goods in process, so petroleum firms require pools of oil in excess of current production levels. Part of this requirement is physical - oil can only be extracted within a certain range of rates since it requires time to flow to the well. In addition, there are certain technical limits to the rate at which oil may be extracted from a given geological formation if total production from a given deposit is to be maximized. A common rule of thumb used for the reserves/production ratio is 8 or 9 to one.²¹ However, in Alberta in 1971, the reserves to production ratio was 20 to one and for the four western provinces, it was 17 to one. Why would petroleum producing firms maintain larger inventories (reserves) than acquired for technical reasons? One might think of several reasons: since there is considerable lead time from the discovery of a petroleum deposit until it can be developed for production, petroleum companies typically explore ahead of production requirements; further certain levels ~~are required in a specific area before the necessary transportation facilities and associated capital equipment could be justified; in addition,~~

¹⁹ J.F. Helliwell, Public Policies and Private Investment, Oxford. Claredon Press, 1968. p. 199. He points out that there may be "external economies accompanying research and exploration in areas where the total discovery value of resources does not accrue to the exploring firm."

²⁰ P.G. Bradley, "Economic Problems in the Regulation of Resource Exports: The Case of Natural Gas", Discussion Paper No. 92, U.B.C., written for the Canadian Economics Association, Sixth Annual Meeting, McGill University, June 4, 1972. p.8.

²¹ H.R. Johnson, "Petroleum in Perspective", Natural Resources Journal, vol. 11, Jan. 1971, p. 136. This ratio is simply derived by dividing the remaining reserves by current annual production levels.

large integrated firms with a large investment in refining and marketing facilities might be willing to hold excess reserves just for the security of having supplies for their capital equipment.

Because petroleum companies typically maintain large inventories (reserves), there is the possibility for the value of these inventories to fluctuate (capital gains or losses) as in any business which maintains working inventories. In addition, there are reasons peculiar to the nature of the petroleum business which could lead to fluctuations in the value of reserves. Table E6 portrays the value of the year-end reserves valued at well-head prices. Valued on this basis, the reserves were generally increasing in value over the post-war period so that by 1971, the value had reached \$34.8 billion. This is the market value of course and not the value to the petroleum companies which must pull them out of the ground in order to realize this value which involves certain costs. The petroleum companies valuation of these reserves will accordingly be somewhat less and will fluctuate for several reasons:

a) Price

One would expect the current value of these reserves to move with current prices. Since these reserves are proven, any change in the well-head price for the output will be reflected as a capital gain (loss) to the petroleum companies. This should be reflected in the stock market prices for the companies concerned.

b) Discoveries

If discoveries are greater than production, the value of the inventories will increase. Large discoveries should be reflected in the price of the shares of the companies involved as soon as it becomes known (assuming that exploration outlays have remained constant).

Table E6

Value of Remaining Proven Reserves* at Year-End Valued
at Average Well-Head Prices
(mil. \$)

Year	B.C.	Alberta	Sask.	Manitoba	Total Western Canada
1947	0.0	606.5	13.6	0.0	620.2
1948	0.0	1,796.7	16.3	0.0	1,813.0
1949	0.0	2,874.3	13.6	0.0	2,887.9
1950	0.0	3,482.1	15.5	0.0	3,497.5
1951	0.0	3,618.9	27.7	1.1	3,647.7
1952	0.0	4,489.5	164.1	3.6	4,657.2
1953	0.0	5,226.5	283.1	27.5	5,537.1
1954	33.6	6,664.6	356.1	75.5	7,129.6
1955	55.7	7,129.7	401.3	103.8	7,690.6
1956	71.0	7,848.8	624.7	97.4	8,641.8
1957	131.8	8,725.2	871.4	85.7	9,814.1
1958	137.5	9,470.8	1,154.8	67.3	10,830.4
1959	180.7	10,291.1	1,093.9	53.0	11,618.8
1960	352.9	10,973.0	1,082.7	46.6	12,455.0
1961	463.5	12,817.4	1,121.8	39.7	14,442.4
1962	688.8	13,342.1	1,066.3	36.1	15,133.4
1963	798.7	15,585.1	1,223.2	58.4	17,665.3
1964	1,056.7	19,662.0	1,431.8	81.4	22,232.0
1965	1,121.3	21,304.8	1,572.2	101.9	24,100.1
1966	1,333.0	25,907.5	1,649.9	145.9	29,036.4
1967	1,520.0	28,094.8	1,736.5	165.2	31,516.5
1968	1,477.1	30,427.8	1,698.3	169.8	33,772.9
1969	1,490.9	30,845.8	1,657.5	162.2	34,156.4
1970	1,583.8	29,709.1	1,604.2	150.7	33,047.8
1971	1,668.8	31,332.1	1,643.9	157.8	34,802.6

* Includes crude oil, natural gas, natural gas liquids and sulphur.

c) Discount Rate

The value of the reserves will also fluctuate with the reserves to output ratio because of the discount rate. If output increases while reserves remain constant, the petroleum companies will realize the value of these inventories earlier and thus the discounted present value of those reserves will be higher. If reserves are increasing faster than output, this would tend to diminish the increase in value of the reserves attributable to discoveries since the value will be realized at a later date.

d) Production Costs

Similarly, a change in the average costs in production would change the market's valuation of the reserves, other things equal. For example, if labour costs were increased with a new contract, net revenues would be decreased accordingly. A percentage royalty would also increase the costs of production, decrease net revenues, and decrease the value of the reserves to the petroleum companies.

e) Tax Provisions

While these capital gains/losses on holding inventories will eventually be realized as increased or decreased profits, they will not be taxed at the same rate as profits earned in other industries because of the depletion allowance on net income. Over time of course, these depletion allowances have also become capitalized in the price of the shares of the oil and gas companies.²²

Of the above mentioned reasons for capital gains in holding revenues, price increases and low cost discoveries would appear to be the predominate factors. Both price decreases and exploration expenditures without discovery would reduce the value of these capital gains. Table E6 portrayed well-head priced remaining reserves at the end of 1971 to be approximately 34.8 billion. From this value must be subtracted the actual costs of pulling these reserves out of the ground, including production taxes payable. In order to derive a value for the reserves in the ground, the existing capital stock was assumed not to be expanded but gradually run down to zero value concurrently with existing reserves. Thus, the value of the undepriciated balance of this asset class must be subtracted from the value of the reserves in order to permit the petroleum industry to recoup its initial investment (see Table E7).

²² Bucovetsky, op. cit., p.52.

Further, in the case where exploration expenditures are treated as capital expenditures, the undepreciated balance must be deducted for similar reasons. The reserves to current year production ratio was 17 years at the end of 1971. It was assumed that production would continue at the 1971 rate for 17 years at which time reserves would be exhausted and the capital equipment would be fully depreciated with no salvage value. Production revenues were then discounted back to 1971 values yielding a value between \$12.3 and \$10.1 billion depending upon the depreciation method employed.²³ This represents then, the accumulated capital gains which have accrued to the petroleum companies out of both well-head price increases and the value of discoveries which were on average greater than exploration costs. The capitalized value of depreciating

Table E7

Present Day Values of Remaining Reserves
(as of Dec. 31, 1971)

<u>Depreciation Treatment of Exploration and Development Expenditures</u>			
	30%	15%	15%
<u>Production Facilities</u>	<u>100%</u>	<u>100%</u>	<u>10%</u>
<u>Exploration Expenditures</u>			
	(billions of \$)		
Well-head Value of Reserves	34.8	34.8	34.8
Less Extraction Costs	10.2	10.2	10.2
	24.6	24.6	24.6
Less Undepreciated Production Facilities ²	0.8	1.2	1.2
	23.8	23.4	23.4
Less Undepreciated Exploration Expenditures ²	0.0	0.0	4.1
	23.8	23.4	19.3
Present Value of Remaining Reserves ³ (10% discount rate)	12.3	12.2	10.1

¹ Volumes of reserves in crude oil equivalent equal 13.7 bil. bbls. Extraction costs (production, royalties, taxes and other) assumed at 0.74 \$/bbl. (see Oilweek, Feb., 19, 1973. p. 38)

² See table D4 for appropriate undepreciated capital expenditures.

³ Reserve life index (Res/Prod) in 1971 equals 17 years. Assumed that reserves would be exhausted at 1971 rate of production in 17 years with no new investment in either production facilities or reserves (exploration). Value of output discounted back to 1971 values at a 10% discount rate.

²³ Since production expenses and future depreciation were not discounted to present values, these estimates are understated.

production equipment at 30 percent rather than 15 percent could be in the area of \$100 million. The value of current year deduction of exploration and development expenditures rather than at a rate of 10 percent could be about \$2.1 billion. The value of price increases and costless discoveries could be in the area of \$10.1 billion. Since these capital gains will someday be taxed as current income (but one-third is a tax exempt depletion allowance), approximately \$4.1 billion should eventually accrue to the tax collector if other things do not change. The remainder, \$8.2 billion, might have been reflected in the share prices of the companies concerned as capital gains. This might explain why the holders of these shares were willing to accept a lower rate of return on their investment.

If the above estimates are at all indicative of the possible magnitude of the capital gains which have arisen in the process of developing our oil and gas resources, some interesting policy implications follow out of the fact that slightly more than 60 percent of the industry is owned outside the country.²⁴ To the extent that these capital gains have been reflected in the prices of the shares of the oil and gas companies, approximately \$5 billion may have been added to our domestic assets without a corresponding increase in the wealth of the nation since these capital gains have accrued to non-nationals, rather than Canadians. It has been recognized that "natural resources are merely one form of capital, and a reduction in this one form is not the same as a reduction in the nation's total capital stock".²⁵ What has not been recognized is that by relying upon foreign capital to delineate the location and magnitude of our natural resources while not somehow appropriating via taxation or some other method the large capital gains that arise in the process.

²⁴ Statistics Canada. Canada's International Investment Position, 1926 to 1967. Ottawa: Information Canada, 1971. Cat. No. 67-202, Table XX, p. 159.

²⁵ H.C.J. Aitken. American Capital and Canadian Resources, Cambridge: Harvard University Press, 1961. p. 79.

the potential increase in the nation's capital stock has been reduced. Public ownership might eliminate this possibility in the future, but it will not recoup losses unless it involves nationalization with only partial compensation since the capital gains have already been recognized in the value of the shares of petroleum companies. It would also appear that a revised taxation system is required for the non-renewable resource industries.²⁶ The Canadian owners of the petroleum companies shares would suffer capital losses, presumably, as the prices declined but this is an internal transfer payment which could be offset if deemed politically expedient.

Part of the capital gains identified above were Ricardian rents which would accrue to intramarginal firms with low cost deposits. While the taxation system might be revised to capture a share of these rents (say 50 percent), they serve a useful purpose in encouraging firms to undertake risky exploration, i.e., they could provide the risk premium to ~~normal~~ returns. In this manner, success would be rewarded rather than failure being subsidized. Unsuccessful exploration expenditures should, of course be recouped but not necessarily at an accelerated rate (100 percent) as under the present system.

Several reasons have been put forward over the years to justify maintenance or increases in the preferential tax treatment for the petroleum industry. One of the most often repeated relates to the balance of payments. It is argued that foreign exchange is earned through exports, saved through import displacement and that during the interim period of building up capacity, foreign capital is available. As estimated in Table E5, however, the net

²⁶ The Report of the Royal Commission on Taxation, vol. 4, op. cit., pp. 368-376.

investment was approximately \$800 million, some of which may have very well been domestic savings directed from other investment possibilities. Table E8 has been put together from available data in order to portray the magnitude of the balance of payments impact. The first three items refer only to the U.S. portion of capital and service payments and also include items related to refining and transportation. On the current account, the balance of payments effect is overstated because of the effects of the National Oil Policy on import displacement. In addition, indirect imports for intermediate inputs are required and may amount to 6 percent of the value of domestic output.²⁷ Evidence has also been presented which would indicate that import leakages out of capital expenditures in the petroleum industry are quite high and may be influenced by non-price considerations.

"In addition to the basic requirements of availability of the proper type of equipment at a competitive price and in the required variety, the market for oilfield equipment appears to be strongly influenced by at least three other factors. These are: (a) the established pattern of distribution through supply houses, (b) the preference for brand names and (c) the emphasis on service. Each of these is discussed below in greater detail. Taken together, these factors help to explain why there continue to be substantial imports of some of the types of oilfield equipment which could be supplied economically from Canadian production".²⁸

²⁷ Estimate based upon the 1961 I/O model, see above page 43.

²⁸ The Tariff Board, An Enquiry Respecting Machinery and Equipment Used in the Mining Industry and the Oil and Gas Industries, Ref. no. 130, vol. 1. Ottawa: The Queen's Printer, 1963. pp. 63-65.

Table E8

The Balance of Payments Impact of the Crude
Petroleum and Natural Gas Industry
(Some Selected Years)

Year	1950	1957	1966
	(millions of dollars)		
1. Net Capital Flows	122	250	178
2. Income Payments	3	-56	-131
3. Royalties, Fees, Rentals and Service Charges	n.a.	n.a.	-12
4. Domestic Production			
(a) Crude oil	84.6	312.6	467.6
(b) Natural gas	6.4	18.7	69.5
Total	216.0	525.3	858.1
5. % of GNP	1.2	1.6	1.4

Source:

1. Items 1, 2, and 3, from U.S. Department of Commerce "U.S. Direct Investments Abroad, 1966. Part 1: Balance of Payments Data". OBE-Sup. 71-01, 1970.
2. Item 4. Appendix A8 and A9.

On the basis of the elements in Table E8, the net impact on foreign exchange could be in the area of 1 percent of GNP. The current account component (line 4) is increasing and will continue to do so in the foreseeable future as a consequence of both increased production and prices.

While foreign exchange earnings are necessary in order to purchase imports, the petroleum industry is not necessarily the most efficient tool to this end. The same argument could be made for the automobile industry or for any other industry output which is traded internationally. While foreign exchange reserves may be necessary to avoid short-term fluctuations in the exchange rate, the equilibrium price for foreign exchange should be based upon comparative cost considerations and relative rates of inflation. Factors of production should

be allocated on the basis of efficiency and income generation, not balance of payments considerations. "The balance of payments of a nation is not a primary economic objective as such; rather, certain balance-of-payments requirements have to be met while a nation pursues its primary economic goals".²⁹

Another ~~more~~ persuasive reason for tax incentives to the petroleum industry arises from that fact that it has a locational impact on employment and population. To the extent that the petroleum industry slowed down the out-movement of population from the prairie provinces, the price paid in terms of tax incentives may have been socially worthwhile. Too often, however, the price is forgotten and only the benefit is brought to the public's attention. Nevertheless, because of the capital intensiveness of the industry, it is questionable that giving tax incentives to this particular industry was the most effective instrument for the goal of regional development and population dispersion. In any case, to logically pursue this goal would suggest that the incentives should be applied to other industries locating in the particular region.³⁰ As estimated above, the tax saving from rapid write-offs alone might be in the area of \$2.2 billion (p.66 above) while direct and indirect employment could be as high as 77 thousand (p.56 above), a cost of \$31 thousand per job.

There is sometimes the presumption that energy intensive industries would be pulled to the prairie region because of the availability of low cost energy. The price of energy in western Canada is no lower than in eastern Canada other than the cost of transporting it to market. Well-head prices are determined

²⁹ D.W. Slater, Perspective on Canada's International Payments, Ottawa: The Queen's Printer, 1966. p.10.

³⁰ Bucovetsky, op. cit., p.89.

by the majors on the basis of the laid-down price of alternative crude oil in Chicago (earlier Sarnia) less the pipeline transportation costs back to the well-head. Prior to implementation of the National Oil Policy, there was some price cutting because of excess capacity and the threat of competition from overseas crude in the Toronto market.³¹ Outside of that period, any connection between well-head prices and long-run costs of production was purely coincidental. The majors control both the pipelines and the refineries and establish the well-head price they are willing to pay for oil from the independent producers. Since it is typically cheaper to transport oil long distances than energy-intensive products, the western provinces have been unable to overcome their locational disadvantages via slightly cheaper energy. Canadians in general have not had a general price advantage in terms of low cost based on domestic supplies. In fact, Ontario has paid a premium for petroleum products since introduction of the National Oil Policy. Natural gas, however, has been relatively cheap but this is a result of American policies, not Canadian.

Security of supply is also suggested as a valid reason for giving special consideration to the petroleum industry. One suspects that this is more of an after the fact justification to support continuation of the special tax treatment. Given the market structure of the industry, it would seem that the majors have an interest in maintaining a certain storage capacity just to protect their investments in refineries and marketing facilities. Any additional requirement for national security could be maintained by the government by direct subsidy at considerably less cost than the present tax incentives.

³¹ Royal Commission on Energy, Second Report. Ottawa: Queen's Printer, p. 84.

In summary, the incomes to be derived from crude oil and natural gas are respectable, but it appears that there may have been a mal-distribution of incomes caused by tax measures which were designed for other purposes. While special tax treatment may have been justified in the past, only the regional development argument appears as a reasonable justification for continued interference with the market's allocation of resources. This argument could be employed to give special treatment to any industry that might decide to move into the west. Given the specific location of the petroleum reserves, one suspects that the tax measures may simply have advanced development of these reserves in time somewhat by lowering the development cost and increasing returns. If this is the case, then the west would have had the development of its petroleum reserves at a later date and the regional development benefits must be discounted considerably.

F. Conclusions and Recommendations

In this examination of the post-war development of the Canadian petroleum industry, we tried to develop an objective framework for evaluating an industry's contribution to the development of the economy. It was hypothesized that most new products or industries follow a sigmoid growth path as they displace substitutes and imports and then level off to "normal" growth until they in turn are displaced. Both crude oil and natural gas demand in Canada appeared to have followed this pattern although natural gas was slightly later than petroleum. Export demand is superimposed on the domestic demand and the important question to be answered is whether the benefits to be derived from meeting this demand warrant special tax incentives or other government action. The examination concentrated on trying to estimate the externalities to be

derived from petroleum and gas production. By tracing through the inter-industry linkages, it was not possible to distinguish any particularly strong positive externalities in terms of economies of scale or income generation. Incomes derived from petroleum production itself were quite respectable. It appears, however, that the special tax treatment offered to the industry might have resulted in an inordinate share of the surplus or rent accruing from oil and gas production going to foreign factors. Other justifications for the special tax treatment were examined and it appears that only the regional development argument security of supply could have justified their existence. Given the strong external demand for our petroleum reserves, it is doubtful that extension of the tax treatment is required any longer even to further this objective.

The framework developed for the evaluation of the crude petroleum industry is generally applicable to any existing industry in Canada. It provides a systematic method for tracing and measuring many of the externalities that one industry by its very existence may pass on to other industries. Of course, not all externalities can be measured and potential new industries must be evaluated on their own merits. Nevertheless, those externalities that are measurable may be evaluated and compared over industries in order to develop a more objective and rationalized basis for ordering the allocation of resources in a manner that is judged to be superior to that dictated by market forces. This framework will not provide the answers to these questions but it does establish a better information base upon which policy-makers may make their decisions.

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Appendix A 1

Petroleum Production in Canada to 1945

Year	Canada		New Brunswick		Ontario		Sask		Alta		NWT	
	mm bbls	mm \$	mm bbls	mm \$	mm bbls	mm \$	mm bbls	mm \$	mm bbls	mm \$	mm bbls	mm \$
Up to												
1911	16.5	22.0	..	..	16.5	22.0	-	-	-	-	-	-
1911	.3	.4	..	..	.3	.4	-	-	-	-	-	-
12	.2	.4	..	..	.2	.3	-	-	-	-	-	-
13	.2	.4	..	..	.2	.4	-	-	-	-	-	-
14	.2	.3	..	..	.2	.3	-	-	..	..	-	-
15	.2	.3	..	..	.2	.3	-	-	-	-	-	-
16	.2	.4	..	..	.2	.4	-	-	-	-	-	-
17	.2	.5	..	..	.2	.5	-	-	..	..	-	-
18	.3	.9	..	..	.3	.8	-	-	..	.1	-	-
19	.2	.7	..	..	.2	.6	-	-	..	.1	-	-
20	.2	.8	..	..	.2	.7	-	-	..	.1	-	-
21	.2	.6	..	..	.2	.6	-	-	..	..	-	-
22	.2	.6	..	..	.2	.5	-	-	..	.1	-	-
23	.2	.5	..	..	.2	.5	-	-	..	.1	-	-
24	.2	.5	..	..	.2	.4	-	-	..	..	-	-
25	.3	1.3	..	..	.1	.4	-	-	.2	.8	-	-
26	.4	1.3	..	..	.1	.4	-	-	.2	.9	-	-
27	.5	1.5	..	..	.1	.3	-	-	.3	1.2	-	-
28	.6	2.0	..	..	.1	.2	-	-	.5	1.8	-	-
29	1.1	3.7	..	..	.1	.3	-	-	1.0	3.5	-	-
30	1.5	5.0	..	..	.1	.2	-	-	1.4	4.8	-	-
31	1.5	4.2	..	..	.1	.2	-	-	1.4	4.0	-	-
32	1.0	3.0	..	..	.1	.2	-	-	.9	2.8	..	..
33	1.1	3.1	..	..	.1	.3	-	-	1.0	2.8	..	..
34	1.4	3.4	..	..	.1	.3	-	-	1.3	3.1	..	..
35	1.4	3.4	..	..	.1	.3	-	-	1.3	3.1	..	..
36	1.5	3.4	..	..	.2	.4	-	-	1.3	3.0	..	..
37	2.9	5.4	..	..	.2	.4	-	-	2.7	5.0	..	.1
38	7.0	9.2	..	..	.2	.4	-	-	6.8	8.8	..	.1
39	7.8	9.8	..	..	.2	.4	-	-	7.6	9.4	..	.1
40	8.6	11.2	..	..	.2	.4	-	-	8.4	10.7	..	..

Appendix A 1

Year	Canada		New Brunswick		Ontario		Sask		Alta		NET	
	mm bbls	mm \$	mm bbls	mm \$	mm bbls	mm \$	mm bbls	mm \$	mm bbls	mm \$	mm bbls	mm \$
1941	10.1	14.4	..	..	.2	.3	-	-	9.9	14.0	..	..
42	10.4	16.0	..	..	.1	.3	-	-	10.1	15.5	.1	.1
43	10.1	16.5	..	..	.1	.3	-	-	9.6	15.7	.3	.4
44	10.1	15.4	..	..	.1	.3	-	-	8.7	14.5	1.2	.6
45	8.5	13.6	..	..	.1	.3	..	..	8.0	13.2	.3	.1
Total	107.5	176.6	.4	.8	22.5	35.3	..	..	82.6	138.8	2.1	1.6

Source: D.B.S. Canadian Mineral Statistics, 1886 - 1956. Reference Paper No. 68
(Ottawa, 1957)

Note: (1) (..) too small to be expressed on table
(2) (-) no values recorded
(3) Totals may not add owing to rounding

Units: (1) m.m. bbls = millions of barrels
(2) m.m. \$ = millions of dollars

Appendix A 2

Natural Gas Production in Canada to 1945

<u>Year</u>	<u>Canada</u>		<u>New Brunswick</u>		<u>Ontario</u>		<u>Saskatchewan</u>		<u>Alberta</u>	
	bcf	mil. \$	bcf	mil. \$	bcf	mil. \$	bcf	mil. \$	bcf	mil. \$
Up to 1911	-	9.4	-	-	-	8.9	-	-	-	.5
1911	10.9	1.9	-	-	10.9	1.8	-	-	..	..
12	12.7	2.4	.2	..	12.5	2.0	-	-	..	..
13	20.5	3.3	.8	..	12.5	2.1	-	-	7.2	1.1
14	21.7	3.5	.4	..	14.1	2.2	-	-	7.2	1.2
15	20.1	3.7	.4	..	15.2	2.6	-	-	4.5	1.0
16	25.5	4.0	.6	..	18.0	2.8	-	-	6.9	1.1
17	27.4	5.0	.8	..	19.9	3.6	-	-	6.7	1.3
18	20.1	4.4	.8	..	13.0	2.9	-	-	6.3	1.4
19	19.9	4.2	.7	..	11.0	2.7	-	-	8.2	1.4
20	16.8	4.2	.7	..	10.5	2.9	-	-	5.6	1.2
21	14.1	4.6	.7	..	8.4	3.1	-	-	4.9	1.4
22	14.7	5.8	.8	..	8.1	4.1	-	-	5.9	1.6
23	16.0	5.9	.6	..	8.1	4.1	-	-	7.2	1.7
24	14.9	5.7	.6	..	7.2	3.8	-	-	7.1	1.8
25	16.9	6.8	.6	..	7.1	4.0	-	-	9.1	2.8
26	19.2	7.6	.6	..	7.8	4.4	-	-	10.8	3.0
27	21.4	8.0	.6	..	7.3	4.3	-	-	13.4	3.6
28	22.6	8.6	.7	..	7.6	4.5	-	-	14.3	3.8
29	28.4	10.0	.7	..	8.6	5.0	-	-	19.1	4.7
30	29.4	10.3	.7	..	8.0	5.0	-	-	20.7	4.9
31	25.9	9.0	.7	..	7.4	4.6	-	-	17.8	4.1
32	23.4	9.0	.7	..	7.4	4.7	-	-	15.4	3.9
33	23.1	8.7	.6	..	7.2	4.5	-	-	15.4	3.9
34	23.2	8.6	.6	..	7.7	4.7	..	..	14.8	3.7
35	24.9	9.4	.6	..	8.2	4.9	..	..	16.1	4.1
36	28.1	10.8	.6	..	10.0	6.1	..	..	17.4	4.4
37	32.4	11.7	.6	..	10.7	6.6	..	..	21.0	4.8
38	33.4	11.6	.6	..	11.0	6.5	..	..	21.8	4.8
39	35.2	12.5	.6	..	12.0	7.3	..	..	22.5	4.9
40	41.2	13.0	.6	..	13.1	7.7	..	..	27.5	4.9

Appendix A 2

<u>Year</u>	<u>Canada</u>		<u>New Brunswick</u>		<u>Ontario</u>		<u>Saskatchewan</u>		<u>Alberta</u>	
	bcf	mil. \$	bcf	mil. \$	bcf	mil. \$	bcf	mil. \$	bcf	mil. \$
1941	43.5	12.7	.7	..	11.8	7.1	..	..	30.9	5.2
42	45.7	13.3	.6	..	10.5	6.8	..	..	34.5	6.1
43	44.3	13.2	.7	..	7.9	6.5	..	..	35.6	6.2
44	45.1	11.4	.7	..	7.1	4.7	..	..	37.2	6.3
45	48.4	12.3	.7	..	7.2	4.8	..	..	40.4	7.1
Total	911.0	286.4	21.5	7.4	354.8	164.5	1.2	.4	533.4	114.1

Source: D.B.S. Canadian Mineral Statistics, 1886 - 1956. Reference Paper No. 68. (Ottawa, 1957).

Note: (1) Canada totals contain small amounts produced in NWT starting in 1936.
 (2) (..) too small to be expressed on table.
 (3) (-) no values recorded.
 (4) Totals may not add owing to rounding.

Units: (1) bcf = billions of cubic feet.
 (2) mil. \$ = million of dollars.

Appendix A3

Petroleum Production in Canada, 1945 to 1971

YEAR	CANADA		BRITISH COLUMBIA		ALBERTA		SASKATCHEWAN		MANITOBA		ONTARIO		NORTHWEST TERRITORIES	
	m m bbls	m m \$	m m bbls	m m \$	m m bbls	m m \$	m m bbls	m m \$	m m bbls	m m \$	m m bbls	m m \$	m m bbls	m m \$
1946	7.6	15.0	-	-	7.1	14.3	.1	.1	-	-	.1	.3	.2	.2
1947	7.7	19.6	-	-	6.8	18.1	.5	.6	-	-	.1	.4	.2	.5
1948	12.3	37.4	-	-	10.9	35.1	.8	1.0	-	-	.2	.6	.4	.7
1949	21.3	61.1	-	-	20.1	59.0	.8	.8	-	-	.3	.9	.2	.4
1950	29.0	84.6	-	-	27.5	82.2	1.0	1.1	-	-	.3	.9	.2	.4
1951	47.6	116.7	-	-	45.9	113.9	1.2	1.7	..	..	.2	.7	.2	.4
1952	61.2	143.0	-	-	58.9	139.5	1.7	2.3	.1	.2	.2	.6	.3	.4
1953	80.8	200.6	-	-	76.8	193.8	2.8	3.8	.7	1.7	.3	1.0	.3	.3
1954	96.1	243.9	-	-	87.7	228.3	5.4	8.2	2.1	5.6	.4	1.4	.4	.3
1955	129.4	305.6	-	-	113.0	274.9	11.3	18.3	4.1	9.6	.5	1.6	.4	1.2
1956	172.0	406.6	.1	.3	143.9	353.6	21.1	36.3	5.8	13.6	.6	2.0	.4	.8
1957	181.8	453.6	.3	.8	137.5	355.6	36.9	79.3	6.1	15.5	.6	2.2	.4	.3
1958	165.5	398.7	.5	1.0	113.3	283.3	44.6	96.7	5.8	14.4	.8	2.6	.5	.7
1959	184.8	422.1	.9	1.6	130.0	306.9	47.4	97.7	5.1	11.6	1.0	3.2	.4	1.0
1960	189.5	422.9	.9	1.6	130.5	302.8	51.9	104.0	4.8	10.7	1.0	3.2	.5	.6
1961	224.1	512.2	1.0	1.9	161.1	380.2	55.9	115.7	4.5	10.2	1.1	3.5	.5	.7
1962	251.2	564.4	8.9	16.9	172.2	391.9	64.4	141.7	3.9	9.4	1.1	3.7	.6	.8
1963	260.8	631.9	12.5	24.8	171.4	433.1	71.3	160.3	3.8	9.2	1.2	3.8	.6	.6
1964	275.4	676.3	11.6	23.4	176.2	451.2	81.4	186.9	4.4	10.3	1.2	4.0	.6	.5
1965	292.3	719.0	13.5	28.6	184.2	473.1	87.8	201.0	4.9	11.5	1.3	4.1	.6	.6
1966	320.5	789.3	16.7	36.4	203.3	523.0	93.2	211.8	5.2	13.1	1.3	4.2	.7	.9
1967	351.3	866.0	19.7	44.8	231.5	591.0	92.5	211.7	5.6	14.0	1.2	3.5	.7	.9
1968	379.4	937.3	22.2	50.2	257.2	660.5	91.9	206.9	6.2	15.6	1.2	3.2	.8	.9
1969	411.0	1,014.6	25.4	58.4	290.0	740.4	87.4	196.1	6.2	15.6	1.2	3.1	.8	1.0
1970	461.2	1,156.5	25.5	60.9	338.4	876.9	89.5	199.8	5.9	14.9	1.0	2.8	.8	1.1
1971	500.3	1,351.0	25.4	60.9	377.4	1,070.4	90.0	201.6	5.6	14.2	1.0	2.6	.9	1.3

Source: Statistics Canada

- (a) 1946 - 1955, Reference Paper #68
- (b) 1955 - 1960, Cat. no. 26-203, 1962 issue
- (c) 1961 - 1969, Cat. no. 26-203, 1970 issue
- (d) 1970 - 1971, Cat. no. 26-202, 1971 issue

Note: (1) (..) too small to be expressed on table

(2) (-) no values recorded

(3) Totals may not add owing to rounding

(4) Small amounts produced in New Brunswick over the entire period are included in Canada totals

Units: (1) m.m. bbls = millions of barrels

(2) m.m. \$ = millions of dollars

APPENDIX A4

NATURAL GAS PRODUCTION IN CANADA, 1945 TO 1971

YEAR	CANADA		NORTHWEST TERRITORIES		BRITISH COLUMBIA		ALBERTA		SASKATCHEWAN		ONTARIO		QUEBEC		NEW BRUNSWICK	
	bcf	mm \$	bcf	mm \$	bcf	mm \$	bcf	mm \$	bcf	mm \$	bcf	mm \$	bcf	mm \$	bcf	mm \$
1946	47.9	12.2	..	..	-	-	40.1	7.2	.2	.1	7.1	4.7	-	-	.5	.3
1947	52.7	13.4	-	-	-	-	44.1	7.7	.3	.1	7.8	5.3	-	-	.5	.3
1948	58.6	15.6	.2	..	-	-	49.0	8.3	.5	..	8.6	7.0	-	-	.4	.3
1949	60.5	11.6	.1	..	-	-	51.2	2.6	.8	.1	8.0	8.8	-	-	.4	.1
1950	67.8	6.4	..	..	-	-	58.6	2.9	.8	.1	8.0	3.2	-	-	.4	.2
1951	79.5	7.2	..	..	-	-	69.9	3.5	.9	.1	8.4	3.4	-	-	.3	.2
1952	88.7	9.5	..	..	-	-	79.1	5.9	1.0	.1	8.3	3.3	-	-	.2	.2
1953	101.0	10.9	..	..	-	-	89.7	6.7	1.4	.1	9.7	3.9	-	-	.2	.1
1954	120.7	12.5	..	..	-	-	107.2	8.0	3.3	.3	10.0	4.9	-	-	.2	.1
1955	150.8	15.1	..	..	-	-	133.0	10.0	6.7	.6	10.9	4.3	-	-	.2	.1
1956	169.2	16.8	..	..	.2	..	146.1	11.0	9.8	1.0	12.8	4.7	-	-	.2	.1
1957	220.0	21.0	..	..	8.3	.4	183.1	13.7	14.0	1.4	14.4	5.3	-	-	.2	.2
1958	337.8	32.1	..	..	63.6	3.9	239.0	20.1	18.8	1.9	16.1	6.0	-	-	.1	.2
1959	417.3	39.6	.1	..	69.1	4.6	297.6	25.0	33.6	3.3	16.8	6.5	-	-	.1	.2
1960	523.0	52.2	..	..	85.6	7.6	383.7	34.1	36.6	3.7	17.0	6.6	-	-	.1	.2
1961	634.1	72.0	..	..	102.4	9.0	480.6	53.8	36.5	3.4	14.5	5.6	-	-	.1	.1
1962	894.7	104.1	.1	..	120.4	10.9	720.6	83.5	37.8	3.8	15.6	5.8	-	-	.1	.1
1963	993.4	124.5	..	..	117.4	11.4	821.2	102.8	38.6	4.1	15.9	6.0	-	-	.1	.1
1964	1,134.2	145.7	..	..	134.2	13.2	946.5	122.7	39.6	4.4	13.8	5.3	-	-	.1	.1
1965	1,236.8	158.9	..	..	157.9	15.9	1,023.3	132.1	42.7	5.0	12.7	5.8	-	-	.1	.1
1966	1,341.8	178.2	..	..	185.6	19.4	1,090.7	146.6	49.9	6.1	15.5	5.9	-	-	.1	.1
1967	1,471.7	198.0	..	..	225.4	24.0	1,181.9	161.8	50.0	6.6	14.2	5.4	.1	..	.1	.1
1968	1,692.3	225.3	..	..	259.9	27.9	1,363.4	185.4	56.8	7.3	12.0	4.6	.1	..	.1	.1
1969	1,977.8	262.9	..	..	302.0	32.9	1,605.7	218.1	58.7	7.4	11.2	4.3	.1	..	.1	.1
1970	2,277.1	315.1	.1	..	326.6	35.2	1,870.5	265.9	62.6	7.3	17.1	6.5	.2	..	.1	.1
1971	2,297.7	318.5	.3	.1	329.9	35.6	1,881.5	267.5	69.0	9.0	16.6	6.3	.2	..	.1	.1

Source: Statistics Canada

- a) 1946 to 1955, Reference Paper # 68.
- b) 1956 to 1960, Cat. no. 26-203, 1962 issue.
- c) 1961, Cat. no. 26-203, 1969 issue.
- d) 1962 to 1969, Cat. no. 26-203, 1970 issue.
- e) 1970 to 1971, Cat. no. 26-202, 1971 issue.

Note: (1) (..) too small to be expressed on table.
 (2) (-) no values recorded.
 (3) Totals may not add owing to rounding

Units: (1) bcf = billions of cubic feet
 (2) mm \$ = millions of dollars

APPENDIX A5

Principal Statistics of the Crude Petroleum and Natural Gas Industry 1946-59

Year	Firms	Operating Wells	Employees	Salaries & Wages	Cost of fuel & Electricity	Cost of process Supplies	Gross Value of production	Net Value Added by Processing
'000 dollars								
1946	459	6,139	3,218	5,752	1,142	131	25,313	24,041
1949	457	7,093	4,365	11,018	659	391	78,674	77,624
1950	456	7,840	5,035	13,552	791	1,109	91,040	89,140
1951	489	8,746	5,843	18,010	1,237	2,148	123,057	119,672
1954	567	12,134	6,757	24,621	3,135	4,171	256,141	248,841
1955	592	14,126	6,868	26,018	3,569	5,984	319,861	310,308
1956	554	16,626	8,092	36,353	4,807	9,087	417,566	403,672
1957	543	18,885	7,821	36,302	5,970	10,692	465,325	448,662
1958	639	19,854	7,064	33,316	6,404	10,267	423,776	407,106
1959	643	21,557	6,721	33,702	7,420	9,662	455,517	438,435
1960	637	21,446	5,371	27,981	6,355	10,958	470,699	453,386
1961	581	22,076	4,157	23,648	6,160	8,343	569,567	555,064

Source: D.B.S. Cat. no. 26-213, 1961 issue, P. I-4

Note: This table does not include data for the natural gas processing industry.

APPENDIX A5a

Principal Statistics for the Natural Gas Processing Industry, 1957-63

Year	Establish- ments	Employees	Salaries & Wages	Cost of Fuel and Electricity	Cost of Process Supplies	Value of Production	Value Added
	no.	no.	'000 dollars				
1957	10	270	1,409	424	5,247	11,344	5,673
1958	14	411	2,093	734	9,501	17,509	7,274
1959	14	461	2,526	919	7,170	17,364	9,275
1960	30	669	3,790	1,288	25,624	45,763	18,851
1961	49	744	4,477	1,870	39,501	78,020	36,649
1962	50	845	5,563	2,872	63,727	119,656	53,057
1963	56	961	6,312	3,012	78,732	165,427	83,683

Source: Statistics Canada Cat. No. 26-213, 1965 issue, p. 10.

APPENDIX A6

Principal Statistics of the Crude Petroleum and Natural Gas Industry, 1961-69

Year	Establish- ments	Production		Cost of Electricity	Cost of Materials, Supplies & Fuel	Value of Marketable Production	Value Added	Total Activity	
		Number	Workers					Employees	Value
			Wages					No.	Salaries Added
'000 dollars									
1961	632	3,464	18,338	9,903	15,218	608,801	583,680	11,184	71,179 598,902
1962	621	3,490	19,542	11,237	18,180	748,561	719,144	11,232	75,325 730,799
1963	624	3,378	19,280	13,334	21,331	818,457	783,792	11,237	76,012 796,444
1964	640	3,302	18,884	13,531	22,171	903,573	867,871	11,242	77,306 880,828
1965	675	3,262	19,689	14,080	23,724	978,135	940,331	11,817	84,687 952,409
1966	648	3,375	21,914	12,952	29,159	1,092,535	1,050,424	12,378	95,997 1,059,395
1967	745	3,551	25,949	13,455	32,415	1,229,686	1,183,818	13,113	111,855 1,189,867
1968	814	3,467	27,765	14,973	37,284	1,360,252	1,307,995	13,611	123,412 1,312,414
1969	1,017	3,546	30,413	17,478	40,000	1,450,472	1,392,994	14,153	138,248 1,399,638

Source: Statistics Canada Cat. No. 26-213, 1969 issue, p. 11.

Note: This table includes data for the natural gas processing industry.

Appendix A7

Capital Expenditures in the Petroleum and Natural Gas Industry

Year	Petroleum & Nat. Gas Extraction			Trans., incl. rail, water & pipelines			Natural Gas Processing Plants
	Construc- tion	Mach. and Equipment	Total	Construc- tion	Mach. and Equipment	Total	
	millions of dollars						
1946	2.6	1.1	3.7	-	-	5.5	-
1947	6.9	2.7	9.6	-	-	2.6	-
1948	26.2	4.6	30.8	-	-	4.3	-
1949	33.6	11.5	45.1	6.5	1.2	7.7	-
1950	42.6	11.2	53.8	53.2	1.8	55.0	-
1951	60.5	11.6	72.1	9.1	1.6	10.7	-
1952	76.0	17.1	93.1	75.8	18.8	94.6	1.3
1953	87.1	20.1	107.2	72.8	6.7	79.5	0.7
1954	103.6	23.2	126.8	61.4	3.7	65.1	8.5
1955	173.7	27.9	201.6	44.4	1.6	46.0	2.9
1956	213.3	39.1	252.4	172.8	4.3	177.1	10.5
1957	194.8	43.0	237.8	304.0	6.1	310.1	34.5
1958	160.1	21.4	181.5	234.2	4.2	238.4	40.1
1959	167.0	24.9	191.9	55.3	3.9	59.2	24.4
1960	181.0	28.1	209.1	91.4	7.5	98.9	19.4
1961	243.7	28.3	272.0	147.6	17.3	164.9	76.5
1962	235.7	33.2	268.9	60.8	11.4	72.2	21.9
1963	261.8	35.3	297.1	99.2	8.7	107.9	38.6
1964	294.6	42.1	336.7	146.2	17.8	164.0	40.6
1965	356.4	24.6	381.0	96.5	15.6	112.1	41.5
1966	414.3	39.2	453.5	139.0	15.0	154.0	50.1
1967	352.9	32.2	385.1	150.7	54.2	204.9	89.7
1968	342.7	31.6	374.3	204.5	43.3	247.9	91.1
1969	401.3	36.8	438.1	189.7	30.9	220.6	103.8
1970	396.0	53.3	449.3	205.6	40.5	246.1	189.5
1971	439.9	34.2	474.1	354.5	17.5	372.0	259.1

Source: Statistics Canada, Business Finance Division.

Note: (1) Capital expenditures made by oil and gas drilling contractors are included back to 1961 in extraction.

(2) Geological and geophysical operations are not included in these figures.

Appendix A8
Canadian Trade in Crude Petroleum

Year	Imports		Exports	
	Millions of bbls	Millions of \$	Millions of bbls	Millions of \$
1946	63.4	89.5	-	-
1947	69.1	128.7	..	..
1948	77.6	197.0	..	..
1949	75.7	193.0	-	-
1950	80.1	204.0	-	-
1951	84.2	233.1	.3	.8
1952	82.8	210.0	1.4	3.5
1953	79.5	208.0	2.5	6.2
1954	78.8	212.5	2.3	6.3
1955	86.7	229.5	14.8	36.3
1956	106.5	270.9	42.9	103.9
1957	111.9	305.6	55.7	141.0
1958	104.0	273.9	31.7	73.0
1959	115.3	277.5	33.4	74.5
1960	125.6	283.2	42.2	94.5
1961	133.2	291.2	65.2	154.3
1962	134.5	304.9	91.6	232.5
1963	147.7	334.8	90.9	233.9
1964	143.5	320.6	101.3	262.0
1965	144.2	372.3	108.0	280.0
1966	146.1	299.0	123.7	321.7
1967	170.4	355.4	150.3	397.9
1968	177.7	372.6	167.5	446.4
1969	193.1	393.5	197.3	525.8
1970	207.6	415.2	240.9	649.1
1971	245.0	541.1	270.8	786.9

Source: Statistics Canada

- (1) Cat. no. 65-004 Exports by Commodities, Dec. issues.
- (2) Cat. no. 65-007 Imports by Commodities, Dec. issues.

APPENDIX A8a

CANADA

REFINED PETROLEUM PRODUCTS

Total All Products
(millions barrels)

	<u>Imports</u>	<u>Exports</u>
1946	7.1	1.0
1947	16.3	1.2
1948	18.6	1.7
1949	12.8	0.5
1950	19.5	..
1951	20.6	..
1952	23.3	1.3
1953*	21.7	0.4
1954	19.6	0.5
1955	37.6	0.9
1956	36.4	2.6
1957	34.5	3.6
1958	29.3	1.0
1959	38.5	2.1
1960	36.0	3.2
1961	29.7	2.2
1962	30.1	4.4
1963	33.8	5.5
1964	43.8	8.7
1965	59.1	8.7
1966	59.1	8.8
1967	68.2	15.2
1968	74.4	18.1
1969	73.1	20.0
1970	70.1	26.6
1971 ^P	56.9	20.0

Source: Refined Petroleum Products
.. Insignificant; P Preliminary

Appendix A9

Canadian Trade in Natural Gas

Year	Imports		Exports	
	billions of cu. ft.	millions of \$	billions of cu. ft.	millions of \$
1946	.4	.2	-	-
1947	.4	.3	-	-
1948	.4	.2	-	-
1949	1.3	.5	-	-
1950	3.3	1.2	..	..
1951	3.7	1.3	..	..
1952	6.0	1.9	8.1	1.2
1953	6.1	2.0	9.6	1.4
1954	6.2	2.0	7.1	1.1
1955	11.2	2.7	11.4	1.7
1956	15.7	3.5	10.8	1.6
1957	30.6	7.2	15.7	2.3
1958	34.7	7.8	87.0	18.0
1959	12.0	3.8	84.8	17.0
1960	5.6	1.6	91.0	18.1
1961	5.6	1.7	168.2	41.7
1962	5.6	1.8	315.6	72.4
1963	6.9	2.4	341.0	75.6
1964	8.0	2.9	404.1	97.6
1965	15.7	5.8	403.9	104.3
1966	43.6	17.6	426.2	108.7
1967	52.9	19.9	505.2	123.7
1968	88.2	35.4	607.4	157.2
1969	37.7	16.0	607.4	157.2
1970	11.9	5.1	768.1	206.0
1971	16.0	7.0	903.1	250.7

Source: Statistics Canada

(1) Cat. no. 65-004 Exports by Commodities, Dec. issues.

(2) Cat. no. 65-007 Imports by Commodities, Dec. issues.

APPENDIX A10

Selected Petroleum Industry Expenditures in Western Canada
1947 to 1970

(millions of dollars)

Year	Land Acquisition and Rentals	Taxes (excl. income tax)	Royalties	Total
1947	7.5	.5	1.5	9.5
1948	12.4	.5	2.0	14.9
1949	35.6	1.0	5.0	56.5
1950	55.6	1.5	6.5	63.6
1951	44.3	.5	11.6	56.4
1952	65.8	2.0	15.6	83.4
1953	63.7	2.6	20.5	86.8
1954	116.8	2.7	26.5	146.0
1955	112.5	3.3	33.8	149.6
1956	127.5	4.0	45.9	177.4
1957	133.9	4.2	49.2	187.3
1958	113.6	4.8	41.7	160.1
1959	145.4	4.3	46.0	195.7
1960	113.8	4.9	48.6	167.3
1961	113.5	8.5	73.2	195.2
1962	112.8	6.8	90.7	210.3
1963	121.9	7.3	101.8	231.0
1964	173.2	9.3	111.1	293.6
1965	254.1	11.3	112.3	377.7
1966	223.5	12.1	129.0	364.6
1967	216.5	13.2	146.7	376.4
1968	226.4	14.6	164.4	405.4
1969	235.9	15.9	175.7	427.5
1970	149.9	16.5	197.9	363.4

Source: Canadian Petroleum Association Statistical Year Book, 1960 and 1970.

Note: Western Canada includes Yukon, N.W.T. and Arctic Islands, B.C., Alberta, Saskatchewan, and Manitoba.

Appendix B1

Identities

- (1) Total Gross Fixed Capital Formation
 $TGFCF = BGFCF + GGFCF$
- (2) Total Exports
 $XTOT = XOTH + XUS$
- (3) Aggregate Demand
 $GDPd = CONP + CONG + TGFCF + HD - (HD-1) + XTOT - MTOT - RHF$
- (4) Necessary Aggregate Supply in Equilibrium
 $GDPs = GDPd / ATECH$
- (5) Change in Inventories (End of Year)
 $HD - (HD-1) = 2(HJ - (HJ-1)) - ((HD-1) - (HD-2))$
- (6) Number Unemployed
 $NUNEM = NLF - NEMPL$
- (7) Percent Unemployed
 $NUNPER = (NUNEM / NLF) \cdot 100$
- (8) Gross National Product
 $GNP = GDP + INDR - INDP$
- (9) Disposable Private Sector Gross Income
 $YDISP = GNP + JINV - YG - RHF$
- (10) Civilian Wage Bill
 $WC = (WHR.HRS) \cdot (NEMPL - NENP)$
- (11) Property, Enterprise or Non-Wage Income (Net of Depreciation Allowances)
 $PIE = GNP + JINV - WC - WM - DEP - ITLS - RHF$
- (12) Stock of Fixed Capital
 $KDCPM = (KDCPM-1) + TGFCF - DNR$
- (13) Capital in Use in Production
 $KP = HJ + KDCPM.UF$ where $UF = (100 - (NUNPER - 2.0)) / 100 \geq 0$
- (14) Average Productivity Relative to Labour
 $PL = GDP / (NEMPL.HRS)$
- (15) Government Surplus or Deficit
 $SG = YG - (CONG + GGFCF)$
- (16) Current Account Surplus or Deficit
 $SF = XTOT + INDR - MTOT - INDP$
- (17) National Saving
 $SN = GNP - CONP - CONG$

(18) Total Petroleum Demand
 $PPTD = PPDD + PPXD$

(19) Total Natural Gas Demand
 $NGTD = NGDD + NGX D$

(20) Value of Petroleum and Natural Gas Production (61\$)
 $VPNGP = 2.286 (PPTD) + .114 (NGTD)$

Appendix B2

Alphabetic Mnemonic List of Variables Used.

1. ATECH Technical progress factor (1945=1.000)
2. BGFCF Business gross fixed capital formation (mil.61\$)
3. CONG Government consumption expenditures (mil.61\$)
4. CONP Private consumption expenditures (mil.61\$)
5. DEP Depreciation (capital consumption allowances, mil.61\$)
6. DNR Real Depreciation (mil.61\$)
7. DSUEZ Dummy equals one in 1956 and 1957 for Suez crisis
8. DWAR Dummy for war equals one in 1946, 1952, 1953, 1954, 1955
9. D6470 Dummy equals one in 1964 through 1970
10. GDPd Gross domestic product demanded (mil.61\$)
11. GDPs Gross domestic product supplied (mil.61\$)
12. GGFCF Government gross fixed capital formation (mil.61\$)
13. GNP Gross National Product (mil.61\$)
14. HD Inventory stock, year end levels (mil.61\$)
15. HJ Inventory stock, mid-year levels (mil.61\$)
16. HRS Hours worked per worker per year (thousand)
17. IMP Imports (mil. 61\$)
18. INDP Interest and Dividends paid abroad (mil.61\$)
19. INDR Interest and Dividends received from abroad (mil.61\$)
20. IPNGX Investment in petroleum and natural gas extraction (mil.61\$)
21. IPNGT Investment in petroleum and natural gas transportation (mil.61\$)
22. ITLS Indirect taxes less subsidies (mil.61\$)
23. JINV Inventory capital gains (mil.61\$)
24. KDCPM Stock of capital in plant, machinery and equipment (mil.61\$)
25. KP Total capital stock-adjusted for capacity utilization plus inventories (mil.61\$)
26. NEMPL Total number employed (thousands)
27. NENP Number of own account workers (thousands)
28. NGDD Natural gas domestic demand (m m c f)
29. NGTD Natural gas total demand (m m c f)
30. NGXD Natural gas export demand (m m c f)

Appendix 2 - cont.

31. NLF	Number in the labour force (thousands)
32. NPOP	Number in the population (thousands)
33. NUNEM	Number unemployed (thousands)
34. NUNPER	Percent unemployed (percent)
35. PIE	Property income (mil.61\$)
36. PL	Productivity of labour (output/labour ratio)
37. PPDP	Petroleum production for domestic demand (mil.bbbs)
38. PPTD	Petroleum production, total demand (mil.bbbs)
39. PPXD	Petroleum production for export demand (mil.bbbs)
40. RBGFCG	Autocorrelation variable for third pass least squares on BGFCE)
41. RHF	One-half the residual error of the estimate
42. SF	Current account surplus or deficit (mil.61\$)
43. SG	Government surplus or deficit (mil.61\$)
44. SN	National saving (mil.61\$)
45. TGFCF	Total gross fixed capital formation (mil.61\$)
46. TIME	Time variable where 1945=45
47. USGNP	United States GNP (bil.of 57\$)
48. VPNGP	Value of petroleum and natural gas production (mil.61\$)
49. WC	Civilian wages and salaries (mil.61\$)
50. WHR	Average hourly earnings (mil.61\$)
51. WM	Military salaries (mil.61\$)
52. XOTH	Exports to countries other than the U.S. (mil.61\$)
53. XTOT	Total Exports (mil.61\$)
54. XUS	Exports to U.S. (mil.61\$)
55. YDISP	Disposable private incomes (mil.61\$)
56. YG	Disposable government incomes (mil.61\$)

Appendix B3

Miscellaneous Variables

Year	Real Depreciation (DNR)	Average Hourly Earnings (WHR)	Average Hours/ Worker/Week (HRS)	Government Disposable Income (YG)	Population (000) (NPOP)	No. of Own Account Workers (NENP)	U.S. GNP (bil. \$) (USGNP)	Exports (XUS)
1946	1,096	0.70	42.7	3,174	12,292	1,529	313	1,98
1947	1,165	0.72	42.5	4,000	12,551	1,557	310	1,89
1948	1,284	0.73	42.3	3,830	12,823	1,508	324	2,55
1949	1,414	0.72	42.2	3,706	13,447	1,473	324	2,47
1950	1,545	0.76	42.3	4,287	13,712	1,454	355	3,16
1951	1,652	0.78	41.7	5,367	14,009	1,375	383	3,13
1952	1,780	0.81	41.5	5,583	14,459	1,303	395	3,19
1953	1,927	0.86	41.3	5,829	14,845	1,280	413	3,45
1954	2,103	0.88	40.7	5,448	15,287	1,282	407	3,38
1955	2,251	0.89	41.0	6,104	15,698	1,231	438	3,65
1956	2,380	0.92	41.0	6,924	16,081	1,196	446	3,85
1957	2,579	0.96	40.4	6,949	16,610	1,191	452	3,92
1958	2,776	0.97	40.2	6,369	17,080	1,146	447	3,87
1959	2,931	0.97	40.7	7,276	17,483	1,135	476	4,21
1960	3,091	0.99	40.4	7,521	17,870	1,122	488	3,99
1961	3,245	1.01	40.6	9,317	18,238	1,144	497	4,17
1962	3,384	1.03	40.7	10,194	18,583	1,136	530	4,73
1963	3,533	1.05	40.8	10,703	18,931	1,134	551	4,88
1964	3,696	1.06	41.0	12,007	19,290	1,143	581	5,26
1965	3,901	1.09	41.0	13,309	19,644	1,102	618	5,94
1966	4,151	1.13	40.8	15,187	20,015	1,056	658	7,07
1967	4,452	1.17	40.3	16,279	20,378	1,074	675	8,30
1968	4,745	1.20	40.3	17,936	20,701	1,047	707	9,82
1969	5,013	1.25	40.0	19,788	21,001	1,060	725	11,14
1970	5,295	1.29	39.7	21,119	21,297	1,040	720	11,18

Appendix B3

Miscellaneous Variables

	Population (000) (NPOP)	No. of Own Account Workers (NENP)	U.S. GNP (bil. 57\$) (USGNP)	Exports to U.S. (XUS)	Exports to Other Countries (XOTH)	Price Deflator (P)	GDP (mil. 61\$) (GDP)	Private Sector Disposable Income (YDISP)
87	12,292	1,529	313	1,987	3,062	58.5	20,921	16,146
93	12,551	1,557	310	1,893	3,125	63.6	21,298	16,148
53	12,823	1,508	324	2,553	2,632	71.2	21,768	16,586
76	13,447	1,473	324	2,476	2,402	74.0	22,549	16,684
60	13,712	1,454	355	3,160	1,684	75.5	24,306	17,977
31	14,009	1,375	383	3,131	2,166	84.1	25,414	18,400
92	14,459	1,303	395	3,192	2,713	87.7	27,730	19,318
58	14,845	1,280	413	3,458	2,385	87.5	29,181	20,435
81	15,287	1,282	407	3,381	2,245	89.3	28,649	19,950
55	15,698	1,231	438	3,655	2,398	89.6	31,473	22,146
55	16,081	1,196	446	3,855	2,653	92.5	34,243	23,775
29	16,610	1,191	452	3,929	2,639	94.4	35,287	24,511
74	17,080	1,146	447	3,874	2,671	95.9	36,006	25,911
10	17,483	1,135	476	4,210	2,589	98.2	37,545	26,651
97	17,870	1,122	488	3,997	3,093	99.4	38,614	27,391
70	18,238	1,144	497	4,170	3,481	100.0	39,802	27,552
30	18,583	1,136	530	4,730	3,280	101.4	42,528	29,732
84	18,931	1,134	551	4,884	3,828	103.3	44,811	31,394
67	19,290	1,143	581	5,267	4,589	105.6	47,901	33,063
41	19,644	1,102	618	5,941	4,407	109.1	51,085	35,233
73	20,015	1,056	658	7,073	4,641	114.0	54,668	37,073
09	20,378	1,074	675	8,309	4,632	118.4	56,625	38,136
22	20,701	1,047	707	9,822	4,685	123.1	59,338	39,698
41	21,001	1,060	725	11,141	4,531	128.9	62,218	41,402
80	21,297	1,040	720	11,180	6,046	134.5	64,218	41,754

Appendix B3

Miscellaneous Variables (mil. of 1961\$)

Year	Capital Stock Structures	Capital Stock Machinery and Equipment	Inventory Stocks	Total Capital Stock	Total Capital Stock Adjustment (In Use) (KP)	Labour Force (000) (NLF)	No. Employed (000) (NEMPL)	<u>U</u> No (00 (NUN)
1946	35,568	8,332	7,708	51,608	51,003	4,829	4,666	16
1947	36,897	9,669	7,941	54,507	54,402	4,942	4,832	11
1948	38,667	11,009	8,130	57,806	57,664	4,988	4,874	11
1949	40,687	12,296	8,190	61,173	60,660	5,158	5,005	15
1950	42,987	13,522	8,502	65,011	64,105	5,163	4,977	18
1951	45,102	14,841	9,151	69,094	68,848	5,223	5,097	12
1952	47,605	16,233	9,757	73,595	73,013	5,324	5,169	15
1953	50,593	17,695	10,297	78,585	77,901	5,397	5,235	16
1954	53,741	18,807	10,421	82,969	81,119	5,493	5,243	25
1955	57,360	19,899	10,409	87,668	85,838	5,610	5,365	24
1956	61,624	21,497	10,966	94,087	92,917	5,782	5,585	19
1957	66,331	23,026	11,424	100,781	98,432	6,008	5,370	27
1958	71,212	24,068	11,391	106,671	101,869	6,137	5,705	43
1959	75,922	25,161	11,438	112,521	108,518	6,242	5,870	37
1960	80,160	26,272	11,760	118,192	112,916	6,411	5,965	44
1961	84,362	27,141	11,992	123,495	117,756	6,521	6,055	46
1962	88,655	28,156	12,318	129,129	124,579	6,615	6,225	39
1963	93,077	29,346	12,873	135,296	130,959	6,748	6,374	37
1964	98,168	30,996	13,358	142,522	139,069	6,933	6,609	32
1965	103,687	33,173	14,102	151,162	148,529	7,141	6,861	28
1966	109,940	36,051	15,222	161,213	158,880	7,420	7,153	26
1967	115,895	38,836	15,951	170,682	167,441	7,694	7,379	31
1968	121,935	41,178	16,413	179,576	174,967	7,919	7,537	38
1969	128,226	43,691	17,173	189,090	184,482	8,162	7,780	38
1970	134,344	46,202	17,649	198,195	191,134	8,374	7,879	49

Appendix B3

Miscellaneous Variables (mil. of 1961\$)

Unempl No. (000) (NUNEM)	Total Capital Adjustment (In Use) (KP)	Labour Force (000) (NLF)	No. Employed (000) (NEMPL)	Unemployed		Man-Hours/Year (000) (HRS)	Capital/ Output	Output/ Labour (PL)	Capital/ Labour
				No. (000) (NUNEM)	% (NUNPER)				
163	51,003	4,829	4,666	163	3.4	10,356	2.44	2.02	4.92
110	54,402	4,942	4,832	110	2.2	10,689	2.55	1.99	5.09
114	57,664	4,988	4,874	114	2.3	10,731	2.65	2.03	5.37
153	60,660	5,158	5,005	153	3.0	10,985	2.69	2.05	5.52
186	64,105	5,163	4,977	186	3.6	10,960	2.64	2.22	5.85
126	68,848	5,223	5,097	126	2.4	11,046	2.71	2.30	6.23
155	73,013	5,324	5,169	155	2.9	11,146	2.63	2.49	6.55
162	77,901	5,397	5,235	162	3.0	11,240	2.67	2.60	6.93
250	81,119	5,493	5,243	250	4.6	11,094	2.83	2.58	7.31
245	85,838	5,610	5,365	245	4.4	11,443	2.73	2.75	7.50
197	92,917	5,782	5,585	197	3.4	11,895	2.71	2.88	7.81
278	98,432	6,008	5,370	278	4.6	12,030	2.79	2.93	8.18
432	101,869	6,137	5,705	432	7.0	11,928	2.83	3.02	8.54
372	108,518	6,242	5,870	372	6.0	12,421	2.89	3.02	8.74
446	112,916	6,411	5,965	446	7.0	12,526	2.92	3.08	9.01
466	117,756	6,521	6,055	466	7.1	12,775	2.96	3.12	9.22
390	124,579	6,615	6,225	390	5.9	13,188	2.93	3.22	9.45
374	130,959	6,748	6,374	374	5.5	13,515	2.92	3.32	9.69
324	139,069	6,933	6,609	324	4.7	14,102	2.90	3.40	9.66
280	148,529	7,141	6,861	280	3.9	14,640	2.91	3.49	10.15
267	158,880	7,420	7,153	267	3.6	15,170	2.91	3.60	10.47
315	167,441	7,694	7,379	315	4.1	15,460	2.96	3.66	9.69
382	174,967	7,919	7,537	382	4.8	15,788	2.95	3.76	9.86
382	184,482	8,162	7,780	382	4.7	16,199	2.97	3.84	10.39
495	191,134	8,374	7,879	495	5.9	16,269	2.98	3.95	11.75

Appendix B3

Income Distribution

(mil. of 1961\$)

Year	Wages and Salaries		Military Pay		Property Income		Inventory Valuation Adjustment		Indirect Taxes Less Subsidies		Capital Consumption Allowance and Miscellaneous Valuation Adjustment	
	Mil. \$	%	Mil. \$	%	Mil. \$	%	Mil. \$	%	Mil. \$	%	Mil. \$	%
	(WG)		(WM)		(PIE)		(IINV)		(ITLS)		(DEP)	
1946	9,373	46.1	581	2.9	6,883	33.9	-434	-2.1	2,342	11.5	1,962	9.6
1947	10,044	48.6	145	0.7	7,193	34.8	-898	-4.3	2,638	12.8	2,157	10.4
1948	10,396	48.8	133	0.6	7,197	33.8	-711	-3.4	2,573	12.1	2,196	10.3
1949	10,791	48.9	173	0.8	6,809	30.9	-151	-0.7	2,537	11.5	2,411	10.9
1950	11,412	48.5	204	0.9	7,823	33.2	-496	-2.1	2,736	11.6	2,610	11.1
1951	12,024	48.4	276	1.1	8,287	33.3	-765	-3.1	3,031	12.2	2,700	10.9
1952	12,915	47.0	348	1.3	8,086	29.4	136	0.5	3,191	11.6	2,883	10.5
1953	14,079	48.8	398	1.4	7,892	27.4	2	0.0	3,421	11.9	3,192	11.1
1954	14,112	49.1	457	1.6	6,968	24.2	99	0.4	3,407	11.9	3,543	12.3
1955	15,100	48.8	490	1.6	8,423	27.2	-205	-0.7	3,707	12.0	3,893	12.6
1956	16,582	49.3	514	1.5	8,951	26.7	-267	-0.8	4,033	12.0	4,245	12.7
1957	17,656	50.7	563	1.6	8,323	23.9	-63	-0.2	4,213	12.1	4,518	13.0
1958	17,845	50.2	570	1.6	8,666	24.4	-43	-0.1	4,209	11.8	4,498	12.6
1959	18,647	50.8	563	1.5	9,039	24.6	-110	-0.3	4,482	12.2	4,805	13.1
1960	19,426	51.3	563	1.5	8,856	23.4	-26	-0.1	4,616	12.2	5,051	13.3
1961	20,136	51.5	610	1.6	8,975	23.0	-41	-0.1	4,838	12.4	5,182	13.2
1962	21,305	51.2	642	1.6	9,999	24.0	-116	-0.3	5,372	12.9	5,517	13.3
1963	22,328	50.9	649	1.5	10,861	24.7	-196	-0.5	5,533	12.6	5,736	13.1
1964	23,877	50.8	632	1.3	11,565	24.6	-132	-0.3	6,098	13.0	5,931	12.6
1965	25,842	51.8	621	1.2	12,088	24.2	-289	-0.6	6,676	13.4	6,099	12.2
1966	27,978	52.3	659	1.2	12,692	23.7	-287	-0.5	7,064	13.2	6,348	11.9
1967	29,789	53.8	709	1.2	12,115	21.9	-273	-0.5	7,420	13.4	6,664	12.0
1968	31,267	53.9	699	1.2	12,821	22.1	-258	-0.4	7,860	13.6	7,039	12.1
1969	33,504	55.0	696	1.2	13,364	21.9	-426	-0.7	8,257	13.5	7,253	11.9
1970	34,973	55.3	674	1.1	12,644	20.0	-127	-0.2	8,364	13.2	7,691	12.1

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Appendix B3

Income Distribution

(mil. of 1961\$)

Inventory Valuation Adjustment		Indirect Taxes Less Subsidies		Capital Consumption Allowance and Miscellaneous Valuation Adjustment		Interest and Dividends Received from Abroad		Interest and Dividends Paid Abroad		Residual Error of Estimate		GNP
Mil. \$	%	Mil. \$	%	Mil. \$	%	Mil. \$	%	Mil. \$	%	Mil. \$	%	Mil. \$
(IINV)		(ITLS)		(DEP)		(INDR)		(INDP)		(RHE)		
-434	-2.1	2,342	11.5	1,962	9.6	147	0.7	-575	-2.8	+50	0.2	20,329
-898	-4.3	2,638	12.8	2,157	10.4	107	0.5	-544	-2.6	-186	-0.9	20,656
-711	-3.4	2,573	12.1	2,196	10.3	110	0.5	-504	-2.4	-72	-0.3	21,318
-151	-0.7	2,537	11.5	2,411	10.9	137	0.6	-568	-2.6	-91	-0.3	22,048
-496	-2.1	2,736	11.6	2,610	11.1	150	0.6	-647	-2.7	-252	-1.1	23,540
-765	-3.1	3,031	12.2	2,700	10.9	151	0.6	-561	-2.3	-278	-1.1	24,865
136	0.5	3,191	11.6	2,883	10.5	206	0.7	-538	-2.0	+276	1.0	27,503
2	0.0	3,421	11.9	3,192	11.1	219	0.7	-538	-1.9	+179	0.6	28,844
99	0.4	3,407	11.9	3,543	12.3	204	0.7	-570	-2.0	+513	1.8	28,173
-205	-0.7	3,707	12.0	3,893	12.6	222	0.7	-617	-2.0	-74	-0.2	30,939
-267	-0.8	4,033	12.0	4,245	12.7	210	0.6	-673	-2.0	+7	0.0	33,602
-63	-0.2	4,213	12.1	4,518	13.0	217	0.6	-794	-2.3	+191	0.5	34,824
-43	-0.1	4,209	11.8	4,498	12.6	245	0.7	-789	-2.2	+357	1.0	35,558
-110	-0.3	4,482	12.2	4,805	13.1	260	0.7	-876	-2.4	-97	0.2	36,713
-26	-0.1	4,616	12.2	5,051	13.3	261	0.7	-881	-2.3	+6	0.0	37,872
-41	-0.1	4,838	12.4	5,182	13.2	300	0.8	-1,022	-2.6	+106	0.2	39,084
-116	-0.3	5,372	12.9	5,517	13.3	285	0.7	-1,035	-2.5	-365	-0.9	41,604
-196	-0.5	5,533	12.6	5,736	13.1	296	0.7	-1,111	-2.5	-204	-0.5	43,592
-132	-0.3	6,098	13.0	5,931	12.6	413	0.9	-1,264	-2.7	-76	-0.2	47,044
-289	-0.6	6,676	13.4	6,099	12.2	433	0.9	-1,370	-2.7	-221	-0.4	49,879
-287	-0.5	7,064	13.2	6,348	11.9	444	0.8	-1,462	-2.7	+58	0.1	53,494
-273	-0.5	7,420	13.4	6,664	12.0	416	0.7	-1,524	-2.8	+214	0.3	55,330
-258	-0.4	7,860	13.6	7,039	12.1	518	0.9	-1,597	-2.8	-371	-0.6	57,578
-426	-0.7	8,257	13.5	7,253	11.9	724	1.2	-1,728	-2.8	-694	-1.1	60,950
-127	-0.2	8,364	13.2	7,691	12.1	899	1.4	-1,906	-3.0	+43	0.6	63,255

Appendix B3

Aggregate Demand Components (mil. of 1961 \$)

Year	Pers. Consump.		Gov't Consump.		Gov't Invest.		Bus. Invest.		Change Invent.		Exports	
	Mil. \$	%	Mil. \$	%	Mil. \$	%	Mil. \$	%	Mil. \$	%	Mil. \$	%
	CONP		CONG		GGFCF		BCFCF		dHD		XTOT	
1946	13,304	65.5	3,728	18.3	478	1.9	2,648	13.0	-141	-0.7	5,049	24.8
1947	13,721	66.4	2,814	13.6	442	2.1	3,390	16.4	233	1.1	5,018	24.3
1948	13,438	63.1	2,682	12.6	549	2.6	3,845	18.0	189	0.9	5,185	24.3
1949	14,083	63.9	2,986	13.5	568	2.6	4,153	18.8	60	0.3	4,878	22.1
1950	15,038	63.9	3,218	13.7	622	2.6	4,449	18.9	312	1.3	4,844	20.6
1951	15,224	61.2	4,175	16.8	645	2.6	4,442	17.9	649	2.6	5,297	21.3
1952	16,514	60.0	5,125	18.6	767	2.8	4,907	17.9	606	2.2	5,905	21.5
1953	17,538	60.8	5,273	18.3	818	2.8	5,559	19.3	540	1.9	5,843	20.2
1954	18,296	63.7	5,070	17.6	912	3.2	5,451	19.0	124	0.4	5,626	19.6
1955	19,757	63.9	5,174	16.7	921	3.0	6,040	19.5	-13	-0.1	6,053	19.6
1956	21,172	63.0	5,334	15.9	1,003	3.0	7,240	21.9	557	1.6	6,508	19.4
1957	22,044	63.3	5,240	15.0	1,233	3.5	7,581	21.8	458	1.3	6,568	18.9
1958	22,876	64.3	5,398	15.2	1,367	3.8	7,332	20.6	-33	0.1	6,545	18.4
1959	24,000	65.4	5,354	14.6	1,472	4.0	7,263	19.8	47	0.2	6,799	18.5
1960	24,866	65.7	5,467	14.4	1,508	4.0	6,931	18.3	322	0.8	7,093	18.7
1961	25,120	64.3	6,350	16.2	1,671	4.3	6,646	17.0	232	0.6	7,651	19.6
1962	26,277	63.1	6,598	15.8	1,867	4.5	6,825	16.4	326	0.8	8,010	19.3
1963	27,551	62.8	6,726	15.3	1,873	4.3	7,271	16.6	555	1.3	8,712	19.8
1964	29,372	62.4	6,980	14.8	1,862	4.0	8,575	18.2	485	1.0	9,856	21.0
1965	31,113	62.4	7,126	14.3	2,108	4.2	9,689	19.4	744	1.5	10,348	20.8
1966	32,771	61.3	7,900	14.8	2,326	4.3	10,756	20.1	1,120	2.1	11,714	21.9
1967	34,309	61.8	8,225	14.8	2,436	4.4	10,755	19.4	729	1.3	12,941	23.3
1968	35,853	61.8	8,539	14.7	2,458	4.2	10,719	18.5	462	0.8	14,507	25.0
1969	37,847	62.1	8,816	14.5	2,417	4.0	11,351	18.6	761	1.2	15,672	25.7
1970	38,610	61.0	9,661	15.3	2,500	4.0	11,425	18.1	476	0.7	17,226	27.2

Appendix B3

Aggregate Demand Components (mil. of 1961 \$)

Bus. Invest.		Change Invent.		Exports		Imports		Res. Im. of Estimate		GNE	
Mil. \$	%	Mil. \$	%	Mil. \$	%	Mil. \$	%	Mil. \$	%	Mil. \$	%
BCFCF		dHD		XTOT		IMP		RHF			
2,648	13.0	-141	-0.7	5,049	24.8	-4,587	-22.6	-50	-0.2	20,329	
3,390	16.4	233	1.1	5,018	24.3	-5,149	-24.9	+187	0.9	20,656	
3,845	18.0	189	0.9	5,185	24.3	-4,643	-21.8	+73	0.3	21,318	
4,153	18.8	60	0.3	4,878	22.1	-4,770	-21.6	+90	0.4	22,048	
4,449	18.9	312	1.3	4,844	20.6	-5,196	-22.1	+253	1.1	23,540	
4,442	17.9	649	2.6	5,297	21.3	-5,845	-23.5	+378	1.1	24,865	
4,907	17.9	606	2.2	5,905	21.5	-6,045	-22.0	-276	-1.0	27,503	
5,559	19.3	540	1.9	5,843	20.2	-6,547	-22.7	-180	-0.6	28,844	
5,451	19.0	124	0.4	5,626	19.6	-6,233	-21.7	-513	-1.8	28,733	
6,040	19.5	-13	-0.1	6,053	19.6	-7,067	-22.8	+74	0.2	30,939	
7,240	21.5	557	1.6	6,508	19.4	-8,204	-24.4	-8	-0.0	33,602	
7,581	21.8	458	1.3	6,568	18.9	-8,108	-23.3	-192	-0.5	34,824	
7,332	20.6	-33	0.1	6,545	18.4	-7,539	-21.2	-358	-1.0	35,558	
7,263	19.8	47	0.1	6,799	18.5	-8,319	-22.7	+97	0.3	36,713	
6,931	18.3	322	0.8	7,093	18.7	-8,380	-21.9	-5	0.0	37,872	
6,646	17.0	232	0.6	7,651	19.6	-8,480	-21.7	-106	-0.3	39,084	
6,825	16.4	326	0.8	8,010	19.3	-8,665	-20.8	+366	0.9	41,604	
7,271	16.6	555	1.3	8,712	19.8	-9,001	-20.5	+205	0.4	43,892	
8,575	18.2	485	1.0	9,856	21.0	-10,163	-21.6	+77	0.2	47,044	
9,689	19.4	744	1.5	10,348	20.8	-11,470	-23.0	+221	0.4	49,879	
10,756	20.1	1,120	2.1	11,714	21.9	-13,034	-24.4	-59	-0.1	53,494	
10,755	19.4	729	1.3	12,941	23.3	-13,652	-24.6	-213	-0.4	55,530	
10,719	18.5	462	0.8	14,507	25.0	-14,931	-25.7	+371	0.6	57,978	
11,351	18.6	761	1.2	15,672	25.7	-16,608	-27.2	+694	1.1	60,950	
11,425	18.1	476	0.7	17,226	27.2	-16,599	-26.2	-44	0.1	63,255	

Appendix B4

The attached tables portray some simulation results from the model as described above in section C: the solid lines represent actual values; the long broken lines the results of a simulation using actual exogenous values and calculated lagged variables (control); the short lines represent a simulation similar to the previous, but imports were adjusted each year by an amount equal to the value of the output of the petroleum and natural gas industry. It was felt that this latter simulation might serve to demonstrate an economy without a petroleum and natural gas industry and could be compared to the "control" solution. Contrary to the industry's estimate (page 12 above), by 1970 employment might have been about the same and the GNP might have been reduced by about \$1.5 billion (compared to \$3 billion). The two primary equilibrating mechanisms were government consumption expenditures which increased to somewhat offset the reduced aggregate demand; further, imports were reduced thereby somewhat offsetting the arbitrary adjustments to the constant term of the import equation.

In the real world, one would also anticipate either a lower exchange rate as a result of the increased current account deficit or lower relative prices vis-à-vis the rest of the world because of the lower level of economic activity, either or both leading to increased exports and reduced imports. This would further offset the negative impact portrayed. (In these simulations, exports were exogenized in order to better isolate the factors at work.)

The petroleum and natural gas demand equations are also portrayed. The petroleum domestic demand curve portrays a growth path which is increasing but at a decreasing rate; the comparable natural gas curve on the other hand,

is increasing at an increasing rate. In the case of the export demand curves, it is evident that significant foreign demand did not begin to make its influence felt until the 1960's. The combined demands are the primary explanatory variable in the investment equation for petroleum and natural gas extraction. The investment equation for pipeline transportation is quite erratic, particularly during the period of construction of the Trans Canada system. The estimated curve tends to follow the trend without picking up the peaks and troughs of this investment activity.

Both investment curves tend to fluctuate more than one might expect on the basis of the corresponding demand curves. While this might be expected in the case of pipelines because of their inherent lumpiness, the variability of the extraction curve may result from "psychological" factors as well as economic causes. The industry is notorious for its gloomy periods during which each member is waiting for news of a significant discovery or "new play". In such circumstances, it is debatable whether giving or removing tax incentives would have any more than a temporary effect, despite the industry's protestations to the contrary.

GROSS NATIONAL PRODUCT (billions of \$)

GOVERNMENT CONSUMPTION EXPENDITURES (billions of \$)

NUMBER EMPLOYED AND UNEMPLOYMENT RATE (millions) (percent)

CAPITAL STOCKS AND BUSINESS INVESTMENT

(billions of \$)

(100,000 of \$)

IMPORTS AND CURRENT ACCOUNT BALANCE (billions of dollars)

PETROLEUM DEMAND (million barrels)

NATURAL GAS DEMAND (Trillion cubic feet)

INVESTMENT IN PETROLEUM AND NATURAL GAS INDUSTRY (millions of dollars)

Appendix C

Final Demand Components of 100 Million
Investment Expenditure in Pipelines

No.	Commodity Name	Value (000\$)		Total
		Domestic	Imported	
078	Millwork(wood)	3,000		3,000
097	Pipes and Tubes	38,000	9,000	47,000
103	Plate, Tanks, Boilers	2,000		2,000
111	Tools and Cutting Equip.	1,000		1,000
113	Forg. and Plumbing Equip.	2,000	2,000	4,000
116	Industrial Machinery	4,000	1,000	5,000
118	Office Machinery	500		500
136	Electrical Ind. Equip.	2,000		2,000
166	Organic Chemicals	1,500	1,000	2,500
169	Scientific and Labor Equip.		1,000	1,000
178	Construction	25,000		25,000
180	Trans. and Storage	6,000		6,000
187	Finance and Insurance	1,000		1,000

Appendix D1

A Description of the Canadian Input/Output System⁽¹⁾

The base year selected was 1961 for which the flows of goods and services were specified in a detailed accounting framework. In the "open" version of the model, the starting point is the 1961 values for Gross Domestic Expenditure at market prices, which are given exogenously and normally referred to as the final demand categories. The main categories are:

- i) personal expenditure on consumer goods and services;
- ii) government expenditure on goods and services;
- iii) business gross fixed capital formation (investment expenditures);
- iv) value of the physical change in inventories;
- v) exports of goods and services;
- iv) imports of goods and services.

Each category contains sub-divisions. For example, government expenditures might be sub-divided into current and investment expenditures or any other sub-division for which data were available. Each category of final demand is broken down into specific commodities that were demanded in the base year - in this case, into 644 commodities. This data is organized into a matrix of final demand (F) with each column representing a category of final demand and each row, one of the 644 commodities. Since imports are substitutes for domestically produced commodities, all the elements in that column have a negative sign. Summation across all columns yields a vector (e) of Gross Domestic Expenditure (GDE) by commodity. Summation down the rows of matrix F yields a row vector (f) of the totals of each final demand category. When each element in a column is divided by its corresponding column total ($F(f)^{-1}$), the result is a matrix (E) representing the base year final demand coefficients.

(1) Dominion Bureau of Statistics, The Input Output Structure of the Canadian Economy, 1961 Ottawa: The Queen's Printer, 1969..

The description relies extensively on the published description, especially by Appendix A, pp.135-166.

The vector (e) represents the final demand by commodity that was produced domestically in the base year. Total commodity outputs will, however, be greater than final demands since some commodities are used as intermediate inputs in the production of goods for final demand. At the same time, some commodities were produced by more than one industry. A matrix (V) may be developed portraying commodity outputs by industry in the base year. In the case at hand, V is a rectangular matrix portraying 644 commodities (rows) by the 187 industries (columns) in which they were produced in 1961. Summation across all columns yields the column vector q of total commodity output.

Summation overall rows yields a row vector (g) of total industry outputs classified by 187 industries. Division of each element in the (V) matrix by its corresponding row total $(V(q)^{-1})$, yields a matrix of coefficients (D) representing the market shares of industries in the domestic production of commodities. For example, the non-zero market shares coefficients for the commodity "furniture" and fixtures"⁴ for one dollar of demand were:

Industry	Market Share Coefficient
1) textile industries	.006692
2) wood and furniture industries	.892734
3) paper industries	.000163
4) metal industries	.053554
5) trans. and elect. equipment	.031486
6) chem., rubber and petroleum products	.001436
7) other manuf. industries	.009007
8) trade and transportation	.004928
Total	1.000000

² Ibid. Small (40 commodity) Aggregation. Includes household, office, special purpose and miscellaneous furniture as well as household lamps. p.281.

Thus, a dollar of final demand for furniture and fixtures would be spread over the industries portrayed in those proportions. The market shares portrayed in the base year are assumed to remain fixed regardless of the source of demand or levels of output. Industry outputs may then be determined by multiplying the vector of commodity outputs by the market shares matrix.

$$g = D.q \quad (1)$$

Each industry is assumed to have a fixed production function as reflected in its purchases of inputs in the base year. The purchases of goods and services are regarded as intermediate inputs since they are the outputs of other industries. All other payments made by the industry are considered as primary inputs or leakages from the production process even though these payments represent the income side of the National Accounts. In the "open" version of the I/O model, these incomes are not respend. The primary inputs in the 1961 I/O model are:

- 1) commodity taxes;
- 2) government subsidies on current account items (negative);
- 3) indirect taxes (property taxes, government fees, etc.);
- 4) government services (airport and labour tolls, etc.);
- 5) wages, salaries and supplementary labour incomes of employees in industry;
- 6) net incomes of unincorporated business (returns to labour of proprietors);
- 7) a residual item called surplus which in principal contains profits before payment of income taxes, interest and dividends as well as capital consumption allowances and certain valuation adjustments.

The summation of the last three items by industry represents Gross Domestic Product (GDP) at Factor Cost.

All the inputs by industry may be arranged in a matrix with the industries on one dimension and commodities (intermediate inputs) and primary inputs on the other. By definition, total inputs equal total outputs by industry. Division of each industry's inputs by its total input (output) yields the input coefficients for each industry. The lower portion relating to the primary input coefficients by industry matrix (Y), is useful in the determination of GDP by industry. The upper portion of the matrix portraying intermediate commodity input coefficients by industry is often called the industry technology matrix (B). This matrix is normally assumed to be fixed which implies that an industry's inputs are directly proportional to the industry's outputs. It also implies that even though an industry may produce more than one commodity, a demand for any one of them will call for the same input requirements. Thus, total commodity output may be defined as the sum of intermediate inputs (B.g) and final demand (e) or:

$$q = B.g + e \quad (2)$$

From equation (1), $g = Dq$, therefore:

$$q = B.D.q + e$$

$$\text{or } q - B.D.q = e$$

$$\text{since } I.q = q$$

$$I.q - B.D.q = e$$

or

$$(I - B.D).q = e$$

Premultiplication of both sides of this equation by:

$$(I - B.D)^{-1} \quad \text{yields:}$$

$$q = (I - B.D)^{-1} \cdot e \quad (3)$$

This expression generates total commodity outputs (q) given final demands (e).

The expression $(I - B.D)^{-1}$ is the rectangular input/output system equivalent for the Leontief inverse in the standard rectangular input/output system where each industry produces a unique commodity.

An expression may also be defined to transform final demand requirements (e) into industry outputs.

$$q = B.g + e \quad (2)$$

therefore $D.q = D.B.g + D.e$

since $g = D.q$ (1), $g = D.B.g + D.e$

therefore $(I - D.B.) g = D.e$

premultiplication of both sides of this equation by:

$$(I - D.B)^{-1} \quad \text{yields:}$$

$$g = (I - D.B)^{-1} \cdot D.e \quad (4)$$

Given the expressions (3) and (4), one may solve for total commodity or industry outputs for any alternative vector of final demand (e). Since the system is strictly linear, there are in effect no supply constraints to be encountered - any final demand may be "produced". Once the industry outputs (g) are known, the primary input matrix (Y) may be employed to determine the equivalent value added or GDP by industry.

So far, imports have been accounted for as a negative component of final demand. While it may be relatively simple to estimate the direct import content of any given final demand expenditure, it would be interesting to have an approximation of the imports that might be generated indirectly in the production of the intermediate inputs associated with this final demand. Taking account of import leakages in the process of transforming goods to meet a final demand would also yield more realistic domestic industry and commodity outputs. Making the assumption that imports are a fixed proportion of the total supply of each commodity, it is possible to develop a modified market shares matrix where part of the demand for particular commodities would be met by imports. The vector of imports (m) may be expressed as:

$$m = \hat{u} (q + m)$$

where (q+m) represents total supply (domestic output plus imports) and $\hat{u}$ is a diagonal matrix of coefficients representing the import proportion in the total supply of each commodity. Defining the modified market shares matrix as:

$$D^* = D \cdot (I - \hat{u})$$

$$\text{then } g = [I - D^* \cdot B]^{-1} \cdot D^* (e + m):$$

A variation of this I/O model has been developed which has been partially "closed" in order to approximate the responding of consumer incomes generated in the production processes. In other words, the consumption element of final demand has been endogenized. Fixed proportions of the wages, supplementary labour income, and the surplus (representing investment income to Canadian residents) are demanded from the "household industry". The intermediate input coefficients of this additional industry are the final demand coefficients for consumer expenditures. In this manner, part of the personal disposable income generated in each industry is respent leading to additional outputs and incomes.

END

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