THE UNIVERSITY OF ALBERTA

# EFFECT OF INCREASED WELLHEAD PETROLEUM PRICES ON SOME ALBERTA INDUSTRIES

by

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE

DEGREE OF MASTER OF SCIENCE

IN

CHEMICAL ENGINEERING

DEPARTMENT OF CHEMICAL AND PETROLEUM ENGINEERING

EDMONTON, ALBERTA

FALL, 1973

ABSTRACT

A model was developed to represent the interdependence of various industries in Alberta. This model was used to estimate the effect which increased wellhead petroleum prices would have on some industries in this Province. It was concluded that if the wellhead prices of crude oil and natural gas were to increase annually to 1985 values of $7.21/barrel and 81.72¢/mcf, respectively, then this could cause yearly increases of the order of 3%, in the prices of commodities produced in Alberta.

## ACKNOWLEDGEMENTS

The author wishes to thank the following people:

Dr. J. T. Ryan for his enthusiastic and considerate supervision of this project,

Mr. Reg Norby for his assistance in obtaining data for the agricultural industry,

Dr. Jorge Flores for all his help and encouragement,

Mrs. Fran Russell for the interest she took in the typing of this manuscript,

Mr. Ron Clouston for his drafting of the figures in this thesis, and

Mr. Bozo Tuttle for keeping the author in good spirits.

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CHAPTER I

# INTRODUCTION

It has been predicted (1, 2) that the prices of wellhead natural gas and crude oil will increase significantly over the next decade. Consequently, it would be extremely useful to estimate h industries in Alberta would be affected by increases in the price these commodities.

One method of determining the effect on an industry of changing wellhead petroleum prices is to estimate the increase whic it would require in its product price in order to maintain a suffic ient return on investment. If a large increase in the price of the industry's product is needed then this would imply that the industr could be seriously affected by greater wellhead petroleum prices.

This thesis will analyze the changes in the product price required by some industries in Alberta which would result from spec fied wellhead natural gas and crude oil prices. In estimating the correspondence between an industry's product price and wellhead pet roleum prices it is necessary to consider the interrelationships between the industry and the other industries with which it is involved.

Consider the farming industry. The prices of many produc used by farmers are dependent (directly or indirectly) on wellhead petroleum prices. The farmer consumes refinery products (gasoline, diesel fuel etc.) in the operation of his machinery. Before these products reach the farmer they must be carried by pipeline to the refinery. They are then processed and brought by truck to the farmer via a distributor. The price paid by the farmer for refinery products will depend on the wellhead crude oil price. It will also depend on pipeline, refining, trucking, and distribution costs. Each of these costs are dependent on either natural gas or refinery product prices. Consequently, the cost of refinery products to the farmer will become greater because of the increasing costs of the intermediate industries as well as because of the new crude oil prices. Therefore the new costs of refinery products to the farmer should not be estimated without considering the intermediate industries.

Consider the fertilizer used by the farmer. This would appear to be independent of petroleum prices. However, this is not correct. Ammonia is used in the manufacture of fertilizer. In Alberta ammonia is produced by a process which consumes large quantities of natural gas as a feedstock and as an electrical power source. Consequently, an increase in the price of wellhead natural gas will ultimately affect the price of fertilizer. The cost of fertilizer to the farmer also depends on the price of the refinery products consumed in transporting the fertilizer to the farmer.

Similarly, it can be shown that most of a farmer's operating costs are affected by wellhead petroleum prices. His capital costs also depend on these prices. Consider the cost of constructing a farm building. The construction materials must be transported to the farm. The cost of this transportation will increase with the price of crude oil. Cement is used in the construction of a farm building. A large amount of natural gas is required in the production of cement. Thus by considering only two of the costs involved in constructing a farm building it can be seen that both wellhead natural gas and crude prices affect the farmer's construction costs.

It has been shown that a farmer's expenses, and consequently his product prices, depend on the petroleum product usage of other industries. A similar situation exists for most industries. Thus to predict the product prices of industries in Alberta it is necessary to consider these industries together as a joint unit which shows their interrelationships.

Twenty-eight industries were examined in this thesis. A model was developed which showed the interrelationships between the product prices of these twenty-eight industries. The dependence of their product prices on wellhead petroleum prices was also incorporated in the model. This model was then used to predict the changes in product prices of various Alberta industries which would result if certain wellhead petroleum prices occurred.

# CHAPTER II

## LITERATURE REVIEW

An economic system is a group of industries which are interconnected in some way. Each system industry will have inputs (costs) from some of the other system industries. There will probably be feedback loops in the system. For example, consider two industries A and B which use each others products. An increase in the price of product A will cause the price of product B to be increased because of its greater operating costs. Product B's price change will increase industry A's costs and consequently, its product price. This situation, of successive increases in the prices of the two products, will continue until a set of equilibrium prices is obtained.

There are methods in the literature for analyzing economic systems. These methods are based on the approximate representation of the interrelationships between the industries of the economic system in terms of simultaneous equations.

### 1. LEONTIEF'S OPEN STATIC INPUT OUTPUT METHOD (3,4,5,6,7)

This is the classical method for the practical modeling of an economic system. The final demand ($y_i$) for a commodity i represents the amount of the commodity sold to consumers which are not members of the economic system being studied. In his static model

Leontief assumed that there is no accumulation of any of the products produced by the economic system. Thus the amount of commodity i produced by industry i ($x_i$) is either consumed by the system industries j ($\sum_{j=1}^{n} a_{ij}x_j$) or sold to the final demand sector ($y_i$). In the form of an equation this is

$$x_i = \sum_{j=1}^{n} a_{ij}x_j + y_i \qquad (1)$$

$$i = 1, 2, \ldots, n$$

where $x_i$ is the physical output from industry i.

$a_{ij}$ is the quantity of commodity i required by industry j to produce one unit of product j.

$a_{ij}x_j$ is the total amount of commodity i which is consumed by industry j.

$y_i$ is the final demand for product i.

n is the number of system industries.

Leontief assumed that the revenue obtained by each system industry i is just sufficient to cover the costs (including interest on debt and profits) incurred in its production. Thus the revenue obtained from the sale of one unit of commodity i($p_i$) is equal to the cost per unit product ($\sum_{j=1}^{n} a_{ji}p_j$) of using the commodities produced by the system industries plus the cost per unit product ($v_i$) of using commodities (including capital) obtained from outside the economic system. This can be stated in the form of an equation as

$$p_i = \sum_{j=1}^{n} a_{ji} p_j + v_i \qquad (2)$$

$$i = 1, 2, \ldots, n$$

where $a_{ji}p_j$ is the cost of the amount of commodity j which industry i requires to produce one unit of commodity i.

If all the $a_{ij}$'s (technical coefficients) and $y_i$'s are known then it is possible to determine each of the $x_i$'s from equations (1). In equations (2) there are 2 n unknowns (the $p_i$'s and the $v_i$'s). To solve these equations it is necessary to specify n of the unknowns.

Leontief also developed a closed static input-output model. In this model there was no flow of materials and money out of the system. In this model $v_i$ and $y_i$ are zero for all i. This model is not convenient for practical applications and is generally not used.

## DISCUSSION OF LEONTIEF'S STATIC PRICE EQUATIONS

There are five major assumptions inherent in Leontief's static price equations and they are as follows:

1. each industry produces only one commodity,
2. no two industries produce the same commodity,
3. there are constant returns to scale (for each industry the required physical inputs per unit product are independent of the amount of output produced),
4. there is no substitution possibility between the various input ingredients, even if the prices of competitive

materials vary, and,

5. the economic system will achieve an equilibrium situation where the price of each commodity is such, that for each industry revenues are equal to costs (including dividends etc.). When the equilibrium situation has been reached the commodity prices will then become independent of time unless the $v_i$ values (external costs) are made time dependent.

Assumptions (1) and (2) (one different product per industry) obviously restrict the use of Leontief's system. However, they do not present an insurmountable obstacle. For example, if industry A produces both wheat and potatoes then it would be assumed in Leontief's models that industry A produces one output which is wheat-potatoes. This assumption is necessary in most input-output applications as generally not enough data is available to consider multiproduct industries.

Assumptions (3) and (4) (constant returns to scale and no substitution possibilities) imply that the technical coefficients (the $a_{ij}$'s) are fixed. These assumptions are necessary unless sufficient data is available to predict the effect of future technoligical and commodity price changes on the technical coefficients.

Assumption (5) leads to a set of equilibrium prices. Unfortunately these equilbrium prices do not depend on prices which actually existed in earlier years. Consequently, a set of prices can be obtained which are very different from actual values. This assumption can be eased slightly to make prices in any year depend on prices in previous years.

## 2. LEONTIEF'S DYNAMIC INPUT-OUTPUT MODEL (3,4,5,6)

Leontief's dynamic output equations are an extension of equations (1). In his static model Leontief only considers flows of commodities. Leontief's dynamic model allows for the fact that inventories of commodities change with time. The previously discussed technical coefficients are supplemented in the dynamic model by a set of capital coefficients which are also considered to be fixed values.

Leontief's static price equations were also modified to allow for varying inventories. Leontief's dynamic price equations were not used in this project because sufficient data was not available to consider inventory changes.

## 3. CLOPPER ALMON'S MODELS

Clopper Almon (8, 9) refined equations (1). In doing so he was forced to assume that commodity prices remain constant. Consequently, Clopper Almon's models were not used as the purpose of this project is to predict price changes.

## 4. MORISHIMA'S MODEL

In his model (10) Morishima uses a set of equilibrium price equations which are very similar to equations (2). The use of Morishima's equations on a year to year basis would inherently contain the assumption that if the construction industry's costs in year t were to increase by x% then the depreciation (due to construction) expense of every industry in the economic system would also increase by x% in year t. This assumption was not considered acceptable. Consequently, Morishima's model was not used in this project.

## 5. SOLOW'S MODEL

Solow (11) derived a set of price equations which relate commodity prices in year t+1 to their prices in year t. Solow used the equation derived by Morishima to allow for depreciation expense. Morishima's treatment of this expense was found unacceptable. Consequently, Solow's model was not used.

## 6. GENERAL EQUILIBRIUM THEORY (4, 12, 13)

If sufficient data is available then this theory can be used to evaluate the values of resources, commodity prices, and the production of each commodity and resource. In order to use this theory the amount of each resource which will be consumed per unit product in each process must be known. Resource value-demand and commodity price-demand relationships must also be available.

The general equilibrium theory was not used because it required much more data than was actually available.

## 7. VON NEUMANN'S MODEL OF AN EXPANDING ECONOMY (3, 4, 14)

Von Neumann's model is only useful for theoretical purposes. Von Neumann allowed for multiproduct industries. He also made provision for different industries producing the same product. The introduction of these refinements produced sets of equations for which it was possible to obtain several solutions. More than one solution could be obtained if the number of commodities produced by the economic system was greater than the number of industries in the system.

# CHAPTER III

## SELECTION OF A MODEL AND ITS RELATIONSHIP TO LEONTIEF'S STATIC PRICE EQUATIONS

The price equations studied in the literature were not used in this project. Some of these equations were too rigorous and sufficient data could not be obtained for their utilization. The errors involved in estimating the unavailable data would have eliminated the extra accuracy obtained by using these equations. Other equations were too simple and did not permit the use of information which could be easily acquired. Thus the model which was developed was a result mainly of the form in which data was available.

The model used in this analysis will now be compared to Leontief's static price equations. In equations (2) the cost to industry i of using the amount of commodity j which it requires for unit production is written as $a_{ji}p_j$, where $a_{ji}$ is the quantity of commodity j required by industry i to produce one unit of commodity i. The term $p_j$ represents the price of one unit of product j.

To use equations (2) it is necessary to know the values of the $a_{ji}$'s. Much of the data available gives the breakdown of an industry's costs in terms of dollars but does not give the physical amounts of inputs ($a_{ji}$) which it uses. Consequently, it was necessary to replace the $a_{ji}$ values by coefficients which could be evaluated.

This resulted in the following set of equations:

$$p_i = \sum_{j=1}^{n} op\ cost_{ji} + v_i \qquad (3)$$

$$i = 1, 2, \ldots, n$$

where op $cost_{ji}$ is the cost to industry i of buying the amount of commodity j which it requires for unit production.

$v_i$ represents the cost of using commodities (including capital) obtained from outside the economic system.

It is assumed that all of the terms in equations (3) are time independent. This assumption is not valid for the situation examined in this thesis. Consequently, equations (3) are modified to make their variables time dependent. This results in the following set of equations:

$$p_i(t) = \sum_{j=1}^{n} op\ cost_{ji}(t) + v_i(t) \qquad (4)$$

$$i = 1, 2, \ldots, n$$

where t is the year in which the equations are being applied.

The $v_i(t)$ terms are now expanded because sufficient data is available for some industries to estimate the components of these terms. This is done in the following set of equations:

$$v_i(t) = BIE_i(t) + PROF_i(t) + RO_i(t) + RG_i(t) \qquad (5)$$

$$i = 1, 2, \ldots, n$$

where $BIE_i(t)$ is the interest on debt capital, per unit product, which industry i must pay in year t.

$PROF_i(t)$ is the profit (before payment of income taxes) per unit product which is required by industry i in year t.

$RO_i(t)$ is the cost to industry i of buying the amount of wellhead crude oil in year t which it requires for unit production.

$RG_i(t)$ is the cost to industry i of buying the amount of wellhead natural gas in year t which it requires for unit production.

Equations (4) and (5) are combined to give the following equations:

$$p_i(t) = \sum_{j=1}^{n} \text{op cost}_{ji}(t) + BIE_i(t) + PROF_i(t) + RO_i(t) + RG_i(t) \qquad (6)$$

$$i = 1, 2, \ldots, n$$

Equations (6) are the basic equations of the model. The presence of the $RO_i(t)$ and the $RG_i(t)$ terms enable the effect of increased wellhead petroleum prices on the prices of the commodities produced by the economic system to be measured. Equations (6) are manipulated in Appendix A to yield further equations. The solution of these equations estimates the increase in prices of the commodities produced by the economic system which would result from various wellhead petroleum prices.

The assumptions made in Appendix A will be discussed in the next chapter.

# CHAPTER IV

# DISCUSSION OF THE ASSUMPTIONS MADE IN THE DEVELOPMENT OF THE MODEL EQUATIONS

In the development of equations in Appendix A the following major assumptions were made.

1. Each system industry produces only one commodity.
2. No two system industries produce the same commodity.
3. The quantity of commodity j required in the production of one unit of commodity k is constant (i.e. there are fixed technological coefficients).
4. If the revenues per unit product of industry j (except for the natural gas utility) become greater in year t then the cost of product j to all industries in that year will be increased in the same proportion.
5. For each system industry the ratio profits (including income taxes)/revenues is constant.
6. The ratio interest payments/revenues is constant for each system industry.

The above assumptions were made in order to develop a model which would fulfill the following two requirements.

1. It must yield unique solutions (values of commodity price changes) for specified wellhead petroleum prices.

2. Sufficient data must be available for its use.

While the assumptions were considered necessary it was also recognized that they represented departures from reality. The possible significance of these departures will now be discussed. Consider an oil refinery. Assumption 1 will lead to the conclusion that if the refinery's costs are increased then the price (at the refinery gate) of all its products (gasoline, asphalt oil etc.) will be increased in the same proportion. This probably will not occur. Gasoline and asphalt are sold under different market conditions. Thus the refinery product which faces little competition will have its price increased more than the product which must compete strongly with other commodities. A similar situation exists for other multiproduct industries.

Assumption 2 can be considered realistic for the Alberta industries analyzed. This is because it is unlikely that any two of these industries produce significant quantities of the same commodity.

Assumption 3 could be considered to be a major source of inaccuracy in the utilization of the model equations. Use of this assumption means that possible changes in the quantities of different commodities consumed by each system industry were not considered. Changes are likely to occur because of:

1. technological advances, and
2. changes in the relative prices of different commodities

(particularly energy sources) which could lead to an industry using another commodity in place of the one which it traditionally used.

The maximum departure from assumption 3 could occur in those technological coefficients which are related to energy sources. There are many sources of energy (refinery products, natural gas, nuclear power, coal, electricity etc.) available. Each industry probably has a choice of using at least two of these sources. The one selected will depend on the relative prices, the availability, and the reliability of the different choices. It will also depend on many other factors. The variables on which the selection of an energy source depends will vary with time. Thus the relative quantities of different energy sources used by a particular industry will also change.

Consider the electric power generation industry. Natural gas is used as a fuel for many power plants in Alberta. Because of the increasing price of natural gas most of the new generators to be constructed over the next decade will probably be based on coal-fired units. Consequently, the quantity of natural gas which is used in the production of one unit of electricity (technological coefficient) will decrease with time. Therefore, the effect of natural gas price increases on the price of electricity is probably overestimated by using 1972 technological coefficients.

It could also be shown that most, if not all, of the technological coefficients vary with time. Some of these coefficients may vary considerably while others may display changes which are insignificant. To estimate the magnitude of the error involved in using fixed (1972) technological coefficients it would be necessary to predict for each year until 1985, the changes which will occur in each technological coefficient. This would require very detailed research.

Assumption 4 is based on the following two suppositions:

1. if the average price of any commodity j (excluding natural gas supplied by utility companies) is raised by x% then so also will the actual prices paid by the industries for this commodity.
2. the effect of inventories is unimportant.

Supposition 1 would appear to be reasonable if all of commodity j is sold to the same type of consumer. Natural gas is sold to three different consumer categories (industrial, commercial, and residential). The cost incurred by the utility companies in supplying natural gas will depend on the type of consumer to which it is being sold. Because of this, natural gas was excluded from supposition 1. Instead it was assumed that the difference in price paid by the three consumer categories for natural gas would remain constant with time. This assumption is discussed in more detail in Appendix C.

The significance of supposition 2 can be seen from the following simple example. Industry A uses commodity B as an input. The price of this commodity is increased at the beginning of year t and is constant for the remainder of the year. Industry A has a six months supply of commodity B in its inventory. Thus industry A's input costs do not increase until the middle of year t. Consequently, the average increase in cost in year t to industry A of using commodity B will be less than the increase in the price of this commodity. Thus supposition 2 would appear to be an oversimplification in that it ignores the effect of inventories. This may be true for a short term analysis. However, when a time span of 13 years is being analyzed the error introduced by neglecting the effect of inventories will not be important. It is not too significant that average prices are predicted for 1985 which would have been predicted as the average values for June 1985 to June 1986 if the effect of inventories had been included in the model. This is particularly true in this analysis where the 1985 values of input variables (the wellhead petroleum prices) could actually occur in 1980.

Assumption 5 implies that the price of a commodity is determined only by the costs (including profits) incurred in its production. This means that the effects of competition are ignored. This would be reasonable if the industry producing the commodity was not in a competitive situation. It would also be reasonable if the prices of the industry's product and competitive commodities were expected to increase by similar amounts. However, the price of competitive commodities (including imports) could remain below the industry's product price, as determined by an analysis of its costs. In this case the industry could be forced to lower its price (and consequently its profits) in order to remain in a competitive position.

Assumption 5 also implies that income taxes will remain a constant percentage of revenues. As it is not very certain how income tax laws will change in the future this implication cannot be considered unreasonable. If the income tax laws were to change significantly then this would obviously affect the prices of commodities produced in Alberta.

Assumption 6 means that if an industry's total costs (required revenues) are increased by a certain percentage then so also will the amount of long term debt capital which it has borrowed. Assumption 6 also implies that the interest rate on long term debt capital will remain constant. It would have been easy to include variable interest rates in the model. It was decided that this would not necessarily improve the accuracy of the model. This was because future interest rates could not be predicted with sufficient accuracy.

The other major inaccuracies are incurred in:

1. representing construction expense,
2. representing products which are not produced by the

system industries, and

3. estimating data.

## 1. REPRESENTATION OF CONSTRUCTION COSTS

There are essentially two types of construction expense and they are as follows:

1. repair construction
2. new construction

These construction expenses are treated differently in the determination of an industry's product price.

Repair construction is considered to be an operating cost. Thus any increase in an industry's repair construction expense will result in an immediate increase in that industry's product price.

New construction is treated as a capital cost and is spread over a number of years. The full impact of an increase in an industry's new construction costs is not shown immediately in its product price. The conventional methods of allocating construction costs to different years were not used in this thesis. In applying these methods for predictive purposes it is necessary to estimate the future construction which will be undertaken by different industries. This could not be done with sufficient accuracy. Instead a very simple approach requiring little data was used. This approach is outlined in Appendix B.

For certain industries previous values of their depreciation (due to construction) expense were known or could be estimated. The construction expense of these industries was treated as a capital cost. For other industries depreciation values were not known. However, previous values of the repair construction expense of some of these industries were available. This expense was treated as an operating cost.

The representation of the construction expense of each industry resulted in inaccuracies either because

1. data was not available to represent the depreciation (due to construction) expense of the industry, or
2. if data was available then it was necessary to make assumptions in order that the effect of increasing construction costs on the industry's depreciation expense could be estimated.

For some industries sufficient data was not available to permit a representation of their depreciation expense in the model equations. For these industries depreciation expense was included in the "other expense" term. This latter expense represents the difference between an industry's revenues and its costs (including profits) which have been accounted for in the model equations. "Other expense" is treated as an operating cost. Thus if depreciation is included in "other expense" it is treated as an operating cost. Thus an immediate increase in an industry's construction costs would result in an immediate proportionate increase in its depreciation expense. If depreciation expense had been included as a separate entity in the model equation representing the industry then the full impact of increasing construction costs would not be felt immediately in this expense. Thus the inclusion of depreciation expense in "other expense" results in an overestimation of the effect on an industry's product price of increasing construction costs (due to increased wellhead petroleum prices).

For those industries where depreciation was considered as a separate entity it was necessary to make certain assumptions (displayed in Appendix B). These assumptions probably resulted in an underestimation of the effect of increasing construction costs.

## 2. REPRESENTATION OF PRODUCTS WHICH ARE NOT PRODUCED BY THE SYSTEM INDUSTRIES

Each of the first twenty-seven industries in Table A-1 use part of their revenues to pay for "other expense". In order to estimate the effect on "other expense" of increasing wellhead petroleum prices it was necessary to create a dummy industry. It was then assumed that the "other expense" per unit product of each industry would increase at the same rate as the revenues required per unit product by the dummy industry.

There are 110 industries in Table 13 of the 1961 Canadian Input-Output Tables (15). The dummy industry is defined to be the sum of those 110 industries which are not members of the first 27 industries considered in this analysis. Wellhead petroleum producers are also excluded from the dummy industry because the input from these industries to the 27 industries is included elsewhere in the model equations.

The following costs are included in the "other expense" term:

a. depreciation of assets which are not produced by the construction industry.

b. the costs of commodities and services which are not produced by the system industries.

c. the costs of commodities and services which are produced by the system industries but which were not included as inputs from these industries as their values were not available.

The error involved in the introduction of the "other expense" term will depend on the values of its three components. Consider an industry whose depreciation of machinery expense accounts for a large percentage (10%) of its total costs. The inclusion of this expense in "other expense" would cause the effect of increased wellhead petroleum prices on the industry's product price to be overestimated. This is because "other expense" is assumed to be an operating cost whereas the expense of using machinery is a capital cost. The inclusion of costs under b and c in "other expense" would introduce errors in the results if they are affected differently than the dummy industry by increased wellhead petroleum prices. The magnitude of these errors will depend on the percentage of the industry's expenses (including profits) which are due to these costs. It will also depend on how great is the difference in the effect of increased wellhead petroleum industries on the costs under b and c and on the revenues required by the dummy industry.

### 3. ESTIMATION OF DATA

In order to use the model equations it was necessary to obtain a large amount of data. Some of this data was not available and it had to be estimated. The assumptions used in estimating data are displayed in Appendix D.

# CHAPTER V

## CAUSES OF WELLHEAD PETROLEUM PRICE INCREASES

It is becoming very obvious that there will be increases in the price of wellhead petroleum products in Alberta. Some of the major causes of these price increases will now be discussed.

Alberta petroleum producers have always been affected by conditions in the United States of America. Consequently, the situation of wellhead petroleum products in that country will now be examined. In the past year the U.S. has experienced difficulties in meeting its crude oil requirements even with the aid of imports. The situation will become very serious in the near future. This is because the demand for crude oil is increasing rapidly and the U.S. and Canadian production of this commodity is not expected to keep pace with it (16). Consequently, the U.S. will import as much crude oil from Canada as it is permitted. This situation will exist until cheaper non-petroleum energy sources are available.

The U.S. will also buy as much crude oil as possible from South American countries. Eastern Canada obtains most of its oil from these countries. Thus in the future Eastern Canada will have to compete with the U.S. for its imported oil. This competition will raise the price paid in Eastern Canada for this commodity. This will result in an increased wellhead price for crude oil in Alberta.

There is a shortage of natural gas in the U.S. (17, 18, 19). Unless major gas fields are discovered this excess of demand over supply will increase in the future. This will result in an increasing demand for Alberta gas.

The price of natural gas was kept artificially low in the U.S. by the regulations of the Federal Power Commission. These regulations have now been lifted. This should result in natural gas approaching its true market value.

Both the Energy Resources Conservation Board (20) and the Lougheed government are of the opinion that natural gas in Alberta is underpriced and that this situation is not in Alberta's best interest. Thus it seems that even the price of previously contracted gas will be increased as the Alberta government has the power to influence these contracts.

When gas from the Arctic passes through Alberta in the early 1980's its value in a central Alberta location could be about three times the present average wellhead price of Alberta natural gas (20). This is bound to increase the wellhead price of natural gas in Alberta.

In conclusion it can be stated that the prices of wellhead petroleum products will be increased because:

1. the U.S. demand for these materials is increasing more rapidly than its supply,

2. Eastern Canada will face more competition for its imported crude oil,
3. the Federal Power Commission has lifted its price regulations,
4. the Lougheed government considers that the price of natural gas should be increased, and
5. Arctic gas passing through Alberta will have a much higher value than the present price of Alberta well-head natural gas.

## CHAPTER VI

## WELLHEAD PETROLEUM PRICES

The National Petroleum Council (2) estimated future wellhead petroleum prices (in constant 1970 dollars) which would be necessary to support certain levels of exploration and development activity. The two extreme wellhead crude oil price profiles mentioned in this source are shown in the following table:

TABLE VI-1

CRUDE OIL PRICE PROFILES
($/bbl.)

| YEAR | LOW PROFILE | HIGH PROFILE |
|---|---|---|
| 1975 | 3.54 | 3.70 |
| 1980 | 4.26 | 5.16 |
| 1985 | 5.06 | 7.21 |

The two extreme wellhead natural gas price profiles considered by the National Petroleum Council are displayed in the next table:

TABLE VI-2

NATURAL GAS PRICE PROFILES
(¢/mcf)

| YEAR | LOW PROFILE | HIGH PROFILE |
|---|---|---|
| 1975 | 25.1 | 28.5 |
| 1980 | 27.6 | 40.9 |
| 1985 | 31.2 | 59.4 |

The prices of wellhead petroleum products in Alberta will be nearly equal to those in the U.S. Consequently, the petroleum prices shown in Tables VI-1 and VI-2 will be used as a basis for estimating the effect of increased wellhead petroleum prices on the twenty-eight system industries.

Dr. J. T. Ryan (21) considered that wellhead natural gas prices could become greater than those suggested by the high price profile in Table VI-2. Consequently, he suggested an alternative natural gas price profile. The effects of this profile were examined.

Petroleum prices suggested by Sherman H. Clark (1) and natural gas prices displayed by Roger F. Naill (22) were within the price range of the price profiles already mentioned. Consequently, the possible effects of these prices were not investigated.

The purpose of this analysis is to estimate the inflationary effect on the products of the system industries which would be caused by greater wellhead petroleum prices. Other inflationary causes are not considered. Thus the model estimates the extra revenues/unit product which the system industries would require merely as a result of increased wellhead petroleum prices. The revenues/unit product will in fact increase more due to other inflationary effects.

The model determines the price of a commodity in year t, relative to its price in year t-1, which would result from increased wellhead petroleum prices. To accomplish this it must be supplied with the prices of wellhead natural gas and crude oil relative to their prices in year t-1. The increases in the prices (expressed in actual dollars) of the system products due to increased wellhead petroleum prices will depend on the prices (expressed in actual dollars) of wellhead natural gas and crude oil. To obtain wellhead petroleum price profiles in actual dollars from those expressed in constant dollars (Tables VI-1 and VI-2) it is necessary to assume that the value of the dollar will be decreased at a certain rate. The following two cases were considered:

1. zero reduction in the value of the dollar (actual dollars = constant dollars).

2. $\frac{\text{the value of the dollar in year t}}{\text{the value of the dollar in year t+1}} = 1.03$

Many sets of wellhead petroleum prices were considered in this analysis. Half of these sets were based on case 1. The remainder were based on case 2.

These sets of petroleum prices which were based on case 1 can be divided into the following two major categories:

1. nonlinear price profiles, and

2. linear price profiles.

The average wellhead price of crude oil in Alberta was $3.0/barrel in 1972 (23). The price paid for the wellhead natural gas which was used within Alberta in 1972 was 14¢/mcf (20). The nonlinear price profiles were obtained by drawing curves through the prices given in Tables VI-1 and VI-2, and the 1972 Alberta values mentioned above. This was done in figures 1 and 2. The values of petroleum prices for each year from 1972 to 1985 were then taken from these figures. This resulted in columns 2-5 of Table VI-3. Dr. Ryan's natural gas price profile (figure 3) was in terms of actual dollars. Column 6 of Table VI-3 was obtained by converting this profile into constant 1972 dollars. The "medium" natural gas price profile shown in Table VI-3 was obtained from the "high" natural gas price profile in Table VI-2. This was because Dr. Ryan's natural gas price profile indicated higher prices than the "high" natural gas profile in Table VI-2.

The linear price profiles were obtained by drawing straight lines from the 1972 actual values to the various 1985 prices which were used in the estimation of Table VI-3. Table VI-4 was obtained from these linear plots.

The effect of the prices in Tables VI-3 and VI-4 on the product prices of the 28 system industries were analyzed in this thesis. The effects of prices corresponding to case 2 (reduction in the value of the dollar) were also examined.

While petroleum prices are expected by many people (1, 2, 21, 22, 24, 25) to increase the exact timing of these price increases would be very difficult to predict accurately. Consequently, the

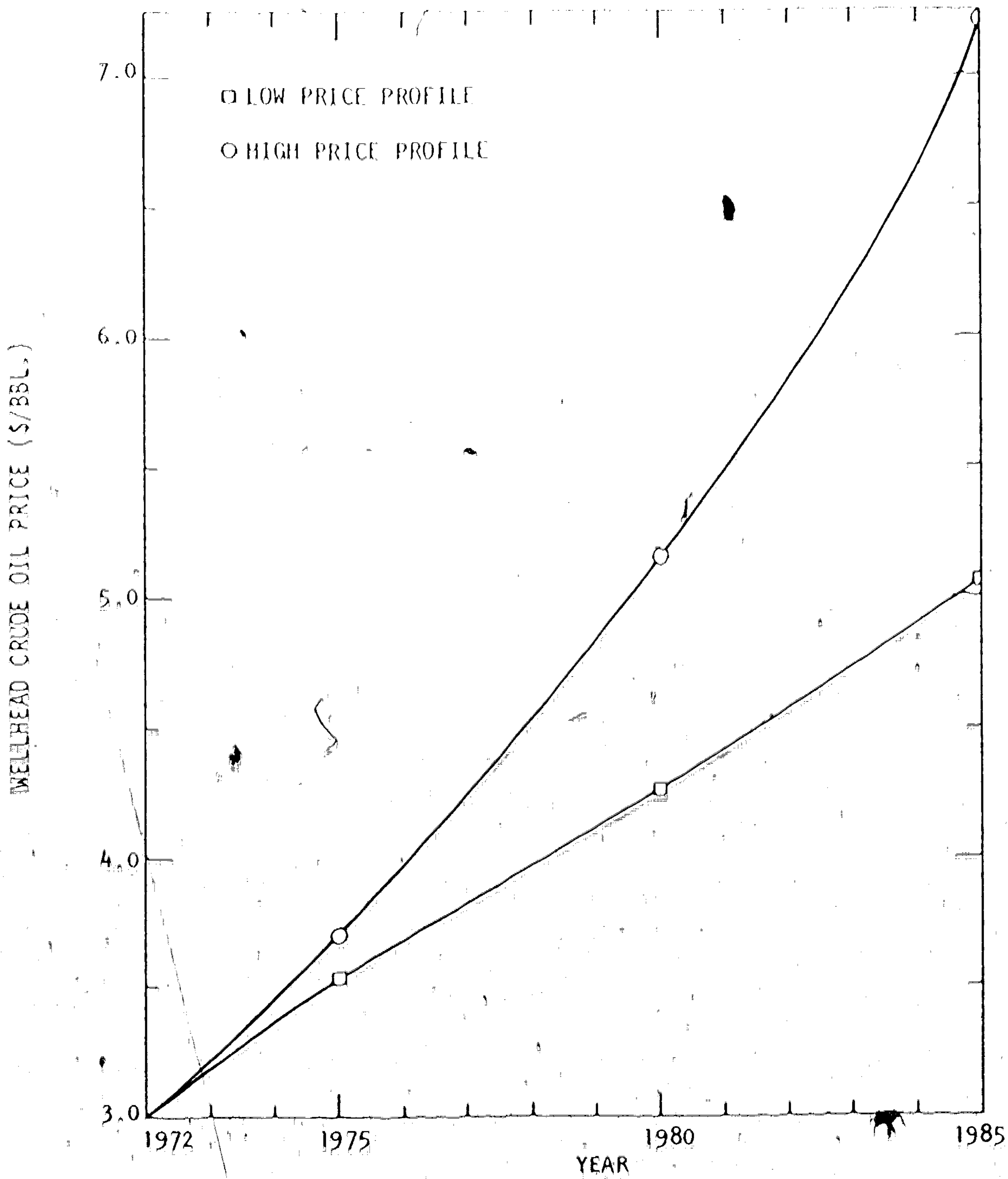


FIGURE 1 - Wellhead Crude Oil Price Profiles (Constant Dollars)

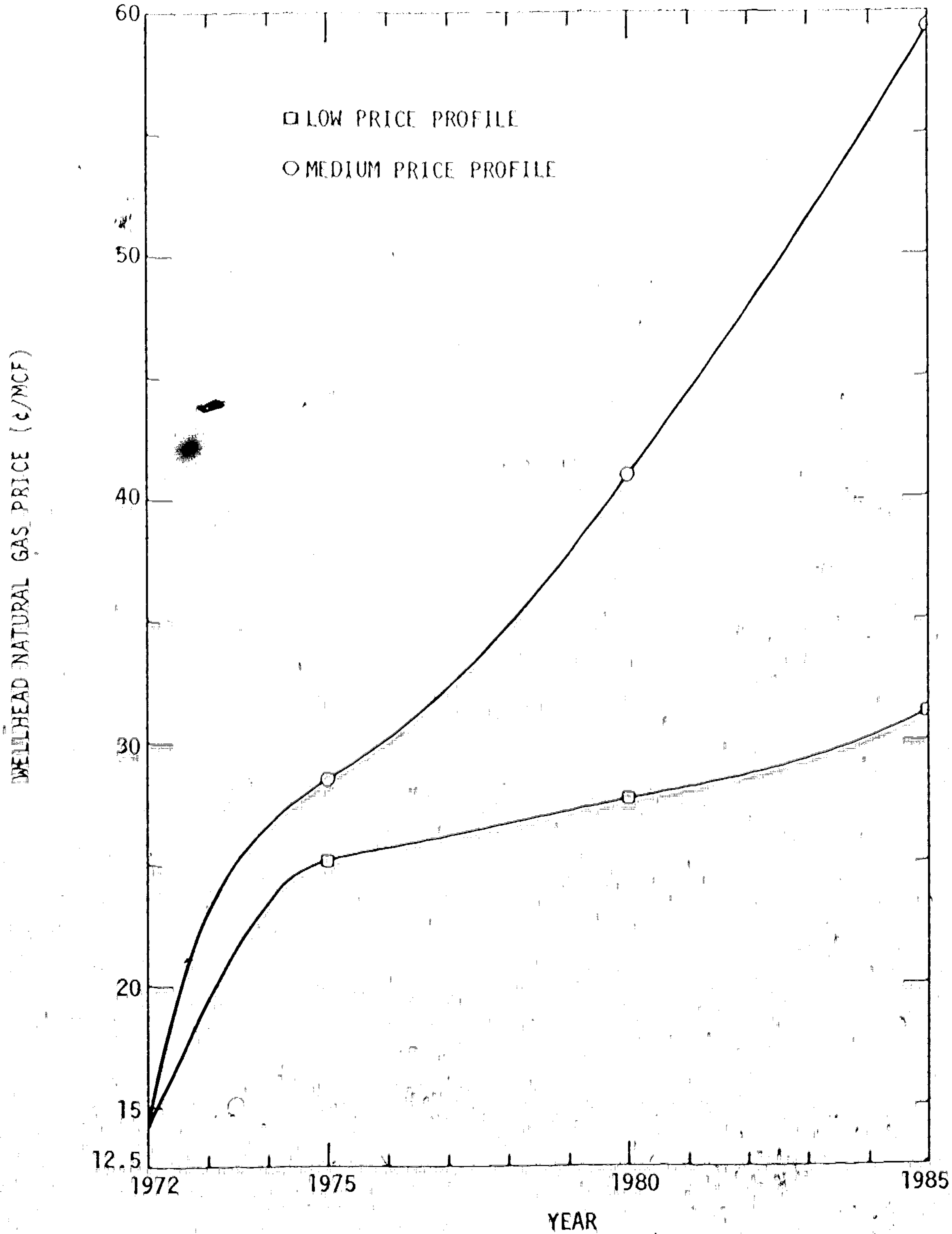


FIGURE 2 - Wellhead Natural Gas Price Profiles (Constant Dollars)

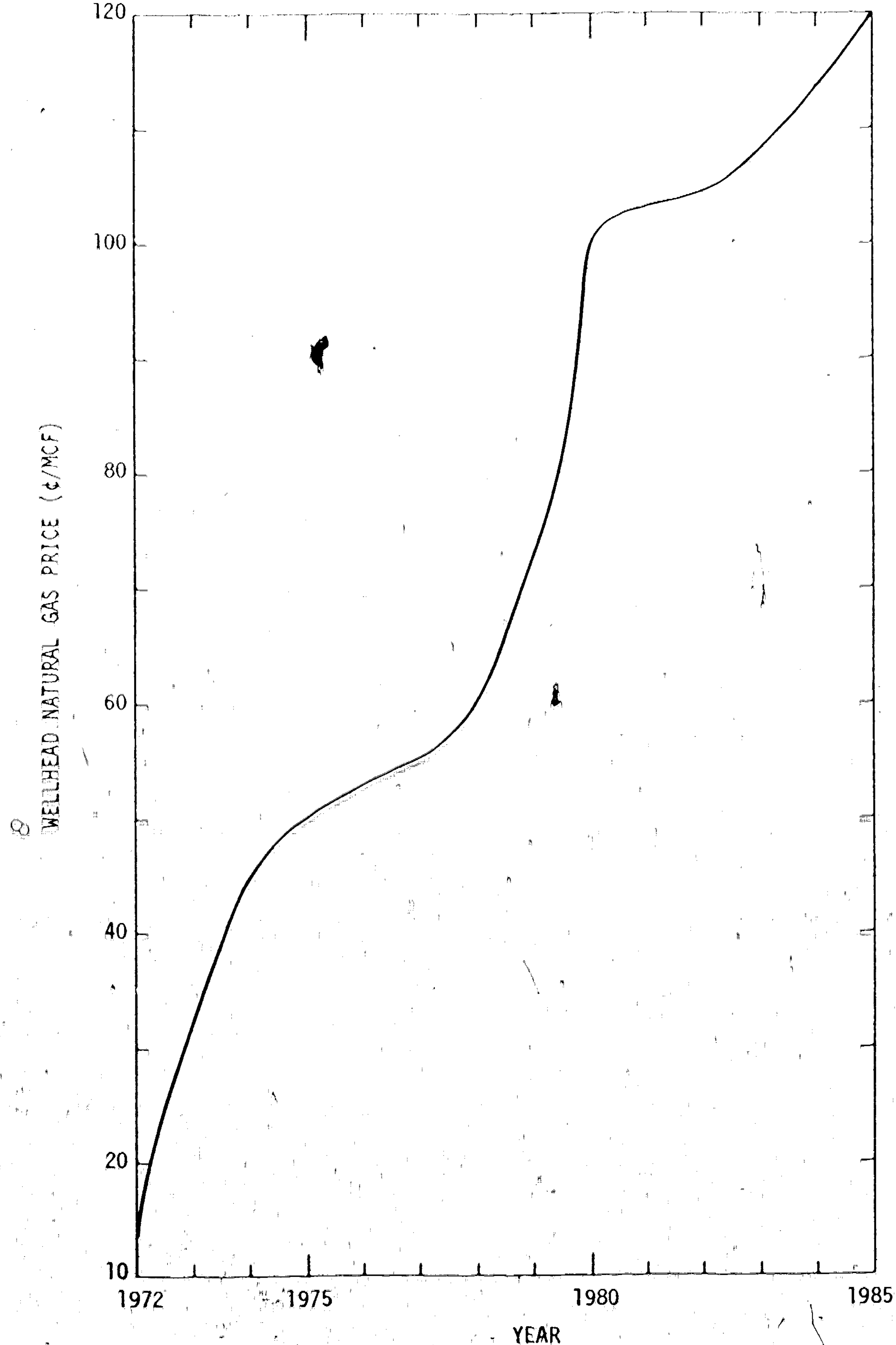


FIGURE 3 - High Wellhead Natural Gas Price Profile (Actual Dollars)

TABLE VI-3

*NON-LINEAR WELLHEAD PETROLEUM PRICE PROFILES

| Year | Low Crude Oil Price Profile ($/barrel) | High Crude Oil Price Profile ($/barrel) | Low Natural Gas Price Profile (¢/mcf) | Medium Natural Gas Price Profile (¢/mcf) | High Natural Gas Price Profile (¢/mcf) |
|---|---|---|---|---|---|
| 1972 | 3.0 | 3.0 | 14 | 14 | 14 |
| 1973 | 3.18 | 3.22 | 19.3 | 23.0 | 31.07 |
| 1974 | 3.35 | 3.45 | 23.5 | 26.6 | 42.42 |
| 1975 | 3.54 | 3.70 | 25.1 | 28.5 | 45.76 |
| 1976 | 3.68 | 3.95 | 25.7 | 30.1 | 47.09 |
| 1977 | 3.82 | 4.24 | 26.2 | 32.0 | 47.44 |
| 1978 | 3.96 | 4.53 | 26.7 | 34.5 | 50.25 |
| 1979 | 4.11 | 4.84 | 27.2 | 37.3 | 56.92 |
| 1980 | 4.26 | 5.16 | 27.6 | 40.9 | 78.94 |
| 1981 | 4.44 | 5.50 | 28.2 | 44.3 | 78.94 |
| 1982 | 4.60 | 5.85 | 28.8 | 47.9 | 77.39 |
| 1983 | 4.75 | 6.23 | 29.4 | 51.5 | 78.02 |
| 1984 | 4.92 | 6.68 | 30.3 | 55.2 | 79.96 |
| 1985 | 5.06 | 7.21 | 31.2 | 59.4 | 81.72 |

*the prices are in constant 1972 dollars.

TABLE VI-4

*LINEAR WELLHEAD PETROLEUM PRICE PROFILES

| Year | Low crude Oil Price Profile ($/barrel) | High Crude Oil Price Profile ($/barrel | Low Natural Gas Price Profile (¢/mcf) | Medium Natural Gas Price Profile (¢/mcf) | High Natural Gas Price Profile (¢/mcf) |
|---|---|---|---|---|---|
| 1972 | 3.0 | 3.0 | 14 | 14 | 14 |
| 1973 | 3.15 | 3.32 | 15.3 | 17.4 | 21.55 |
| 1974 | 3.31 | 3.63 | 16.6 | 20.8 | 28.56 |
| 1975 | 3.46 | 3.95 | 17.9 | 24.3 | 35.23 |
| 1976 | 3.63 | 4.28 | 19.3 | 27.8 | 41.40 |
| 1977 | 3.79 | 4.60 | 20.6 | 31.3 | 47.27 |
| 1978 | 3.95 | 4.93 | 21.9 | 34.8 | 52.68 |
| 1979 | 4.10 | 5.25 | 23.2 | 38.3 | 57.80 |
| 1980 | 4.26 | 5.58 | 24.5 | 41.8 | 62.51 |
| 1981 | 4.43 | 5.90 | 25.9 | 45.3 | 66.97 |
| 1982 | 4.58 | 6.22 | 27.2 | 48.8 | 71.05 |
| 1983 | 4.75 | 6.55 | 28.5 | 52.4 | 74.90 |
| 1984 | 4.90 | 6.87 | 29.8 | 55.9 | 78.40 |
| 1985 | 5.06 | 7.21 | 31.2 | 59.4 | 81.72 |

*the prices are in constant 1972 dollars.

petroleum price profiles used in this thesis should be considered as speculative estimates rather than precise predictions.

In April, 1973 the Natural Gas Pipeline Company of America contracted to pay 50¢/mcf for wellhead natural gas in the Anadarko Basin field in the U.S. (26). On May 1, 1973 Imperial Oil Ltd. announced (27) that it was increasing the price of Western Canadian crude oil by 25¢/barrel. Thus it can be seen that petroleum prices are increasing rapidly and that the price profiles used in this analysis are not unreasonably high.

## CHAPTER VII

## INTERPRETATION OF RESULTS

In analyzing the results obtained from the model it must be remembered that:

1. many assumptions have been made in the development of the model and in the estimation of data, and
2. the prices and inflation rates estimated by the model are based only on wellhead petroleum price increases. The effects of other causes of inflation were not considered.

Thus the prices and inflation rates estimated by the model are not intended to be predictions. Rather they indicate the effect which increased wellhead petroleum prices could have on the industries studied.

The quantity FLA(k) is the inflation rate (industry k's required revenues per unit product in year t/ industry k's required revenues per unit product in year t-1) which if applied every year from 1973 to 1985 will bring the required revenues per unit product of industry k from the 1972 value to the 1985 value produced by the model. Thus FLA(k) gives an indication of the inflationary effect on the products of the different system industries which would be caused by greater wellhead petroleum prices.

Two methods are used in this chapter to show the effect of increasing wellhead petroleum prices on the required operating revenues/unit product of each system industry. The first method is to tabulate and examine the FLA(k) values which occur when certain wellhead petroleum price profiles are used. The second method is to construct graphs for certain industries showing the variation of their required operating revenues/unit product with time.

## 1. EFFECT OF INCREASED WELLHEAD NATURAL GAS PRICES

Each one of Table G-1 to G-8 shows the effect, on the revenues/unit product required by the system industries, of changing the wellhead natural gas profile while maintaining a particular wellhead crude oil price profile. From these tables it can be seen that the following five industries are the system industries which are most affected by wellhead natural gas price increases.

1. Natural gas utilities
2. Electric power industry
3. Fertilizer industry
4. Cement industry
5. Chemical industry

It will also be noticed from these tables that holding the wellhead natural gas price constant, instead of letting it reach one of the higher price profiles, will result in a significant reduction in the extra revenues required by all the system industries except oil refineries. This is particularly true for the above five industries.

Natural gas utilities used 19.1% of their revenues in 1972 (Appendix D) to pay for wellhead natural gas. Consequently, the price of this product will have a large effect on their required revenues. The other four industries are the only system industries which use large quantities of natural gas (from utilities). Thus it is the direct usage of this product which makes the required revenues of these industries more dependent on wellhead natural gas price than the required revenues of the other industries.

The indirect effects of increased wellhead natural gas prices are also important. This can be seen by examining any of the tables in Appendix G. Maintaining the same crude oil price profile and increasing the wellhead natural gas price profile results in a significant increase in all the FLA(k) values. Some of the system industries (e.g. the crop farming and railroad industries) have no direct natural gas expense. Consequently the increases in the FLA(k) values of these industries, which occur because of increased wellhead natural gas prices, are due solely to indirect effects.

Figures 4 - 9 are based on the results in Tables G-9 to G-14. Figures 4 and 6 display the results obtained for the chemical

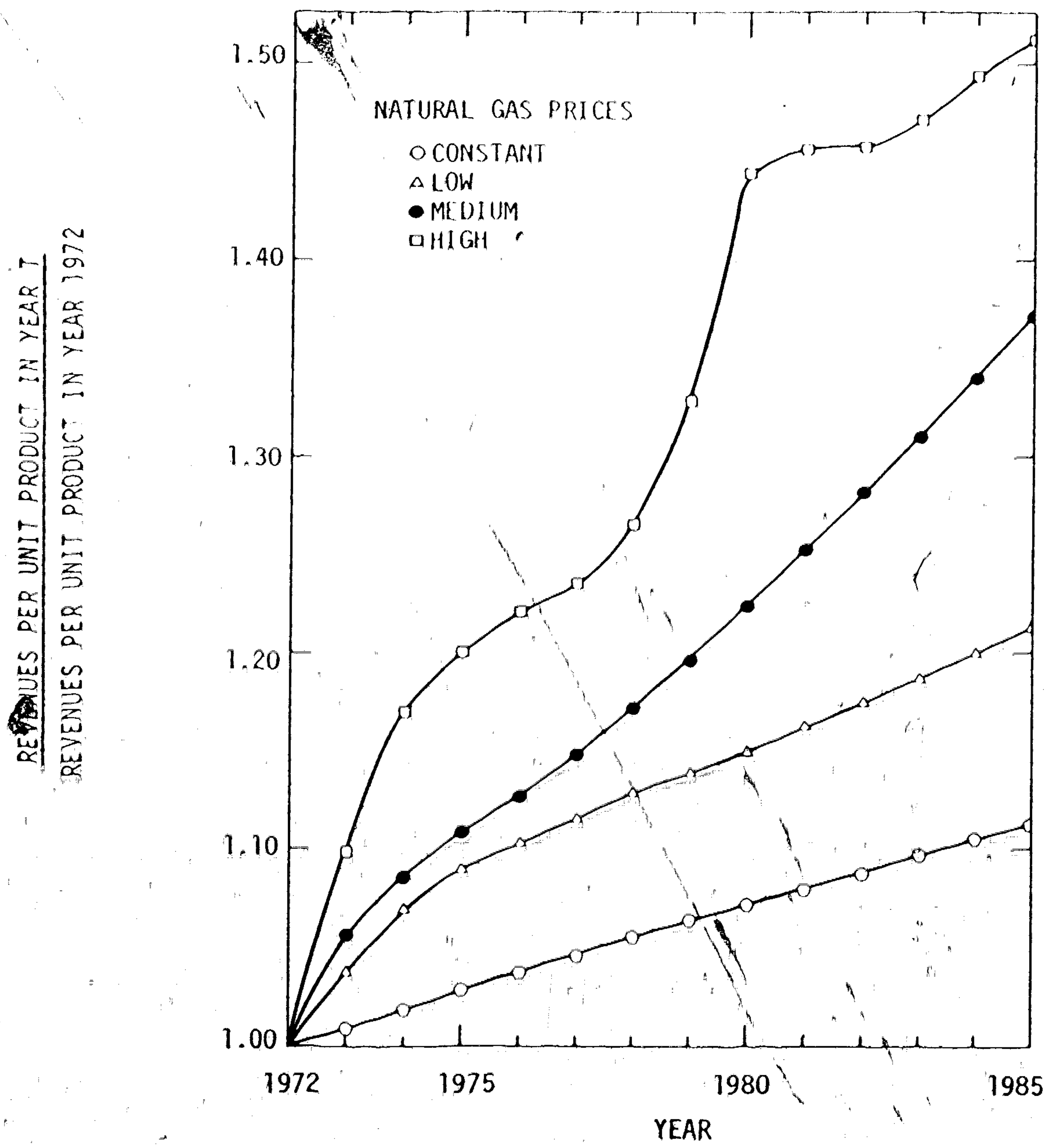


FIGURE 4 - Required Revenues of the Chemical Industry (Low Crude Oil Prices, Constant Value Dollars)

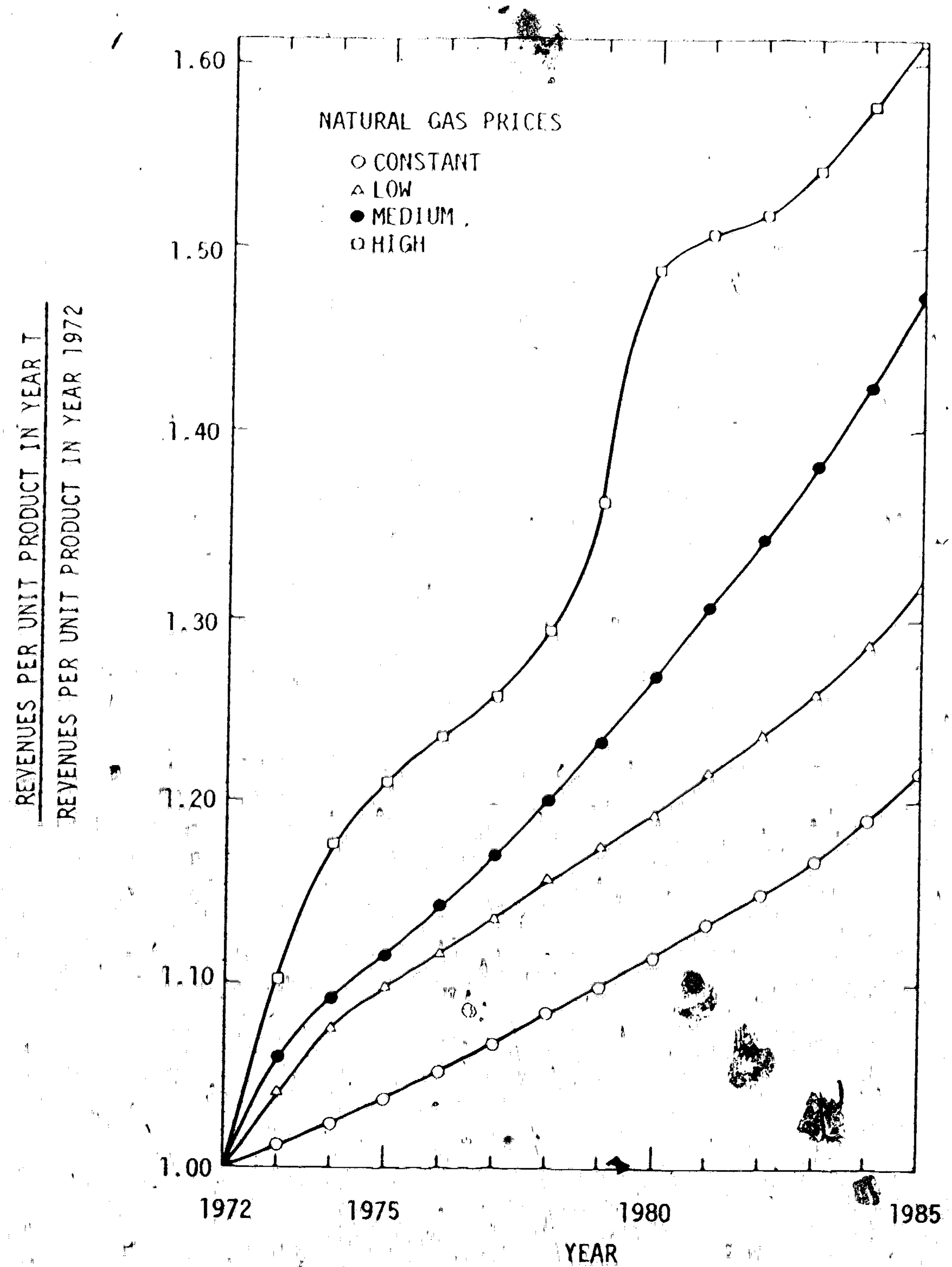


FIGURE 5 - Required Revenues of the Chemical Industry (High Crude Oil Prices, Constant Value Dollars)

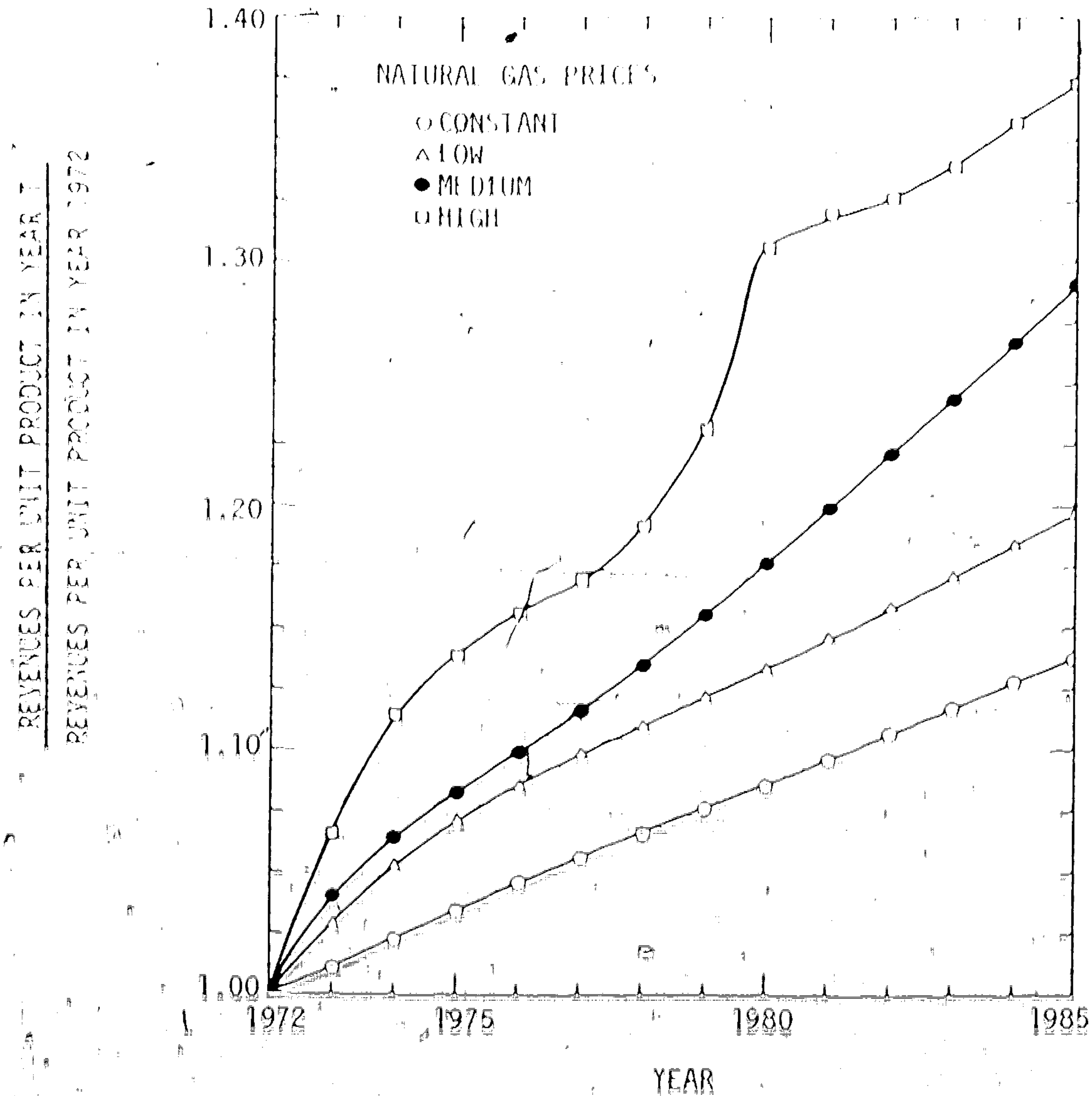


FIGURE 6 – Required Revenues of the Crop Farming Industry (Low Crude Oil Prices, Constant Value Dollars)

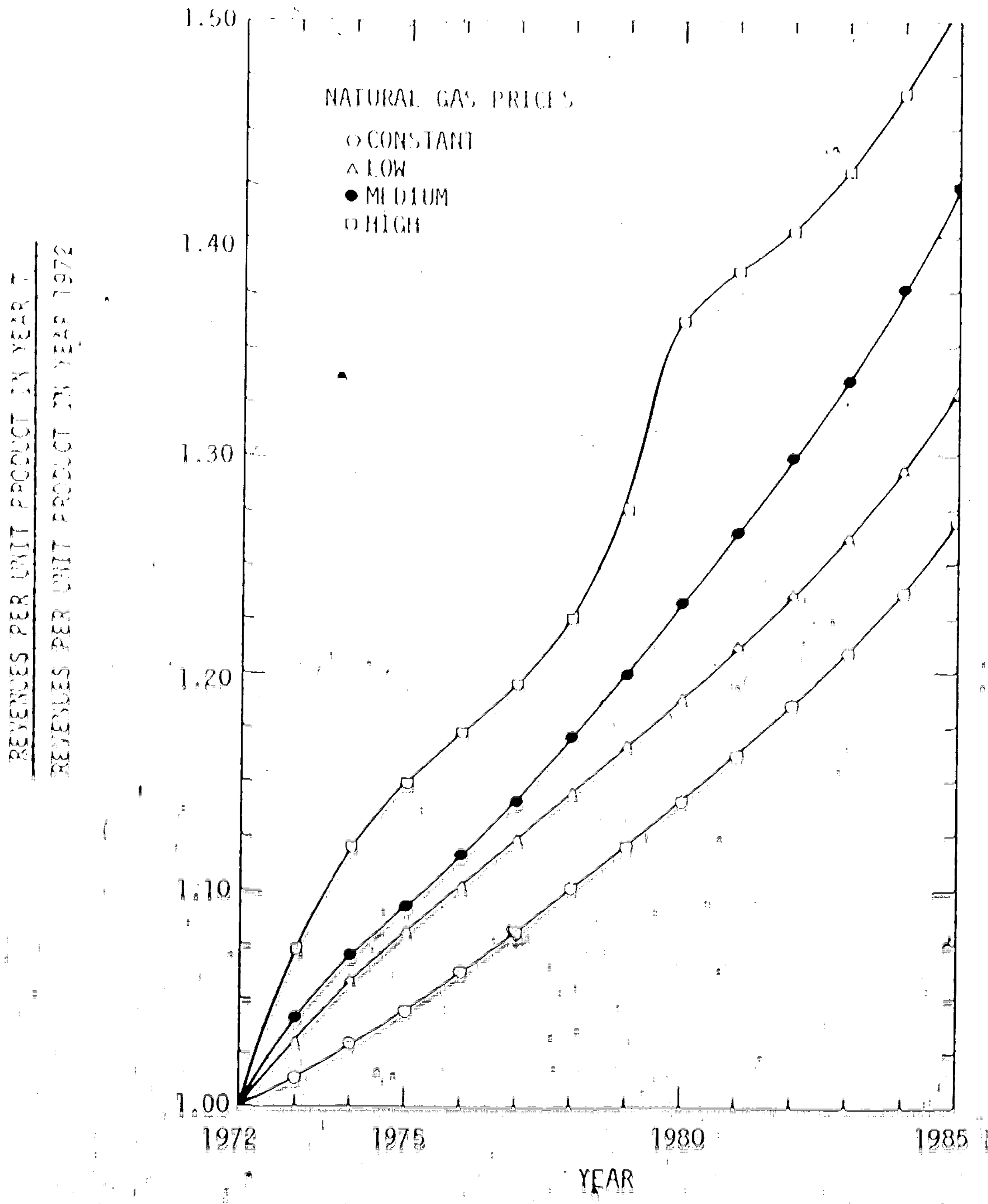


FIGURE 7 - Required Revenues of the Crop Farming Industry (High Crude Oil Prices, Constant Value Dollars)

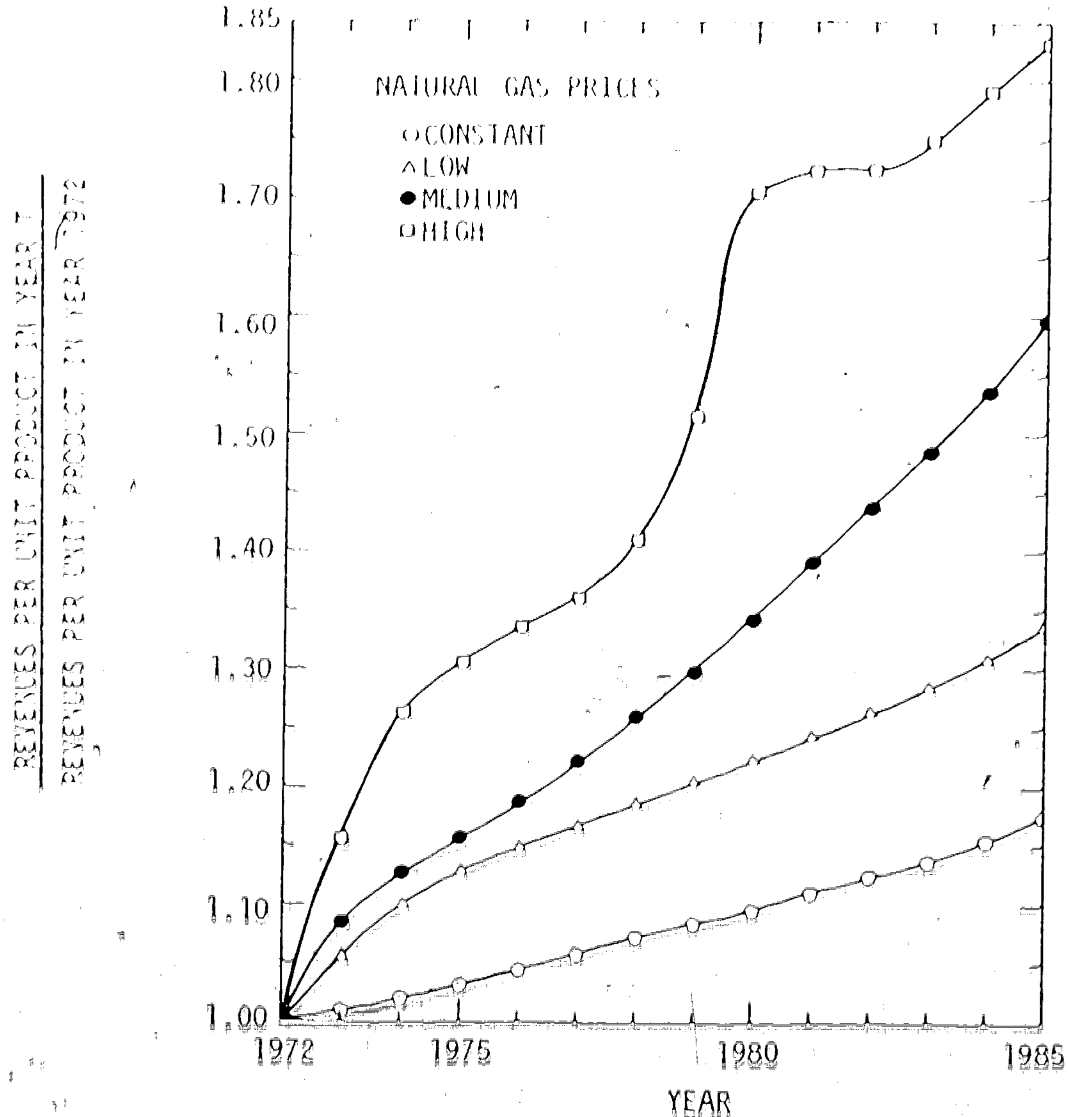


FIGURE 8 - Required Revenues of the Electric Power Industry (High Crude Oil Prices, Constant Value Dollars)

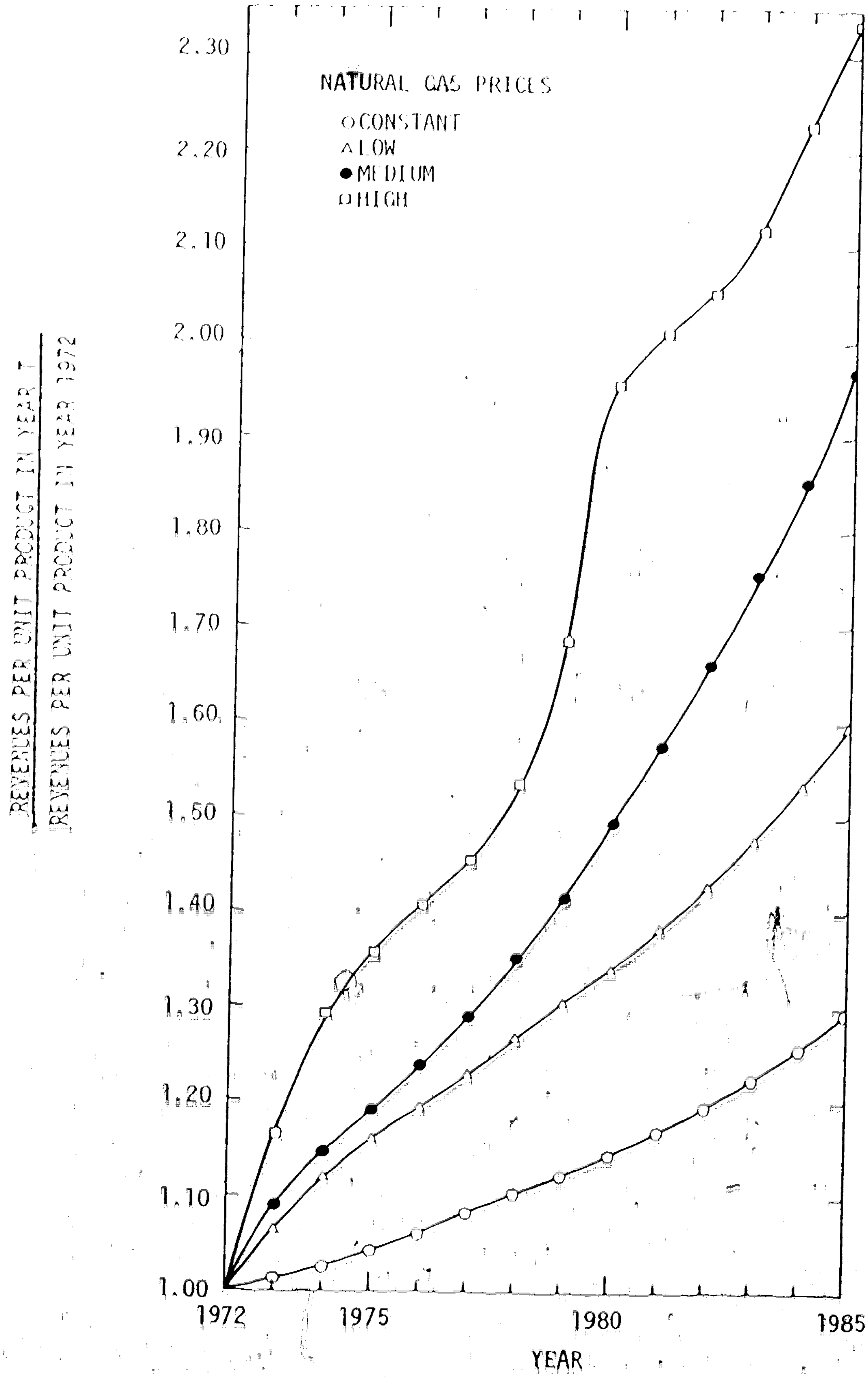


FIGURE 9 - Required Revenues of the Electric Power Industry (High Crude Oil Prices, Reduced Value Dollars)

industry and crop farming industry respectively. These figures result from the use of the wellhead petroleum price profiles in Table VI-3. They show the variation of required revenues with changes in the wellhead natural gas price profile when the low wellhead crude oil price profile was maintained. Figures 5, 7, and 8 show similar results for the chemical, crop farming, and electric power industries when the high wellhead crude oil price profile in Table VI-3 was used. Figure 9 shows the results obtained for the electric power industry when the wellhead petroleum price profiles used, in the estimation of Figure 8, were expressed in terms of reduced-value dollars.

Each graph in Figures 4 - 9 represents pictorially the effect on a particular industry's required revenues per unit product, for a given wellhead crude oil price profile, of using different wellhead natural gas price profiles.

## 2. EFFECT OF INCREASED WELLHEAD CRUDE OIL PRICES

The effect on any system industry of increasing wellhead crude oil prices can be seen by examining corresponding elements in Tables G-1 and G-2, G-3 and G-4, G-5 and G-6, and G-7 and G-8.

Table VII-1 is acquired from information in Appendix G. This table shows the results obtained from different wellhead crude oil price profiles when the wellhead natural gas price (in constant value dollars) was maintained at its 1972 value. Column 3 of Table VII-1 shows the results obtained when the low crude oil nonlinear

TABLE VII-1

EFFECT OF INCREASING WELLHEAD CRUDE OIL PRICE

(constant wellhead natural gas price)

| | CONSTANT CRUDE OIL PRICES | LOW CRUDE OIL PRICES | HIGH CRUDE OIL PRICES |
|---|---|---|---|
| FLA(1) | 1.000 | 1.008 | 1.015 |
| FLA(2) | 1.000 | 1.010 | 1.018 |
| FLA(3) | 1.000 | 1.010 | 1.018 |
| FLA(4) | 1.000 | 1.009 | 1.017 |
| FLA(5) | 1.000 | 1.008 | 1.015 |
| FLA(6) | 1.000 | 1.009 | 1.016 |
| FLA(7) | 1.000 | 1.008 | 1.015 |
| FLA(8) | 1.000 | 1.009 | 1.016 |
| FLA(9) | 1.000 | 1.010 | 1.019 |
| FLA(10) | 1.000 | 1.009 | 1.017 |
| FLA(11) | 1.000 | 1.008 | 1.015 |
| FLA(12) | 1.000 | 1.009 | 1.016 |
| FLA(13) | 1.000 | 1.010 | 1.018 |
| FLA(14) | 1.000 | 1.008 | 1.015 |
| FLA(15) | 1.000 | 1.008 | 1.015 |
| FLA(16) | 1.000 | 1.008 | 1.015 |
| FLA(17) | 1.000 | 1.008 | 1.015 |

TABLE VII-1 (continued)

| | CONSTANT CRUDE OIL PRICES | LOW CRUDE OIL PRICES | HIGH CRUDE OIL PRICES |
|---|---|---|---|
| FLA(18) | 1.000 | 1.008 | 1.015 |
| FLA(19) | 1.000 | 1.008 | 1.015 |
| FLA(20) | 1.000 | 1.009 | 1.016 |
| FLA(21) | 1.000 | 1.008 | 1.015 |
| FLA(22) | 1.000 | 1.008 | 1.015 |
| FLA(23) | 1.000 | 1.007 | 1.012 |
| FLA(24) | 1.000 | 1.031 | 1.055 |
| FLA(25) | 1.000 | 1.005 | 1.009 |
| FLA(26) | 1.000 | 1.003 | 1.007 |
| FLA(27) | 1.000 | 1.007 | 1.014 |
| FLA(28) | 1.000 | 1.008 | 1.015 |

price profile in Table VI-3 was used. Column 4 displays the FLA(k) values which were calculated for the high crude oil price profile in Table VI-3.

From Table VII-1 it can be seen that the petroleum refining industry (k = 24) is affected the most by increased wellhead crude oil prices. The oil pipeline (k = 25) and natural gas utility (k = 26) industries are affected the least. Increased wellhead crude oil prices produce nearly equal effects on the other 25 system industries. This is a very interesting result. Consider the chemical (k = 1) and aviation (k = 13) industries. For the same wellhead petroleum price profiles the value of FLA(13) is only slightly greater than FLA(1). Refinery products accounted for 0% of the revenues of the chemical industry in 1972 (Appendix D). They accounted for 7% of the aviation industry's revenues. Consequently it is apparent that feedback and other indirect effects in an economic system are very important.

## 3. EFFECT OF INCREASED WELLHEAD NATURAL GAS PRICES RELATIVE TO THE EFFECT OF INCREASED WELLHEAD CRUDE OIL PRICES

From an analysis of the results in Appendix G it is apparent that:

1. some industries are affected more by increased wellhead natural gas prices than by increased wellhead crude oil

prices,

2. the wellhead prices of natural gas and of crude oil are of almost equal importance to other industries, and

3. only the petroleum refining industry is affected significantly more by increased wellhead crude oil prices than by increased wellhead natural gas prices.

The above statements will appear reasonable after the following discussion on the chemical and crop farming industries has been concluded.

From an examination of Figures 4 and 5 it can be seen that the operating revenues per unit product required by the chemical industry are affected much more by changing the wellhead natural gas price profile than by changing the wellhead crude oil price profile. This is because

1. the difference (relative to the 1972 price of 14¢/MCF) between any two of the wellhead natural gas price profiles is greater than the difference (relative to the 1972 price of $3.0/barrel) between the high and low wellhead crude oil price profiles.

2. refinery product expense accounted for 0% of the chemical industry's revenues in 1972. The corresponding figure for natural gas (from utilities) expense was

2.7%.

From a comparison of Figures 6 and 7 it is apparent that increases in the price of wellhead crude oil and in the price of wellhead natural gas are of almost equal importance to the crop farming industry. This is because

1. wellhead natural gas prices are expected to increase more rapidly than wellhead crude oil prices, and
2. refinery product expense accounted for 4.2% of the crop farming industry's revenues in 1972. The corresponding figure for natural gas (from utilities) expense was 0%.

From the foregoing analysis of results in this section it is apparent that both the direct and indirect (feedback etc.) effects of increased refinery and natural gas utility product prices (due to increased wellhead petroleum prices) are important. Those industries which have a large consumption of these products are affected the most by wellhead petroleum price increases. However, the other industries are also affected significantly due to the interactions in the economic system.

## 4. RELATIVE IMPORTANCE OF THE INFLATIONARY EFFECTS WHICH WOULD RESULT FROM GREATER WELLHEAD PETROLEUM PRICES

Increased wellhead petroleum prices will produce inflationary effects. The relative importance of these effects can be seen by comparing the results in Appendix G to actual increases, in the prices of various Canadian commodities, which have occurred over the last decade. Tables VII-2 to VII-5 apply to Canada and they were obtained from a Dominion Bureau of Statistics catalogue (28).

From Table VII-2 it can be seen that the price of industrial chemicals remained practically constant from 1968 to 1971. The price of these commodities in December, 1972 relative to their price in January, 1972 was 1.02. For the range of wellhead petroleum prices examined the value of FLA(1) varied from 1.008 to 1.055.

From Table VII-3 it is apparent that the price of grains fell from 1969 to 1971. However, the price of these products in December, 1972 was 1.510 times its value in December, 1971. The values of FLA(2) in Appendix G ranged from 1.010 to 1.048.

Using the information in Table VII-4 it is easily shown that the 1972 price of electricity to domestic users relative to its price in 1971 was 1.027. The price in 1971 relative to the price in 1970 was 1.034. The values of FLA(23) in Appendix G ranged from 1.007 to 1.067.

The price of domestic gas in 1972 was 1.007 times its value in 1971. The price in 1971 relative to the price in 1970 was 1.014. The values of FLA(26) in Appendix G were in the range of 1.003 to 1.129.

TABLE VII-2

INDUSTRY SELLING PRICE INDEXES

(1961 price = 100)

| INDUSTRY | 1968 | 1969 | 1970 | 1971 | January 1972 | December 1972 |
|---|---|---|---|---|---|---|
| industrial chemicals | 96.3 | 96.0 | 94.7 | 95.4 | 96.1 | 98.2 |
| mixed fertilizers | 116.6 | 110.0 | 108.9 | 112.8 | 107.8 | 117.2 |
| feed | 107.5 | 105.8 | 108.0 | 110.2 | 108.2 | 127.8 |
| cement | 116.3 | 121.1 | 125.8 | 130.3 | 136.7 | 139.4 |
| wood | 135.9 | 146.0 | 131.3 | 145.3 | 156.8 | 191.5 |
| iron and steel mills | 103.0 | 106.7 | 112.6 | 118.0 | 120.5 | 124.8 |
| steel pipe and tube mills | 95.3 | 95.5 | 98.9 | 103.0 | 105.5 | 110.6 |
| petroleum refining | 97.8 | 99.7 | 102.8 | 113.7 | 113.8 | 115.3 |

TABLE VII-3

WHOLESALE PRICE INDEXES

(1935-39 price = 100)

| COMMODITY | 1969 | 1970 | 1971 | NOV. 1971 | DEC. 1971 | NOV. 1972 | DEC. 1972 |
|---|---|---|---|---|---|---|---|
| grains | 200.4 | 193.7 | 192.3 | 181.1 | 181.3 | 242.3 | 273.8 |
| livestock | 400.3 | 396.2 | 386.0 | 396.8 | 410.0 | 473.3 | 494.5 |

TABLE VII-4

CONSUMER PRICE INDEXES

(1961 price = 100)

| ITEM | 1970 | 1971 | 1972 | NOV. 1971 | DEC. 1971 | NOV. 1972 | DEC. 1972 |
|---|---|---|---|---|---|---|---|
| all items | 129.7 | 133.4 | 139.8 | 135.4 | 136.3 | 142.3 | 143.3 |
| streetcar and local bus fares | 175.5 | 178.6 | 180.3 | 179.6 | 179.8 | 180.6 | 180.6 |
| taxi fare | 135.1 | 136.9 | 146.7 | 137.6 | 137.6 | 150.7 | 150.7 |
| electricity | 121.9 | 126.1 | 129.5 | 127.0 | 127.2 | 131.3 | 131.3 |
| domestic gas | 100.8 | 102.2 | 102.9 | 102.7 | 102.7 | 102.9 | 102.9 |

TABLE VII-5

BUILDING CONSTRUCTION PRICE INDEXES

(1961 price = 100)

| | 1969 | 1970 | 1971 | NOV. 1971 | DEC. 1971 | NOV. 1972 | DEC. 1972 |
|---|---|---|---|---|---|---|---|
| residential | 151.4 | 162.2 | 176.6 | 184.0 | 184.0 | 206.0 | 206.5 |
| non-residential | 143.3 | 155.1 | 168.3 | 174.5 | 174.8 | 190.0 | 190.4 |

The above examples indicate that the following statements are valid. Greater wellhead petroleum prices will cause increases in the prices of commodities produced in Alberta. These increases can be considered important relative to previous increases which occurred in the prices of Canadian commodities.

## 5. EFFECT OF INCREASED WELLHEAD PETROLEUM PRICES ON COMPONENTS OF SYSTEM INDUSTRIES

It should also be noted that some of the system industries were comprised of a number of smaller component industries. For example, the wood industry consisted of sawmills, planing mills, and many other industries engaged in activities relating to wood. The chemical industry was comprised of the petrochemical, organic chemical, inorganic chemical, and other chemical producing industries.[4] The effect of increased wellhead petroleum prices on any of these smaller industries may be much greater than the effect on their combination. For example, petrochemical product prices in Alberta will probably be increased (due to greater wellhead petroleum prices) more than the average product price of the entire chemical industry.

## 6. DEPENDENCE OF THE RESULTS ON THE SHAPE OF THE WELLHEAD PETROLEUM PRICE PROFILES

If construction expense was treated as an operating cost for every system industry then (for given 1985 wellhead petroleum prices) the values of the 1985 prices of the system products (and consequently of the FLA(k)s) would be independent of the shape of the wellhead petroleum profiles. However, for some industries construction expense is treated as a capital cost. The depreciation expense of these industries will depend on the construction costs it incurred in earlier years. These construction costs were dependent on wellhead petroleum prices. Thus the depreciation expense, and consequently the FLA(k) values, will be greater in 1985 the more quickly the wellhead petroleum prices increased in earlier years.

The wellhead petroleum price profiles which would give the largest FLA(k) values (for given 1985 petroleum prices) would be those where the wellhead petroleum prices rose from their 1972 to their 1985 values in one year. Thus, to estimate the dependence of the computed FLA(k) values on the shape of the wellhead petroleum price profiles, the following procedure was adopted. The model was used to calculate the FLA(k) values which would result if the prices of wellhead natural gas and crude oil went to $1.20/MCF and $10.60/barrel, respectively in 1972 and remained at these values until 1985. The results obtained from these calculations were compared with those acquired when the prices of wellhead petroleum products went linearly to 1985 values of $1.20/MCF and $10.60/barrel. The maximum difference obtained in a FLA(k) value was only 0.002. The FLA(k) values for these 1985 wellhead petroleum prices are of the order of 1.04. Thus for given 1985 wellhead petroleum prices the FLA(k) values (and consequently the prices of the system products in 1985) are nearly independent of the wellhead petroleum price profile. Their only significant dependence is on the 1985 wellhead petroleum prices.

The prices of the system products in intervening years will, however, depend on the shape of the wellhead petroleum price profiles. If the wellhead petroleum prices rise gradually from 1972 to 1985 then so also will the prices of the system products. However, a sharp increase in the price of a wellhead petroleum product will cause a similar increase in the price of the system products. In Figures 4 and 5 the required operating revenues per unit product of the chemical industry, corresponding to the high natural gas price profile, increased rapidly between 1978 and 1980. This was because the high wellhead natural gas price profile rose sharply from 1978 to 1980. Similarly, the price profile of any system product will follow the same trend as the wellhead petroleum prices used in its determination.

## 7. DEPENDENCE OF THE RESULTS ON WHETHER THE VALUE OF THE DOLLAR IS REDUCED

Two sets of wellhead petroleum price profiles were discussed in Chapter VI. They were based on the following two assumptions:

1. zero reduction in the value of the dollar, and

2. $\frac{\text{value of the dollar in year t}}{\text{value of the dollar in year t+1}} = 1.03.$

The first set of petroleum prices (Tables VI-3 and VI-4) was based on assumption 1. The results obtained from this set are shown in Tables G-1 to G-4. The second set of petroleum prices was based on assumption 2. The results from this set are contained in Tables G-5 to G-8.

The effect of using assumption 1 instead of assumption 2 (or vice versa) can be seen by comparing corresponding elements in Tables G-1 and G-5, G-2 and G-6, G-3 and G-7, and G-4 and G-8. Assumption 2 produces higher wellhead petroleum prices than assumption 1. These in turn lead to higher FLA(k) values. Thus any figure in Table G-5 is greater than the corresponding one in Table G-1. The dissimilarity in results obtained by using different assumptions (as regards the future value of the dollar) can be seen pictorially for the electric power industry by comparing Figures 8 and 9. The curves in Figure 9 are steeper and attain higher 1985 values.

The results obtained from using wellhead petroleum prices expressed in reduced-value dollars indicate the increase in revenues (in actual dollars) which would be required by the system industries if the value of the dollar was to decrease in the future. Those obtained from using constant-value dollars indicate the increased revenues (in actual dollars) which would be needed by these industries if the value of the dollar was to remain equal to its 1972 value.

## 8. SENSITIVITY

To test the sensitivity of the results to variations in the input data a sample calculation was undertaken. The electric power industry is the one where there is most likely to be changes in the amount of natural gas consumed in unit production. Consequently, it was decided to estimate the effect on the FLA(k) values of changing $comp_{26,23}(1972)$, where $comp_{26,23}(1972)$ is the estimated fraction of the revenues obtained by the electric power industry in 1972 which was used to pay for the natural gas (from the gas utility industry) it consumed.

The variable $comp_{26,23}(1972)$ was reduced by 0.024 (i.e. its value was halved) and $comp_{28,23}(1972)$ was increased by 0.024. The quantity $comp_{28,23}(1973)$ is the estimated fraction of the revenues obtained by the electric power industry in 19[illegible] was used to pay for the "other expense" it incurred. With these new $comp_{jk}(1972)$ values the model calculated FLA(k) values which would result from the high nonlinear wellhead petroleum price profiles in columns 3 and 6 of Table VI-3. These FLA(k) values are shown in column 2 of Table VII-6. Column 3 of this table displays the FLA(k) values which were obtained when using the "actual" $comp_{jk}$ (1972) values (those used to estimate the effect of wellhead petroleum price increases) and the same wellhead petroleum price profiles. From Table VII-6 it can be seen that reducing the value of $comp_{26,23}(1972)$ by 0.024 and increasing $comp_{28,23}(1972)$ by the same amount caused FLA(k) for the electric power industry to fall from 1.048 to 1.034. The value of FLA(k) also decreased for the other 27 industries. However, for these industries the maximum reduction in FLA(k) was 0.003.

## 9. DEPRECIATION OF "OTHER ASSETS"

Depreciable assets (machinery etc.) which are not produced by the construction industry are called "other assets". In the model equations the depreciation of these assets was included in the "other expense" term. A sample calculation was undertaken in order to estimate the change in the results which would have occurred if the depreciation of "other assets" had been included as a separate entity in the model equations. In this calculation the high nonlinear wellhead petroleum price profiles in columns 3 and 6 of Table VI-3 were used.

Column 2 of Table VII-7 shows the FLA(k) values obtained

TABLE VII-6

EFFECT OF CHANGING $comp_{26,23}(1972)$

| | RESULTS FOR ACTUAL $comp_{26,23}(1972)$ | RESULTS FOR CHANGED $comp_{26,23}(1972)$ |
|---|---|---|
| FLA(1) | 1.038 | 1.035 |
| FLA(2) | 1.032 | 1.030 |
| FLA(3) | 1.031 | 1.029 |
| FLA(4) | 1.031 | 1.029 |
| FLA(5) | 1.043 | 1.040 |
| FLA(6) | 1.031 | 1.028 |
| FLA(7) | 1.029 | 1.026 |
| FLA(8) | 1.030 | 1.028 |
| FLA(9) | 1.032 | 1.029 |
| FLA(10) | 1.031 | 1.028 |
| FLA(11) | 1.029 | 1.027 |
| FLA(12) | 1.030 | 1.028 |
| FLA(13) | 1.032 | 1.029 |
| FLA(14) | 1.030 | 1.027 |
| FLA(15) | 1.030 | 1.027 |
| FLA(16) | 1.030 | 1.027 |
| FLA(17) | 1.041 | 1.038 |

TABLE VII-6 (continued)

| | RESULTS FOR ACTUAL $comp_{26,23}(1972)$ | RESULTS FOR CHANGED $comp_{26,23}(1972)$ |
|---|---|---|
| FLA(18) | 1.029 | 1.027 |
| FLA(19) | 1.030 | 1.027 |
| FLA(20) | 1.033 | 1.030 |
| FLA(21) | 1.032 | 1.029 |
| FLA(22) | 1.032 | 1.029 |
| FLA(23) | 1.048 | 1.034 |
| FLA(24) | 1.059 | 1.058 |
| FLA(25) | 1.021 | 1.018 |
| FLA(26) | 1.100 | 1.100 |
| FLA(27) | 1.028 | 1.025 |
| FLA(28) | 1.029 | 1.027 |

TABLE VII-7

EFFECT OF ALLOWING FOR ALL DEPRECIATION EXPENSE

| INDUSTRY k | $\hat{FLA}(k)$ (before allowance) | FLA(k) (after allowance) |
|---|---|---|
| 1 | 1.038 | 1.034 |
| 2 | 1.032 | 1.027 |
| 3 | 1.031 | 1.026 |
| 4 | 1.031 | 1.026 |
| 5 | 1.043 | 1.038 |
| 6 | 1.031 | 1.027 |
| 7 | 1.029 | 1.025 |
| 8 | 1.030 | 1.026 |
| 9 | 1.032 | 1.027 |
| 10 | 1.031 | 1.026 |
| 11 | 1.029 | 1.025 |
| 12 | 1.030 | 1.026 |
| 13 | 1.032 | 1.027 |
| 14 | 1.030 | 1.026 |
| 15 | 1.030 | 1.026 |
| 16 | 1.030 | 1.026 |
| 17 | 1.041 | 1.036 |

TABLE VII-7 (continued)

| INDUSTRY k | FLA(k)* (before allowance) | FLA(k) (after allowance) |
|---|---|---|
| 18 | 1.029 | 1.025 |
| 19 | 1.030 | 1.026 |
| 20 | 1.033 | 1.028 |
| 21 | 1.032 | 1.028 |
| 22 | 1.032 | 1.027 |
| 23 | 1.048 | 1.045 |
| 24 | 1.059 | 1.057 |
| 25 | 1.021 | 1.018 |
| 26 | 1.100 | 1.099 |
| 27 | 1.028 | 1.025 |
| 28 | 1.029 | 1.026 |

when depreciation of "other assets" is included in "other expense". Column 3 shows the corresponding values when depreciation of "other assets" is considered as a separate entity and is treated as shown in Appendix F. It can be seen that the entries in column 2 are all greater than the corresponding values in column 3. Also the maximum difference between corresponding FLA(k) values is 0.005. Consequently, the inclusion of depreciation of "other assets" in "other expense" biased the FLA(k) values in an upward direction. However, considering the other assumptions made, this bias cannot be considered crucial.

# CHAPTER VIII

## CONCLUSIONS

1. Of the industries analyzed the following five would be most affected by increases in wellhead natural gas prices:

   a. natural gas utilities

   b. electric power industry

   c. fertilizer industry

   d. cement industry

   e. chemical industry

2. The petroleum refining industry would be affected the most by increases in the wellhead crude oil price.

3. In analyzing an economic system it is important to consider the interactions between the different system industries.

4. Some industries (e.g. the chemical industry) are affected more by increased wellhead natural gas prices than by increased wellhead crude oil prices.

5. The wellhead prices of natural gas and of crude oil are of almost equal importance to some industries (e.g. the crop farming industry).

6. Only the petroleum refining industry is affected significantly more by increased wellhead crude oil prices than by increased wellhead natural gas prices.

7. If the wellhead prices of crude oil and natural gas were to increase annually to 1985 values of \$7.21/barrel and 81.72¢/mcf, respectively, then this could cause yearly increases of the

order of 3%, in the prices of commodities produced in Alberta.

8. Replacement of half of the natural gas used by the electric power industry with coal would not significantly reduce the dependence of the other system industries' required operating revenues on the price of wellhead petroleum products.

9. Treatment of the depreciation of "other assets" as a separate entity in the model equations would not change any of the above conclusions.

NOMENCLATURE

| | |
|---|---|
| $a_{ij}$ | represents the quantity of commodity i required by industry j to produce one unit of product j. |
| $A_{jk}(t)$ | this variable is used in equation (A-9). It is defined after that equation. |
| AC(t) | this variable is used in Appendix C. It is equal to 2.0 YI(t) - 1.7 YR(t). |
| AI(t) | this variable is used in Appendix C. It is equal to 2.0 YI(t) - 1.7 YR(t) - 2.0. |
| AR(t) | this variable is used in Appendix C. It is equal to 2.0 YI(t) - 1.7 YR(t) + 1.7. |
| $b_{jk}$ | a constant (for given j and k) which is used in equation (A-7) and is estimated in Appendix B. |
| $B_{jk}(t)$ | this variable is used in equation (A-9). It is defined after that equation. |
| $BIE_k(t)$ | the interest on debt capital, per unit product, which industry k must pay in year t. |
| $c_e(t)$ | a variable used in equation (A-8) and estimated in Appendix C. |
| $c_{jk}(t)$ | this variable is used in equation (A-9). It is defined after that equation. |

NOMENCLATURE (continued)

$comp_{jk}(t)$ the fraction of industry k's revenues in year t which is used to pay for the amount of product j it requires.

$d_c(t)$ is a variable used in equation (A-8) and estimated in Appendix C.

$DEPN_k(t)$ is the estimated fraction of industry k's operating revenues in year t which were allocated to compensate for the depreciation of "other assets".

FLA(k) is the inflation rate (industry k's required revenues per unit product in year t/industry k's required revenues per unit product in year t-1) which if applied every year from 1973 to 1985 will bring the required revenues per unit product of industry k from the 1972 value to the 1985 value produced by the model.

$h_{jk}(t)$ is the cost incurred by industry k in year t in buying one unit of product j.

$I_k(t)$ $P_k(t)/P_k(t-1)$.

n is the number of system industries.

op $cost_{ji}$ is the cost to industry i of buying the amount of product j which it requires for unit production.

op $cost_{jk}(t)$ is the cost to industry k, assigned to year t, of buying the amount of product j, $1 \leq j \leq 27$, which it requires for unit production in year t.

NOMENCLATURE (continued)

| | |
|---|---|
| op $cost_{28,k}(t)$ | is defined by equation (A-1). |
| $P_j$ | is the price of one unit of product j. |
| $P_k(t)$ | represents the revenues obtained per unit product by industry k in year t. Except for natural gas utilities (k=26) it also represents the price of one unit of product k in year t. |
| PC(t) | is used in Appendix C. It is the price paid by the commercial consumer for natural gas. |
| PI(t) | is used in Appendix C. It is the price paid in year t by the industrial consumer for natural gas. |
| PR(t) | is used in Appendix C. It is the price paid in year t by the residential consumer for natural gas. |
| $PROF_k(t)$ | is the profit (before payment of income taxes) per unit product which is required by industry k in year t. |
| $RG_k(t)$ | is the cost to industry k of buying the amount of wellhead natural gas in year t which it requires for unit production. |
| $RO_k(t)$ | is the cost to industry k of buying the amount of wellhead crude oil in year t which it requires for unit production. |

NOMENCLATURE (continued)

RPG(t) — $\frac{\text{wellhead natural gas price in year } t}{\text{wellhead natural gas price in year } t\text{-}1}$

RPO(t) — $\frac{\text{wellhead crude oil price in year } t}{\text{wellhead crude oil price in year } t\text{-}1}$

t — year

$v_i$ — is the cost per unit product to industry i of using commodities (including capital) obtained from outside the economic system.

$v_i(t)$ — is the cost per unit product to industry i in year t of using commodities (including capital) obtained from outside the economic system.

$x_i$ — is the physical output from industry i.

$y_i$ — is the final demand for product i.

YC(t) — is used in Appendix C. It is the fraction of the natural gas volume sold in year t which is bought by commercial consumers.

YI(t) — is used in Appendix C. It is the fraction of the natural gas volume sold in year t which is bought by industrial consumers.

YR(t) — is used in Appendix C. It is the fraction of the natural gas volume sold in year t which is bought by residential consumers.

NOMENCLATURE (continued)

$z_{jk}$ — is a constant (for given j and k) which is used in equation (A-7) and is estimated in Appendix B.

Subscripts

e — designates the category of natural gas user to which an industry belongs

i — refers to industry i

j — refers to industry j

k — refers to industry k

l — refers to a commercial user of natural gas

m — refers to an industrial user of natural gas

n — refers to a residential user of natural gas

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APPENDIX A

DEVELOPMENT OF MODEL

Twenty-eight industries are analysed in this thesis. They are assigned classification numbers and these are shown in the following table.

Table A-1.

INDUSTRY CLASSIFICATION NUMBERS

| Industry Number | Industry Title |
|---|---|
| 1 | industrial chemicals |
| 2 | crop farming |
| 3 | livestock farming |
| 4 | "other farming" |
| 5 | fertilizer |
| 6 | feed |
| 7 | railroad |
| 8 | truck |
| 9 | inland water transport |
| 10 | Pacific water transport |
| 11 | urban transit |
| 12 | taxi |
| 13 | aviation |
| 14 | industrial construction |
| 15 | residential construction |
| 16 | architectural metals |
| 17 | cement |

Table A-1 Continued - Industry Classification Numbers

| Industry Number | Industry Title |
|---|---|
| 18 | forestry |
| 19 | wood |
| 20 | iron mines |
| 21 | iron and steel mills |
| 22 | steel pipe and tube mills |
| 23 | electricity |
| 24 | refinery products |
| 25 | oil pipeline |
| 26 | natural gas |
| 27 | labour |
| 28 | dummy |

Each of the industries in Table A-1 is called a "system industry". Any industry which is not in Table A-1 is not a system industry. The "dummy industry" produces all those products, excluding wellhead petroleum products, which are used by the system industries, and which are not produced by any of the other system industries. Thus the revenues of each system industry are consumed in paying for the following expenses:

1. purchase of the products of the 28 system industries,
2. interest payments,
3. profits,
4. purchase of wellhead crude oil, and
5. purchase of wellhead natural gas.

## DEVELOPMENT OF MODEL

It is desired to estimate, until 1985, the effect which increasing wellhead petroleum prices will have on the price of the commodities produced by the 28 system industries. To accomplish this a model was used which estimates prices, relative to 1972 prices, of the 28 industry products for each year from 1973 to 1985. The model is developed in this appendix. In its development there are three major steps undertaken and they are as follows:

1. development of an equation for each system industry which relates its revenues to its inputs (equation A-1).
2. development of an equation which relates the price of each system product k in year t ($P_k(t)$) to its price in year t-1 ($P_k(t-1)$) (equation A-2).
3. development of a set of simultaneous equations whose solution will yield all the values of $P_k(t)/P_k(t-1)$ for $1 \leq k \leq 28$ (equations A-19).

### STEP 1

### RELATION BETWEEN REVENUES AND COSTS

The price obtained for the product of an industry is equal to the costs (including profits etc.) incurred in its production. This statement is written in the form of an equation for each of the 28 industries as follows:

$$P_k(t) = \text{op cost}_{1k}(t) + \text{op cost}_{2k}(t) + \text{----} \; \text{op cost}_{28,k}(t)$$
$$+ BIE_k(t) + PROF_k(t) + RO_k(t) + RG_k(t)$$
$$k = 1, 2, \ldots\ldots\ldots 28 \qquad \text{(A-1)}$$

where $P_k(t)$ is the revenue obtained per unit product in year t by industry k.

op $\text{cost}_{jk}(t)$ is the cost to industry k, assigned to year t, of buying the amount of product j, $1 \leq j \leq 27$, which it requires for unit production in year t. Product j is produced by the industry whose industrial classification number is equal to the value of j.

op $\text{cost}_{28,k}(t)$ is defined by equation (A-1). It includes all those costs which have not been allowed for by the other terms on the right hand side of equation (A-1).

$BIE_k(t)$ is the interest on debt capital, per unit product, which industry k must pay in year t.

$PROF_k(t)$ is the profit (before payment of income taxes) per unit product which is required by industry k in year t.

$RO_k(t)$ is the cost to industry k of buying the amount of wellhead crude oil in year t which it requires for unit production.

$RG_k(t)$ is the cost to industry k of buying the amount of wellhead natural gas in year t which it requires for unit production.

STEP 2

RELATION BETWEEN PRICES IN CONSECUTIVE YEARS

Equation A-1 is divided by $P_k(t-1)$ to yield:

$$\frac{P_k(t)}{P_k(t-1)} = \sum_{j=1}^{28} \frac{\text{op cost}_{jk}(t)}{P_k(t-1)} + \frac{BIE_k(t)}{P_k(t-1)} + \frac{PROF_k(t)}{P_k(t-1)}$$

$$+ \frac{RO_k(t)}{P_k(t-1)} + \frac{RG_k(t)}{P_k(t-1)}$$

$k = 1, 2, \ldots\ldots 28$ (A-2)

STEP 3

EQUATIONS WHOSE SOLUTION YIELDS EACH $P_k(t)/P_k(t-1)$

To simplify matters a new variable will be defined as

$I_k(t) = P_k(t)/P_k(t-1)$ $\quad k = 1, 2, \ldots\ldots 28$

All of the terms in equations (A-2) will be expressed in terms of the $I_k(t)$ values and previously evaluated variables. When this has been achieved there will be a set of 28 simultaneous equations which must be solved for 28 unknowns (the $I_k(t)^s$).

Each term on the right hand side of equation (A-2) will how be considered.

$$\frac{\text{op cost}_{jk}(t)}{P_k(t-1)} = \frac{\text{op cost}_{jk}(t)}{\text{op cost}_{jk}(t-1)} \cdot \frac{\text{op cost}_{jk}(t-1)}{P_k(t-1)}$$

$j = 1, 2, \ldots 28$

$k = 1, 2, \ldots 28$

Therefore,

$$\frac{\text{op cost}_{jk}(t)}{P_k(t-1)} = \frac{\text{op cost}_{jk}(t)}{\text{op cost}_{jk}(t-1)} \cdot \text{comp}_{jk}(t-1) \qquad \text{(A-3)}$$

$j = 1, 2, \ldots 28$

$k = 1, 2, \ldots 28$

where
$$comp_{jk}(t-1) = \frac{op\ cost_{jk}(t-1)}{P_k(t-1)},$$

$j = 1, 2, \ldots, 28$

$k = 1, 2, \ldots, 28$

The value of $comp_{jk}(t-1)$ will be known in year t as it will have been previously evaluated (if t-1 > 1972) or specified (if t-1 = 1972). The next step is to relate $op\ cost_{jk}(t)/op\ cost_{jk}(t-1)$ to the $l_j(t)$ variables.

It is assumed that the physical amount of inputs required for unit production in any industry are constant (i.e. there are fixed technological coefficients). It follows from this assumption that

$$\frac{op\ cost_{jk}(t)}{op\ cost_{jk}(t-1)} = \frac{h_{jk}(t)}{h_{jk}(t-1)} \qquad (A-4)$$

$j = 1, 2, \ldots, 28$
$k = 1, 2, \ldots, 28$

where $h_{jk}(t)$ is the cost incurred by industry k in year t in buying one unit of product j. If constant technological coefficients were not used then it would be necessary to predict changes in their values. To do this accurately would require an exhaustive research effort.

For most industries j, it is reasonable to assume that if its revenues per unit product in year t become greater then the cost of product j to all industries k in that year will be increased in the same proportion. This assumption can be stated in mathematical form as follows:

$$\frac{h_{jk}(t)}{h_{jk}(t-1)} = \frac{P_j(t)}{P_j(t-1)} \qquad \text{(A-5)}$$

Equation (A-5) applies for all j and k ($1 \leq j \leq 28$; $1 \leq k \leq 28$) apart from those exceptions which will now be discussed. This equation is not used for the industrial construction expense (j=14) incurred by some industries ($k \in \{2, 3, 4, 7, 23, 25, 26, 28\}$). This is because the construction costs of these industries are considered to be capital costs and are distributed over a number of years. Similarly, the residential construction expense (j=15) of the labour industry (k=27) is spread over a number of years and is considered to be an exception to equation (A-5). Natural gas expense (j=26) is not represented by equation (A-5) for any k value. This is because natural gas users pay three different prices (commercial, industrial, and residential) for natural gas.

From equations (A-4) and (A-5), and the definition of $l_j(t)$ it follows that

$$\frac{\text{op cost}_{jk}(t)}{\text{op cost}_{jk}(t-1)} = l_j(t) \qquad \text{(A-6)}$$

$k = \{1,2,\ldots,28\}$ and $j = \{1,2,\ldots,13,16,17,\ldots,25,27,28\}$

$k = \{1,5,6,8,9,\ldots,22,24,27\}$ and $j = 14$

$k = \{1,2,\ldots,26,28\}$ and $j = 15$

Equations (A-5) and (A-6) possess the same exceptions. Equations analogous to equation (A-6) have been developed for these exceptions.

The following equation is developed in Appendix B for those industries whose construction costs are distributed over a number of years:

$$\frac{\text{op cost}_{jk}(t)}{\text{op cost}_{jk}(t-1)} = \frac{z_{jk} + l_j(t-1)}{b_{jk}} \qquad \text{(A-7)}$$

$k \epsilon \{2,3,4,7,23,25,26,28\}$ and $j=14$

$K= 27$ and $j=15$

The following equations were developed in Appendix C and they are applicable for natural gas expense.

$$\frac{\text{op cost}_{26k}(t)}{\text{op cost}_{26k}(t-1)} = c_e(t) + d_e(t) \times l_{26}(t)$$

$$k = 1,2,\ldots,28 \qquad \text{(A-8)}$$

$$e = 1,2, \text{ or } 3$$

where $c_e(t)$ and $d_e(t)$ are variables which will have been evaluated before equation (A-8) is used. They are described in greater detail in Appendix C. The value of e selected for a given k will depend on whether industry k is a commercial, industrial, or residential consumer of natural gas. These consumers are represented by e values of 1, 2, and 3 respectively.

Equations (A-6), (A-7), and (A-8) are combined to give an equation which is valid for all j and k. It is

$$\frac{\text{op cost}_{jk}(t)}{\text{op cost}_{jk}(t-1)} = \frac{A_{jk}(t) + C_{jk}(t) \times l_j(t)}{B_{jk}} \qquad \text{(A-9)}$$

$$j = 1,2,\ldots,28$$

$$k = 1,2,\ldots,28$$

7

where

$A_{jk}(t) = 0$, and $C_{jk}(t) = B_{jk}$ if $k \epsilon \{1,2,\ldots,28\}$ and $j \epsilon \{1,2,\ldots,13,16,17,18,\ldots,25,27\}$ or if $k \epsilon \{1,5,6,8,9,\ldots,22,24,27\}$ and $j=14$ or if $k \epsilon \{1,2,\ldots,26,28\}$ and $j=15$.

$A_{jk}(t) = z_{jk}, C_{jk}(t) = \frac{1_j(t-1)}{1_j(t)}$ and $B_{jk} = b_{jk}$ if $k \epsilon \{2,3,4,7,23,25,26,28\}$ and $j=14$ or if $k = 27$ and $j = 15$.

$A_{jk}(t) = c_e(t)$, $C_{jk}(t) = d_e(t)$, and $B_{jk} = 1$ if $k \epsilon \{1,2,\ldots,28\}$ and $j = 26$

If op $cost_{jk}(t)$ and op $cost_{jk}(t-1)$ are both zero then it is still reasonable to use equation (A-9) as under these conditions the term representing op $cost_{jk}(t)$/op $cost_{jk}(t-1)$ will eventually be multiplied by zero and will drop out of the analysis.

From equations (A-2), (A-3) and (A-9), and the definition of $1_k(t)$ it follows that

$$1_k(t) = \sum_{j=1}^{28} \left\{ \frac{A_{jk}(t) + C_{jk}(t) \times 1_j(t)}{B_{jk}} \times comp_{jk}(t-1) \right\} + \frac{BIE_k(t)}{P_k(t-1)} + \frac{PROF_k(t)}{P_k(t-1)} + \frac{RO_k(t)}{P_k(t-1)} + \frac{RG_k(t)}{P_k(t-1)} \quad \text{(A-10)}$$

$k = 1, 2, \ldots, 28$

The last four terms on the right hand side of equation (A-10) will now be put in more useful form.

$$\frac{BIE_k(t)}{P_k(t-1)} = \frac{BIE_k(t)}{P_k(t)} \cdot \frac{P_k(t)}{P_k(t-1)} \qquad k = 1,2,\ldots,28$$

Therefore

$$\frac{BIE_k(t)}{P_k(t-1)} = \frac{BIE_k(t)}{P_k(t)} \cdot 1_k(t) \qquad k = 1,2,\ldots,28 \qquad \text{(A-11)}$$

It is assumed that

$$\frac{BIE_k(t)}{P_k(t)} = \frac{BIE_k(1972)}{P_k(1972)} \qquad k = 1,2,\ldots,28, \quad t = 1973,1974,\ldots,1985$$

This assumption and equation (A-11) are combined to yield

$$\frac{BIE_k(t)}{P_k(t-1)} = \frac{BIE_k(1972)}{P_k(1972)} \cdot 1_k(t) \qquad k = 1,2,\ldots,28 \qquad \text{(A-12)}$$

The value of $BIE_k(1972)/P_k(1972)$ is estimated in Appendix D for all $k = 1,2,\ldots,28$. Consequently, $1_k(t)$ is the only unknown on the right hand side of equation (A-12).

It is apparent that

$$\frac{PROF_k(t)}{P_k(t-1)} = \frac{PROF_k(t)}{P_k(t)} \cdot \frac{P_k(t)}{P_k(t-1)}$$

$k = 1,2,\ldots,28$

Therefore

$$\frac{PROF_k(t)}{P_k(t-1)} = \frac{PROF_k(t)}{P_k(t)} \cdot I_k(t) \qquad \text{(A-13)}$$

$k = 1,2,\ldots,28$

It is assumed that

$$\frac{PROF_k(t)}{P_k(t)} = \frac{PROF_k(1972)}{P_k(1972)}$$

$k = 1,2,\ldots,28$

$t = 1973,1974,\ldots,1985$

From this assumption and equation (A-13) it follows that

$$\frac{PROF_k(t)}{P_k(t-1)} = \frac{PROF_k(1972)}{P_k(1972)} \cdot I_k(t) \qquad \text{(A-14)}$$

$k = 1,2,\ldots,28$

The value of $PROF_k(1972)/P_k(1972)$ is estimated in Appendix D for all $k = 1,2,\ldots,28$.

$$\frac{RO_k(t)}{P_k(t-1)} = \frac{RO_k(t)}{RO_k(t-1)} \cdot \frac{RO_k(t-1)}{P_k(t-1)} \qquad \text{(A-15)}$$

$k = 1,2,\ldots,28$

As it is assumed that each industry uses a constant amount (physical) of its various inputs for unit production it follows that

It is apparent that

$$\frac{RO_k(t)}{RO_k(t-1)} = RPO(t), \qquad \text{(A-16)}$$

$$k = 1,2,\ldots,28$$

where $RPO(t) = \dfrac{\text{wellhead crude oil price in year } t}{\text{wellhead crude oil price in year } t-1}$

Equations (A-15) and (A-16) are combined to yield

$$\frac{RO_k(t)}{P_k(t-1)} = RPO(t)\ \frac{RO_k(t-1)}{P_k(t-1)} \qquad \text{(A-17)}$$

$$k = 1,2,\ldots,28$$

The value of RPO(t) is specified. For $t-1 = 1972$ the value of $RO_k(t-1)/P_k(t-1)$ is determined in Appendix D. For $t-1>1972$ the value of $RO_k(t-1)/P_k$ will have been previously evaluated.

The following equation is derived in a similar manner to equation (A-17).

$$\frac{RG_k(t)}{P_k(t-1)} = RPG(t)\ \frac{RG_k(t-1)}{P_k(t-1)} \qquad \text{(A-18)}$$

$$k = 1,2,\ldots,28$$

where $RPG(t) = \dfrac{\text{wellhead natural gas price in year } t}{\text{wellhead natural gas price in year } t-1}$

As RPG(t) is specified $RG_k(t)/P_k(t-1)$ can be estimated from equation (A-18) if there is a solution to the system for year t-1.

Equations (A-10), (A-12), (A-14), (A-17), and (A-18) are combined to yield

$$I_k(t) = \sum_{j=1}^{28} \left[ comp_{jk}(t-1) \times \frac{A_{jk}(t) + C_{jk}(t)}{B_{jk}} \times I_j(t) \right]$$

$$+ \frac{BIE_k(1972) I_k(t)}{P_k(1972)} + \frac{PROF_k(1972) I_k(t)}{P_k(1972)} + \frac{RPO(t) RO_k(t-1)}{P_k(t-1)}$$

$$+ \frac{RPG(t)\ RG_k(t-1)}{P_k(t-1)}$$

$$K = 1,2,\ldots,28$$

This equation is rearranged to give

$$\left[ 1 - \frac{BIE_k(1972)}{P_k(1972)} - \frac{PROF_k(1972)}{P_k(1972)} \right] I_k(t) - \sum_{j=1}^{28} \{ \left[ comp_{jk}(t-1) \right]$$

$$\times \frac{A_{jk}(t) + C_{jk}(t) \times I_j(t)}{B_{jk}} \} = RPO(t) \left[ \frac{RO_k(t-1)}{P_k(t-1)} \right]$$

$$+ RPG(t) \left[ \frac{RG_k(t-1)}{P_k(t-1)} \right]$$

$$k = 1,2,\ldots,28 \qquad \text{(A-19)}$$

Considering one year at a time equations (A-19) are solved for the $I_j(t)$'s for each year from 1973 to 1985. For t = 1973 all of the terms inside the square brackets in these equations will have been estimated (Appendix D). The $A_{jk}(1973)$'s, $B_{jk}$'s, and $C_{jk}(1973)$'s will also be known (the values of the $A_{jk}(t)$'s, $B_{jk}$'s, and $C_{jk}(t)$'s are estimated in Appendices B and C for $1973 \leq t \leq 1985$). The values of RPO(1973) and RPG(1973) will have been predicted (RPO(t) and RPG(t) are predicted in Appendix E for $1973 \leq t \leq 1985$). Thus for 1973 the only unknowns in equations (A-19) are the twenty-eight $l_j(1973)$'s. Therefore the number of equations and the number of unknowns are equal. Consequently equations (A-19) can be solved for the $l_j(1973)$'s.

After the $l_j(1973)$'s have been evaluated, the analysis for 1974 is begun. To do this it is necessary to determine the 1973 values of the ratios inside the square brackets of equations (A-19). First of all an equation will be developed which relates $\text{comp}_{jk}(t-1)$ to variables whose values have already been determined. From the definition of $\text{comp}_{jk}(t-1)$ it follows that

$$\text{comp}_{jk}(t-1) = \frac{\text{op cost}_{jk}(t-1)}{P_k(t-1)} \qquad \begin{array}{l} j = 1,2,\ldots,28 \\ k = 1,2,\ldots,28 \end{array}$$

Therefore

$$\text{comp}_{jk}(t-1) = \frac{\text{op cost}_{jk}(t-1)}{\text{op cost}_{jk}(t-2)} \times \frac{\text{op cost}_{jk}(t-2)}{P_k(t-2)} \times \frac{P_k(t-2)}{P_k(t-1)}$$

$$\begin{array}{l} j = 1,2,\ldots,28 \\ k = 1,2,\ldots,28 \end{array} \qquad \text{(A-20)}$$

It follows from equations (A-9) that

$$\frac{\text{op cost}_{jk}(t-1)}{\text{op cost}_{jk}(t-2)} = \frac{A_{jk}(t-1) + C_{jk}(t-1) \times l_j(t-1)}{B_{jk}} \qquad \text{(A-21)}$$

$$j = 1,2,\ldots,28$$

$$k = 1,2,\ldots,28$$

From equations (A-20) and (A-21), and the definition of $l_k(t-1)$ it follows that

$$\text{comp}_{jk}(t-1) = \frac{A_{jk}(t-1) + C_{jk}(t-1) \times l_j(t-1)}{B_{jk}} \times \text{comp}_{jk}(t-2) \times \frac{1}{l_k(t-1)}$$

$$j = 1,2,\ldots,28 \qquad \text{(A-22)}$$

$$k = 1,2,\ldots,28$$

For t=1974 all of the terms on the right hand side of equations (A-22) will be known. The values of $A_{jk}(1973)$, $C_{jk}(1973)$ and $B_{jk}$ are determined in Appendices B and C. The values of $\text{comp}_{jk}(1972)$ are estimated in Appendix D. The values of $l_k(1973)$ will already have been determined from equations (A-19). Therefore, $\text{comp}_{jk}(1973)$ can be evaluated from equations (A-22).

The next term inside square brackets in equations (A-19) will now be considered. It is apparent that

$$\frac{RO_k(t-1)}{P_k(t-1)} = \frac{RO_k(t-1)}{RO_k(t-2)} \times \frac{RO_k(t-2)}{P_k(t-2)} \times \frac{P_k(t-2)}{P_k(t-1)} \qquad \text{(A-23)}$$

$$k = 1,2,\ldots,28$$

From equations (A-16) it follows that

$$\frac{RO_k(t-1)}{RO_k(t-2)} = RPO(t-1) \qquad \text{(A-24)}$$

$$k = 1,2,\ldots,28$$

From equations (A-23) and (A-24), and the definition of $1_k(t-1)$ it follows that

$$\frac{RO_k(t-1)}{P_k(t-1)} = RPO(t-1) \times \frac{RO_k(t-2)}{P_k(t-2)} \times \frac{1}{1_k(t-1)} \qquad \text{(A-25)}$$

$$k = 1,2,\ldots,28$$

For t= 1974 all of the terms on the right hand side of equation (A-25) will be known. The value of RPO(1973) is predicted in Appendix E. The value of $RO_k(1972)/P_k(1972)$ is estimated in Appendix D. Therefore $RO_k(1973)/P_k(1973)$ can be evaluated from equation (A-25).

The following equation is derived in a manner similar to equation (A-25).

$$\frac{RG_k(t-1)}{P_k(t-1)} = RPG(t-1) \times \frac{RG_k(t-2)}{P_k(t-2)} \times \frac{1}{1_k(t-1)} \qquad \text{(A-26)}$$

The value of RPG(1973) is predicted in Appendix E. The value of $RG_k(1972)/P_k(1972)$ is estimated in Appendix D. Thus $RG_k(1973)/P_k$ (1973) can be evaluated from equation (A-26).

Thus all of the terms inside the square brackets of equations (A-19) have been determined for t=1974. The values of the $1_j(1974)$'s are evaluated from equations (A-19). Equations (A-22), (A-25), (A-26), and (A-29) are then solved for 1975. This procedure is followed for every year until 1985.

For t > 1974 the values of $comp_{jk}(t-2)$, $RO_k(t-2)/P_k(t-2)$, and $RG_k(t-2)/P_k(t-2)$ used in the right hand side of equations (A-22), (A-25), and (A-26) will already have been evaluated by these equations in previous runs.

APPENDIX B

CONSIDERATION OF CONSTRUCTION EXPENSE

TREATMENT OF CONSTRUCTION EXPENSE

In this thesis depreciation due to construction is considered to be the construction expense allocated to a particular year which is used internally by a company to determine its profits or product price. It is not the allocated construction expense which is used for income tax evaluation.

For certain industries the value of depreciation (due to construction) was known or could be estimated. For these industries construction expense was treated as a capital expense and was not represented by equation (A-6). Instead their construction expense was described by equation (A-7). This equation represents the dependence of an industry's depreciation (due to construction) expense on the revenues required by the construction industry.

For other industries the value of depreciation due to construction was either negligible or could not be estimated very accurately. For some of these industries previous values of repair construction expense were known. This expense is represented by equation (A-6). This equation is also used to represent those industries whose construction expense is assumed to be zero (due to insufficient data or because it is in fact negligible). Their inclusion in this equation has no practical significance, but it makes the derivation of the basic model equations more compact.

Thus whether an industry's construction expense was represented by equation (A-6) or equation (A-7), depended on the magnitude of its construction expense and on the form in which data was available.

INDUSTRIES WHERE CONSTRUCTION EXPENSE IS DISTRIBUTED

They are as follows:

1. crop farming industry
2. livestock farming industry
3. "other farming" industry
4. railroad industry
5. electric power industry
6. oil pipeline industry
7. natural gas utility industry
8. labour industry
9. dummy industry

The variation with time of the allocated construction expense per unit of production for these nine industries is represented by the following equation:

$$\frac{\text{op cost}_{jk}(t)}{\text{op cost}_{jk}(t-1)} = \frac{z_{jk} + 1_j(t-1)}{b_{jk}} \qquad (A-7)$$

$j = 14$ or $15$

If $j = 14$ (industrial construction expense) then this equation is valid for k = (2, 3, 4, 7, 23, 25, 26, 28). If j = 15 (residential construction expense) then equation (A-7) applies for k = 27 (labour industry).

The procedure and assumptions used to evaluate the $z_{jk}$'s and $b_{jk}$'s will be explained in detail for the crop farming industry (k = 2). For the other eight industries the procedure followed was the same. The assumptions made and the results (the $z_{jk}$'s and $b_{jk}$'s) obtained for all of the nine industries will be summarized in Table B-1.

CROP FARM INDUSTRY

It is assumed that

1. crop farm buildings are depreciated linearly over 10 years
2. if the price of industrial construction in year t-1 is equal to its price in year t-2 (i.e. if $I_{14}(t-1) = 1$) then the industrial construction (measured in dollars) undertaken by the crop farming industry in year t-1 is equal to its average value over the year t-10 to t-2.
3. $$\frac{\left(\begin{array}{l}\text{average annual construction over}\\ \text{years t-10 to t-2 undertaken by}\\ \text{the crop farming industry}\end{array}\right)}{\left(\begin{array}{l}\text{crop farming industry's}\\ \text{production in year t}\end{array}\right)} = \frac{\left(\begin{array}{l}\text{average annual con-}\\ \text{struction over years}\\ \text{t-11 to t-2 undertaken}\\ \text{by the crop farming}\\ \text{industry}\end{array}\right)}{\left(\begin{array}{l}\text{crop farming industry's}\\ \text{production in year t-1}\end{array}\right)}$$

The above simplifying assumptions are used to estimate the effect on crop product prices of increasing construction costs in a simple manner which does not necessitate a prediction of future construction activity. Assumptions 2 and 3 indicate that the annual construction of crop farm buildings does not increase significantly with time.

It can be easily seen that

$$\text{average annual construction over year t-10 to t-1} = \frac{9 \times \begin{Bmatrix}\text{average annual construction} \\ \text{over year t-10 to t-2}\end{Bmatrix}}{10} + \frac{\text{construction in year t-1}}{10} \quad \text{(B-1)}$$

It follows from assumption 2 that

$$\text{construction in year t-1} = \begin{Bmatrix}\text{average annual construction} \\ \text{over years t-10 to t-2}\end{Bmatrix} \times 1_{14}(t-1) \quad \text{(B-2)}$$

$$\text{where } 1_{14}(t-1) = \frac{\begin{Bmatrix}\text{revenues per unit product obtained by the} \\ \text{construction industry in year t-1}\end{Bmatrix}}{\begin{Bmatrix}\text{revenues per unit product obtained by the} \\ \text{construction industry in year t-2}\end{Bmatrix}}$$

Equations (B-1) and (B-2) are combined to obtain:

$$\text{average construction over years t-10 to t-1} = \frac{9 + 1_{14}(t-1)}{10} \times \text{average construction over years t-10 to t-2} \quad \text{(B-3)}$$

Assumption 3 is applied to equation (B-3) to yield:

$$\frac{\text{average construction over years t-10 to t-1}}{\text{crop farming industry's production in year t}} = \frac{9 + 1_{14}(t-1)}{10} \times \frac{\text{average construction over years t-11 to t-2}}{\text{crop farming industry's production in year t-1}} \quad \text{(B-4)}$$

The crop farm buildings are depreciated over ten years. Consequently the following two equations are obtained:

$$\text{construction expense assigned to year t} = \text{average construction over years t-10 to t-2} \quad \text{(B-5)}$$

$$\text{construction expense assigned to year t-1} = \text{average construction over years t-11 to t-2} \quad \text{(B-6)}$$

Equations (B-4), (B-5) and (B-6) are combined to give

$$\frac{\text{construction expense assigned to year t}}{\text{crop farming industry's production in year t}} = \frac{9 + 1_{14}(t-1)}{10} \times \frac{\text{construction expense assigned to year t-1}}{\text{crop farming industry's production in year t-1}} \quad \text{(B-7)}$$

The variable op $\text{cost}_{jk}(t)$ was defined to be the cost to industry k, assigned to year t, of buying the amount of product j which it requires to produce one unit of product k in year t. Consequently, equation (B-7) becomes

$$\text{op cost}_{14,2}(t) = \frac{9 + 1_{14}(t-1)}{10} \times \text{op cost}_{14,2}(t-1)$$

Therefore

$$\frac{\text{op cost}_{14,2}(t)}{\text{op cost}_{14,2}(t-1)} = \frac{9 + 1_{14}(t-1)}{10} \quad \text{(B-8)}$$

By comparing equations (A-7) and (B-8) it can be seen that $z_{14,2}$ is 9 and $b_{14,2}$ is 10. Values of $z_{jk}$ and $b_{jk}$ are obtained in a similar manner for the other eight industries concerned. The assumptions and results obtained for the nine industries are summarized in the following table.

TABLE B-1

SUMMARY OF ASSUMPTIONS AND RESULTS FOR THE NINE INDUSTRIES

| INDUSTRY | ASSUMPTIONS | RESULTS |
| --- | --- | --- |
| Crop Farming | 1. depreciation life of 10 years | $z_{14,2} = 9$ |
| | 2. industrial construction in year t-1 is equal to the average value over the year t-10 to t-2 if $I_{14}(t-1) = 1$ | $b_{14,2} = 10$ |
| | 3. $\frac{\text{average construction over years t-10 to t-2}}{\text{production in year t}} = \frac{\text{average construction over year t-11 to t-2}}{\text{production in year t-1}}$ | |
| Livestock Farming | same as for crop farming | $z_{14,3} = 9$<br>$b_{14,3} = 10$ |
| Other Farming | same as for crop farming | $z_{14,4} = 9$<br>$b_{14,4} = 10$ |

TABLE B-1 (continued)

| INDUSTRY | ASSUMPTIONS | RESULTS |
| --- | --- | --- |
| Railroad | 1. depreciation life of 40 years | $z_{14,7} = 39$ |
| | 2. construction in year t-1 = average value over years t-40 to t-2 if $1_{14}(t-1)$ is 1 | $b_{14,7} = 40$ |
| | 3. $\frac{\text{average construction over years t-40 to t-2}}{\text{production in year t}} = \frac{\text{average construction over years t-41 to t-2}}{\text{production in year t-1}}$ | |
| Electric Power | 1. depreciation life of 20 years | $z_{14,23} = 19$ |
| | 2. construction in year t-1 = average value over years t-20 to t-2 if $1_{14}(t-1)$ is 1 | $b_{14,23} = 20$ |
| | 3. $\frac{\text{average construction over years t-20 to t-2}}{\text{production in year t}} = \frac{\text{average construction over years t-21 to t-2}}{\text{production in year t-1}}$ | |
| Oil Pipeline | same as for the electric power industry | $z_{14,25} = 19$ <br> $b_{14,25} = 20$ |
| Natural Gas Utility | same as for the railroad industry | $z_{14,26} = 39$ <br> $b_{14,26} = 39$ |

TABLE B-1 (continued)

| INDUSTRY | ASSUMPTIONS | RESULTS |
| --- | --- | --- |
| Labour Industry | 1. residential construction costs are paid for over 15 years<br>2. residential construction in year t-1 = average value over years t-15 to t-2 if $I_{15}(t-1)$ is 1<br>3. $\frac{\text{average construction over years t-15 to t-2}}{\text{production in year t}} = \frac{\text{average construction over years t-16 to t-2}}{\text{production in year t-1}}$ | $z_{15,27} = 14$<br>$b_{15,27} = 15$ |
| Dummy Industry | same as for the electric power industry | $z_{14,28} = 19$<br>$b_{14,28} = 20$ |

APPENDIX C

(1) Treatment of Natural Gas Expense

(2) Treatment of Electricity Expense

(3) Treatment of Refinery Product Expense

TREATMENT OF NATURAL GAS EXPENSE

There are three major categories of natural gas users and they are as follows:

1. industrial users
2. commercial users
3. residential users

Each of these consumer classes pays a different price for the natural gas it requires. Industrial users buy natural gas at a lower price than commercial users. This is because they use it at greater rate which results in a lower cost, per mcf of gas supplied, to the gas utility companies of installing the facilities necessary for the transportation of the gas to the consumer. Similarly, residential users pay a higher price for natural gas than commercial users. Unless stated otherwise all of the data used in this section applies to Alberta.

Commercial consumers paid $2.0 more for 10 mcf's of natural gas in 1968 than industrial consumers (29). In the same year residential users paid $1.7 per mcf more than commercial consumers (29). It is assumed that until 1985 the price differential per 10 mcf between commercial and industrial users, and between residential and commercial users will always be $2.0 and $1.7 respectively. This assumption is necessary as otherwise three $1_j(t)$ values would have to be calculated for the natural gas utility industry. Basically this would result in the number of unknowns in the basic model equations (A-19) exceeding the number of equations. An alternative approach could have been adopted. This would have been to assume that the relative prices (e.g. price paid by industrial users/price paid by commercial users) remained constant. This assumption would have been less realistic than the one which was actually used (Northwestern Utilities).

This section can be divided into four parts and they are as follows:

1. estimation of the relationship between the prices paid by the three classes of consumer for natural gas and the revenue obtained per unit product by the gas utility companies.
2. derivation of equations relating changes with time in the prices paid by the the three consumer classes to the $l_{26}(t)$ value. The relation between op $cost_{26,k}(t)$/ op $cost_{26,k}(t-1)$ and $l_{26}(t)$ is then determined for $1 < k < 28$.
3. categorization of the natural gas using industries into the three types of consumer classes.
4. estimation of variables which depend on predicted natural gas requirements of industrial, commercial, and residential users.

PART I

In this part the prices paid by the three classes of consumer for natural gas are related to the revenues obtained per unit product by the gas utility companies.

The unit of production of the gas utility industry is defined to be 10 mcf. The total revenues obtained by natural gas utilities in year t are equal to the sum of the revenues obtained from the three classes of natural gas users. This statement is put in the form of an equation as follows:

$$P_{26}(t) = PI(t)YI(t) + PC(t)YC(t) + PR(t)YR(T) \quad (C-1)$$

where $P_{26}(t)$ is the average revenue obtained from the sale of 10 mcf by the natural gas industry in year t.

PI(t) is the price paid in year t by the industrial consumer for natural gas.

PC(t) is the price paid in year t by the commercial consumer for natural gas.

PR(t) is the price paid in year t by the residential consumer for natural gas.

YI(t) is the fraction of the natural gas volume sold in year t which was bought by industrial consumers.

YC(t) is the fraction of the natural gas volume sold in year t which was bought by commercial consumers.

YR(t) is the fraction of the natural gas volume sold in year t which was bought by residential consumers.

Industrial consumers pay \$2/10 mcf more for natural gas than commercial consumers. Residential users pay \$1.7/10 mcf less than commercial users. Putting these two statements in the form of an equation yields:

$$PI(t) = PC(t) - 2.0 \quad (C-2)$$

and

$$PR(t) = PC(t) + 1.7 \quad (C-3)$$

Equations (C-1), (C-2) and (C-3) are combined to yield:

$$P_{26}(t) = \left[PC(t) - 2.0\right]YI(t) + PC(t)YC(t) + \left[PC(t) + 1.7\right]YR(t)$$

$$= PC(t)\left[YI(t) + YC(t) + YR(t)\right] - 2.0YI(t) + 1.7YR(t)$$

$$= PC(t) - 2.0YI(t) + 1.7\,YR(t) \quad (C-4)$$

Therefore

$$PC(t) = P_{26}(t) + 2.0YI(t) - 1.7YR(t) \quad (C-5)$$

$$= P_{26}(t) + AC(t) \quad (C-6)$$

where $AC(t) = 2.0YI(t) - 1.7YR(t)$.

A combination of equations (C-2) and (C-5) yields

$$PI(t) = P_{26}(t) + 2.0YI(t) - 1.7YR(t) - 2.0$$

$$= P_{26}(t) + AI(t) \quad (C-7)$$

where $AI(t) = 2.0YI(t) - 1.7YR(t) - 2.0$.

Equations (C-3) and (C-5) are combined to give

$$PR(t) = P_{26}(t) + 2.0YI(t) - 1.7YR(t) + 1.7$$

$$= P_{26}(t) + AR(t) \qquad \text{(C-8)}$$

where $AR(t) = 2.0\,YI(t) - 1.7YR(t) + 1.7$.

Equations (C-6), (C-7), and (C-8) relate the prices paid by commercial, industrial, and residential users for natural gas to the revenues obtained per unit product by the gas utility companies. The values of AC(t), AI(t), and AR(t) are estimated for each year t, $1972 \leq t \leq 1985$, before the model is used. Their values are determined in Part 4 of this Appendix.

## PART 2

In this part the variation with time in the prices paid by the three consumer classes is related to the $1_{26}(t)$ values. The value of $1_{26}(t)$ is equal to the revenue obtained per unit product by the natural gas utility industry in year t divided by the revenue it obtained in year t-1.

Applying equation (C-6) to 1973 it follows that

$$PC(1973) = P_{26}(1973) + AC(1973)$$

$$= 1_{26}(1973)\,P_{26}(1972) + AC(1973) \qquad \text{(C-9)}$$

where $l_{26}(1973) = P_{26}(1973)/P_{26}(1972)$.

For 1972 equation (C-6) yields

$$PC(1972) = P_{26}(1972) + AC(1972) \qquad \text{(C-10)}$$

Equations (C-9) and (C-10) are combined to give

$$\frac{PC(1973)}{PC(1972)} = \frac{l_{26}(1973)P_{26}(1972) + AC(1973)}{P_{26}(1972) + AC(1972)} \qquad \text{(C-11)}$$

Similarly,

$$\frac{PC(1974)}{PC(1973)} = \frac{l_{26}(1974)P_{26}(1973) + AC(1974)}{P_{26}(1973) + AC(1973)} \qquad \text{(C-12)}$$

Substituting for $P_{26}(1973)$ in this equation yields

$$\frac{PC(1974)}{PC(1973)} = \frac{l_{26}(1974)l_{26}(1973)P_{26}(1972) + AC(1974)}{l_{26}(1973)P_{26}(1972) + AC(1973)}$$

In general

$$\frac{PC(t)}{PC(t-1)} = \frac{l_{26}(t)l_{26}(t-1)----l_{26}(1972)P_{26}(1972) + AC(t)}{l_{26}(t-1)l_{26}(t-2)----l_{26}(1972)P_{26}(1972) + AC(t-1)} \qquad \text{(C-13)}$$

where $l_{26}(1972) = 1$.

Similarly,

$$\frac{PI(t)}{PI(t-1)} = \frac{l_{26}(t)l_{26}(t-1)----l_{26}(1972)P_{26}(1972) + AI(t)}{l_{26}(t-1)l_{26}(t-2)----l_{26}(1972)P_{26}(1972) + AI(t-1)} \qquad \text{(C-14)}$$

and

$$\frac{PR(t)}{PR(t-1)} = \frac{I_{26}(t)I_{26}(t-1)----I_{26}(1972)P_{26}(1972) + AR(t)}{I_{26}(t-1)I_{26}(t-2)----I_{26}(1972)P_{26}(1972) + AR(t-1)} \qquad (C-15)$$

Equations (C-13), (C-14), and (C-15) relate the changes with time in the prices paid by the three consumer categories to the value of $I_{26}(t)$.

The next step is to relate op $cost_{26,k}(t)$/op $cost_{26,k}(t-1)$ to $I_{26}(t)$ for $1 \leq k \leq 28$.

It is assumed that for each industry the quantity of natural gas required for unit production is constant and does not vary with time. It follows from this assumption that

$$\frac{\text{op } cost_{26,k}(t)}{\text{op } cost_{26,k}(t-1)} = \frac{h_{26,k}(t)}{h_{26,k}(t-1)} \qquad (C-16)$$

$$k = 1,2,...,28$$

where op $cost_{26,k}(t)$ is the cost to industry k in year t of buying the amount of natural gas which it requires for unit production.

$h_{26,k}(t)$ is the cost to industry k of buying 10mcf (one unit) of natural gas in year t.

If an industry 1 can be considered to be a commercial user of natural gas then

$$\frac{h_{26,1}(t)}{h_{26,1}(t-1)} = \frac{PC(t)}{PC(t-1)} \qquad (C-17)$$

Gas utility companies in 1968 received \$3.2 for each 10 mcf of natural gas sold (29). Consequently, $P_{26}(1972)$ is taken to be 3.2.

A combination of equations (C-13), (C-16), and (C-17), and the value of $P_{26}(1972)$ yields:

$$\frac{\text{op cost}_{26,1}(t)}{\text{op cost}_{26,1}(t-1)} = \frac{1_{26}(t)1_{26}(t-1)----1_{26}(1972) \times 3.2 + AC(t)}{1_{26}(t-1)1_{26}(t-2)----1_{26}(1972) \times 3.2 + AC(t-1)} \tag{C-18}$$

Similarly, if an industry m is considered to be an industrial user of natural gas then

$$\frac{\text{op cost}_{26,m}(t)}{\text{op cost}_{26,m}(t-1)} = \frac{1_{26}(t)1_{26}(t-1)----1_{26}(1972) \times 3.2 + AI(t)}{1_{26}(t-1)1_{26}(t-2)----1_{26}(1972) \times 3.2 + AI(t-1)} \tag{C-19}$$

Also if an industry n is considered to be a residential user of natural gas then

$$\frac{\text{op cost}_{26,n}(t)}{\text{op cost}_{26n}(t-1)} = \frac{1_{26}(t)1_{26}(t-1)----1_{26}(1972) \times 3.2 + AR(t)}{1_{26}(t-1)1_{26}(t-2)----1_{26}(1972) \times 3.2 + AR(t-1)} \tag{C-20}$$

The AC(t), AI(t), and AR(t) values are estimated in Part 4 of this section and are thus known before equations (C-16), (C-17), and (C-18) are used.

Now consider equation (C-18). If this equation is being used for 1973 then $1_{26}(1973)$ is the only unknown on its right hand side. When the equation is being applied for 1974 the value of $1_{26}$ (1973) will already have been determined. Thus there is again only one unknown ($l_{26}(1974)$) on the right hand side of equation (C-18). In general the only unknown on the right hand side of equation (C-18) is $l_{26}(t)$ as $l_{26}(t-1)$, $l_{26}(t-2)$ etc. will already have been estimated. Similarly, $l_{26}(t)$ is the only unknown on the right hand side of equations (C-19) and (C-20). Therefore, equations (C-18), (C-19) and (C-20) can be combined into the following general equation, which will have only one unknown, $l_{26}(t)$, on its right hand side.

$$\frac{\text{op cost}_{26,k}(t)}{\text{op cost}_{26,k}(t-1)} = C_e(t) + d_e(t)l_{26}(t) \qquad \text{(A-8)}$$

$$k = 1, 2, \ldots, 28$$

$$e = 1, 2 \text{ or } 3$$

where $C_1(t) = AC(t)/\left[l_{26}(t-1)l_{26}(t-2)----l_{26}(1972) \times 3.2 + AC(t-1)\right]$

$$C_2(t) = AI(t)/\left[l_{26}(t-1)l_{26}(t-2)----l_{26}(1972) \times 3.2 + AI(t-1)\right]$$

$$C_3(t) = AR(t)/\left[l_{26}(t-1)l_{26}(t-2)----l_{26}(1972) \times 3.2 + AR(t-1)\right]$$

$$d_1(t) = \frac{l_{26}(t-1)l_{26}(t-2)----l_{26}(1972) \times 3.2}{l_{26}(t-1)l_{26}(t-2)----l_{26}(1972) \times 3.2 + AC(t-1)}$$

$$d_2(t) = \frac{l_{26}(t-1)l_{26}(t-2)----l_{26}(1972) \times 3.2}{l_{26}(t-1)l_{26}(t-2)----l_{26}(1972) \times 3.2 + AI(t-1)}$$

$$d_3(t) = \frac{l_{26}(t-1)l_{26}(t-2)----l_{26}(1972) \times 3.2}{l_{26}(t-1)l_{26}(t-2)----l_{26}(1972) \times 3.2 + AR(t-1)}$$

The value of e selected for a given k will depend on whether industry k is a commercial, industrial, or residential consumer of natural gas. These consumers are represented by e values of 1, 2, and 3 respectively.

When equation (A-8) is used the values of $C_e(t)$ and $d_e(t)$, $1 \leq e \leq 3$, will already have been estimated. Thus equation (A-6) relates op cost$_{26,k}(t)$/op cost$_{26,k}(t-1)$ to $1_{26}(t)$ and predetermined values.

PART 3

In this part of Appendix C the various industries which use natural gas are categorized into commercial, industrial, and residential consumers. This categorization is used to determine the e values which correspond to particular k values in equation (A-8).

The following table shows the price paid by different Canadian industries in 1968 for natural gas. In this table the numbers in brackets indicate the references from which various values were taken.

TABLE C-1

PRICES PAID FOR NATURAL GAS IN 1968

| INDUSTRY | PRICE PAID BY INDUSTRY FOR NATURAL GAS IN 1968 |
|---|---|
| chemical | 35.3 ¢/mcf (30) |
| feed | 41.0 C/mcf (31) |
| architectural metals | 83.1 ¢/mcf (32) |
| wood | 57.3 ¢/mcf (33-36) |
| iron mines | 44.7 ¢/mcf (37) |
| iron and steel mills | 48.2 ¢/mcf (38) |
| steel pipe and tube mills | 44.2 ¢/mcf (39) |
| petroleum refining | 28.5 ¢/mcf (40) |

The average price paid in Canada in 1968 by commercial, industrial, and residential consumers was 73¢/mcf, 39¢/mcf, and 105¢/mcf respectively (29). Table C-2 was estimated on the basis of this information and the data in Table C-1. The fertilizer, cement, and electric power industries consume large quantities of natural gas and are thus included in the "industrial natural gas user" category.

TABLE C-2

CATEGORIZATION OF INDUSTRIES

| INDUSTRY | NATURAL GAS CONSUMER CATEGORY |
|---|---|
| chemical industry | industrial |
| fertilizer industry | industrial |
| feed industry | industrial |
| architectural metals | commercial |
| cement | industrial |
| wood products | commercial |
| iron mines | industrial |
| iron and steel mills | industrial |
| steel pipe and tube mills | industrial |
| electric power | industrial |
| petroleum refining | industrial |
| labour | residential |
| dummy | commercial |

PART 4

In order to estimate the $c_e(t)$'s and $d_e(t)$'s in equation (A-8) it is necessary to know the values of AC(t), AI(t) and AR(t).

These values will now be estimated for 1973 $\leq$ t $\leq$ 1985.

The predicted values of commercial and residential natural gas requirements in the following table were taken from an Oil and Gas Conservation Board publication (41). The predicted industrial requirements for natural gas were obtained from a Hu Harries report (42).

TABLE C-3

PREDICTED NATURAL GAS REQUIREMENTS

| YEAR | PREDICTED INDUSTRIAL REQUIREMENT FOR NATURAL GAS | PREDICTED COMMERCIAL REQUIREMENT FOR NATURAL GAS | PREDICTED RESIDENTIAL REQUIREMENT FOR NATURAL GAS |
|---|---|---|---|
| | Billions of Cubic Feet | | |
| 1972 | 141.8 | 54.5 | 61.3 |
| 1973 | 149.4 | 56.3 | 63.0 |
| 1974 | 158.4 | 58.1 | 64.8 |
| 1975 | 168.7 | 60.5 | 67.1 |
| 1976 | 185.6 | 62.5 | 69.0 |
| 1977 | 203.2 | 64.5 | 70.9 |
| 1978 | 223.1 | 66.6 | 72.8 |
| 1979 | 232.4 | 68.7 | 74.8 |
| 1980 | 239.7 | 71.0 | 76.8 |
| 1981 | 253.2 | 73.2 | 78.7 |
| 1982 | 264.0 | 75.4 | 80.5 |
| 1983 | 274.1 | 77.6 | 82.3 |

TABLE C-3 (continued)

| YEAR | PREDICTED INDUSTRIAL REQUIREMENT FOR NATURAL GAS | PREDICTED COMMERCIAL REQUIREMENT FOR NATURAL GAS | PREDICTED RESIDENTIAL REQUIREMENT FOR NATURAL GAS |
|---|---|---|---|
| | Billions of Cubic Feet | | |
| 1984 | 284.4 | 79.8 | 84.1 |
| 1985 | 291.8 | 82.2 | 86.1 |

The following table is obtained directly from the data in Table D-3.

TABLE C-4

PREDICTION OF YI(t) AND YR(t)

| YEAR | FRACTION OF THE TOTAL NATURAL GAS SOLD IN YEAR t WHICH IS BOUGHT BY INDUSTRIAL CONSUMERS = YI(t) | FRACTION OF THE TOTAL NATURAL GAS SOLD IN YEAR t WHICH IS BOUGHT BY RESIDENTIAL CONSUMERS = YR(t) |
|---|---|---|
| 1972 | 0.550 | 0.238 |
| 1973 | 0.557 | 0.234 |
| 1974 | 9.563 | 0.230 |
| 1975 | 0.569 | 0.226 |
| 1976 | 0.585 | 0.218 |
| 1977 | 0.600 | 0.209 |

TABLE C-4 (continued)

| YEAR | FRACTION OF THE TOTAL NATURAL GAS SOLD IN YEAR t WHICH IS BOUGHT BY INDUSTRIAL CONSUMERS = YI(t) | FRACTION OF THE TOTAL NATURAL GAS SOLD IN YEAR t WHICH IS BOUGHT BY RESIDENTIAL CONSUMERS = YR(t) |
|---|---|---|
| 1978 | 0.615 | 0.201 |
| 1979 | 0.618 | 0.200 |
| 1980 | 0.619 | 0.198 |
| 1981 | 0.625 | 0.194 |
| 1982 | 0.629 | 0.192 |
| 1983 | 0.632 | 0.190 |
| 1984 | 0.634 | 0.188 |
| 1985 | 0.634 | 0.187 |

The following table is obtained from Table C-14 and the definitions of AC(t), AI(t), and AR(t).

TABLE C-5

PREDICTION OF AC(t), AI(t) AND AR(t)

| YEAR | AC(t) | AI(t) | AR(t) |
|---|---|---|---|
| 1972 | 0.695 | -1.305 | 2.395 |
| 1973 | 0.716 | -1.284 | 2.417 |
| 1974 | 0.735 | -1.265 | 2.435 |
| 1975 | 0.754 | -1.246 | 2.454 |

TABLE C-5 (continued)

| YEAR | AC(t) | AI(t) | AR(t) |
|---|---|---|---|
| 1976 | 0.799 | -1.201 | 2.499 |
| 1977 | 0.845 | -1.155 | 2.545 |
| 1978 | 0.888 | -1.112 | 2.588 |
| 1979 | 0.896 | -1.104 | 2.596 |
| 1980 | 0.901 | -1.099 | 2.601 |
| 1981 | 0.920 | -1.080 | 2.620 |
| 1982 | 0.932 | -1.068 | 2.632 |
| 1983 | 0.941 | -1.059 | 2.641 |
| 1984 | 0.948 | -1.052 | 2.648 |
| 1985 | 0.950 | -1.050 | 2.650 |

## TREATMENT OF ELECTRICITY EXPENSE

It was originally intended to treat electricity expense in the same way as natural gas expense. The following three categories of electricty consumers were defined:

1. industrial consumers
2. commercial consumers
3. domestic and farm consumers

Commercial users paid a slightly higher rate in 1970 for electricity than domestic and farm consumers (43). Consequently, it was decided to combine categories 2 and 3 into a single category called "nonindustrial electricity users". Thus it was then considered that two classes of electricity users existed and these were:

1. industrial users
2. nonindustrial users

Industrial users as defined by Statistics Canada generate their own electricty (43). In this analysis electricity was only considered as an industry's input cost if it was purchased from the electric power industry. Consequently, none of the industries analyzed fit into the first category of electricity users. Therefore, there is only one class of electricity user involved in the analysis. This is the reason that electricity expense is represented by equation (A-6).

## TREATMENT OF REFINERY PRODUCT EXPENSE

It might appear that the refinery product expense should be treated similarly to natural gas expense. However, though some refinery products (e.g. gasoline) are sold in different markets at different prices, the netback to the refinery from the sale of refinery products is nearly independent of the type of consumer to which they are sold. The existence of a refinery product price differential between different markets in Alberta is due to the costs which are incurred beyond the refinery gate. Thus if refinery costs become greater the price (at the refinery gate) of a refinery product to a consumer will probably be increased in the same proportion as the price to any other consumer. In this analysis the cost of product j to industry k($h_{jk}$) is the value of the commodity at its place of production. Consequently, equation (A-6) can be used for the oil refinery industry.

# APPENDIX D

## ESTIMATION OF $comp_{jk}(1972)$ VALUES

ESTIMATION OF 1972 VARIABLES

To use the model which has been developed it is necessary to estimate the composition of the price of each system product for 1972 ($comp_{jk}(1972)$). This estimation will be carried out in the following section. The industries will be considered in order of their industrial classification numbers.

The information used was obtained from the following sources:

1. Dominion Bureau of Statistics (DBS) catalogues,
2. 1961 Canadian Input-Output Table (15),
3. 1962 Alberta Input-Output Table (44),
4. industrialists,
5. economists,
6. relevant literature.

An industry's transportation expense is the cost of transporting materials to its place of manufacture. The expense incurred by industry A in using industry B's product is the cost to A of buying product B at B's place of manufacture. The actual transportation charges are considered to be cost inputs to industry A from the transportation industries involved.

In this analysis natural gas is the commodity produced by the natural gas utilities. Wellhead natural gas is the natural gas in the field before it has been transported to the utility companies.

In general, the procedure followed in the estimation process will be to assume that the 1972 value of a variable is equal to its most recent known value. There are exceptions to this procedure. They arise if the most recent value of the variable differs appreciably from values in earliers years. In this case the estimate for 1972 would be an average of the variable value over a number of years.

Sometimes variable values could not be obtained from past data and it was necessary to estimate them from a combination of known values. For example, consider four variables A, B, C, and D. It is desired to evaluate A/B for 1972 and its value for a previous year is not available. However, A/D is known for 1969, D/C for 1970, and C/B for 1970. It would be assumed that these three values apply for 1972. Consequently, their product will give an estimate of A/B for 1972.

Another problem encountered is that some of the desired variable values are only available for Canada. In some instances it is assumed that these values are also applicable to Alberta. Consider the electricity expense of the industrial chemicals industry. It is is assumed that the value of electricity expense/revenues for Alberta in 1972 is equal to the corresponding Canadian value in 1969.

In other circumstances, Canadian figures are altered to make them more appropriate to conditions in Alberta. In Alberta, fuel oil usage is very low as most of its functions are performed by natural gas. In Eastern Canada, where the natural gas price is higher, fuel oil is used to a much greater extent. Fuel oil costs are a component of the refinery product expense of an industry. Consequently, before applying Canadian figures for refinery product and natural gas expense to some Alberta industries it is necessary to modify them. This is because fuel oil usage in Alberta is very small. For example, consider the feed manufacturing industry. The modification of the Canadian figures for refinery product and natural gas expense is based on the following assumptions:

1. The only refinery products consumed by Alberta feed mills are gasoline and diesel oil. Other fuel oils are not used.
2. Canadian and Alberta feed mills use the same volume of gasoline and diesel oil for each dollar spent on fuel and electricity.
3. Diesel oil accounts for 14% of the fuel oil volume consumed by Canadian feed mills.
4. Natural gas expense accounts for the same percentage of fuel and electricity costs for both Alberta and Canadian feed mills.

Assumption 3 comes from the fact that 14% of the fuel oil volume sold in Canada in 1970 was diesel oil (45). This assumption is necessary because the Dominion Bureau of Statistics (DBS) catalogue on feed mills only contains the amount of all fuel oils used and it is not possible to obtain the quantity of diesel oil used. This variable is necessary for the application of assumption 2. It is estimated by the utilization of assumption 3.

Assumption 4 is based on the fact that while the Alberta feed manufacturing industry uses a greater volume of natural gas per unit product (as natural gas is used instead of fuel oil) than its Canadian counterpart it also obtains it at a cheaper rate. Assumptions similar to the four mentioned above are used for other industries which are considered in the analysis.

The DBS catalogues contain figures showing the expense to various industries of using refinery products. However, these figures include the costs of transporting the products from the refinery, wholesalers mark-up, marketing costs and taxes. To construct the input-output table it was necessary to estimate the money received by refineries from the sale of its various products to different industries. This was accomplished for many industries by adopting a procedure similar to the following one, which was applied to the chemical industry. This procedure was adopted to determine the fraction of the chemical industry's revenues which were used to pay for gasoline.

1. Determine the volume of gasoline used by the chemical industry.

2. Estimate the revenue obtained by the refineries for each gallon of gasoline consumed by the chemical industry.

3. Calculate the revenues received by the oil refineries from the chemical industry's expenditure on gasoline.

4. Estimate the percentage of the chemical industry's revenues which are received by the oil refineries as a result of the chemical industry's use of gasoline.

The revenue obtained by Canadian refineries per gallon of different products is summarized in the following table which was obtained by a simple manipulation of data given in the DBS catalogue on oil refineries(40).

TABLE D-1

REVENUES OBTAINED BY REFINERIES FROM VARIOUS PRODUCTS

| Refinery Product | Value to Refinery Per Gallon - ¢/Gal. |
|---|---|
| Gasoline | 13.3 |
| Diesel oil | 11.3 |
| Light and Heavy fuel oils | 8.4 |
| Heavy fuel oil | 5.8 |
| LPGs | 7.1 |
| Lube oils and grease | 50.8 |
| Aviation turbine fuel | 11.5 |
| Aviation gasoline | 19.3 |

In the above table the figure for LPGs is for 1968. All the other figures are 1969 values. This is because the 1969 figure for LPGs was not available.

For each industry the only costs considered were those which accounted for at least 0.1% of the revenues obtained. Having discussed the problems of estimating 1972 variable values which are common to some of the twenty-eight industries it is now appropriate to examine the individual industries and the problems which are peculiar to each of them.

## 1. INDUSTRIAL CHEMICALS INDUSTRY

Most of the data for this industry was taken from DBS publications (15, 30) or from the 1962 input-output table for Alberta (44). It is possible to estimate the percentages of 1969 selling price of Alberta industrial chemicals which were used to pay for materials, fuel and electricity, and labour (30). It is not possible, without obtaining detailed cost figures from every chemical plant in Alberta to acquire a further breakdown of costs (for recent years) for the Alberta industrial chemicals industry. In order to subdivide material, fuel and electricity costs, it is necessary to manipulate Canadian data and to use some 1962 Alberta figures.

The term $comp_{ji}(t)$ is the estimated fraction of the revenues obtained by the Alberta Chemical industry in year t which was used to pay for its use of input j.

IRON AND STEEL MILL PRODUCT EXPENSE OF THE CHEMICAL INDUSTRY: ESTIMATION OF $comp_{21,1}(1972)$

In 1962 the percentage of the selling price of Alberta industrial chemicals which was due to the primary metal expense incurred (44) was 1.3%. In 1961 the percentage of the primary metals expense of the Canadian chemical industry which was due to iron and steel mill products (15) was 47.2%. Assuming that these two percentages applied for Alberta in 1972 then $comp_{21,1}(1972)$ was 0.013 x 0.472 = 0.006.

ELECTRICITY EXPENSE OF THE CHEMICAL INDUSTRY: ESTIMATION OF $comp_{23,1}(1972)$

In 1962 the percentage of the selling price of Alberta industrial chemicals attributable to electricity and water expense (44) was 2.2%. A reasonable estimate for $comp_{23,1}(1972)$ would be 0.020 as a large percentage of the electricity and water expense would be due to electricity costs.

REFINERY PRODUCT EXPENSE OF THE CHEMICAL INDUSTRY: ESTIMATION OF $comp_{24,1}(1972)$

For the industrial chemicals industry there are two sources of refinery product expense. Refinery products are used as fuel. They are also used as petrochemical feedstocks. In 1969, Canadian refineries received $36,601,000 for petrochemical feedstocks (40). In 1970, Alberta chemical plants consumed 0.023% of the total volume of the petrochemical feedstocks (produced by refineries) used by Canadian industries (45). It is consequently assumed that the Alberta chemical industry contributed 0.023% of the money received by oil refineries in 1969 from the sale of petrochemical feedstocks. Therefore, the chemical industry in Alberta spent $36,601,000 x 0.023 on petrochemical feedstocks. In 1969 the total value of production of Alberta industrial chemicals was $86,656,000 (30). Consequently, the percentage of the selling price of Alberta industrial chemicals which was due to petrochemical feedstocks was $\frac{0.00023 \times 36,601,000}{86,656,000} \times 100\%$.

For each dollar worth of fuel and electricity consumed in 1969 the Canadian chemical industry used 0.018 gallons of gasoline (30). Oil refineries received 13.3¢/gallon for gasoline (Table D-1). Therfore 0.018 x 0.133 dollars of each dollar spent by chemical plants on fuel and electricity is acquired by refineries In Alberta, fuel and electricity expense accounts for 6.9% of the selling price of chemical products (30). Consequently, the percentage which was due to gasoline (valued at the refinery gate) was

0.069 x 0.018 x 0.133 x 100%.

The portion of the price of industrial chemicals which results from the usage of refinery products is the sum of the contributions of petrochemical feedstocks and gasoline. Thus $comp_{24,1}$(1972) is

$$\frac{0.0002 \times 36{,}601{,}000}{43{,}913{,}000} + 0.069 \times 0.018 \times 0.133$$

which is zero (less than 0.001). This may appear to be a very surprising result but in actual fact there is a very small petrochemical industry in Alberta. Ontario and Quebec are responsible for about 97% of Canada's petrochemical feedstocks consumption (45).

## NATURAL GAS EXPENSE OF THE CHEMICAL INDUSTRY: ESTIMATION OF $comp_{26,1}$(1972)

All of the data used in the estimation of $comp_{26,1}$(1972) was for 1969 and was taken from Reference 30. Natural gas is consumed both as a raw material and as a fuel. The percentage of Canadian chemical plants' fuel and electricity costs attributable to their natural gas expense is 24.1%. Fuel and electricity costs are responsible for 6.9% of the price of Alberta industrial chemicals. The percentage of the 1972 price of Alberta chemical products which is due to the use of natural gas as a fuel is estimated to be 0.241 x 0.069 x 100%.

Natural gas is responsible for 3.6% of the material costs of the Canadian chemical industry. As there is such a small petrochemical industry in Alberta it could be argued that natural gas would account for less than 3.6% of material costs in this province. However, this overestimation of natural gas costs is balanced by the fact that the percentage of fuel and electricity costs which are due to natural gas usage was underestimated by accepting the Canadian figure. This is because natural gas is used in Alberta for purposes where fuel oil would be used in Eastern Canada. Material costs accounted for 30% of the revenues of Alberta chemicals. The percentage of 1972 revenues which was attributable to the use of natural gas as a raw material is estimated to be 0.036 x 0.3 x 100%. Addition of the two natural gas contributions implies $comp_{26,1}(1972)$ is 0.241 x 0.069 + 0.036 x 0.300 = 0.027.

INTEREST EXPENSE OF THE CHEMICAL INDUSTRY:
ESTIMATION OF $BIE_1(1972)/P_1(1972)$

Interest expense accounted for 1.8% of the 1968 revenues of the Canadian chemical industry (46). Thus $BIE_1(1972)/P_1(1972)$ is 0.018.

PROFIT REQUIRED BY THE CHEMICAL INDUSTRY:
ESTIMATION OF $PROF_1(1972)/P_1(1972)$

The Canadian chemical industry obtained profits of $0.082 per unit revenue in 1968 (46). Therefore, $PROF_1(1972)/$

$P_1(1972)$ is 0.082.

LABOUR EXPENSE OF THE CHEMICAL INDUSTRY:
ESTIMATION OF $comp_{27,1}(1972)$

Labour expense accounted for 14.2% of the Alberta chemical industry's revenues in 1969 (30). Consequently, $comp_{27,1}$ (1972) is 0.142.

The values of all the other nonzero inputs to the chemical industry were taken from the 1962 Alberta input-output table (44). The following table was then obtained. It shows the fractions of the 1972 revenues obtained by the Alberta chemical industry which were used to pay for the various input costs.

TABLE D-2

1972 INPUT VECTOR OF THE CHEMICAL INDUSTRY

| INPUT | FRACTION OF THE CHEMICAL INDUSTRY'S 1972 REVENUES |
|---|---|
| chemical products | 0.112 |
| crop products | 0 |
| livestock products | 0 |
| other farm products | 0 |
| fertilizer | 0 |
| feed | 0 |
| railroad | 0.074 |
| trucking | 0.101 |
| inland water | 0 |
| Pacific water | 0 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| *industrial construction | 0.007 |
| residential construction | 0 |
| architectural metals | 0 |
| cement | 0 |
| forestry | 0 |

TABLE D-2 (continued)

1972 INPUT VECTOR OF THE CHEMICAL INDUSTRY

| INPUT | FRACTION OF THE CHEMICAL INDUSTRY'S 1972 REVENUES |
|---|---|
| wood | 0.004 |
| iron mines | 0 |
| iron and steel mills | 0.006 |
| steel pipe and tube mills | 0 |
| electricity | 0.020 |
| refinery products | 0 |
| oil pipeline | 0 |
| natural gas | 0.027 |
| bond interest | 0.018 |
| profit | 0.082 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0.142 |
| **other expense | 0.407 |

*the input from the industrial construction industry is a a result of the repair construction which is required.

**the value corresponding to other expense is such that the sum of the figures in column 2 is equal to one.

THE AGRICULTURAL INDUSTRY

It was decided to divide this industry into three component industries: crop farming, livestock farming, and other farming. The subdivision was undertaken in order that the effect of increased petroleum prices on these component industries could be estimated. Crop farmers produce wheat, oats, barley, rye, mixed grain, flaxseed, rapeseed and tame hay. Livestock farmers produce cattle and calves, hogs, sheep and lambs, dairy produce, poultry produce and wool. "Other farmers" produce all other agricultural products which are not produced by crop and livestock farms.

Some of the information used in this section was taken from enterprise analyses prepared by the Marketing Division of the Department of Agriculture (47, 48, 49, 50). For example, ~~this~~ department analyzed the crop farming enterprise by studying a number of crop farms. The farmers who take part in these analyses are normally in the top third farming income group. Consequently, the analyses are limited in that they give results which are not truly representative of farming in Alberta. However, they do point out the major operating expenses of a particular enterprise.

Detailed figures are published by the Dominion Bureau of Statistics (51) and by the Economics Division of the Alberta Department of Agriculture (52) for the Alberta agricultual industry.

For example, the agricultural industry's expenditure on fertilizer can be obtained from these publications. However, using this reference alone, it was not possible to determine the fertilizer used by the component farming industries. To solve this problem it was necessary to distribute the total fertilizer costs among the three farming industries. Income in kind expense, industrial construction costs, electricity costs, refinery product costs, interest payments and profits were also allocated to the component farming industries after consultation with an agricultural economist (Reg Norby) and a careful study of relevant enterprise analyses.

## DISTRIBUTION OF COSTS AMONG THE COMPONENT FARMING INDUSTRIES

Unless stated otherwise all the cost distributions will have been estimated by Reg Norby. It should be noted that he based some of his estimates on experience as detailed information was not always available. All costs for which absolute figures (dollars) are quoted are 1971 values and they were obtained from Reference 51 unless otherwise specified.

### 1. DISTRIBUTION OF INCOME IN KIND EXPENSE

Income in kind expense is the cost to the agricultural industry of consuming livestock or "other farm" products.

The use of crop products by the livestock industry is not considered to be an income in kind expense and will be discussed at a later stage. The income in kind expenses of the agricultural industry due to the usage of livestock products and "other farm" products were respectively $13,882,000 and $4,563,000 (51). It was decided to allocate these income in kind expenses among the three farming industries in proportion to their annual values of production. This is done in the following table.

TABLE D-3

ALLOCATION OF INCOME IN KIND EXPENSE

| Farming Industry i | Value of Production of Industry i | Value of Production of Industry i / $1,115,294,000 | Livestock Expense to Industry i = column 2 x $13,880,000 | "Other Farm" Product Expense to Industry i = column 2 x $4,563,000 |
|---|---|---|---|---|
| Crop Farming | $518,180,000 | 0.465 | $6,455,000 | $2,122,000 |
| Livestock Farming | $545,657,000 | 0.489 | $6,788,000 | $2,231,000 |
| "Other Farming" | $ 51,457,000 | 0.046 | $ 639,000 | $ 210,000 |
| | $1,115,294,000 | | | |

Column 1 was obtained from Reference 52. From the above table it can be seen that the crop farming industry spent $6,454,000 on livestock products, the livestock farming industry $2,231,000 on "other farm" products etc.

## 2. DISTRIBUTION OF FERTILIZER COSTS

Farmers spent $27,663,000 on fertilizer. About 47.4% of this money was received by fertilizer plants according to a source in the fertilizer industry (Chris Freeborn). Consequently, the agricultural industry paid $27,663,000 x 0.474 = $13,112,000 to the fertilizer industry for its product. Crop farmers and "other farmers" are responsible for 90% and 10% respectively of the agricultural industry's fertilizer consumption. Therefore, the cost of fertilizer (valued at the fertilizer plant gate) to crop farmers is $13,112,000 x 0.9 = $11,801,000. The cost to "other farmers" is $1,311,000.

## 3. DISTRIBUTION OF INDUSTRIAL CONSTRUCTION COSTS

Industrial construction costs are represented in the agricultural price determining equations by the variable which is called depreciation of farm buildings. The value of this variable for the agricultural industry was $29,347,000. The percentages of this cost allocated to crop farming, livestock farming, and "other farming" were respectively 35%, 60%, and 5%. Therefore, the farm building depreciation allocated to crop farmers, livestock farmers, and "other farmers" was $10,272,000, $17,608,000, and $1,467,000 respectively.

## 4. DISTRIBUTION OF ELECTRICITY COSTS

The agricultural industry paid $10,198,000 for electricity and telephone services. Assume $10,000,000 of this went to electricity companies. $9,500,000 and $500,000 of the agricultural electricity expense were allocated to livestock farmers and "other farmers" respectively.

## 5. DISTRIBUTION OF REFINERY PRODUCT COSTS

The agricultural industry spent $72,670,000 on refinery products. Farmers paid 26.4¢/gallon for gasoline and 13.7¢/gallon for diesel oil. Oil refineries received 13.3¢/gallon for gasoline and 11.3¢/gallon for diesel oil (Table D-1). Consequently, the oil refineries received 50% of the money spent by farmers on gasoline and 48% of their diesel oil expenditure. Consequently, as there is no detailed breakdown of fuel costs it is assumed that the oil refineries received 49% of the agricultural industry's expenditure on all refinery products. Therefore, the oil refineries obtained $72,670,000 x 0.49 = $35,608,000 from this industry. Crop farmers contributed 65% of this amount, livestock farmers 30% and "other farmers" 5%. Therefore, crop farmers, livestock farmers and "other farmers" paid $23,145,000, $19,682,000, and $1,781,000 respectively to the oil refineries.

## 6. DETERMINATION OF PROFIT/REVENUES FOR THE COMPONENT FARMING INDUSTRIES

In 1970 profit per unit revenue was 0.197 for a beef feeder enterprise (48) and 0.162 for a crop enterprise (47). In 1971, profits were 33.1% of revenues for the agricultural industry. This value is approximately double the values given for the two enterprise analyses. Consequently, it would appear that the enterprise analyses give values for profits/revenues which are too low.

The enterprise analyses do indicate that crop farmers obtain a slightly lower amount of profit per unit revenue. However, 1970 was a bad year for crop farmers. Consequently, it is assumed that the three component farming industries possess the same value for profits/revenues and this is 0.331, which is the figure for the agricultural industry.

## 7. DISTRIBUTION OF PAYMENTS ON LONG TERM DEBT

The interest on investment of an enterprise is the required return (interest and profits) on the capital invested in the enterprise.

The livestock industry obtains most of its revenues from the sale of cattle, calves and hogs. The cattle and calves producing industry is composed of two enterprises: the cow-calf enterprise and the beef feeder enterprise. The values of interest on investment per unit revenue for the cow-calf, beef feeder, and hog enterprises are combined to give a value of this variable for the livestock industry. A similar value is known for a crop enterprise. The long term debt interest payments for the whole agricultural industry will be allocated on the basis of the relative values of interest on investment per unit revenue for the crop farming and livestock farming industries.

Interest on investment per unit revenue was 0.144 and 0.161 respectively for a cow-calf enterprise in 1968 (49) and a beef feeder enterprise in 1970 (48). The interest on investment per unit revenue for the cattle and calves industry was obtained from the equation

$$\begin{bmatrix}\text{interest on investment}\\ \text{per unit revenue for}\\ \text{the cattle and calves}\\ \text{industry}\end{bmatrix} = \begin{bmatrix}\text{interest on investment}\\ \text{per unit revenue for a}\\ \text{beef feeder enterprise}\end{bmatrix} \times a + \begin{bmatrix}\text{interest on investment}\\ \text{per unit revenue for}\\ \text{a cow-calf enterprise}\end{bmatrix} \times (1-a) \qquad \text{(D-1)}$$

This equation merely obtains a variable (interest on investment per unit revenue) value from the values of the variable for the industry's component enterprises. The variable a is a weighting factor which depends on the relative income received by the beef feeder and cow-calf enterprises. It was estimated by R. Norby to be 0.6

Therefore

$$\begin{pmatrix}\text{interest on investment for}\\ \text{cattle and calves industry}\end{pmatrix} = 0.161 \times 0.6 + 0.144 \times 0.4 = 0.154$$

The interest on investment per unit revenue for the livestock industry was obtained from the equation:

$$\begin{pmatrix}\text{interest on investment}\\ \text{per unit revenue for}\\ \text{the livestock industry}\end{pmatrix} = \begin{pmatrix}\text{interest on investment}\\ \text{per unit revenue for}\\ \text{the cattle and calves}\\ \text{industry}\end{pmatrix} \times \frac{\text{income from cattle and calves}}{\text{income from cattle, calves, and hogs}} + \begin{pmatrix}\text{interest on investment per unit}\\ \text{revenue for a hog enterprise.}\end{pmatrix} \times \frac{\text{income from hogs}}{\text{income from cattle, calves, and hogs}} \quad \text{(D-2)}$$

The value of the ratio $\frac{\text{income from cattle and calves}}{\text{income from cattle, calves, and hogs}}$ was 0.761 in 1971 (51).

The interest on investment per unit revenue for a hog enterprise was 0.116 in 1970 (50). Therefore

$$\begin{pmatrix}\text{interest on investment per unit}\\ \text{revenue for the livestock industry}\end{pmatrix} = 0.154 \times 0.761 + 0.116 \times 0.239 = 0.145$$

The interest on investment per unit revenue for a crop enterprise in 1970 (47) was 0.363. Therefore

$$\frac{\text{interest on investment per unit revenue for livestock farming}}{\text{interest on investment per unit revenue for crop farming}}$$

$$= \frac{0.145}{0.363} = 0.399$$

It is assumed that the debt ratio is the same for livestock farming and crop farming. Therefore

$$\frac{\text{interest on debt per unit revenue for livestock farming}}{\text{interest on debt per unit revenue for crop farming}} = 0.399$$

Let y be the value of the interest on debt per unit revenue for a crop farm. Therefore interest on debt per unit revenue for a livestock farm is 0.399y. It is assumed that the interest paid by the agricultural industry was $64,350,000 (51).

$$\left(\begin{array}{l}\text{Interest on debt for the}\\ \text{agricultural industry}\end{array}\right) = \left(\begin{array}{l}\text{interest on debt per}\\ \text{unit revenue for live-}\\ \text{stock farming}\end{array}\right) \times \begin{array}{l}\text{Livestock}\\ \text{Revenues}\end{array}$$

$$+ \left(\begin{array}{l}\text{interest on debt per}\\ \text{unit revenue for}\\ \text{crop farming}\end{array}\right) \times \begin{array}{l}\text{crop}\\ \text{revenues}\end{array}$$

$$+ \left(\begin{array}{l}\text{interest on debt per}\\ \text{unit revenue for}\\ \text{"other farming"}\end{array}\right) \times \begin{array}{l}\text{"Other Farm"}\\ \text{Revenues}\end{array}$$

In the next few pages livestock revenues, crop revenues, and "other farm" revenues are estimated to be \$574,347,000, \$545,461,000 and \$54,156,000 respectively.

Therefore,

$$64{,}350 = 0.399y \times 574{,}347 + y \times 545{,}461 + y \times 54{,}156$$

Therefore, $y = 0.078$ and $0.399y = 0.031$

Consequently, crop farmers and "other farmers" used 7.8% of their revenues for debt payments. The corresponding percentage for livestock farmers is 3.1%.

## DISTRIBUTION OF LABOUR COSTS

The following table was obtained from enterprise analyses (51, 47 - 50).

TABLE D-4

LABOUR COSTS OF FARM ENTERPRISES

| Enterprise | Labour Cost Per Unit Revenue |
|---|---|
| beef feeder | \$0.109 |
| cow-calf | 0.134 |
| hog | 0.200 |
| crop | 0.232 |

Wages to farm labour amounted to 43,798 thousand dollars (51). Using this fact, Table D-4, and the procedure followed for the distribution of interest payments, Table D-5 was obtained.

TABLE D-5

LABOUR COSTS PER UNIT REVENUE FOR THE THREE FARMING CATEGORIES

| Farming Industry | Labour Cost Per Unit Revenue |
|---|---|
| crop farming | $0.047 |
| livestock farming | 0.028 |
| "other farming" | 0.047 |

Consequently, crop farmers and "other farmers" used 4.7% of their revenues to pay their labour costs. The corresponding figure for livestock farmers is 2.8%.

## ESTIMATION OF TOTAL REVENUES FOR THE COMPONENT FARMING INDUSTRIES

In addition to the revenues obtained from the sale of commodities the agricultural industry also received income in kind due to house rent. This amounted to $58,670,000 (51). This house rent will be allocated to the three farming industries in proportion to their annual values of production. Crop farming, livestock farming, and "other farming" are responsible for 46.5%, 48.9%, and 4.6% of the value of production of the agricultural industry (column 3, Table D-3). Therefore, the house rent allocated to crop farming is $58,670,000 x 0.465 = $27,281,000. Similarly, livestock farmers and "other farmers" receive $28,690,000 and $2,699,000 respectively (column 2, Table D-3).

Crop farmers, livestock farmers, and "other farmers" produced commodities worth $518,180,000, $545,657,000, and $51,457,000 respectively (column 2, Table D-3). For each farming industry the total revenue is the sum of house rent and production value. Thus the total revenue for crop farming, livestock farming and "other farming" is $545,461,000, $574,347,000, and $54,156,000 respectively.

## 2. CROP FARMING INDUSTRY

The term $comp_{j2}(t)$ is the estimated fraction of the revenues obtained by Alberta crop farmers in year t which was used to pay for input j.

### CROP PRODUCT EXPENSE OF THE CROP FARMING INDUSTRY: ESTIMATION OF $comp_{22}(1972)$

In 1970 crop farmers used 4.3% of their revenues to pay for seed (47). Thus $comp_{22}(1972)$ is 0.043.

LIVESTOCK PRODUCT EXPENSE OF THE CROP FARMING INDUSTRY:
ESTIMATION OF $comp_{32}(1972)$

The livestock expense to crop farmers was $6,455,000 (Table D-3). Their total revenues were estimated to be $545,461,000. Therefore $comp_{32}(1972)$ is 6,455/545,461 = 0.012.

"OTHER FARM" PRODUCT EXPENSE OF THE CROP FARMING INDUSTRY:
ESTIMATION of $comp_{42}(1972)$

Crop farmers spent $2,122,000 on other farm products (Table D-3). Consequently, $comp_{42}(1972)$ is 2,122/545,461 = 0.004.

FERTILIZER EXPENSE OF THE CROP FARMING INDUSTRY:
ESTIMATION OF $comp_{52}(1972)$

It has been already estimated that the cost of fertilizer to crop farmers was $11,801,000. Therefore $comp_{52}(1972)$ is 11,801/545,461 = 0.022.

RAILROAD EXPENSE OF THE CROP FARMING INDUSTRY:
ESTIMATION OF $comp_{72}(1972)$

The value of railroad expense/revenues for agriculture was 0.034 in 1962 (44). Thus $comp_{72}(1972)$ is 0.034.

TRUCKING EXPENSE OF THE CROP FARMING INDUSTRY:
ESTIMATION OF $comp_{82}(1972)$

In 1962 the agricultural industry used 7% of its revenues to pay for trucking facilities (44). Therefore $comp_{82}$ (1972) is 0.070.

INDUSTRIAL CONSTRUCTION EXPENSE OF THE CROP FARMING INDUSTRY:
ESTIMATION OF $comp_{14,2}(1972)$

The depreciation of farm buildings allocated to crop farmers was $10,272,000. Therefore $comp_{14,2}(1972)$ is 10,272/545,461 = 0.019.

WOOD PRODUCT EXPENSE OF THE CROP FARMING INDUSTRY:
ESTIMATION OF $comp_{19,2}(1972)$

For the agricultural industry in 1962 wood product expense per unit revenue (44) was 0.005. Thus $comp_{19,2}(1972)$ is 0.005.

REFINERY PRODUCT EXPENSE OF THE CROP FARMING INDUSTRY:
ESTIMATION OF $comp_{24,2}(1972)$

Crop farmers paid $23,145,000 to the oil refineries. Consequently, $comp_{24,2}(1972)$ is 23,145/545,461 = 0.042.

INTEREST EXPENSE OF THE CROP FARMING INDUSTRY:
ESTIMATION OF $BIE_2(1972)/P_2(1972)$

It has already been determined that crop farmers used 7.8% of their revenues for debt payments. Therefore, $BIE_2(1972)/P_2(1972)$ is 0.078.

PROFITS REQUIRED BY THE CROP FARMING INDUSTRY:
ESTIMATION OF $PROF_2(1972)/P_2(1972)$

It has been estimated that 33.1% of the crop farming industry's revenues were attributable to profits. Consequently, $PROF_2(1972)/P_2(1972)$ is 0.331.

LABOUR EXPENSE OF THE CROP FARMING INDUSTRY:
ESTIMATION OF $comp_{27,2}(1972)$

It has been estimated that labour expense accounted for 4.7% of the revenues obtained by crop farmers. Thus $comp_{27,2}(1972)$ is 0.047.

OTHER EXPENSE OF THE CROP FARMING INDUSTRY:

ESTIMATION OF $comp_{28,2}(1972)$

The value of $comp_{28,2}(1972)$ is obtained from the following equation:

$$comp_{28,2}(1972) = 1 - \sum_{j=1}^{27} comp_{j2}(1972) - \frac{PROF_2(1972)}{P_2(1972)} - \frac{BIE_2(1972)}{P_2(1972)}$$

$$- \frac{RO_2(1972)}{P_2(1972)} - \frac{RG_2(1972)}{P_2(1972)} = 1 - [0.043 + 0.012$$

$$+ 0.004 + 0.022 + 0.034 + 0.07 + 0.019 + 0.005$$

$$+ 0.042 + 0.047] - 0.078 - 0.331 = 0.293.$$

ESTIMATION OF THE 1972 INPUT VECTOR OF THE CROP FARMING INDUSTRY

The following table shows the fractions of the crop farming industry's 1972 revenues which were attributable to the various inputs.

TABLE D-6

1972 INPUT VECTOR OF THE CROP FARMING INDUSTRY

| INPUT | FRACTION OF CROP FARMER'S 1972 REVENUES |
|---|---|
| chemical products | 0 |
| crop products | 0.043 |
| livestock products | 0.012 |
| other farm products | 0.004 |
| fertilizer | 0.022 |
| feed | 0 |
| railroad | 0.034 |
| trucking | 0.070 |
| inland water | 0 |
| Pacific water | 0 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| industrial construction | 0.019 |
| residential construction | 0 |
| architectural metals | 0 |
| cement | 0 |
| forestry | 0 |

TABLE D-6 (continued)

1972 INPUT VECTOR OF THE CROP FARMING INDUSTRY

| INPUT | FRACTION OF CROP FARMER'S 1972 REVENUES |
|---|---|
| wood | 0.005 |
| iron mines | 0 |
| iron and steel mills | 0 |
| steel pipe and tube mills | 0 |
| electricity | 0 |
| refinery products | 0.042 |
| oil pipeline | 0 |
| natural gas | 0 |
| bond interest | 0.078 |
| profit | 0.331 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0.047 |
| other expense | 0.293 |

## 3. LIVESTOCK FARMING INDUSTRY

The term $comp_{j3}(t)$ is the estimated fraction of the revenues obtained by Alberta Livestock farmers in year t which was used to pay for input j.

### CROP EXPENSE OF THE LIVESTOCK FARMING INDUSTRY: ESTIMATION OF $comp_{23}(1972)$

The crop expense per unit revenue for the livestock industry is obtained by combining the value of this variable for beef feeder, cow-calf, and hog enterprises. Grain and roughage are considered to be the crop inputs of the livestock industry.

For a beef feeder enterprise, grain and roughage costs were responsible for 43.7% of revenues (48). For a cow-calf enterprise the only available figure was a combined one for grain and feed. To obtain a value for the grain costs of this enterprise it is necessary to assume that grain costs contribute the same fraction of grain and feed costs in both a beef feeder and a cow-calf enterprise. This fraction was 0.838 (48). Therefore, for a cow-calf enterprise

$$\frac{\text{grain and roughage costs}}{\text{revenues}} = \frac{\left(\begin{array}{l}0.838\text{ (grain and feed costs)}\\ +\text{ roughage costs}\end{array}\right)}{\text{revenues}}$$

Using this equation and the results of a cow-calf enterprise analysis (49), a value of 0.339 is obtained for grain and roughage costs for unit revenue.

The following equation is analogous to equation (D-1), which was used when interest payments were distributed.

$$\begin{pmatrix}\text{grain and roughage costs}\\ \text{per unit revenue for the}\\ \text{cattle and calves industry}\end{pmatrix} = \begin{pmatrix}\text{grain and roughage costs}\\ \text{per unit revenue for a}\\ \text{beef feeder enterprise}\end{pmatrix}$$

$$\times\ 0.6 + \begin{pmatrix}\text{grain and roughage costs}\\ \text{per unit revenue for a}\\ \text{cow-calf enterprise}\end{pmatrix} \times 0.4$$

$$= 0.437 \times 0.6 + 0.339 \times 0.4$$

$$= 0.398$$

For a hog enterprise in 1967 the value of the ratio grain costs/ (grain and feed costs) was 0.739 (53). Therefore, for this enterprise

$$\frac{\text{grain and roughage costs}}{\text{revenues}} = \frac{0.739\ (\text{grain and feed costs}) + \text{roughage costs}}{\text{revenues}}$$

From this equation and the results of a cow-calf enterprise (50), a value of 0.290 is obtained for grain and roughage costs per unit revenue for the cattle and calves industry.

The following equation is analogous to equation (D-2).

$$\begin{bmatrix}\text{grain and roughage costs}\\ \text{per unit revenue for}\\ \text{livestock industry}\end{bmatrix} = \begin{bmatrix}\text{grain and roughage costs}\\ \text{per unit revenue for the}\\ \text{cattle and calves industry}\end{bmatrix} \times 0.761$$

$$+ \begin{bmatrix}\text{grain and roughage costs}\\ \text{per unit revenue for a}\\ \text{hog enterprise}\end{bmatrix} \times 0.239$$

$$= 0.398 \times 0.761 + 0.290 \times 0.239$$

$$= 0.372$$

Therefore, 37.2% of the livestock industry's revenues are used to pay for crop products. In 1968 transportation charges were responsible for 7.17% of the wholesale price of oats (64). Consequently, it is reasonable to assume that 7.2% of the livestock farmer's crop expense was due to freight charges.

Therefore $comp_{23}(1972)$ is 0.372 x 0.928 = 0.345.

LIVESTOCK EXPENSE OF THE LIVESTOCK INDUSTRY:
ESTIMATION OF $comp_{43}(1972)$

The livestock expense allocated to the livestock industry was $6,788,000 (Table D-2). The revenues of this industry were $574,347,000. Therefore $comp_{33}(1972)$ is 6,788/574,347 = 0.012.

"OTHER FARM" PRODUCT EXPENSE OF THE LIVESTOCK INDUSTRY:
ESTIMATION OF $comp_{43}(1972)$

The livestock industry spent $2,231,000 on "other farm" products (Table D-2). Thus $comp_{43}(1972)$ is 2,231/574,347 = 0.004.

FEED EXPENSE OF THE LIVESTOCK INDUSTRY:

ESTIMATION OF $comp_{63}(1972)$

The agricultural industry spent $50,000,000 on feed. As there are no intermediate industries and little transportation involved, about 95% of this money was received by feed mills. Assuming that all of the feed was consumed by the livestock industry, then the feed mills received $50,000,000 x 0.95 = $47,500,000 from this industry. Therefore, $comp_{63}(1972)$ is 47,500/574,347 = 0.083.

RAILWAY EXPENSE OF THE LIVESTOCK INDUSTRY:

ESTIMATION OF $comp_{73}(1972)$

The value of $comp_{73}(1972)$ is taken to be zero. This is because the major inputs (crops, feed and refinery products) of this industry are nearly always transported by truck.

TRUCKING EXPENSE OF THE LIVESTOCK INDUSTRY:

ESTIMATION OF $comp_{83}(1972)$

It has already been estimated that 5% of feed expense and 7.2% of crop expense were attributable to trucking charges. In 1968 freight charges accounted for 6% of the price of gasoline (54). Consequently, it is assumed that 6% of refinery product expense is due to trucking costs. Using these values the following equation is obtained:

$$\begin{pmatrix}\text{Trucking expense}\\ \text{per unit revenue}\end{pmatrix} = \begin{pmatrix}\text{crop expense}\\ \text{per unit revenue}\end{pmatrix} \times 0.072$$

$$+ \begin{pmatrix}\text{Feed expense per}\\ \text{unit revenue}\end{pmatrix} \times 0.05$$

$$+ \begin{pmatrix}\text{Refinery product expense}\\ \text{per unit revenue}\end{pmatrix} \times 0.06 \qquad \text{(D-3)}$$

Crop expense per unit revenue is 0.372. Feed expense per unit revenue is 50,000/574,347 = 0.087. The agricultural industry spent $72,670,000 on refinery products. Livestock farmers contributed 30% of this amount. Therefore the refinery product expense per unit revenue was $\frac{72,670 \times 0.3}{574,347} = 0.038$. Substituting into equation (D-3), a value of 0.033 is obtained for trucking expense per unit revenue ($comp_{83}(1972)$).

INDUSTRIAL CONSTRUCTION EXPENSE OF THE LIVESTOCK INDUSTRY: ESTIMATION OF $comp_{14,3}(1972)$

The depreciation of farm buildings allocated to the livestock industry was $17,608,000. Therefore $comp_{14,3}(1972)$ is 17,608/574,347 = 0.031.

WOOD PRODUCT EXPENSE OF THE LIVESTOCK INDUSTRY:

ESTIMATION OF $comp_{19,3}(1972)$

Wood product expense per unit revenue in 1962 was 0.005 for the agricultural industry (44). Thus $comp_{19,3}(1972)$ is 0.005.

ELECTRICITY EXPENSE OF THE LIVESTOCK INDUSTRY:

ESTIMATION OF $comp_{23,3}(1972)$

The agricultural electricity expense assigned to the livestock farming industry was $9,500,000. Consequently, $comp_{23,2}(1972)$ is 9,500/ 574,347 = 0.017.

REFINERY PRODUCT EXPENSE OF THE LIVESTOCK FARMING INDUSTRY:

ESTIMATION OF $comp_{24,3}(1972)$

Livestock farmers paid $10,682,000 to the oil refineries. Therefore $comp_{24,3}(1972)$ is 10,682/574,347 = 0.019.

INTEREST EXPENSE OF THE LIVESTOCK FARMING INDUSTRY:

ESTIMATION OF $BIE_3(1972)/P_3(1972)$

Livestock farmers used 3.1% of their revenues for interest payments. Thus $BIE_3(1972)/P_3(1972)$ is 0.031.

PROFITS REQUIRED BY THE LIVESTOCK FARMING INDUSTRY:
ESTIMATION OF $\hat{PROF}_3(1972)/P_3(1972)$

33.1% of the livestock farming industry's revenues were due to profit requirements. Consequently, $PROF_3(1972)/P_3(1972)$ is 0.331.

LABOUR EXPENSE OF THE LIVESTOCK FARMING INDUSTRY:
ESTIMATION OF $\overline{comp}_{27,3}(1972)$

Labour expense accounted for 2.8% of the revenues obtained by livestock farmers. Thus $comp_{27,3}(1972)$ is 0.028.

ESTIMATION OF THE 1972 INPUT VECTOR OF THE LIVESTOCK FARMING INDUSTRY

The following table shows the fractions of the livestock farming industry's 1972 revenues which were due to the use of various inputs.

TABLE D-7

1972 INPUT VECTOR OF THE LIVESTOCK INDUSTRY

| INPUT | FRACTION OF LIVESTOCK FARMERS' 1972 REVENUES |
|---|---|
| chemical products | 0 |
| crop products | 0.345 |
| livestock products | 0.012 |
| other farm products | 0.004 |
| fertilizer | 0 |
| feed | 0.083 |
| railroad | 0 |
| trucking | 0.033 |
| inland water | 0 |
| Pacific water | 0 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| industrial construction | 0.031 |
| residential construction | 0 |
| architectural metals | 0 |
| cement | 0 |
| forestry | 0 |

TABLE D-7 (continued)

1972 INPUT VECTOR OF THE LIVESTOCK INDUSTRY

| INPUT | FRACTION OF LIVESTOCK FARMERS' 1972 REVENUES |
|---|---|
| wood | 0.005 |
| iron mines | 0 |
| iron and steel mills | 0 |
| steel pipe and tube mills | 0 |
| electricity | 0.017 |
| refinery products | 0.019 |
| oil pipeline | 0 |
| natural gas | 0 |
| bond interest | 0.031 |
| profit | 0.331 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0.061 |
| other expense | 0.028 |

4. "OTHER FARMING" INDUSTRY

The term $comp_{j4}(t)$ is the estimated fraction of the revenues obtained by the "other farming" industry in Alberta in year t which was used to pay for input j.

LIVESTOCK PRODUCT EXPENSE OF THE "OTHER FARMING" INDUSTRY: ESTIMATION OF $comp_{34}(1972)$

The livestock product expense and the revenues of the "other farming" industry were estimated to be respectively $639,000 (Table D-3) and $54,156,000. Consequently, $comp_{34}(1972)$ is 639/54,156 = 0.012.

"OTHER FARM" PRODUCT EXPENSE OF THE "OTHER FARMING" INDUSTRY: ESTIMATION OF $comp_{44}(1972)$

The "other farming" industry spent $210,000 on "other farm" products (Table D-3). Thus $comp_{44}(1972)$ is 210/54,156 = 0.004.

FERTILIZER EXPENSE OF THE "OTHER FARMING" INDUSTRY: ESTIMATION OF $comp_{54}(1972)$

The agricultural fertilizer expense assigned to "other farmers" was $1,311,000. Therefore, $comp_{54}(1972)$ is 1,311/54,155 = 0.024.

RAILROAD EXPENSE OF THE "OTHER FARMING" INDUSTRY: ESTIMATION OF $comp_{74}(1972)$

In 1962, the agricultural industry used 3.4% of its revenues to pay for the cost of railroad facilities (44). Consequently $comp_{74}(1972)$ is 0.034.

TRUCKING EXPENSE OF THE "OTHER FARMING" INDUSTRY: ESTIMATION OF $comp_{84}(1972)$

Trucking expense per unit revenue for the agricultural industry in 1962 was 0.070. Thus $comp_{84}(1972)$ is 0.070.

INDUSTRIAL CONSTRUCTION EXPENSE OF THE "OTHER FARMING" INDUSTRY: ESTIMATION OF $comp_{14,4}(1972)$

The depreciation of farm buildings allocated to "other farmers" was $1,467,000. Therefore $comp_{14,4}(1972)$ is 1,467/54,156 = 0.027.

WOOD PRODUCT EXPENSE OF THE "OTHER FARMING" INDUSTRY: ESTIMATION OF $comp_{19,4}(1972)$

For the agricultural industry in 1962, wood product expense per unit revenue was 0.005 (44). Thus $comp_{19,4}(1972)$ is 0.005.

ELECTRICITY EXPENSE OF THE "OTHER FARMING" INDUSTRY:
ESTIMATION OF $comp_{23,4}(1972)$

The electricity costs of the "other farming" industry were estimated to be \$500,000. Consequently, $comp_{23,3}(1972)$ is 500/54,156 = 0.009.

REFINERY PRODUCT EXPENSE OF THE "OTHER FARMING" INDUSTRY:
ESTIMATION OF $comp_{24,4}(1972)$

"Other farmers" paid \$1,781,000 to the oil refineries. Therefore, $comp_{24,4}(1972)$ is 1,781/54,156 = 0.033.

INTEREST EXPENSE OF THE "OTHER FARMING" INDUSTRY:
ESTIMATION OF $BIE_4(1972)/P_4(1972)$

"Other farmers" used 7.8% of their revenues for interest payments. Thus $BIE_4(1972)/P_4(1972)$ is 0.078.

PROFITS REQUIRED BY THE "OTHER FARMING" INDUSTRY:
ESTIMATION OF $PROF_4(1972)/P_4(1972)$

The "other farming" industry used 33.1% of its revenues to meet its profit requirements. Consequently, $PROF_4(1972)/P_4(1972)$ is 0.331.

LABOUR EXPENSE OF THE "OTHER FARMING" INDUSTRY:

ESTIMATION OF $comp_{27,4}(1972)$

Labour expense accounted for 4.7% of the revenues obtained by the "other farming" industry. Thus $comp_{27,4}(1972)$ is 0.047.

ESTIMATION OF THE 1972 INPUT VECTOR OF THE "OTHER FARMING" INDUSTRY

The following table shows the fractions of the "other farming" industry's 1972 revenues which were attributable to the various inputs.

TABLE D-8

1972 INPUT VECTOR OF THE "OTHER FARMING" INDUSTRY

| INPUT | FRACTION OF THE "OTHER FARMERS" 1972 REVENUES |
|---|---|
| chemical products | 0 |
| crop products | 0 |
| livestock products | 0.012 |
| other farm products | 0.094 |
| fertilizer | 0.024 |
| feed | 0.0 |
| railroad | 0.034 |
| trucking | 0.070 |
| inland water | 0 |
| Pacific water | 0 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| industrial construction | 0.027 |
| residential construction | 0 |
| architectural metals | 0 |
| cement | 0 |
| forestry | 0 |

TABLE D-8 (continued)

1972 INPUT VECTOR OF THE "OTHER FARMING" INDUSTRY

| INPUT | FRACTION OF THE "OTHER FARMERS" 1972 REVENUES |
|---|---|
| wood | 0.005 |
| iron mines | 0 |
| iron and steel mills | 0 |
| steel pipe and tube mills | 0 |
| electricity | 0.009 |
| refinery products | 0.033 |
| oil pipeline | 0 |
| natural gas | 0 |
| bond interest | 0.078 |
| profit | 0.331 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0.047 |
| other expense | 0.326 |

# 5. FERTILIZER INDUSTRY

The Dominion Bureau of Statistics only publish figures for the mixed fertilizer industry. This industry is not the equivalent of the fertilizer industry in that it does not include the whole of the fertilizer manufacturing process. The first step in the production of fertilizer is the conversion of natural gas into ammonia and ammonia compounds. The mixed fertilizer industry analyses the situation after this conversion has taken place. Consequently, ammonia and its compounds are considered as inputs to this industry. The fertilizer industry as thought of in this analysis embraces the wholse process of fertilizer manufacture. It includes the conversion of natural gas into ammonia and its compounds. Thus natural gas and not ammonia is an input of the fertilizer industry. Consequently, DBS catalogues were not used in this section.

All of the information used was obtained from a person (Chris Freeborn) in the fertilizer industry. There are many different types of fertilizer and they have a wide range in prices. Before the data was given it was weighted to allow for these differences. The information acquired is summarized in the following table. It should be noted that the figures in this table are approximate.

TABLE D-9

INPUT COSTS PER TON OF FERTILIZER

| INPUT | COST PER TON OF FERTILIZER PRODUCED |
|---|---|
| chemical products | $0.3 |
| railroad charges | $3.3 |
| truck charges | $1.1 |
| Pacific water transport charges | $6 |
| electric power | $1.0 |
| natural gas | $2.6 |
| labour costs | $7 |

The average value of fertilizer at the plant gate is $46 per ton.

ESTIMATION OF THE 1972 INPUT VECTOR OF THE FERTILIZER INDUSTRY

The following table was easily obtained from the information which has just been displayed.

TABLE D-10

1972 INPUT VECTOR OF THE FERTILIZER INDUSTRY

| INPUT | FRACTION OF THE 1972 REVENUES OF THE FERTILIZER INDUSTRY |
|---|---|
| chemical products | 0.007 |
| crop products | 0 |
| livestock products | 0 |
| other farm products | 0 |
| fertilizer | 0 |
| feed | 0 |
| railroad | 0.073 |
| trucking | 0.024 |
| inland water | 0 |
| Pacific water | 0.133 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| industrial construction | 0 |
| residential construction | 0 |
| architectural metals | 0 |
| cement | 0 |
| forestry | 0 |

TABLE D-10 (continued)

1972 INPUT VECTOR OF THE FERTILIZER INDUSTRY

| INPUT | FRACTION OF THE 1972 REVENUES OF THE FERTILIZER INDUSTRY |
|---|---|
| wood | 0 |
| iron mines | 0 |
| iron and steel mills | 0 |
| steel pipe and tube mills | 0 |
| electricity | 0.022 |
| refinery products | 0 |
| oil pipeline | 0 |
| natural gas | 0.058 |
| bond interest | 0 |
| profit | 0 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0.156 |
| other expense | 0.527 |

## 6. FEED MANUFACTURERS

All of the data in this section was obtained from DBS catalogures (31, 55, 56, 15), the 1962 Alberta input-output table, and a report prepared for the Royal Commission on transportation in the Prairies (54). Unless stated otherwise the data used in this section applies to 1961.

The term $comp_{j6}(t)$ is the estimated fraction of Alberta feed mill revenues in year t which must be paid to industry j for the use of its product or service.

CHEMICAL PRODUCTS EXPENSE OF FEED MILLS:
ESTIMATION OF $comp_{16}(1972)$

The percentage of the materials costs of Canadian feed mills which is due to the consumption of chemical products (15) is 0.4%. From 1967 to 1969, an average of 75.7% of Alberta feed mill revenues was used to pay for raw materials (31, 55). Consequently, $comp_{16}(1972)$ is $0.004 \times 0.757 = 0.003$.

CROP PRODUCT EXPENSE OF FEED MILLS:
ESTIMATION OF $comp_{26}(1972)$

The average fraction of Alberta feed mill revenues attributable to the payment of crop product expense in 1968 and 1969

(55) was 0.303. This value includes the transportation of crop products to the feed mills. About 5.51% of crop product expense is due to transportation (54). Therefore, $comp_{26}(1972)$ is $0.303 \times (1 - 0.0551) = 0.286$.

"OTHER FARM" PRODUCT EXPENSE OF FEED MILLS:
ESTIMATION OF $comp_{46}(1972)$

"Other farm" product expense is responsible for 0.5% of the material costs of a Canadian feed mill (15). Thus, using the average fraction of revenues for 1967 to 1969 which is attributable to material costs, $comp_{46}(1972)$ is $0.005 \times 0.757 = 0.004$.

FEED MILL PRODUCT EXPENSE OF FEED MILLS:
ESTIMATION OF $comp_{66}(1972)$

Feed mill product expense accounts for 10.1% of the material costs of a Canadian feed mill(15). Consequently, $comp_{66}(1972)$ is $0.101 \times 0.75 = 0.076$.

RAILROAD EXPENSE OF FEED MILLS:
ESTIMATION OF $comp_{76}(1972)$

For Alberta, grain mills in 1962 (feed mills and flour mills) railroad expense accounted for 1.1% of revenues (44). Thus $comp_{76}(1972)$ is 0.011.

TRUCKING EXPENSE OF FEED MILLS:

ESTIMATION OF $comp_{36}(1972)$

Trucking expense was responsible for 4.1% of the revenues received by Alberta grain mills in 1962 (44). Consequently, $comp_{36}(1972)$ is 0.041.

INDUSTRIAL CONSTRUCTION EXPENSE OF FEED MILLS:

ESTIMATION OF $comp_{14,6}(1972)$

Industrial repair construction expense accounted for 2.1% of the revenues received by Alberta grain mills in 1962 (44). Therefore, $comp_{14,6}(1972)$ is 0.021.

IRON AND STEEL MILL PRODUCT EXPENSE OF FEED MILLS:

ESTIMATION OF $comp_{21,6}(1972)$

Iron and steel mill products were responsible for 0.3% of the material costs of Canadian feed mills (15). Thus $comp_{21,6}$ (1972) is $0.003 \times 0.757 = 0.002$.

ELECTRICITY EXPENSE OF FEED MILLS:

ESTIMATION OF $comp_{23,6}(1972)$

For Canadian feed mills in 1968 and 1969, electricity expense accounted for an average of 43% of their fuel and electricity costs (55, 56). The average percentage of the revenues obtained by Alberta feed mills in the years 1967 to 1969 which was attributable to fuel and electricity expense was 1.2% (31, 55). Thus $comp_{23,6}(1972)$ is 0.43 x 0.012 = 0.005.

REFINERY PRODUCTS EXPENSE OF FEED MILLS:
ESTIMATION OF $comp_{24,6}(1972)$

For each dollar worth of fuel and electricity consumed in 1970, Canadian feed mills used 0.84 gallon of gasoline and 0.75 gallons of fuel oil (56). If 14% (explained at the beginning of this Appendix) of this fuel oil is diesel oil, then the quantity of diesel oil consumed was 0.14 x 0.75 gallons = 0.105 gallons. Oil refineries received 13.3¢/gallon for gasoline and 11.3¢/gallon for diesel oil (Table D-1). Therefore, 0.84 x 0.133 + 0.105 x 0.113 = 0.124 dollars for each dollar spent by feed mills on fuel and electricity is received by oil refineries. Consequently, as fuel and electricity expense accounts for 1.2% of revenues, $comp_{24,6}$ (1972) is 0.124 x 0.012 = 0.001.

NATURAL GAS EXPENSE OF FEED MILLS:
ESTIMATION OF $comp_{26,6}(1972)$

Natural gas expense accounted for 7.9% of the fuel and electricity expense of Canadian feed mills in 1970 (56). Consequently, $comp_{26,6}(1972)$ is $0.079 \times 0.012 = 0.001$.

INTEREST EXPENSE OF FEED MILLS:
ESTIMATION OF $BIF_6(1972)/P_6(1972)$

For Canadian grain mills in 1968, interest payments accounted for 1.2% of revenues (46). Therefore, $BIF_6(1972)/P_6(1972)$ is 0.012.

PROFITS REQUIRED BY FEED MILLS:
ESTIMATION OF $PROF_6(1972)/P_6(1972)$

Profits per unit revenue obtained by Canadian grain mills in 1968 were $0.036 (46). Thus $PROF_6(1972)/P_6(1972)$ is 0.036.

LABOUR EXPENSE OF FEED MILLS:
ESTIMATION OF $comp_{27,6}(1972)$

Alberta feed mills used 9.8% of their 1969 revenues to pay their labour costs (55). Consequently, $comp_{27,6}(1972)$ is 0.098.

ESTIMATION OF THE 1972 INPUT VECTOR OF THE FEED INDUSTRY:

The following table shows the fractions of the 1972 revenues of feed mills which were used to pay for their various inputs.

TABLE D-11

1972 INPUT VECTOR OF THE FEED INDUSTRY

| INPUT | FRACTION OF 1972 FEED PRICE |
|---|---|
| chemical products | 0.003 |
| crop products | 0.286 |
| livestock products | 0 |
| other farm products | 0.004 |
| fertilizer | 0 |
| feed | 0.076 |
| railroad | 0.011 |
| trucking | 0.041 |
| inland water | 0 |
| Pacific water | 0 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| industrial construction | 0.021 |
| residential construction | 0 |
| architectural metals | 0 |
| cement | 0 |
| forestry | 0 |

TABLE D-11 (continued)

1972 INPUT VECTOR OF THE FEED INDUSTRY

| INPUT | FRACTION OF 1972 FEED PRICE |
|---|---|
| wood | 0 |
| iron mines | 0 |
| iron and steel mills | 0.002 |
| steel pipe and tube mills | 0 |
| electricity | 0.005 |
| refinery products | 0.001 |
| oil pipeline | 0 |
| natural gas | 0.001 |
| bond interest | 0.012 |
| profit | 0.036 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0.098 |
| other expense | 0.403 |

## 7. RAILROAD INDUSTRY

The information used in this section was taken from two of the 1970 DBS catalogues on railroads (57, 58) and the 1962 Alberta Input-Output Table (44). Unless otherwise stated, the figures taken from the DBS catalogures were obtained by combining the data for the Canadian Pacific, Canadian National and Northern Alberta railroads.

### INDUSTRIAL CONSTRUCTION EXPENSE OF THE RAILROAD INDUSTRY: ESTIMATION OF $comp_{14,7}(1972)$

Depreciation of road property accounted for 4.4% of revenues in 1970 (57). Therefore, $comp_{14,7}(1972)$ is 0.044.

### IRON AND STEEL MILL PRODUCT EXPENSE OF THE RAILROAD INDUSTRY: ESTIMATION OF $comp_{21,7}(1972)$

The use of primary metal products was responsible for 4.43% of the revenues of the Alberta railroad industry in 1962 (44). The percentage of the cost of primary metals to the Canadian transportation and storage industry in 1961, which was attributable to iron and steel mill products (15), was 44.4%. Consequently, $comp_{21,7}(1972)$ is 0.043 x 0.444 = 0.019.

REFINERY PRODUCT EXPENSE OF THE RAILROAD INDUSTRY:
ESTIMATION OF $comp_{24,7}(1972)$

Canadian railroad companies in 1970 consumed 0.029 gallons of fuel oil, 0.249 gallons of diesel oil, and 0.003 gallons of gasoline for each dollar of revenue received (57, 58). Oil companies received 8.4¢/gallon for fuel oil, 11.3¢/gallon for diesel oil and 13.3¢/gallon for gasoline (Table D-1). Therefore, $comp_{24,7}(1972)$ is $0.029 \times 0.084 + 0.249 \times 0.113 + 0.003 \times 0.133 = 0.031$.

INTEREST EXPENSE OF THE RAILROAD INDUSTRY:
ESTIMATION OF $BIE_7(1972)/P_7(1972)$

The percentage of revenues which was used to pay interest expense in 1970 (57) was 5.7%. Thus $BIE_7(1972)/P_7(1972)$ is 0.057.

PROFIT REQUIRED BY THE RAILROAD INDUSTRY:
ESTIMATION OF $PROF_7(1972)/P_7(1972)$

Net income before tax was responsible for 1.4% of the 1970 revenues (57). Consequently, $PROF_7(1972)/P_7(1972)$ is 0.014.

LABOUR EXPENSE OF THE RAILROAD INDUSTRY:
ESTIMATION OF $comp_{27,7}(1972)$

Labour expense accounted for 50.3% of revenues in 1970

(57, 59). Therefore, $comp_{27,7}(1972)$ is 0.503.

ESTIMATION OF THE 1972 INPUT VECTOR OF THE RAILROAD INDUSTRY

The following table shows the fraction of the railroad industry's 1972 revenues which were used to pay for its various inputs.

TABLE D-12

1972 INPUT VECTOR OF THE RAILROAD INDUSTRY

| INPUT | FRACTION OF THE 1972 REVENUES OF THE RAILROAD INDUSTRY |
| --- | --- |
| chemical products | 0 |
| crop products | 0 |
| livestock products | 0 |
| other farm products | 0 |
| fertilizer | 0 |
| feed | 0 |
| railroad | 0.016 |
| trucking | 0.020 |
| inland water | 0 |
| Pacific water | 0 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| industrial construction | 0.044 |
| residential construction | 0 |
| architectural metals | 0 |
| cement | 0 |
| forestry | 0 |

TABLE D-12 (continued)

## 1972 INPUT VECTOR OF THE RAILROAD INDUSTRY

| INPUT | FRACTION OF THE 1972 REVENUES OF THE RAILROAD INDUSTRY |
|---|---|
| wood | 0.018 |
| iron mines | 0 |
| iron and steel mills | 0.019 |
| steel pipe and tube mills | 0 |
| electricity | 0.001 |
| refinery products | 0.031 |
| oil pipeline | 0 |
| natural gas | 0 |
| bond interest | 0.057 |
| profit | 0.014 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0.503 |
| other expense | 0.277 |

## 8. TRUCKING INDUSTRY

In this section all of the data was obtained from DBS catalogues (60, 61). Figures for carriers with annual operating revenues greater than $500,000 were obtained in Reference 60. Corresponding figures for carriers with annual revenues between $20,000 and $99,999 were taken from Reference 61. Combining the data obtained from these sources it was possible to calculate desired ratios for all carriers in Alberta with revenues in excess of $20,000. Sufficient data was not available for carriers with revenues less than $20,000. In 1969, firms with revenues greater than $20,000 were responsible for about 98% of the revenues obtained by the trucking industry (60, 61). Thus it is reasonable to assume that the ratios calculated for these firms will be valid for the whole of the trucking industry.

The term $comp_{jk}(t)$ is the estimated fraction of the Alberta truck industry's revenues in year t which must be paid to industry j for the use of its product or service.

### TRUCKING EXPENSE OF THE TRUCKING INDUSTRY: ESTIMATION OF $comp_{88}(1972)$

Trucking expense is the cost incurred by trucking companies in using the services of other trucking firms. The value of $comp_{88}$(1972) is the average of the corresponding values in 1968 and 1969 as obtained from References 60 and 61. This is 0.286.

REFINERY PRODUCT EXPENSE OF THE TRUCKING INDUSTRY:
ESTIMATION OF $comp_{24,8}$(1972)

For each dollar of revenue obtained in 1969 the trucking industry consumed 0.052 gallons of gasoline and 0.152 gallons of diesel oil (60, 61). Oil refineries received 13.3¢/gallon of gasoline and 11.3¢/gallon of diesel oil (Table D-1). Consequently, $comp_{24,8}(1972) = 0.052 \times 0.133 + 0.152 \times 0.113 = 0.024$.

ESTIMATION OF THE 1972 INPUT VECTOR OF THE TRUCKING INDUSTRY

The following table shows the fractions of the trucking industry's 1972 revenues which were used to pay for various inputs. The nonzero values which have not already been explained were taken from 1969 DBS catalogues (60, 61).

TABLE D-13

1972 INPUT VECTOR OF THE TRUCKING INDUSTRY

| INPUT | FRACTION OF THE TRUCKING INDUSTRY'S 1972 REVENUES |
|---|---|
| chemical products | 0 |
| crop products | 0 |
| livestock products | 0 |
| other farm products | 0 |
| fertilizer | 0 |
| feed | 0 |
| railroad | 0 |
| trucking | 0.286 |
| inland water | 0 |
| Pacific water | 0 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| industrial construction | 0 |
| residential construction | 0 |
| architectural metals | 0 |
| cement | 0 |
| forestry | 0 |

TABLE D-13 (continued)

1972 INPUT VECTOR OF THE TRUCKING INDUSTRY

| INPUT | FRACTION OF THE TRUCKING INDUSTRY'S 1972 REVENUES |
|---|---|
| wood | 0 |
| iron mines | 0 |
| iron and steel mills | 0 |
| steel pipe and tube mills | 0 |
| electricity | 0 |
| refinery products | 0.024 |
| oil pipeline | 0 |
| natural gas | 0 |
| bond interest | 0 |
| profit | 0.058 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0.256 |
| other expense | 0.376 |

9. THE INLAND WATER TRANSPORT INDUSTRY

The inland water transport industry is composed of all those carriers whose principle region of operation is the "inland waters" as defined by the Canadian Shipping Act. There is essentially no transfer of materials within Alberta by means of water transport. The inland water transport industy is included in the analysis because part of the costs of the iron mining industry are due to transportation of materials to the mine by inland water transport. All of the data used in this section was obtained from a DBS catalogue (62). Unless stated otherwise the figures used will have been obtained from 1970 data and they apply to all public carriers which operate in the inland region of Canada.

LIVESTOCK PRODUCT EXPENSE OF THE INLAND WATER TRANSPORT INDUSTRY: ESTIMATION OF $comp_{3,9}$(1972)

Passenger food accounted for 1.3% of revenues. In the section on the labour industry it can be seen that for each $50.5 paid by the labour industry for livestock products $16 was spent on "other farm" products. Consequently, $1.3 \times \frac{50.5\%}{66.5} = 1.0\%$ of the revenues of the inland water transport industry were used to pay for livestock products. Similarly, 0.3% of revenues were spent on "other farm" products. Farmers received 54.4% of the retail price of livestock products (section on labour industry). Therefore, $comp_{3,9}(1972)$ is 0.010 x 0.644 = 0.005.

"OTHER FARM" PRODUCT EXPENSE OF THE INLAND WATER TRANSPORT INDUSTRY: ESTIMATION OF $comp_{4,9}(1972)$

"Other farm"products accounted for 0.3% of revenues. Farmers obtained 25.4% of this amount (section on labour industry). Consequently, $comp_{4,9}(1972)$ is 0.003 x 0.254 = 0.001.

REFINERY PRODUCT EXPENSE OF THE INLAND WATER TRANSPORT INDUSTRY: ESTIMATION OF $comp_{24,9}(1972)$

For each dollar of revenue obtained, the inland water transport industry consumed 0.557 gallons of fuel oil, 0.201 gallons of diesel oil, 0.003 gallons of lubricating oil and 0.001 gallons of gasoline. The oil refineries received 8.4¢/gallon for lubricating oil and 11.3¢/gallon for diesel oil, 50.8¢/gallon for lubricating oil and 13.3¢/gallon for gasoline (Table D-1). Therefore, $comp_{24,9}$ (1972) is 0.557 x 0.084 + 0.201 x 0.113 + 0.003 x 0.508 + 0.001 x 0.133 = 0.071.

INTEREST EXPENSE OF THE INLAND WATER TRANSPORT INDUSTRY: ESTIMATION OF $BIE_9(1972)/P_9(1972)$

For carriers with revenues greater than $50,000 interest expense accounted for 3.5% of revenues. Consequently, $BIF_9(1972)/P_9(1972)$ is 0.035.

PROFIT REQUIRED BY THE INLAND WATER TRANSPORT INDUSTRY: ESTIMATION OF $PROF_9(1972)/P_9(1972)$

Net income before taxes was 10.5% of revenues. Therefore, $PROF_9(1972)/P_9(1972)$ is 0.105.

LABOUR EXPENSE OF THE INLAND WATER TRANSPORT INDUSTRY: ESTIMATION OF $comp_{27,9}(1972)$

Labour expense accounted for 31.8% of revenues. Consequently, $comp_{27,9}(1972)$ is 0.318.

ESTIMATION OF THE 1972 INPUT VECTOR OF THE INLAND WATER TRANSPORT INDUSTRY

The following table shows the fractions of the inland water transport industry's revenues which were used to pay for various inputs.

TABLE D-14

1972 INPUT VECTOR OF THE INLAND WATER TRANSPORT INDUSTRY

| INPUT | FRACTION OF THE 1972 REVENUES OF THE INLAND WATER TRANSPORT INDUSTRY |
|---|---|
| chemical products | 0 |
| crop products | 0 |
| livestock products | 0.005 |
| other farm products | 0.001 |
| fertilizer | 0 |
| feed | 0 |
| railroad | 0 |
| trucking | 0 |
| inland water | 0 |
| Pacific water | 0 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| industrial construction | 0 |
| residential construction | 0 |
| architectural metals | 0 |
| cement | 0 |
| forestry | 0 |

TABLE D-14 (continued)

1972 INPUT VECTOR OF THE INLAND WATER TRANSPORT INDUSTRY

| INPUT | FRACTION OF THE 1972 REVENUES OF THE INLAND WATER TRANSPORT INDUSTRY |
|---|---|
| wood | 0 |
| iron mines | 0 |
| iron and steel mills | 0 |
| steel pipe and tube mills | 0 |
| electricity | 0 |
| refinery products | 0.071 |
| oil pipeline | 0 |
| natural gas | 0 |
| bond interest | 0.035 |
| profit | 0.105 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0.318 |
| other expense | 0.465 |

## 10. PACIFIC WATER TRANSPORT INDUSTRY

The Pacific water transport industry consists of those carriers whose principle region of operation is the waters adjacent to the Pacific coast. This industry is included in the analysis because part of the cost of raw materials to fertilizer plants in Alberta is due to the expense involved in transporting them through the Pacific waters.

Using the same source of information (62) and the same procedure as for the inland water transport industry the following table was constructed for the Pacific water transport industry.

TABLE D-15

1972 INPUT VECTOR OF THE PACIFIC WATER TRANSPORT INDUSTRY

| INPUT | FRACTION OF THE 1972 REVENUES OF THE PACIFIC WATER TRANSPORT INDUSTRY |
|---|---|
| chemical products | 0 |
| crop products | 0 |
| livestock products | 0.002 |
| other farm products | 0 |
| fertilizer | 0 |
| feed | 0 |
| railroad | 0 |
| trucking | 0 |
| inland water | 0 |
| Pacific water | 0 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| industrial construction | 0 |
| residential construction | 0 |
| architectural metals | 0 |
| cement | 0 |
| forestry | 0 |

TABLE D-15 (continued)

1972 INPUT VECTOR OF THE PACIFIC WATER TRANSPORT INDUSTRY

| INPUT | FRACTION OF THE 1972 REVENUES OF THE PACIFIC WATER TRANSPORT INDUSTRY |
|---|---|
| wood | 0 |
| iron mines | 0 |
| iron and steel mills | 0 |
| steel pipe and tube mills | 0 |
| electricity | 0 |
| refinery products | 0.043 |
| oil pipeline | 0 |
| natural gas | 0 |
| bond interest | 0.037 |
| profit | 0.053 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0.392 |
| other expense | 0.473 |

## 11. URBAN TRANSIT INDUSTRY

All of the values used in this section were obtained from 1970 Alberta data. This data was contained in a DBS catalogue (63). The term $comp_{j11}(t)$ is the estimated fraction of the revenues obtained by the Alberta Urban Transit Industry in year t which is used to pay for input j.

REFINERY PRODUCT EXPENSE OF THE URBAN TRANSIT INDUSTRY: ESTIMATION OF $comp_{24,11}(1972)$

The Urban-Transit systems consumed 2,075,000 gallons of diesel oil, 223,000 gallons of gasoline, and 179,000 gallons of LPG's. The oil refineries received 11.3¢/gallon for diesel oil, 13.3¢/gallon for gasoline and 7.14¢/gallon for LPG (Table D-1). It is easily calculated from these figures that the Urban-Transit system paid $276,915 to the oil refineries. The total operating revenues of the Urban-Transit systems were $13,638,000. Therefore, $comp_{24,11}(1972)$ is 276,915/13,638,000 = 0.020.

ESTIMATION OF THE 1972 INPUT VECTOR OF THE URBAN TRANSIT INDUSTRY

All the other nonzero $comp_{j11}(1972)$ values were obtained directly from data in the 1970 DBS catalogue on the urban transit industry (63). The following table shows the fractions of the urban transit industry's 1972 revenues which were used to pay for its various inputs.

TABLE D-16

1972 INPUT VECTOR OF THE URBAN TRANSIT INDUSTRY

| INPUT | FRACTION OF THE URBAN TRANSIT INDUSTRY'S 1972 REVENUES |
|---|---|
| chemical products | 0 |
| crop products | 0 |
| livestock products | 0 |
| other farm products | 0 |
| fertilizer | 0 |
| feed | 0 |
| railroad | 0 |
| trucking | 0 |
| inland water | 0 |
| Pacific water | 0 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| industrial construction | 0 |
| residential construction | 0 |
| architectural metals | 0 |
| cement | 0 |
| forestry | 0 |

TABLE D-16 (continued)

1972 INPUT VECTOR OF THE URBAN TRANSIT INDUSTRY

| INPUT | FRACTION OF THE URBAN TRANSIT INDUSTRY'S 1972 REVENUES |
|---|---|
| wood | 0 |
| iron mines | 0 |
| iron and steel mills | 0 |
| steel pipe and tube mills | 0 |
| electricity | 0.009 |
| refinery products | 0.020 |
| oil pipeline | 0 |
| natural gas | 0 |
| bond interest | 0.042 |
| profit | -0.205 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0.691 |
| other expense | 0.443 |

## 12. TAXI INDUSTRY

REFINERY PRODUCT EXPENSE OF THE TAXI INDUSTRY:
ESTIMATION OF $comp_{24,12}(1972)$

"Other costs" for this industry are all expenses except labour, rent, interest, depreciation, and the required profit. "Other costs" were responsible for 37.8% of revenues obtained by the Canadian taxi industry in 1968 (46). About 30% of these expenses are due to fuel costs (City Cabs). Thus the taxi industry spent 11.3% of its revenues on fuel. It should be noted that this figure is very approximate as there is no data available to obtain a more accurate estimate. Taxi firms pay about 40¢/gallon for gasoline (Yellow Cabs). Refineries receive 13.3¢/gallon for gasoline. Therefore, the oil refineries receive $\frac{13.3}{40} \times 11.3\% = 3.8\%$ of the taxi industry's revenues. Thus $comp_{24,12}(1972)$ is 0.038.

ESTIMATION OF THE 1972 INPUT VECTOR OF THE TAXI INDUSTRY

All the other nonzero $comp_{j12}(1972)$ values were calculated directly from Canadian data obtained in a 1968 DBS catalogue (46). The following table shows the fractions of the taxi industry's 1972 revenues which were used to pay for its various inputs.

TABLE D-17

1972 INPUT VECTOR OF THE TAXI INDUSTRY

| INPUT | FRACTION OF THE TAXI INDUSTRY'S 1972 REVENUES |
|---|---|
| chemical products | 0 |
| crop products | 0 |
| livestock products | 0 |
| other farm products | 0 |
| fertilizer | 0 |
| feed | 0 |
| railroad | 0 |
| trucking | 0 |
| inland water | 0 |
| Pacific water | 0 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| industrial construction | 0 |
| residential construction | 0 |
| architectural metals | 0 |
| cement | 0 |
| forestry | 0 |

TABLE D-17 (continued)

1972 INPUT VECTOR OF THE TAXI INDUSTRY

| INPUT | FRACTION OF THE TAXI INDUSTRY'S 1972 REVENUES |
|---|---|
| wood | 0 |
| iron mines | 0 |
| iron and steel mills | 0 |
| steel pipe and tube mills | 0 |
| electricity | 0 |
| refinery products | 0.038 |
| oil pipeline | 0 |
| natural gas | 0 |
| bond interest | 0.005 |
| profit | 0.055 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0.430 |
| other expense | 0.472 |

## 13. AVIATION INDUSTRY

The data in this section apply to all services (scheduled and unscheduled) of Canadian civil airlines in 1971, and was taken from a DBS catalogue (64) unless otherwise stated.

### LIVESTOCK PRODUCT EXPENSE OF THE AVIATION INDUSTRY: ESTIMATION OF $comp_{3,13}(1972)$

Passenger food was responsible for 3.4% of the operating expenses of scheduled services. Operating expenses accounted for 93.6% of the revenues of all services. Consequently, the percentage of revenues attributable to food expense was 3.4 x 0.936% = 3.2%. All of this food expense was due to the use of livestock and "other farm" products. In the section on the labour industry, it can be seen that, for each $50.5 paid by the labour industry for livestock products, $16 was spent on "other farm" products. Therefore, it is assumed that $3.2 \times \frac{50.5\%}{66.5} = 2.4\%$ of the aviation industry's revenues were used to pay for livestock product costs. Similarly, 0.8% of its revenues were consumed in paying for "other farm" products. Farmers receive 54.4% of the retail price of livestock products (section on the labour industry). Thus, $comp_{3,13}(1972)$ is 0.024 x 0.544 = 0.013.

"OTHER FARM" PRODUCT EXPENSE OF THE AVIATION INDUSTRY:
ESTIMATION OF $comp_{4,13}(1972)$

"Other farm" products accounted for 0.8% of the aviation industry's revenues. Farmers received 25.4% of this amount (section on the labour industry). Therefore, $comp_{4,13}(1972)$ is 0.008 x 0.254 ≏ 0.002.

ELECTRICITY EXPENSE OF THE AVIATION INDUSTRY:
ESTIMATION OF $comp_{23,13}(1972)$

Utility expense accounted for 0.36% of the operating expenses of scheduled services. Consequently, the percentage of revenues allocated to pay for utilities was 0.36 x 0.936% = 0.33%. The utility expense for the aviation industry is due to the utilities used by the airline company offices. The Federal Government pays the utility costs of the airports. Electricity costs account for about 90% of the costs of an apartment building (Cambridge Building). Therefore, $comp_{23,13}(1972)$ is 0.0033 x 0.9 = 0.003.

REFINERY PRODUCT EXPENSE OF THE AVIATION INDUSTRY:
ESTIMATION OF $comp_{24,13}(1972)$

The aviation industry consumed 0.563 gallons of turbo fuel and 0.021 gallons of gasoline per dollar of revenue received. The oil refineries received 11.5¢/gallon for turbo fuel and 19.3¢/gallon for aviation gasoline (Table D-1). Therefore, as a result of using these two commodities, the aviation industry paid $0.563 \times 0.115 + 0.021 \times 0.193 = \$0.069$ for each dollar of its revenues to the oil refineries.

The oil refineries also received money from the sale of oil to the aviation industry. This industry consumed oil worth $0.0014 for each dollar of revenue obtained. If the oil refineries received 50% of this money then the aviation industry contributed $0.001, per dollar of revenue obtained, to the oil refineries as a result of its oil consumption. The two sources of income to the oil refineries from the aviation industry are combined to give

$comp_{24,13}(1972) = 0.069 + 0.001 = 0.070.$

INTEREST EXPENSE OF THE AVIATION INDUSTRY:
ESTIMATION OF $BIE_{13}(1972)/P_{13}(1972)$

Interest expense accounted for 5.5% of revenues. Therefore, $BIE_{13}(1972)/P_{13}(1972)$ is 0.055.

PROFIT REQUIRED BY THE AVIATION INDUSTRY:
ESTIMATION OF $PROF_{13}(1972)/P_{13}(1972)$

Net income before tax per unit revenue was $0.023. Consequently, $PROF_{13}(1972)/P_{13}(1972)$ is 0.023.

LABOUR EXPENSE OF THE AVIATION INDUSTRY:

ESTIMATION OF $comp_{27,13}(1972)$

Labour expense was responsible for 34.1% of revenues. Thus, $comp_{27,13}(1972)$ is 0.341.

ESTIMATION OF THE 1972 INPUT VECTOR OF THE AVIATION INDUSTRY

The following table shows the fractions of the aviation industry's 1972 revenues which were used to pay for its various inputs.

TABLE D-18

1972 INPUT VECTOR OF THE AVIATION INDUSTRY

| INPUT | FRACTION OF AVIATION INDUSTRY'S 1972 REVENUES |
|---|---|
| chemical products | 0 |
| crop products | 0.013 |
| livestock products | 0.002 |
| other farm products | 0 |
| fertilizer | 0 |
| feed | 0 |
| railroad | 0 |
| trucking | 0 |
| inland water | 0 |
| Pacific water | 0 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| *industrial construction | 0 |
| residential construction | 0 |
| architectural metals | 0 |
| cement | 0 |
| forestry | 0 |

*Industrial construction expense is zero because the airports are taken care of by the Federal Government.

TABLE D-18 (continued)

1972 INPUT VECTOR OF THE AVIATION INDUSTRY

| INPUT | FRACTION OF AVIATION INDUSTRY'S 1972 REVENUES |
|---|---|
| wood | 0 |
| iron mines | 0 |
| iron and steel mills | 0 |
| steel pipe and tube mills | 0 |
| electricity | 0.003 |
| refinery products | 0.070 |
| oil pipeline | 0 |
| natural gas | 0 |
| bond interest | 0.055 |
| profit | 0.023 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0.341 |
| other expense | 0.493 |

## 14. INDUSTRIAL CONSTRUCTION INDUSTRY

Most of the data in this section was taken from the 1962 Alberta Input-Output Table (44). Other sources of information were the 1961 Canadian Input-Output Table (15) and a DBS catalogue on the construction industry (65).

ARCHITECTURAL METAL EXPENSE OF THE INDUSTRIAL CONSTRUCTION INDUSTRY: ESTIMATION OF $comp_{16,14}(1972)$

The percentage of the Canadian construction (industrial and residential) industry's expenditure on materials in 1961, which was due to its purchase of architectural metals(15), was 3.4%. In 1971, this industry used 41.2% of its revenues to pay for the materials which it used (65). Therefore, $comp_{16,14}(1972)$ is $0.412 \times 0.034 = 0.014$.

INTEREST EXPENSE OF THE INDUSTRIAL CONSTRUCTION INDUSTRY: ESTIMATION OF $BIE_{14}(1972)/P_{14}(1972)$

For the Canadian construction industry (industrial and residential) in 1968, interest payments accounted for 1.2% of revenues (46). Consequently, $BIE_{14}(1972)/P_{14}(1972)$ is 0.012.

PROFIT REQUIRED BY THE INDUSTRIAL CONSTRUCTION INDUSTRY:

ESTIMATION OF $PROF_{14}(1972)/P_{14}(1972)$

Profits per unit revenue in 1968 were $0.037 for the Canadian construction (industrial and residential) industry (46). Therefore, $PROF_{14}(1972)/P_{14}(1972)$ is 0.037.

LABOUR EXPENSE OF THE INDUSTRIAL CONSTRUCTION INDUSTRY:

ESTIMATION OF $comp_{27,14}(1972)$

Labour expense accounted for 34.4% of the revenues of the Canadian construction (industrial and residential) industry in 1971 (65). Thus, $comp_{27,14}(1972)$ is 0.344.

ESTIMATION OF THE 1972 INPUT VECTOR OF THE INDUSTRIAL CONSTRUCTION INDUSTRY

The values of inputs corresponding to the use of cement, iron and steel mill products, steel pipe and tube mill products, and refinery products (excluding fuel oil) were evaluated in the same way as the input value for architectural metal products.

All the other nonzero inputs to the industrial construction industry were taken from the 1962 Alberta Input-Output Table (44). The following table shows the fractions of the industrial construction industry's 1972 revenues which were used to pay for its various inputs.

TABLE D-19

1972 INPUT VECTOR OF THE INDUSTRIAL CONSTRUCTION INDUSTRY

| INPUT | FRACTION OF THE INDUSTRIAL CONSTRUCTION INDUSTRY'S 1972 REVENUES |
|---|---|
| chemical products | 0.013 |
| crop products | 0 |
| livestock products | 0 |
| other farm products | 0 |
| fertilizer | 0 |
| feed | 0 |
| railroad | 0.023 |
| trucking | 0.103 |
| inland water | 0 |
| Pacific water | 0 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| industrial construction | 0.001 |
| residential construction | 0 |
| architectural metals | 0.014 |
| cement | 0.007 |
| forestry | 0.002 |

TABLE D-19 (continued)

1972 INPUT VECTOR OF THE INDUSTRIAL CONSTRUCTION INDUSTRY

| INPUT | FRACTION OF THE INDUSTRIAL CONSTRUCTION INDUSTRY'S 1972 REVENUES |
|---|---|
| wood | 0.022 |
| iron mines | 0 |
| iron and steel mills | 0.016 |
| steel pipe and tube mills | 0.018 |
| electricity | 0.003 |
| refinery products | 0.010 |
| oil pipeline | 0 |
| natural gas | 0 |
| bond interest | 0.012 |
| profit | 0.037 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0.344 |
| other expense | 0.375 |

## 15. RESIDENTIAL CONSTRUCTION INDUSTRY

Using the same sources of information (15, 44, 65) and the same procedure, as for the industrial construction industry, the following table was constructed for the residential construction industry.

TABLE D-20

1972 INPUT VECTOR OF THE RESIDENTIAL CONSTRUCTION INDUSTRY

| INPUT | FRACTION OF THE RESIDENTIAL CONSTRUCTION INDUSTRY'S 1972 REVENUES |
|---|---|
| chemical products | 0.009 |
| crop products | 0 |
| livestock products | 0 |
| other farm products | 0 |
| fertilizer | 0 |
| feed | 0 |
| railroad | 0 |
| trucking | 0.024 |
| inland water | 0 |
| Pacific water | 0 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| industrial construction | 0 |
| residential construction | 0 |
| architectural metals | 0.014 |
| cement | 0.007 |
| forestry | 0 |

TABLE D-20 (continued)

1972 INPUT VECTOR OF THE RESIDENTIAL CONSTRUCTION INDUSTRY

| INPUT | FRACTION OF THE RESIDENTIAL CONSTRUCTION INDUSTRY'S 1972 REVENUES |
|---|---|
| wood | 0.066 |
| iron mines | 0 |
| iron and steel mills | 0.016 |
| steel pipe and tube mills | 0.018 |
| electricity | 0.001 |
| refinery products | 0.010 |
| oil pipeline | 0 |
| natural gas | 0 |
| bond interest | 0.012 |
| profit | 0.037 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0.344 |
| other expense | 0.442 |

## 16. ARCHITECTURAL METALS INDUSTRY

The data in this section was taken from DBS catalogues and from the 1961 Input-Output Table.

RAILROAD EXPENSE OF THE ARCHITECTURAL METALS INDUSTRY:
ESTIMATION OF $comp_{7,16}(1972)$

Transportation expense accounted for 4.6% of the revenues obtained by Alberta fabricating metal industries 1962 (44). Transportation expense would account for a similar percentage of the revenues of the architectural metal industry. Approximately 75% of transportation costs are due to the use of railroads. The remainder is due to trucking charges (Dominion Bridge). Therefore, $comp_{7,16}(1972)$ is $0.046 \times 0.75 = 0.035$.

TRUCKING EXPENSE OF THE ARCHITECTURAL METALS INDUSTRY:
ESTIMATION OF $comp_{8,16}(1972)$

The percentage of transportation expense which is attributable to trucking charges is 25%. Consequently, $comp_{8,16}(1972)$ is $0.046 \times 0.25 = 0.011$.

ELECTRICITY EXPENSE OF THE ARCHITECTURAL METALS INDUSTRY: ESTIMATION OF $comp_{23,16}(1972)$

In 1969 the Alberta architectural metals industry used 0.7% of its revenues to pay for fuel and electricity costs (32). In the same year, 41.3% of the Canadian architectural metals industry's fuel and electricity expense was attributable to electricity costs (32). Therefore, $comp_{23,16}(1972)$ is 0.007 x 0.413 = 0.003.

REFINERY PRODUCT EXPENSE OF THE ARCHITECTURAL METALS INDUSTRY: ESTIMATION OF $comp_{24,16}(1972)$

For each dollar of its 1969 fuel and electricity expense the Canadian architectural metals industry used 0.53 gallons of gasoline and 0.51 gallons of fuel oil (32). If 14% of this fuel oil was diesel oil then the quantity of diesel fuel consumed was 0.14 x 0.51 = 0.07 gallons. Oil refineries received 13.3¢/gallon for gasoline and 11.3¢/gallon for diesel oil (Table D-1). Therefore, 0.53 x 0.133 + 0.07 x 0.113 = 0.078 dollars of each dollar spent by architectural metal producers on fuel and electricity is obtained by oil refineries. Consequently, as fuel and electricity expense accounts for 0.7% of revenues, $comp_{24,16}(1972)$ is 0.078 x 0.007 = 0.001.

NATURAL GAS EXPENSE OF THE ARCHITECTURAL METALS INDUSTRY: ESTIMATION OF $comp_{26,16}(1972)$

Natural gas expense accounted for 22.7% of the fuel and electricity costs of the Canadian architectural metals industry in 1969 (32). Therefore, $comp_{26,16}(1972)$ is $0.227 \times 0.007 = 0.002$.

INTEREST EXPENSE OF THE ARCHITECTURAL METALS INDUSTRY: ESTIMATION OF $BIE_{16}(1972)/P_{16}(1972)$

For Canadian architectural metal producers in 1968, interest payments accounted for 1.1% of revenues (46). Thus $BIE_{16}(1972)/P_{16}(1972)$ is 0.011.

PROFITS REQUIRED BY THE ARCHITECTURAL METALS INDUSTRY: ESTIMATION OF $PROF_{16}(1972)/P_{16}(1972)$

Profits per unit revenue in 1968 were $0.038 for Canadian architectural metal producers (46). Therefore, $PROF_{16}(1972)/P_{16}(1972)$ is 0.038.

LABOUR EXPENSE OF THE ARCHITECTURAL METALS INDUSTRY: ESTIMATION OF $comp_{27,16}(1972)$

Labour expense accounted for 28.1% of the revenues earned by Alberta architectural metal manufacturers in 1969 (32).

Consequently, $comp_{27,16}(1972)$ is 0.281.

ESTIMATION OF THE 1972 INPUT VECTOR OF THE ARCHITECTURAL METALS INDUSTRY

The values of all the other nonzero inputs to this industry were obtained by combining 1961 Canadian data and 1969 Alberta data. The following table was obtained from the 1961 Canadian Input-Output Table.

TABLE D-21

SOME COMPONENTS OF THE INDUSTRY'S MATERIAL COSTS

| INPUT | FRACTION OF COST OF TOTAL MATERIAL INPUTS TO THE ARCHITECTURAL METALS INDUSTRY |
|---|---|
| chemical products | 0.0049 |
| architectural metals | 0.0049 |
| wood | 0.0213 |
| iron and steel mill products | 0.2995 |
| steel pipe and tube mills | 0.0033 |

Material inputs accounted for 50.7% of the Alberta architectural metals industry in 1969 (32). Therefore, using the above table it can be seen that 0.49 x 0.507% = 0.2% of revenues were used to pay the chemical product expense. The percentages of revenues which were used to pay for the other products in Table D-21 are calculated in a similar fashion.

The following table shows the fractions of the architectural metals industry's 1972 revenues which were used to pay for its various inputs.

TABLE D-22

1972 INPUT VECTOR OF THE ARCHITECTURAL METALS INDUSTRY

| INPUT | FRACTION OF THE REVENUES OBTAINED BY THE ARCHITECTURAL METALS INDUSTRY IN 1972 |
|---|---|
| chemical products | 0.002 |
| crop products | 0 |
| livestock products | 0 |
| other farm products | 0 |
| fertilizer | 0 |
| feed | 0 |
| railroad | 0.035 |
| trucking | 0.011 |
| inland water | 0 |
| Pacific water | 0 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| industrial construction | 0 |
| residential construction | 0 |
| architectural metals | 0.002 |
| cement | 0 |
| forestry | 0 |

TABLE D-22 (continued)

1972 INPUT VECTOR OF THE ARCHITECTURAL METALS INDUSTRY

| INPUT | FRACTION OF THE REVENUES OBTAINED BY THE ARCHITECTURAL METALS INDUSTRY IN 1972 |
|---|---|
| wood | 0.011 |
| iron mines | 0 |
| iron and steel mills | 0.152 |
| steel pipe and tube mills | 0.002 |
| electricity | 0.003 |
| refinery products | 0.001 |
| oil pipeline | 0 |
| natural gas | 0.002 |
| bond interest | 0.011 |
| profit | 0.038 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0.281 |
| other expense | 0.449 |

# 17. CEMENT INDUSTRY

The Dominion Bureau of Statistics did not publish figures for the Alberta cement manufacturing industry. This was because there were only two major cement manufacturers in Alberta. Unless stated otherwise, all of the information used in this section were aprroximations obtained from Inland Cement Ltd.

RAILROAD EXPENSE OF THE CEMENT INDUSTRY:
ESTIMATION OF $comp_{7,17}(1972)$

About 14% of the revenues of Inland Cement Ltd. are used to pay for the transportation (by rail) of limestone to the plant. Canada Cement Lafarge have their quarry beside the plant. Inland Cement and Canada Cement Lafarge produce approximately equal amounts of cement in Alberta. Consequently, $comp_{7,17}(1972$ is 0.070.

FORESTRY EXPENSE OF THE CEMENT-INDUSTRY:
ESTIMATION OF $comp_{18,17}(1972)$

The percentage of the Canadian cement industry's revenues in 1961 which were attributable to the usage of forestry products (15) was 0.1%. Thus $comp_{18,17}(1972)$ is 0.001.

ELECTRICITY EXPENSE OF THE CEMENT INDUSTRY:
ESTIMATION OF $comp_{23,17}(1972)$

The value of $comp_{23,17}(1972)$ is 0.021.

REFINERY PRODUCT EXPENSE OF THE CEMENT INDUSTRY:
ESTIMATION OF $comp_{24,17}(1972)$

Refinery product expense accounts for 0.8% of revenues. The cement producing plants probably pay about 40¢/gallon for refinery products. Of this, the refinery would receive about 13¢/gallon. Therefore, $comp_{24,17}(1972)$ is $0.008 \times \frac{13}{40} = 0.003$.

NATURAL GAS EXPENSE OF THE CEMENT INDUSTRY:
ESTIMATION OF $comp_{26,17}(1972)$

The value of $comp_{26,17}(1972)$ is 0.040.

INTEREST EXPENSE OF THE CEMENT INDUSTRY:
ESTIMATION OF $BIE_{17}(1972)P_{17}(1972)$:

For Canadian cement manufacturers in 1968, interest payments accounted for 6% of revenues (46). Consequently, $BIE_{17}(1972)/P_{17}(1972)$ is 0.060.

PROFITS REQUIRED BY THE CEMENT INDUSTRY:
ESTIMATION OF $PROF_{17}(1972)/P_{17}(1972)$

Profits per unit revenue in 1968 were $0.099 for Canadian cement manufacturers (46). Therefore, $PROF_{17}(1972)/P_{17}(1972)$ is 0.099.

LABOUR EXPENSE OF THE CEMENT INDUSTRY:
ESTIMATION OF $comp_{27,17}(1972)$

Labour expense was responsible for 10% of the revenues obtained by the cement industry. Thus, $comp_{27,17}(1972)$ is 0.100.

ESTIMATION OF THE 1972 INPUT VECTOR OF THE CEMENT INDUSTRY

The following table shows the fractions of the cement industry's 1972 revenues which were used to pay for its various inputs.

TABLE D-23

1972 INPUT VECTOR OF THE CEMENT INDUSTRY

| INPUT | FRACTION OF THE CEMENT INDUSTRY'S 1972 REVENUES |
|---|---|
| chemical products | 0 |
| crop products | 0 |
| livestock products | 0 |
| other farm products | 0 |
| fertilizer | 0 |
| feed | 0 |
| railroad | 0.070 |
| trucking | 0 |
| inland water | 0 |
| Pacific water | 0 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| industrial construction | 0 |
| residential construction | 0 |
| architectural metals | 0 |
| cement | 0 |
| forestry | 0.001 |

TABLE D-23 (continued)

1972 INPUT VECTOR OF THE CEMENT INDUSTRY

| INPUT | FRACTION OF THE CEMENT INDUSTRY'S 1972 REVENUES |
|---|---|
| wood | 0 |
| iron mines | 0 |
| iron and steel mills | 0 |
| steel pipe and tube mills | 0 |
| electricity | 0.021 |
| refinery products | 0.003 |
| oil pipeline | 0 |
| natural gas | 0.040 |
| bond interest | 0.060 |
| profit | 0.099 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0.100 |
| other expense | 0.606 |

## 18. FORESTRY INDUSTRY

Unless stated otherwise all of the data in this section was taken from the 1962 Alberta Input-Output Table (44).

ELECTRICITY EXPENSE OF THE FORESTRY INDUSTRY:
ESTIMATION OF $comp_{23,18}(1972)$

The forestry industry used 0.16% of its revenues to pay for electricity and water. A large percentage of electricity and water expense would be due to electricity costs. Therefore, a reasonable estimate for $comp_{23,18}(1972)$ is 0.001.

REFINERY PRODUCT EXPENSE OF THE FORESTRY INDUSTRY:
ESTIMATION OF $comp_{24,18}(1972)$

For each dollar worth of fuel and electricity consumed in 1969, the Canadian forestry industry used 0.96 gallons of gasoline and 1.85 gallons of fuel oil (66). Oil refineries received 13.3¢/gallon for gasoline and 8.4¢/gallon for diesel oil (Table D-1). Therefore 0.96 x 0.133 + 1.85 x 0.084 = \$0.283 of each dollar spent by the forestry industry on fuel and electricity is received by oil refineries. In Alberta, fuel and electricity costs accounted for 3.2% of the 1969 forestry revenues (66). Therefore, $comp_{24,18}$ (1972) is 0.283 x 0.032 = 0.009.

INTEREST EXPENSE OF THE FORESTRY INDUSTRY:

ESTIMATION OF $BIE_{18}(1972)/P_{18}(1972)$

Interest payments accounted for 1.9% of the Canadian forestry industry's 1968 revenues (46). Thus $BIE_{18}(1972)/P_{18}(1972)$ is 0.019.

PROFITS REQUIRED BY THE FORESTRY INDUSTRY:

ESTIMATION OF $PROF_{18}(1972)/P_{18}(1972)$

The Canadian forestry industry in 1968 obtained profits of $0.086 per unit revenue (46). Therefore, $PROF_{18}(1972)/P_{18}(1972)$ is 0.086.

LABOUR EXPENSE OF THE FORESTRY INDUSTRY:

ESTIMATION OF $comp_{27,18}(1972)$

Labour expense accounted for 28.8% of the Alberta forestry industry's revenues in 1969 (66). Consequently, $comp_{27,18}$ (1972) is 0.288.

ESTIMATION OF THE 1972 INPUT VECTOR OF THE FORESTRY INDUSTRY

The values of all the other nonzero inputs to the forestry industry were taken from the 1962 Alberta Input-Output Table (44). The following table was then obtained.

TABLE D-24

1972 INPUT VECTOR OF THE FORESTRY INDUSTRY[a]

| INPUT | FRACTION OF THE FORESTRY INDUSTRY'S 1972 REVENUES |
|---|---|
| chemical products | 0 |
| crop products | 0 |
| livestock products | 0 |
| other farm products | 0 |
| fertilizer | 0 |
| feed | 0 |
| railroad | 0.027 |
| trucking | 0.119 |
| inland water | 0 |
| Pacific water | 0 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| *industrial construction | 0.015 |
| residential construction | 0 |
| architectural metals | 0 |
| cement | 0 |
| forestry | 0 |

*The input from the industrial construction industry is a result of repair construction required.

TABLE D-24

1972 INPUT VECTOR OF THE FORESTRY INDUSTRY

| INPUT | FRACTION OF THE FORESTRY INDUSTRY'S 1972 REVENUES |
|---|---|
| wood | 0.001 |
| iron mines | 0 |
| iron and steel mills | 0 |
| steel pipe and tube mills | 0 |
| electricity | 0.001 |
| refinery products | 0.009 |
| oil pipeline | 0 |
| natural gas | 0 |
| bond interest | 0.019 |
| profit | 0.086 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0.288 |
| other expense | 0.435 |

## 19. WOOD PRODUCT INDUSTRY

This industry is the sum of the following four industries:

1. sawmills and planing mills,
2. veneer and plywood mills,
3. sash, door and other millwork plants, and
4. miscellaneous wood using industries.

### IRON AND STEEL MILL PRODUCT EXPENSE OF THE WOOD PRODUCT INDUSTRY: ESTIMATION OF $comp_{21,18}(1972)$

The percentage of the Canadian wood product industry's 1961 revenues which was used to pay for the produce obtained from iron and steel mills (15) was 0.1%. Thus $comp_{21,18}(1972)$ is 0.001.

### ELECTRICITY EXPENSE OF THE WOOD PRODUCT INDUSTRY: ESTIMATION OF $comp_{23,18}(1972)$

The percentage of the revenues received by the Alberta wood product industry in 1970 which were consumed in the payment of fuel and electricity expense (67 - 70) was 2.0%. In the same year, 52.1% of the Canadian wood product industry's fuel and electricity expense was attributable to electricity costs (67 - 70). Therefore, $comp_{23,18}(1972)$ is $0.020 \times 0.521 = 0.010$.

REFINERY PRODUCT EXPENSE OF THE WOOD PRODUCT INDUSTRY:
ESTIMATION OF $comp_{24,18}(1972)$

For each dollar spent on fuel and electricity in 1970, the Canadian wood product industry used 0.52 gallons of gasoline and 0.94 gallons of fuel oil (67 - 70). If 14% of this fuel oil was diesel oil then the quantity of diesel oil consumed was 0.14 x 0.94 = 0.13 gallons. Oil refineries received 13.3¢/gallon for gasoline and 11.3¢/gallon for diesel oil (Table D-1). Therefore, 0.52 x 0.133 + 0.13 x 0.113 = 0.084 dollars of each dollar spent by the wood product industry on fuel and electricity is obtained by oil refineries. Consequently, as fuel and electricity expense accounts for 2.0% of revenues, $comp_{24,18}(1972)$ is 0.084 x 0.002 = 0.002.

NATURAL GAS EXPENSE OF THE WOOD PRODUCTS INDUSTRY:
ESTIMATION OF $comp_{26,18}(1972)$

Natural gas expense accounted for 6.8% of the fuel and electricity costs of the Canadian wood products industry in 1970 (67 - 70). Therefore, $comp_{26,18}(1972)$ is 0.068 x 0.02 = 0.001.

INTEREST EXPENSE OF THE WOOD PRODUCT INDUSTRY:

ESTIMATION OF $BIE_{18}(1972)/P_{18}(1972)$

Interest payments accounted for 2.0% of the revenues obtained by the Canadian wood product industry in 1968 (46). Thus, $BIE_{18}(1972)/P_{18}(1972)$ is 0.020.

PROFITS REQUIRED BY THE WOOD PRODUCT INDUSTRY:

ESTIMATION OF $PROF_{18}(1972)/P_{18}(1972)$

Profits per unit revenue in 1968 were $0.071 for the Canadian wood product industry (46). Therefore, $PROF_{18}(1972)/P_{18}(1972)$ is 0.071.

LABOUR EXPENSE OF THE WOOD PRODUCT INDUSTRY:

ESTIMATION OF $comp_{27,18}(1972)$

In 1969 the Alberta wood product industry used 24.9% of its revenues to pay wages and salaries (71). Consequently, $comp_{27,18}(1972)$ is 0.249.

ESTIMATION OF THE 1972 INPUT VECTOR OF THE WOOD PRODUCT INDUSTRY

The values of all the other nonzero inputs to the wood product industry were taken from the 1962 Alberta Input-Output Table (44). The following table was then obtained.

TABLE D-25

1972 INPUT VECTOR OF THE WOOD PRODUCT INDUSTRY

| INPUT | FRACTION OF THE WOOD PRODUCT INDUSTRY'S 1972 REVENUES |
|---|---|
| chemical products | 0.025 |
| crop products | 0 |
| livestock products | 0 |
| other farm products | 0 |
| fertilizer | 0 |
| feed | 0 |
| railroad | 0.059 |
| trucking | 0.099 |
| inland water | 0 |
| Pacific water | 0 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| *industrial construction | 0.009 |
| residential construction | 0 |
| architectural metals | 0 |
| cement | 0 |
| forestry | 0.197 |

*The input from the industrial construction industry is a result of the repair construction required.

TABLE D-25 (continued)

1972 INPUT VECTOR OF THE WOOD PRODUCT INDUSTRY

| INPUT | FRACTION OF THE WOOD PRODUCT INDUSTRY'S 1972 REVENUES |
|---|---|
| wood | 0.041 |
| iron mines | 0 |
| iron and steel mills | 0.001 |
| steel pipe and tube mills | 0 |
| electricity | 0.010 |
| refinery products | 0.002 |
| oil pipeline | 0 |
| natural gas | 0.001 |
| bond interest | 0.020 |
| profit | 0.071 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0.249 |
| other expense | 0.216 |

## 20. IRON MINING INDUSTRY

Although there is no iron ore produced in Alberta, it was decided to include iron mining in the analysis as its produce is used by iron and steel mills. Canadian figures are used for this industry and they were obtained from DBS catalogues, and from the 1961 Canadian Input-Output Table. The main problem in this section is the estimation of the proportion of revenues which is due to the various transportation expenses.

### CHEMICAL PRODUCT EXPENSE OF THE IRON MINING INDUSTRY: ESTIMATION OF $comp_{1,20}(1972)$

In 1961, the iron mining industry used 0.1% of its revenues to pay for chemical products (15). Therefore $comp_{1,20}$ (1972) is 0.001.

### TRANSPORTATION EXPENSE OF THE IRON MINING INDUSTRY

The percentage of the revenues of the iron mining industry in 1961 which was attributable to transportation expense (15) was 3.9%. The proportions of this expense which are due to the various forms of transportation will now be estimated. The following table was obtained from a booklet prepared by the Mining Association of Canada (72).

TABLE D-26

PERCENTAGE OF CANADA'S IRON ORE PRODUCED BY DIFFERENT PROVINCES

| PROVINCE | PERCENTAGE OF CANADA'S IRON ORE PRODUCED BY DIFFERENT PROVINCES |
|---|---|
| Newfoundland | 51.3% |
| Ontario | 25.5% |
| Quebec | 20.2% |
| B. C. | 3% |

The next table is very approximate and was based on the location of the major iron mines in the four provinces.

TABLE D-27

DISTRIBUTION OF PROVINCIAL IRON ORE

PRODUCERS' TRANSPORTATION EXPENSES

| PROVINCE | PERCENTAGES OF PROVINCE'S TRANSPORTATION EXPENSES WHICH ARE DUE TO THE FOLLOWING MODES OF TRANSPORTATION | | | |
|---|---|---|---|---|
| | INLAND WATER TRANSPORT | PACIFIC WATER TRANSPORT | RAILROAD | TRUCK |
| Newfoundland | 50% | - | 50% | - |
| Ontario | - | - | 30% | 70% |
| Quebec | 50% | - | 50% | - |
| B. C. | - | 100% | - | - |

The railroad expense of the Canadian iron mining industry is the sum of this expense for the four iron ore producing provinces. Consequently, the fraction of the Canadian iron mining industry's transportation expense which is due to railroad expense is 0.513 x 0.5 + 0.255 x 0.3 + 0.20 x 0.5 + 0.03 x 0 = 0.434. In 1961 transportation and storage expenses accounted for 16.4% of the iron mining industry's raw material costs (15). Between 1967 and 1970 the average percentage of this industry's revenues which was used to pay its raw material costs (73, 74, 37, 75) was 23.8%. Therefore, 0.164 x 0.238 x 100% = 3.9% of the revenues of the iron mining industry are due to transportation expense. Consequently, the railroad expense per unit revenue is \$0.039 x 0.434 = \$0.017. Thus $comp_{7,20}(1972)$ is 0.017. Similarly, values are obtained which show the proportion of revenues which are due to the other modes of transportation.

ELECTRICITY EXPENSE OF THE IRON MINING INDUSTRY: ESTIMATION OF $comp_{23,20}(1972)$

The average value of electricity expense per unit revenue for the years 1967 to 1970 (73, 74, 37, 75) was \$0.033. Consequently, $comp_{23,20}(1972)$ is 0.033.

REFINERY PRODUCT EXPENSE OF THE IRON MINING INDUSTRY: ESTIMATION OF $comp_{24,20}(1972)$

In 1970 the iron mining industry used 0.003 gallons of gasoline, 0.221 gallons of fuel oil, and 0.006 gallons of LPG per unit revenue obtained (75). The oil refineries received 13.3¢/gallon for gasoline, 8.4¢/gallon for fuel oil, and 7.1¢/gallon for LPGs (Table D-1). Therefore, $comp_{24,20}(1972)$ is $0.003 \times 0.133 + 0.221 \times 0.08 + 0.006 \times 0.071 = 0.019$.

NATURAL GAS EXPENSE OF THE IRON MING INDUSTRY: ESTIMATION OF $comp_{26,20}(1972)$

Natural gas expense accounted for 0.7% of revenues in 1970 (75). Thus $comp_{26,20}(1972)$ is 0.007.

INTEREST EXPENSE OF THE IRON MINING INDUSTRY: ESTIMATION OF $BIE_{20}(1972)/P_{20}(1972)$

For the iron mining industry in 1968, interest payments accounted for 5.0% of revenues (46). Thus, $BIE_{20}(1972)/P_{20}(1972)$ is 0.050.

PROFITS REQUIRED BY THE IRON MINING INDUSTRY:

ESTIMATION OF $PROF_{20}(1972)/P_{20}(1972)$

Profits per unit revenue in 1968 were $0.160 (46). Therefore, $PROF_{20}(1972)/P_{20}(1972)$ is 0.160.

LABOUR EXPENSE OF THE IRON MINING INDUSTRY:

ESTIMATION OF $comp_{27,20}(1972)$

Labour expense accounted for 19.2% of revenues in 1970 (75). Consequently, $comp_{27,20}(1972)$ is 0.192.

ESTIMATION OF THE 1972 INPUT VECTOR OF THE IRON MINING INDUSTRY

The following table shows the fractions of the iron mining industry's 1972 revenues which were used to pay for its various inputs.

TABLE D-28

1972 INPUT VECTOR OF THE IRON MINING INDUSTRY

| INPUT | FRACTION OF THE IRON MINING INDUSTRY'S 1972 REVENUES |
|---|---|
| chemical products | 0.001 |
| crop products | 0 |
| livestock products | 0 |
| other farm products | 0 |
| fertilizer | 0 |
| feed | 0 |
| railroad | 0.017 |
| trucking | 0.007 |
| inland water | 0.014 |
| Pacific water | 0.001 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| industrial construction | 0 |
| residential construction | 0 |
| architectural metals | 0 |
| cement | 0 |
| forestry | 0 |

TABLE D-28 (continued)

1972 INPUT VECTOR OF THE IRON MINING INDUSTRY

| INPUT | FRACTION OF THE IRON MINING INDUSTRY'S 1972 REVENUES |
|---|---|
| wood | 0 |
| iron mines | 0 |
| iron and steel mills | 0 |
| steel pipe and tube mills | 0 |
| electricity | 0.033 |
| refinery products | 0.019 |
| oil pipeline | 0 |
| natural gas | 0.007 |
| bond interest | 0.050 |
| profit | 0.160 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0.192 |
| other expense | 0.499 |

## 21. IRON AND STEEL MILLS

There are no iron and steel mills in Alberta. Consequently, Canadian figures from DBS catalogues and the 1961 Input-Output Table were used for this industry. Iron and steel mills are included in the analysis because their products are used by many industries in Alberta.

RAILROAD EXPENSE OF IRON AND STEEL MILLS:
ESTIMATION OF $comp_{7,21}(1972)$

Transportation and storage costs accounted for 3.6% of revenues in 1961 (15). About 80% of these costs are due to transportation expenses. Therefore, 3.6 x 0.8% = 2.9% of revenues were used to pay for transportation charges. If the same transportation distribution is used as for architectural metals then 75% of transportation charges were due to railroad costs and 25% to trucking costs. Therefore, $comp_{7,21}(1972)$ is 0.029 x 0.75 = 0.022.

TRUCKING EXPENSE OF IRON AND STEEL MILLS:
ESTIMATION OF $comp_{8,21}(1972)$

The percentage of transportation expense attributable to trucking charges is 25%. Consequently, $comp_{8,21}(1972)$ is 0.029 x 0.25   0.007.

ELECTRICITY EXPENSE OF IRON AND STEEL MILLS:
ESTIMATION OF $comp_{23,21}(1972)$

Electricity expense accounted for 1.9% of the industry's revenues in 1969 (38). Thus, $comp_{23,21}(1972)$ is 0.019.

REFINERY PRODUCT EXPENSE OF IRON AND STEEL MILLS:
ESTIMATION OF $comp_{24,21}(1972)$

In 1969, iron and steel mills used 0.001 gallons of gasoline, 0.103 gallons of fuel oil and 0.001 gallons of LPGs per unit revenue obtained (38). The oil refineries received 13.3¢/gallon for gasoline, 8.4¢/gallon for fuel oil, and 7.1¢/gallon for LPGs (Table D-1). Therefore, $comp_{24,21}(1972)$ is $0.001 \times 0.133 + 0.103 \times 0.084 + 0.001 \times 0.071 = 0.009$.

NATURAL GAS EXPENSE OF IRON AND STEEL MILLS:
ESTIMATION OF $comp_{26,21}(1972)$

In 1969 the industry used 0.7% of its revenues to pay for natural gas (38). Consequently, $comp_{26,21}(1972)$ is 0.007.

INTEREST EXPENSE OF IRON AND STEEL MILLS:
ESTIMATION OF $BIE_{21}(1972)/P_{21}(1972)$

For iron and steel mills in 1968, interest payments accounted for 1.5% of revenues (46). Thus $BIE_{21}(1972)/P_{21}(1972)$ is 0.015.

PROFITS REQUIRED BY IRON AND STEEL MILLS:
ESTIMATION OF $PROF_{21}(1972/P_{21}(1972)$

Profits per unit revenue in 1968 were $0.119 (46). Therefore, $PROF_{21}(1972)/P_{21}(1972)$ is 0.119.

LABOUR EXPENSE OF IRON AND STEEL MILLS:
ESTIMATION OF $comp_{27,21}(1972)$

Labour expense accounted for 23.2% of revenues in 1969 (38). Consequently, $comp_{27,21}(1972)$ is 0.232.

ESTIMATION OF THE 1972 INPUT VECTOR OF IRON AND STEEL MILLS

The values of all the other nonzero inputs to iron and steel mills were taken from the 1961 Canadian Input-Output Tables. The following table was then obtained.

TABLE D-29

1972 INPUT VECTOR OF THE IRON AND STEEL MILL INDUSTRY

| INPUT | FRACTION OF THE REVENUES OBTAINED BY IRON AND STEEL MILLS IN 1972 |
|---|---|
| chemical products | 0.004 |
| crop products | 0 |
| livestock products | 0 |
| other farm products | 0 |
| fertilizer | 0 |
| feed | 0 |
| railroad | 0.022 |
| trucking | 0.007 |
| inland water | 0 |
| Pacific water | 0 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| industrial construction | 0 |
| residential construction | 0 |
| architectural metals | 0 |
| cement | 0 |
| forestry | 0 |

TABLE D-29 (continued)

1972 INPUT VECTOR OF THE IRON AND STEEL MILL INDUSTRY

| INPUT | FRACTION OF THE REVENUES OBTAINED BY IRON AND STEEL MILLS IN 1972 |
|---|---|
| wood | 0.002 |
| iron mines | 0.112 |
| iron and steel mills | 0.015 |
| steel pipe and tube mills | 0 |
| electricity | 0.019 |
| refinery products | 0.009 |
| oil pipeline | 0 |
| natural gas | 0.007 |
| bond interest | 0.015 |
| profit | 0.119 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0.232 |
| other expense | 0.437 |

## 22. STEEL PIPE AND TUBE MILLS

The data in this section is taken from DBS catalogues and the 1961 Input-Output Table.

CHEMICAL PRODUCT EXPENSE OF STEEL PIPE AND TUBE MILLS:
ESTIMATION OF $comp_{1,22}(1972)$

Chemical product expense accounted for 0.1% of the material costs of Canadian steel pipe and tube mills in 1961 (15). Material costs were equal to 80.2% of the industry's revenues in Alberta in 1970 (76). Consequently, $comp_{1,22}(1972)$ is 0.802 x 0.001 = 0.001.

RAILROAD EXPENSE OF STEEL PIPE AND TUBE MILLS:
ESTIMATION OF $comp_{7,22}(1972)$

Transportation and storage costs accounted for 3.2% of the revenues of Canadian steel pipe and tube mills in 1961 (15). About 95% of this expense is due to transportation costs. Approximately 75% of the transportation expense is due to railroad usage and the remainder is attributable to trucking costs (Stelco). Therefore, $comp_{7,22}(1972)$ is 0.032 x 0.95 x 0.75 = 0.023.

TRUCKING EXPENSE OF STEEL PIPE AND TUBE MILLS:
ESTIMATION OF $comp_{8,22}(1972)$

The value of $comp_{8,22}(1972)$ is $0.032 \times 0.95 \times 0.25 = 0.008$.

IRON AND STEEL MILL PRODUCT EXPENSE OF STEEL PIPE AND TUBE MILLS:
ESTIMATION OF $comp_{21,22}(1972)$

The percentage of the material costs of Canadian steel pipe and tube mills in 1961, which were attributable to the expense of using iron and steel mill products (15), was 77.9%. As material costs accounted for 80.2% of revenues, for the Alberta steel pipe and tube manufacturing industry, $comp_{21,22}(1972)$ is $0.802 \times 0.779 = 0.625$.

ELECTRICITY EXPENSE OF STEEL PIPE AND TUBE MILLS:
ESTIMATION OF $comp_{23,22}(1972)$

In 1970, Alberta steel pipe and tube mills used 0.66% of their revenues to pay for fuel and electricity (76). The percentage of the fuel and electricity expense of Canadian steel pipe and tube mills in 1969, which was due to electricity usage (39) was 59.2%. Therefore, $comp_{23,22}(1972)$ is $0.066 \times 0.592 = 0.004$.

NATURAL GAS EXPENSE OF STEEL PIPE AND TUBE MILLS:

ESTIMATION OF $comp_{26,22}(1972)$

Natural gas expense was responsible for 24.5% of the 1969 fuel and electricity costs of Canadian steel pipe and tube mills (39). Thus $comp_{26,22}(1972)$ is 0.0066 x 0.245 = 0.002.

INTEREST EXPENSE OF STEEL PIPE AND TUBE MILLS:

ESTIMATION OF $BIE_{22}(1972)/P_{22}(1972)$

Interest payments accounted for 1.9% of the revenues obtained by Canadian primary metal manufacturers in 1968 (46). Consequently, $BIE_{22}(1972)/P_{22}(1972)$ is 0.019.

PROFIT REQUIRED BY STEEL PIPE AND TUBE MILLS:

ESTIMATION OF $PROF_{22}(1972)/P_{22}(1972)$

Canadian primary metal manufacturers received profits of $0.144 per unit revenue in 1968 (46). Therefore, $PROF_{22}(1972)/P_{22}(1972)$ is 0.144.

LABOUR EXPENSE OF STEEL PIPE AND TUBE MILLS:

ESTIMATION OF $comp_{27,22}(1972)$

Labour expense accounted for 10.5% of the revenues obtained by steel pipe and tube mills in 1970 (76). Consequently, $comp_{27,22}(1972)$ is 0.105.

ESTIMATION OF THE 1972 INPUT VECTOR OF STEEL PIPE AND TUBE MILLS

The following table shows the fractions of the steel pipe and tube mill industry's 1972 revenues which were used to pay for its various inputs.

TABLE D-39

1972 INPUT VECTOR OF THE STEEL PIPE AND TUBE MILL INDUSTRY

| INPUT | FRACTION OF STEEL PIPE AND TUBE MILLS 1972 REVENUES |
|---|---|
| chemical products | 0.001 |
| crop products | 0 |
| livestock products | 0 |
| other farm products | 0 |
| fertilizer | 0 |
| feed | 0 |
| railroad | 0.023 |
| trucking | 0.008 |
| inland water | 0 |
| Pacific water | 0 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| industrial construction | 0 |
| residential construction | 0 |
| architectural metals | 0 |
| cement | 0 |
| forestry | 0 |

TABLE D-30 (continued)

1972 INPUT VECTOR OF THE STEEL PIPE AND TUBE MILL INDUSTRY

| INPUT | FRACTION OF STEEL PIPE AND TUBE MILLS 1972 REVENUES |
|---|---|
| wood | 0 |
| iron mines | 0 |
| iron and steel mills | 0.625 |
| steel pipe and tube mills | 0 |
| electricity | 0.004 |
| refinery products | 0 |
| oil pipeline | 0 |
| natural gas | 0.002 |
| bond interest | 0.019 |
| profit | 0.144 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0.105 |
| other expense | 0.069 |

# 23. ELECTRIC POWER INDUSTRY

Unless otherwise stated all of the data in this section was taken from the 1969 DBS Catalogue on electric power companies (77), and they apply to the province of Alberta.

## INDUSTRIAL CONSTRUCTION EXPENSE OF THE ELECTRIC POWER INDUSTRY: ESTIMATION OF $comp_{14,23}(1972)$

Depreciation expense accounted for 12.5% of revenues.[1] From an analysis of the composition of the fixed assets of electric power companies it can be seen that at least 90% of the depreciation expense is due to depreciation of assets produced by the construction industry. Thus, $comp_{14,23}(1972)$ is $0.9 \times 0.125 = 0.113$.

## REFINERY PRODUCT EXPENSE OF THE ELECTRIC POWER INDUSTRY: ESTIMATION OF $comp_{24,23}(1972)$

The electric power industry consumed 0.09 gallons of heavy fuel oil and 0.007 gallons of diesel oil per dollar of revenue obtained. The oil refineries received 5.8¢/gallon for heavy fuel oil and 11.3¢/gallon for diesel oil (Table D-1). Therefore, $comp_{24,23}(1972)$ is $0.09 \times 0.058 + 0.007 \times 0.113 = 0.006$.

ESTIMATION OF THE 1972 INPUT VECTOR OF THE ELECTRIC POWER INDUSTRY

The values of all the other nonzero inputs to the electric power industry were obtained directly from data in the 1969 DBS catalogue on electric power companies (77). The following table was then obtained.

TABLE D-31

1972 INPUT VECTOR OF THE ELECTRIC POWER INDUSTRY

| INPUT | FRACTION OF THE ELECTRIC POWER INDUSTRY'S 1972 REVENUES |
|---|---|
| chemical products | 0 |
| crop products | 0 |
| livestock products | 0 |
| other farm products | 0 |
| fertilizer | 0 |
| feed | 0 |
| railroad | 0 |
| trucking | 0 |
| inland water | 0 |
| Pacific water | 0 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| industrial construction | 0.113 |
| residential construction | 0 |
| architectural metals | 0 |
| cement | 0 |
| forestry | 0 |

TABLE D-31 (continued)

1972 INPUT VECTOR OF THE ELECTRIC POWER INDUSTRY

| INPUT | FRACTION OF THE ELECTRIC POWER INDUSTRY'S 1972 REVENUES |
|---|---|
| wood | 0 |
| iron mines | 0 |
| iron and steel mills | 0 |
| steel pipe and tube mills | 0 |
| electricity | 0.194 |
| refinery products | 0.006 |
| oil pipeline | 0 |
| natural gas | 0.048 |
| bond interest | 0.089 |
| profit | 0.279 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0.143 |
| other expense | 0.128 |

## 24. PETROLEUM REFINING INDUSTRY

The information used in this section was obtained from DBS catalogues (46, 78, 79), the 1961 Canadian Input-Output Table (15), Federated Pipelines Ltd., and the Energy Resources Conservation Board. Unless stated otherwise all of the data applies to 1970.

### CHEMICAL PRODUCT EXPENSE OF THE PETROLEUM REFINING INDUSTRY: ESTIMATION OF $comp_{1,24}(1972)$

Chemical product expense accounted for 3.3% of the revenues obtained by Canadian refineries in 1961 (15). Thus, $comp_{1,24}(1972)$ is 0.033.

### INDUSTRIAL CONSTRUCTION EXPENSE OF THE PETROLEUM REFINING INDUSTRY: ESTIMATION OF $comp_{14,24}(1972)$

Alberta refineries spent 1.8% of their revenues on repair construction of processing units (78, 79). Therefore, $comp_{14,24}(1972)$ is 0.018.

ELECTRICITY EXPENSE OF THE PETROLEUM REFINING INDUSTRY: ESTIMATION OF $comp_{23,24}(1972)$

Electricity costs accounted for 77.3% of the fuel and electricity expense of Canadian petroleum refineries (78). Alberta refineries used 1.14% of their revenues to pay fuel and electricity costs (78). Consequently, $comp_{23,24}(1972)$ is 0.773 x 0.0114 = 0.009.

OIL PIPELINE EXPENSE OF THE PETROLEUM REFINING INDUSTRY: ESTIMATION OF $comp_{25,24}(1972)$

In 1972, the average wellhead price of crude oil in Alberta was \$3/barrel (23). At the same time, Alberta oil refineries paid \$3.2 for delivered crude oil (approximate estimate made by Federated Pipelines Ltd.). Therefore, it costs \$0.2/3 = \$0.067 to transport \$1 worth of wellhead crude oil to the refineries. It will be shown that 58.2% of the refineries' revenues were consumed by wellhead crude oil expense. Therefore, $comp_{25,24}(1972)$ is 0.582 x 0.067 = 0.039.

NATURAL GAS EXPENSE OF THE PETROLEUM REFINING INDUSTRY: ESTIMATION OF $comp_{26,24}(1972)$

Natural gas costs were responsible for 20.2% of Canadian refineries' fuel and electricity expense (78). Thus $comp_{26,24}(1972)$

is 0.202 x 0.0114 0.002.

INTEREST EXPENSE OF THE PETROLEUM REFINING INDUSTRY:
ESTIMATION OF $BIF_{24}(1972)/P_{24}(1972)$

In 1968, Canadian refineries used 1.6% of their revenues to pay the interest expense they incurred (46). Therefore, $BIF_{24}(1972)/P_{24}(1972)$ is 0.016.

PROFIT REQUIRED BY THE PETROLEUM REFINING INDUSTRY:
ESTIMATION OF $PROF_{24}(1972)/P_{24}(1972)$

Profits accounted for 11.8% of the revenues received by Canadian refineries in 1968 (46). Consequently, $PROF_{24}(1972)/P_{24}(1972)$ is 0.118.

WELLHEAD CRUDE OIL EXPENSE OF THE PETROLEUM REFINING INDUSTRY:
ESTIMATION OF $RO_{24}(1972)/P_{24}(1972)$

Alberta refineries consumed 0.224 barrels of crude oil for each dollar of revenue they received (45, 78). The average Alberta wellhead crude oil price in 1970 was $2.6 per barrel (80). Thus $RO_{24}(1972)/P_{24}(1972)$ is $0.224 \times 2.6 = 0.582$.

LABOUR EXPENSE OF THE PETROLEUM REFINING INDUSTRY:

ESTIMATION OF $comp_{27,24}(1972)$

Labour expense accounted for 5.3% of the revenues received by Alberta refineries in 1969 (40). Consequently, $comp_{27,24}(1972)$ is 0.053.

ESTIMATION OF THE 1972 INPUT VECTOR OF THE PETROLEUM REFINING INDUSTRY

The following table shows the fractions of the petroleum refining industry's 1972 revenues which were used to pay for its various inputs.

TABLE D-32

1972 INPUT VECTOR OF THE PETROLEUM REFINING INDUSTRY

| INPUT | FRACTION OF THE PETROLEUM INDUSTRY'S 1972 REVENUES |
|---|---|
| chemical products | 0.033 |
| crop products | 0 |
| livestock products | 0 |
| other farm products | 0 |
| fertilizer | 0 |
| feed | 0 |
| railroad | 0 |
| trucking | 0 |
| inland water | 0 |
| Pacific water | 0 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| industrial construction | 0.018 |
| residential construction | 0 |
| architectural metals | 0 |
| cement | 0 |
| forestry | 0 |

TABLE D-32 (continued)

1972 INPUT VECTOR OF THE PETROLEUM REFINING INDUSTRY

| INPUT | FRACTION OF THE PETROLEUM INDUSTRY'S 1972 REVENUES |
|---|---|
| wood | 0 |
| iron mines | 0 |
| iron and steel mills | 0 |
| steel pipe and tube mills | 0 |
| electricity | 0.009 |
| refinery products | 0 |
| oil pipeline | 0.039 |
| natural gas | 0.002 |
| bond interest | 0.016 |
| profit | 0.118 |
| wellhead crude oil | 0.582 |
| wellhead natural gas | 0 |
| labour | 0.053 |
| other expense | 0.130 |

25. OIL PIPELINE TRANSPORTATION INDUSTRY

This industry only transports crude oil from the well-head to the refinery. It does not buy the crude oil and then sell it to the refinery. Consequently, the price of crude oil does not enter into the basic equations for this industry.

The figures used for this industry were taken from a DBS Catalogue (81), and they apply to interprovincial pipelines in 1969.

INDUSTRIAL CONSTRUCTION EXPENSE OF THE OIL PIPELINE INDUSTRY: ESTIMATION OF $comp_{14,25}(1972)$

Depreciation per unit revenue was $0.174. As most of the depreciation is due to depreciation of constructible assets, $comp_{14,25}(1972)$ is 0.170.

ELECTRICITY EXPENSE OF THE OIL PIPELINE INDUSTRY: ESTIMATION OF $comp_{23,25}(1972)$

Operating fuel and power accounted for 3.7% of revenues. About 98% of fuel and power expense is due to electricity costs (Interprovincial Pipe Line Company). Therefore, $comp_{23,25}(1972)$ is $0.037 \times 0.98 = 0.036$.

ESTIMATION OF THE 1972 INPUT VECTOR OF THE OIL PIPELINE INDUSTRY

The values of all the other nonzero inputs to the oil pipeline industry were obtained directly from data in the 1969 DBS Catalogue on oil pipeline transportation (81). The following table was then obtained.

TABLE D-33

1972 INPUT VECTOR OF THE OIL PIPE LINE TRANSPORTATION INDUSTRY

| INPUT | FRACTION OF OIL PIPE LINE'S 1972 REVENUES |
|---|---|
| chemical products | 0 |
| crop products | 0 |
| livestock products | 0 |
| other farm products | 0 |
| fertilizer | 0 |
| feed | 0 |
| railroad | 0 |
| trucking | 0 |
| inland water | 0 |
| Pacific water | 0 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| industrial construction | 0.170 |
| residential construction | 0 |
| architectural metals | 0 |
| cement | 0 |
| forestry | 0 |

TABLE D-33 (continued)

1972 INPUT VECTOR OF THE OIL PIPE LINE TRANSPORTATION INDUSTRY

| INPUT | FRACTION OF OIL PIPE LINE'S 1972 REVENUES |
|---|---|
| wood | 0 |
| iron mines | 0 |
| iron and steel mills | 0 |
| steel pipe and tube mills | 0 |
| electricity | 0.036 |
| refinery products | 0 |
| oil pipeline | 0 |
| natural gas | 0 |
| bond interest | 0.115 |
| profit | 0.473 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0.073 |
| other expense | 0.133 |

# 26. NATURAL GAS UTILITIES

Unless stated otherwise all of the figures in this section apply to the operations of Canadian Western Natural Gas Ltd. and Northwestern Utilities Ltd. in 1971. They were either taken from the annul reports of the above companies or were obtained directly from Northwestern Utilities. As these two companies supply about 70% of the natural gas used in Alberta, their figures can be considered representative of the Alberta natural gas utility industry.

## INDUSTRIAL CONSTRUCTION EXPENSE OF GAS UTILITY COMPANIES: ESTIMATION OF $comp_{15,26}(1972)$

Depreciation and amortization for the two companies amounted to $5,038,000 (82, 83). For Canadian natural gas utilities in 1968, depreciation accounted for 98% of the depreciation and amortization expense (29). Therefore, the depreciation expense was 0.98 x $5,039,000 = $4,937,240. The revenues obtained from the sale of natural gas were equal to $66,654,000 (82, 83). Consequently, $comp_{15,26}(1972)$ is 4,937,240/66,654,000 = 0.074.

REFINERY PRODUCT EXPENSE OF GAS UTILITY COMPANIES:
ESTIMATION OF $comp_{24,26}(1972)$

Gasoline expense accounts for 0.3% of revenues (Northwestern Utilities). If the utility company pays 40¢/gallon for gasoline and the oil refinery receives 13.3¢/gallon (Table D-1) then $comp_{24,26}(1972)$ is $0.003 \times \frac{13.3}{40} = 0.001$. The price paid by the gas utility companies for gasoline is not important since the coefficients are only being estimated to the third decimal place. The value of $comp_{24,26}(1972)$ would still be 0.001 if the gas utility companies paid 50¢/gallon for gasoline.

INTEREST EXPENSE OF GAS UTILITY COMPANIES:
ESTIMATION OF $BIE_{26}(1972)/P_{26}(1972)$

The percentage of revenues which was used to pay interest on long term debt (82, 83) was 6.2%. Therefore, $BIE_{26}(1972)/P_{26}(1972)$ is 0.062.

PROFIT REQUIRED BY GAS UTILITY COMPANIES:
ESTIMATION OF $PROF_{26}(1972)/P_{26}(1972)$

Net earnings (excluding extraordinary income) accounted for 19.1% of revenues (82, 83). Thus $PROF_{26}(1972)/P_{26}(1972)$ is 0.191.

WELLHEAD NATURAL GAS EXPENSE OF GAS UTILITY COMPANIES: ESTIMATION OF $RG_{26}(1972)/P_{26}(1972)$

The percentage of revenues which was used to purchase wellhead natural gas (82, 83) was 34.8%. Therefore, $RG_{26}(1972)/P_{26}(1972)$ is 0.348.

LABOUR EXPENSE OF GAS UTILITY COMPANIES: ESTIMATION OF $comp_{27,26}(1972)$

Labour expense accounted for 15.1% of revenues (Northwestern Utilities). Consequently, $comp_{27,26}(1972)$ is 0.151.

ESTIMATION OF THE 1972 INPUT VECTOR OF GAS UTILITY COMPANIES

The following table shows the fractions of the revenues obtained by gas utility companies in 1972 which were used to pay for their various inputs.

TABLE D-34

1972 INPUT VECTOR OF NATURAL GAS UTILITIES

| INPUT | FRACTION OF THE 1972 REVENUES OF NATURAL GAS UTILITIES |
|---|---|
| chemical products | 0 |
| crop products | 0 |
| livestock products | 0 |
| other farm products | 0 |
| fertilizer | 0 |
| feed | 0 |
| railroad | 0 |
| trucking | 0 |
| inland water | 0 |
| Pacific water | 0 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| industrial construction | 0.074 |
| residential construction | 0 |
| architectural metals | 0 |
| cement | 0 |
| forestry | 0 |

TABLE D-34 (continued)

1972 INPUT VECTOR OF NATURAL GAS UTILITIES

| INPUT | FRACTION OF THE 1972 REVENUES OF NATURAL GAS UTILITIES |
|---|---|
| wood | 0 |
| iron mines | 0 |
| iron and steel mills | 0 |
| steel pipe and tube mills | 0 |
| electricity | 0 |
| refinery products | 0.001 |
| oil pipeline | 0 |
| natural gas | 0 |
| bond interest | 0.062 |
| profit | 0.191 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0.348 |
| labour | 0.151 |
| other expense | 0.173 |

## 27. LABOUR INDUSTRY

Labour is considered as an industry in that it produces output (work) after it has consumed inputs (food, natural gas etc.). It is assumed that when the costs of these inputs are raised (due to wellhead natural gas and crude oil price increases), the price of labour will be increased to compensate for the rising input costs.

CROP PRODUCT EXPENSE OF THE LABOUR INDUSTRY:
ESTIMATION OF $comp_{2,27}(1972)$

Canadians spent 18.7% of their 1969 revenues on food (84). In 1968, the percentage of the food expenditure of Prairie inhabitants which was due to their use of crop products (85) was 12%. Therefore, the labour industry used 18.7 x 0.12% = 2.24% of its revenues to pay for crop products. For the first nine months of 1972, the U.S. crop farmer received 16% of the money spent by the labour industry on food (86). The rest of the money went to retailers, packagers etc. Therefore, $comp_{2,27}(1972)$ is 0.0224 x 0.16 = 0.004.

LIVESTOCK PRODUCT EXPENSE OF THE LABOUR INDUSTRY:
ESTIMATION OF $comp_{3,27}(1972)$

The percentage of the food expenditure of the average person living in the Prairies in 1968, which was attributable to the purchase of livestock products (85), was 50.5%. Consequently, 18.7 x 0.505% = 9.44% of the labour industry's revenues were used to buy livestock products. For the first nine months of 1972, livestock farmers in the U.S. received 54.4% of the retail price of livestock products (86). Thus, $comp_{3,27}(1972)$ is 0.0944 x 0.544 = 0.051.

"OTHER FARM" PRODUCT EXPENSE OF THE LABOUR INDUSTRY: ESTIMATION OF $comp_{4,27}(1972)$

The percentage of the money spent on food in 1968 by Prairie inhabitants which was attributable to the purchase of "other farm" products (85) was 16%. Therefore, 18.7 x 0.16% = 2.99% of the labour industry's revenues were consumed in buying "other farm" products. For the first nine months of 1972, U.S. farmers received 25.4% of the retail price of "other farm" products (86). Consequently, $comp_{4,27}(1972)$ is 0.0299 x 0.254 = 0.008.

RAILROAD EXPENSE OF THE LABOUR INDUSTRY: ESTIMATION OF $comp_{7,27}(1972)$

The percentage of the average Canadian's expenditure in 1969 which was due to his use of public transportation (84) was 2.3%. The percentage of an Edmontonian's public transportation expense in 1964, which was due to his out of town travelling (87), was 41.4%. Therefore, 2.3 x 0.414% = 0.955% of the labour industry's revenues are used for out of town travelling. This type of travelling expense will now be subdivided into railroad, bus and aviation expenses in proportion to the passenger revenues obtained by the industries involved in these transportation categories. The following table was constructed for Canada in 1969 (88, 89, 90).

TABLE D-35

REVENUES OBTAINED BY TRANSPORTATION SYSTEMS

| INDUSTRY | PASSENGER REVENUES $'000 |
|---|---|
| Canadian railroads | 62,952 |
| Intercity and rural passenger bus companies | 72,652 |
| Canadian airlines | 480,256 |
| TOTAL | 615,753 |

From this table it is estimated that the fraction of out of town transportation due to the use of railroads, buses, and airlines is 10.2%, 11.8% and 78%, respectively. Therefore, 0.955 x 0.102% = 0.097% of the labour industry's revenues were used to pay for its railroad expense. Similarly, the percentage of this industry's revenues paid to Intercity and rural passenger bus companies, and Canadian airline companies was 0.113% and 0.745%, respectively. The value of $comp_{7,27}(1972)$ is 0.001.

URBAN TRANSIT EXPENSE OF THE LABOUR INDUSTRY:
ESTIMATION OF $comp_{11,27}(1972)$

The percentage of the industry's revenues which was used to pay for public transportation was 2.3%. The percentage of an Edmontonian's public transportation costs in 1964 which was due to his use of Urban Transit (87) was 27.8%. Therefore, 2.3 x 0.278% = 0.639% of the labour industry's revenues were consumed in paying for the use of Urban Transit.

Intercity and rural passenger bus companies are included in the Urban-Transit industry. It was shown that the labour industry paid 0.113% of its revenues to the Intercity and rural bus companies. The total cost per unit revenue of the use of the Urban-Transit industry's facilities to the labour industry is the sum of the component costs (Urban-Transit, and Intercity and rural passenger bus companies). Therefore, $comp_{11,27}(1972)$ is 0.00639 + 0.00113 = 0.008.

TAXI EXPENSE OF THE LABOUR INDUSTRY:
ESTIMATION OF $comp_{12,27}(1972)$

The percentage of an Edmontonian's public transportation expense in 1964 which was due to his payment of taxi fares (87) was 7.2%. Therefore, $comp_{12,27}(1972)$ is 0.02 x 0.072 = 0.002.

AVIATION EXPENSE OF THE LABOUR INDUSTRY:
ESTIMATION OF $comp_{13,27}(1972)$

It was shown that the labour industry had an aviation expense per unit revenue of $0.00745. Consequently, $comp_{13,27}$ (1972) is 0.007.

RESIDENTIAL CONSTRUCTION EXPENSE OF THE LABOUR INDUSTRY:
ESTIMATION OF $comp_{15,27}(1972)$

The percentage of a Canadian's revenues in 1969 which was used to pay for housing costs (84) was 12.1%. Therefore, $comp_{15,27}(1972)$ is 0.121.

ELECTRICITY EXPENSE OF THE LABOUR INDUSTRY:
ESTIMATION OF $comp_{23,27}(1972)$

Canadians used 3.1% of their revenues in 1969 to pay water, power and fuel costs. It is estimated, therefore, that electricity and natural gas costs accounted for 3% of revenues.

Natural gas sales to the Alberta residential section in 1968 amounted to $27,491,933 (29). The corresponding value for electric power was \$33,607,000 (91). Thus the fraction of the residential electricty and natural gas expense which was due to the use of electricity was $\frac{33,607,000}{33,607,000 + 27,491,933} = 0.55$.

Therefore, $comp_{23,27}(1972)$ is 0.030 x 0.55 = 0.017.

REFINERY PRODUCT EXPENSE OF THE LABOUR INDUSTRY:
ESTIMATION OF $comp_{24,27}(1972)$.

The percentage of a Canadian's revenues in 1969 which was used to pay for his car and truck operating expenses (84) was 5.8%. After an examination of the operating costs of a GMC three ton truck (92), of a Dodge three ton truck (92), and of the motor vehicles of a few private citizens, it was decided that 50% of the cost of a motorist's operating expenses was attributable to his use of refinery products. Therefore, 5.8 x 0.5% = 2.9% of the labour industry's revenues were consumed in the purchase of refinery products.

In 1972, the average Alberta motorist paid approximately 50¢/gallon for gasoline. The oil refineries received 13.3¢/gallon (Table D-1). Consequently, $\frac{13.3}{50} \times 100\% = 26.6\%$ of the labour industry's expenditure on gasoline was received by the refineries. As most of the motorist's refinery product expense is due to the use of gasoline, it is reasonable to assume that the oil refineries received 26.6% of the money spent by the labour industry on refinery products. Therefore, $comp_{24,27}(1972)$ is 0.029 x 0.266 = 0.008.

NATURAL GAS EXPENSE OF THE LABOUR INDUSTRY:
ESTIMATION OF $comp_{26,27}(1972)$.

The percentage of the labour industry's revenues which was spent on electricity and natural gas was 3%. The percentage of electricity and natural gas expense which was attributable to natural gas was 45%. Therefore, $comp_{26,27}(1972)$ is 0.030 x 0.45 = 0.013.

ESTIMATION OF THE 1972 INPUT VECTOR OF THE LABOUR INDUSTRY

The following table shows the fractions of the labour industry's 1972 revenues which were used to pay for its various inputs:

TABLE D-36

1972 INPUT VECTOR OF THE LABOUR INDUSTRY

| INPUT | FRACTION OF LABOUR INDUSTRY'S 1972 REVENUES |
|---|---|
| chemical products | 0 |
| crop products | 0.004 |
| livestock products | 0.051 |
| other farm products | 0.008 |
| fertilizer | 0 |
| feed | 0 |
| railroad | 0.001 |
| trucking | 0 |
| inland water | 0 |
| Pacific water | 0 |
| urban transit | 0.008 |
| taxi | 0.002 |
| aviation | 0.007 |
| industrial construction | 0 |
| residential construction | 0.121 |
| architectural metals | 0 |
| cement | 0 |
| forestry | 0 |

TABLE D-36 (continued)

1972 INPUT VECTOR OF THE LABOUR INDUSTRY

| INPUT | FRACTION OF LABOUR INDUSTRY'S 1972 REVENUES |
|---|---|
| wood | 0 |
| iron mines | 0 |
| iron and steel mills | 0 |
| steel pipe and tube mills | 0 |
| electricity | 0.017 |
| refinery products | 0.008 |
| oil pipeline | 0 |
| natural gas | 0.013 |
| bond interest | 0 |
| profit | 0 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0 |
| other expense | 0.760 |

## 28. DUMMY INDUSTRY

Unless stated otherwise all of the data in this section was taken from the 1961 Input-Output Tables (15). The "dummy industry" spent 913.6 million dollars on transportation and storage. It is assumed that 900 million dollars were attributable to transportation expense. The portions of this expense which were due to the different transportation modes will now be estimated.

The following table was obtained by using data taken from 1969 DBS catalogues (58, 60, 61, 93).

TABLE D-37

1969 REVENUES OBTAINED BY DIFFERENT TRANSPORTATION SYSTEMS

| COMPONENT TRANSPORTATION INDUSTRY | FREIGHT REVENUES OBTAINED IN 1969 $'000 | COMPONENT FREIGHT REVENUES / TOTAL |
|---|---|---|
| Railroad | 1,425,963 | 0.548 |
| Truck | 1,029,132 | 0.396 |
| Inland Water | 121,734 | 0.047 |
| Pacific Water | 23,783 | 0.009 |
| TOTAL | 2,600,612 | |

The cost to the dummy industry of using the different transportation systems is estimated from the values in column 3 of Table D-37. This is accomplished in the following table.

TABLE D-38

DUMMY INDUSTRY'S EXPENDITURE ON DIFFERENT MODES OF TRANSPORTATION IN 1961

| COMPONENT TRANSPORTATION INDUSTRY | COST TO DUMMY INDUSTRY OF USING COMPONENT TRANSPORTATION SYSTEM (millions of dollars) |
|---|---|
| Railroad | 900 x 0.548 = 493.2 |
| Truck | 900 x 0.396 = 356.4 |
| Inland Water Transport | 900 x 0.047 = 42.3 |
| Pacific Water Transport | 900 x 0.009 = 8.1 |

Nonresidential natural gas consists of all the natural gas sold by utility companies which does not go the residential sector (labour industry). Thus, the labour industry's nonresidential natural gas consumption is zero.

Sixteen of the first twenty-seven industries spent 55,285 dollars on nonresidential natural gas in 1968 (31, 30,40, 58, 66, 74, 38, 32, 94, 77, 95, 96). The cost of natural gas to the other 11 industries (classification numbers 7-15, 25, 26) was not available as they use such small quantities of this commodity. Consequently, a reasonable estimate of the money paid by the 27 industries for natural gas in 1968 is 58,000 dollars.

Canadian nonresidential natural gas sales in that year amounted to 263,753 dollars (29). Therefore, the 27 industries accounted for $\frac{58,000 \times 100\%}{263,753} = 22\%$ of these sales. The revenue obtained from nonresidential natural gas sales in Canada in 1961 was 105.7 million dollars (97). It is therefore estimated that the dummy industry spent (1-0.22) x 105.7) = 82.4 million dollars on natural gas in that year.

Table D-39 was obtained by combining the estimated transportation and natural gas expenses of the dummy industry with data obtained directly from the 1961 Canadian Input-Output Tables.

TABLE D-39

1961 EXPENDITURE OF THE DUMMY INDUSTRY ON VARIOUS INPUTS

| INPUT | DUMMY INDUSTRY EXPENDITURE ON INPUT (millions of dollars) |
|---|---|
| chemical products | 335.9 |
| crop | 196.1 |
| livestock | 1,423.2 |
| other farm products | 143.4 |
| fertilizer | 0.9 |
| feed | 6.3 |
| railroad | 493.2 |
| truck | 356.4 |
| inland water | 42.3 |
| Pacific water | 8.1 |
| industrial construction | 689.4 |
| architectural metals | 1.4 |
| cement | 45.5 |
| forestry | 348.1 |
| wood | 102.5 |
| iron mines | 0.5 |
| iron and steel mills | 509.3 |

TABLE D-39 (continued)

1961 EXPENDITURE OF THE DUMMY INDUSTRY ON VARIOUS INPUTS

| INPUTS | DUMMY INDUSTRY EXPENDITURE ON INPUT (millions of dollars) |
|---|---|
| steel pipe | 35 |
| electricity | 309.5 |
| refinery products | 299 |
| natural gas | 82.4 |
| labour | 11,067 |
| *other expense | 27,458.2 |

*The use by the dummy industry of its own products accounted for 16,778.7 million dollars of "other expense". Profits, interest, and commodity taxes were responsible for the remaining 10,679.5 million dollars.

The 1972 input vector to the dummy industry is obtained by dividing each term in Table D-39 by 43,952.6 million dollars, which is the value of the revenues obtained by the dummy industry in 1961

TABLE D-40

1972 INPUT VECTOR OF THE DUMMY INDUSTRY

| INPUT | FRACTION OF THE 1972 REVENUES OF THE DUMMY INDUSTRY |
|---|---|
| chemical products | 0.008 |
| crop products | 0.004 |
| livestock products | 0.032 |
| other farm products | 0.003 |
| fertilizer | 0 |
| feed | 0 |
| railroad | 0.011 |
| trucking | 0.008 |
| inland water | 0.001 |
| Pacific water | 0 |
| urban transit | 0 |
| taxi | 0 |
| aviation | 0 |
| industrial construction | 0.016 |
| residential construction | 0 |
| architectural metals | 0 |
| cement | 0.001 |
| forestry | 0.008 |

TABLE D-40 (continued)

1972 INPUT VECTOR OF THE DUMMY INDUSTRY

| INPUT | FRACTION OF THE 1972 REVENUES OF THE DUMMY INDUSTRY |
|---|---|
| wood | 0.002 |
| iron mines | 0 |
| iron and steel mills | 0.012 |
| steel pipe and tube mills | 0.001 |
| electricity | 0.007 |
| refinery products | 0.007 |
| oil pipeline | 0 |
| natural gas | 0.002 |
| bond interest | 0 |
| profit | 0 |
| wellhead crude oil | 0 |
| wellhead natural gas | 0 |
| labour | 0.252 |
| other expense | 0.625 |

# APPENDIX E

## ESTIMATION OF RPO(t) AND RPG(t) VALUES

The quantities RPO(t) and RPG(t) are defined as follows:

$$RPO(t) = \frac{\text{wellhead crude oil price in year } t}{\text{wellhead crude oil price in year } t+1} \quad \text{and}$$

$$RPG(t) = \frac{\text{wellhead natural gas price in year } t}{\text{wellhead natural gas price in year } t+1}$$

Tables E-1 and E-2 show the values of RPO(t) and RPG(t) which correspond to the wellhead petroleum prices (constant dollars) in Tables VI-3 and VI-4. Table E-1 is obtained from Table VI-3 by dividing each element in the table by the element in the row above it. Table E-2 is obtained from Table VI-4 in a similar manner.

A similar procedure could be followed to determine the RPO(t) and RPG(t) profiles which correspond to the case where there is a reduction in the value of the dollar. To do this would require the conversion of the prices in Tables VI-3 and VI-4 into new prices which were based on the assumption that

$$\frac{\text{the value of the dollar in year } t}{\text{the value of the dollar in year } t+1} = 1.03 .$$

These new prices could then be used to evaluate the RPO(t) and RPG(t) profiles. However, it is easier to obtain these profiles by multiplying each element in Tables E-1 and E-2 by 1.03. This was the method used to calculate the values in Tables E-3 and E-4.

TABLE E-1

RPO(t) AND RPG(t) PROFILES CORRESPONDING TO PRICES IN TABLE VI-3

| YEAR t | LOW RPO(t) PROFILE | HIGH RPO(t) PROFILE | LOW RPG(t) PROFILE | MEDIUM RPG(t) PROFILE | HIGH RPG(t) PROFILE |
|---|---|---|---|---|---|
| 1973 | 1.060 | 1.073 | 1.379 | 1.643 | 2.219 |
| 1974 | 1.053 | 1.071 | 1.218 | 1.157 | 1.365 |
| 1975 | 1.057 | 1.072 | 1.068 | 1.071 | 1.079 |
| 1976 | 1.040 | 1.068 | 1.024 | 1.056 | 1.029 |
| 1977 | 1.038 | 1.073 | 1.019 | 1.063 | 1.008 |
| 1978 | 1.037 | 1.068 | 1.019 | 1.078 | 1.059 |
| 1979 | 1.038 | 1.068 | 1.019 | 1.081 | 1.182 |
| 1980 | 1.036 | 1.066 | 1.015 | 1.097 | 1.3[illegible]0 |
| 1981 | 1.042 | 1.066 | 1.022 | 1.083 | 1.000 |
| 1982 | 1.036 | 1.064 | 1.021 | 1.081 | 0.981 |
| 1983 | 1.033 | 1.065 | 1.021 | 1.075 | 1.008 |
| 1984 | 1.036 | 1.072 | 1.031 | 1.072 | 1.025 |
| 1985 | 1.028 | 1.079 | 1.030 | 1.076 | 1.022 |

TABLE E-2

RPO(t) AND RPG(t) PROFILES CORRESPONDING TO PRICES IN TABLE VI-4

| YEAR t | LOW RPO(t) PROFILE | HIGH RPO(t) PROFILE | LOW RPG(t) PROFILE | MEDIUM RPG(t) PROFILE | HIGH RPG(t) PROFILE |
|---|---|---|---|---|---|
| 1973 | 1.050 | 1.107 | 1.093 | 1.243 | 1.540 |
| 1974 | 1.051 | 1.093 | 1.085 | 1.195 | 1.325 |
| 1975 | 1.045 | 1.088 | 1.078 | 1.168 | 1.234 |
| 1976 | 1.049 | 1.084 | 1.078 | 1.144 | 1.175 |
| 1977 | 1.044 | 1.075 | 1.067 | 1.126 | 1.142 |
| 1978 | 1.042 | 1.072 | 1.063 | 1.112 | 1.115 |
| 1979 | 1.038 | 1.065 | 1.059 | 1.101 | 1.097 |
| 1980 | 1.039 | 1.063 | 1.056 | 1.091 | 1.082 |
| 1981 | 1.040 | 1.057 | 1.057 | 1.084 | 1.072 |
| 1982 | 1.034 | 1.054 | 1.050 | 1.077 | 1.061 |
| 1983 | 1.037 | 1.053 | 1.048 | 1.073 | 1.054 |
| 1984 | 1.032 | 1.049 | 1.046 | 1.067 | 1.047 |
| 1985 | 1.033 | 1.049 | 1.047 | 1.063 | 1.042 |

*TABLE E-3

RPO(t) AND RPG(t) PROFILES BASED ON THE EXPRESSION

OF THE PRICES IN TABLE VI-3 IN REDUCED VALUE DOLLARS

| YEAR t | LOW RPO(t) PROFILE | HIGH RPO(t) PROFILE | LOW RPG(t) PROFILE | MEDIUM RPG(t) PROFILE | HIGH RPG(t) PROFILE |
|---|---|---|---|---|---|
| 1973 | 1.092 | 1.105 | 1.420 | 1.692 | 2.286 |
| 1974 | 1.085 | 1.103 | 1.255 | 1.192 | 1.406 |
| 1975 | 1.089 | 1.104 | 1.100 | 1.103 | 1.111 |
| 1976 | 1.071 | 1.100 | 1.055 | 1.088 | 1.060 |
| 1977 | 1.069 | 1.105 | 1.050 | 1.095 | 1.038 |
| 1978 | 1.068 | 1.100 | 1.050 | 1.110 | 1.091 |
| 1979 | 1.069 | 1.100 | 1.050 | 1.113 | 1.217 |
| 1980 | 1.067 | 1.098 | 1.045 | 1.130 | 1.370 |
| 1981 | 1.073 | 1.098 | 1.053 | 1.115 | 1.030 |
| 1982 | 1.067 | 1.096 | 1.052 | 1.113 | 1.010 |
| 1983 | 1.064 | 1.097 | 1.052 | 1.107 | 1.038 |
| 1984 | 1.067 | 1.104 | 1.062 | 1.104 | 1.056 |
| 1985 | 1.059 | 1.111 | 1.061 | 1.108 | 1.053 |

*this table is obtained by multiplying each element in Table E-1 by 1.03.

TABLE E-4*

RPO(t) AND RPG(t) PROFILES BASED ON THE EXPRESSION OF THE PRICES IN TABLE VI-4 IN REDUCED VALUE DOLLARS

| YEAR t | LOW RPO(t) PROFILE | HIGH RPO(t) PROFILE | LOW RPG(t) PROFILE | MEDIUM RPG(t) PROFILE | HIGH RPG(t) PROFILE |
|---|---|---|---|---|---|
| 1973 | 1.082 | 1.140 | 1.126 | 1.280 | 1.586 |
| 1974 | 1.083 | 1.126 | 1.118 | 1.231 | 1.365 |
| 1975 | 1.076 | 1.121 | 1.110 | 1.203 | 1.271 |
| 1976 | 1.080 | 1.117 | 1.110 | 1.178 | 1.210 |
| 1977 | 1.075 | 1.107 | 1.099 | 1.160 | 1.176 |
| 1978 | 1.073 | 1.104 | 1.095 | 1.145 | 1.148 |
| 1979 | 1.069 | 1.097 | 1.091 | 1.134 | 1.130 |
| 1980 | 1.070 | 1.095 | 1.088 | 1.124 | 1.114 |
| 1981 | 1.071 | 1.089 | 1.089 | 1.117 | 1.104 |
| 1982 | 1.065 | 1.086 | 1.082 | 1.109 | 1.093 |
| 1983 | 1.068 | 1.085 | 1.079 | 1.105 | 1.086 |
| 1984 | 1.063 | 1.080 | 1.077 | 1.099 | 1.078 |
| 1985 | 1.064 | 1.080 | 1.078 | 1.095 | 1.073 |

*this table is obtained by multiplying each element in Table E-2 by 1.03.

# APPENDIX F

## DEPRECIATION OF "OTHER ASSETS"

"Other Assets" are those depreciable assets which are not produced by the construction industry. The variable $DEPN_k(t)$, $1 \leq k \leq 28$, is the estimated fraction of industry k's operating revenues in year t which were allocated to compensate for the depreciation of "other assets". In the sample calculation the variation of $DEPN_k(t)$ with time was treated analogously to the depreciation of assets which were produced by the construction industry. It was assumed that:

$$\frac{DEPN_k(t)}{DEPN_k(t-1)} = \frac{2 + l_{28}(t)}{3} \qquad k = 1, 2, \ldots, 28$$

This assumption is based on two main suppositions and they are:

1. "other assets" are depreciated linearly over three years (beginning in the year of construction),
2. the cost of producing these assets is inflated at the same rate as the required operating revenues of the dummy industry ($l_{28}(t)$).

The values of $DEPN_k(1972)$ used in the sample calculation are shown in Table F-1. The procedure adopted to obtain them will now be discussed. The total depreciation (depreciation of assets produced by the construction industry + depreciation of "other assets") expense of most industries is available for Canada in 1968 (46), and for Alberta in 1962 (44).

TABLE F-1

VALUES OF $DEPN_k(1972)$

| INDUSTRY k | $DEPN_k(1972)$ | INDUSTRY k | $DEPN_k(1972)$ |
|---|---|---|---|
| 1 | 0.045 | 15 | 0.018 |
| 2 | 0.068 | 16 | 0.019 |
| 3 | 0.028 | 17 | 0.108 |
| 4 | 0.068 | 18 | 0.055 |
| 5 | 0.156 | 19 | 0.004 |
| 6 | 0.011 | 20 | 0.113 |
| 7 | 0.054 | 21 | 0.069 |
| 8 | 0.065 | 22 | 0.069 |
| 9 | 0.115 | 23 | 0.012 |
| 10 | 0.115 | 24 | 0.049 |
| 11 | 0.073 | 25 | 0.004 |
| 12 | 0.079 | 26 | 0.000 |
| 13 | 0.103 | 27 | 0.000 |
| 14 | 0.046 | 28 | 0.000 |

For other industries the value of total depreciation expense was obtained from the DBS catalogues pertaining to these industries (51, 57, 60, 61, 62, 63, 64, 77, 81). Apart from two exceptions the value of $DEPN_k(1972)$ was obtained for each industry by subtracting the depreciation expense due to assets produced by the construction industry (determined in Appendix D) from the total depreciation expense. For the crop farming industry and steel pipe and tube mills, $DEPN_k(1972)$ was made equal to $comp_{28,k}(1972)$. The latter variable was then equated to zero.

It should be remembered that $comp_{28,k}(1972)$ represents the "other expense" of industry k. Thus the new (after the incorporation of $DEPN_k(t)$ into the model) value for $comp_{28,k}(1972)$ is obtained by subtracting $DEPN_k(1972)$ from the old (as estimated in Appendix D) value of $comp_{28,k}(1972)$. If the two exceptions had been treated similarly to the other industries then $DEPN_k(1972)$ would have been greater than the old value of $comp_{28,k}(1972)$. This would have resulted in the new value of $comp_{28,k}(1972)$ being negative. This would not be acceptable.

# APPENDIX G

## RESULTS

Tables G-1 and G-2 contain the results obtained from the use of the nonlinear wellhead petroleum price (constant-value 1972 dollars), shown in Table VI-3. Table G-1 shows the differences in the values of FLA(k), $1 \leq k \leq 28$, which would result from changing the wellhead natural gas price profile while maintaining the low wellhead crude oil price profile. Table G-2 shows corresponding results for the high wellhead crude oil price profile.

Tables G-3 and G-4 result from the use of linear wellhead petroleum price (constant-value 1972 dollars) profiles as shown in Table VI-4. They also show the effect on the FLA(k) values of changing the wellhead natural gas price profile while keeping the wellhead crude oil price profile constant.

Tables G-5 to G-8 show the results obtained from using wellhead petroleum prices based on the assumption that

$$\frac{\text{the value of the dollar in year } t}{\text{the value of the dollar in year } t+1} = 1.03.$$

TABLE(G-1)
************

*RESULTS FROM NON-LINEAR WELLHEAD PETROLEUM PRICE PROFILES (LOW CRUDE OIL)

| | CONSTANT GAS | LOW GAS | MEDIUM GAS | HIGH GAS |
|---|---|---|---|---|
| FLA( 1) | 1.008 | 1.015 | 1.025 | 1.032 |
| FLA( 2) | 1.010 | 1.014 | 1.020 | 1.025 |
| FLA( 3) | 1.010 | 1.013 | 1.019 | 1.024 |
| FLA( 4) | 1.009 | 1.013 | 1.019 | 1.024 |
| FLA( 5) | 1.008 | 1.017 | 1.028 | 1.038 |
| FLA( 6) | 1.009 | 1.013 | 1.019 | 1.024 |
| FLA( 7) | 1.008 | 1.012 | 1.018 | 1.023 |
| FLA( 8) | 1.009 | 1.013 | 1.019 | 1.024 |
| FLA( 9) | 1.010 | 1.014 | 1.020 | 1.024 |
| FLA(10) | 1.009 | 1.013 | 1.019 | 1.024 |
| FLA(11) | 1.008 | 1.012 | 1.018 | 1.023 |
| FLA(12) | 1.009 | 1.013 | 1.019 | 1.024 |
| FLA(13) | 1.010 | 1.014 | 1.020 | 1.024 |
| FLA(14) | 1.008 | 1.012 | 1.019 | 1.024 |
| FLA(15) | 1.008 | 1.012 | 1.019 | 1.024 |
| FLA(16) | 1.008 | 1.012 | 1.019 | 1.024 |
| FLA(17) | 1.008 | 1.016 | 1.027 | 1.035 |
| FLA(18) | 1.008 | 1.012 | 1.018 | 1.024 |
| FLA(19) | 1.008 | 1.012 | 1.019 | 1.024 |
| FLA(20) | 1.009 | 1.014 | 1.021 | 1.027 |
| FLA(21) | 1.008 | 1.013 | 1.021 | 1.027 |
| FLA(22) | 1.008 | 1.013 | 1.020 | 1.026 |
| FLA(23) | 1.007 | 1.018 | 1.033 | 1.044 |
| FLA(24) | 1.031 | 1.033 | 1.035 | 1.036 |
| FLA(25) | 1.005 | 1.008 | 1.013 | 1.017 |
| FLA(26) | 1.003 | 1.039 | 1.077 | 1.099 |
| FLA(27) | 1.007 | 1.011 | 1.018 | 1.023 |
| FLA(28) | 1.008 | 1.012 | 1.019 | 1.024 |

*PRICES WERE IN CONSTANT-VALUE DOLLARS

TABLE(G-2)
************

*RESULTS FROM NON-LINEAR WELLHEAD PETROLEUM PRICE PROFILES (HIGH CRUDE OIL)

| | CONSTANT GAS | LOW GAS | MEDIUM GAS | HIGH GAS |
|---|---|---|---|---|
| FLA( 1) | 1.015 | 1.021 | 1.030 | 1.038 |
| FLA( 2) | 1.018 | 1.022 | 1.027 | 1.032 |
| FLA( 3) | 1.018 | 1.021 | 1.027 | 1.031 |
| FLA( 4) | 1.017 | 1.021 | 1.027 | 1.031 |
| FLA( 5) | 1.015 | 1.023 | 1.034 | 1.043 |
| FLA( 6) | 1.016 | 1.020 | 1.026 | 1.031 |
| FLA( 7) | 1.015 | 1.019 | 1.024 | 1.029 |
| FLA( 8) | 1.016 | 1.020 | 1.026 | 1.030 |
| FLA( 9) | 1.019 | 1.022 | 1.027 | 1.032 |
| FLA(10) | 1.017 | 1.020 | 1.026 | 1.031 |
| FLA(11) | 1.015 | 1.019 | 1.025 | 1.029 |
| FLA(12) | 1.016 | 1.020 | 1.026 | 1.030 |
| FLA(13) | 1.018 | 1.022 | 1.027 | 1.032 |
| FLA(14) | 1.015 | 1.019 | 1.025 | 1.030 |
| FLA(15) | 1.015 | 1.019 | 1.025 | 1.030 |
| FLA(16) | 1.015 | 1.019 | 1.025 | 1.030 |
| FLA(17) | 1.015 | 1.022 | 1.032 | 1.041 |
| FLA(18) | 1.015 | 1.019 | 1.025 | 1.029 |
| FLA(19) | 1.015 | 1.019 | 1.025 | 1.030 |
| FLA(20) | 1.016 | 1.020 | 1.027 | 1.033 |
| FLA(21) | 1.015 | 1.020 | 1.027 | 1.032 |
| FLA(22) | 1.015 | 1.020 | 1.026 | 1.032 |
| FLA(23) | 1.012 | 1.023 | 1.037 | 1.048 |
| FLA(24) | 1.055 | 1.056 | 1.057 | 1.059 |
| FLA(25) | 1.009 | 1.012 | 1.017 | 1.021 |
| FLA(26) | 1.007 | 1.041 | 1.078 | 1.100 |
| FLA(27) | 1.014 | 1.018 | 1.023 | 1.028 |
| FLA(28) | 1.015 | 1.019 | 1.025 | 1.029 |

*PRICES WERE IN CONSTANT-VALUE DOLLARS

TABLE(G-3)
************

*RESULTS FROM LINEAR WELLHEAD PETROLEUM PRICE PROFILES (LOW CRUDE OIL)

| | CONSTANT GAS | LOW GAS | MEDIUM GAS | HIGH GAS |
|---|---|---|---|---|
| FLA( 1) | 1.008 | 1.014 | 1.024 | 1.032 |
| FLA( 2) | 1.010 | 1.014 | 1.020 | 1.024 |
| FLA( 3) | 1.010 | 1.013 | 1.019 | 1.024 |
| FLA( 4) | 1.009 | 1.013 | 1.019 | 1.024 |
| FLA( 5) | 1.008 | 1.016 | 1.028 | 1.037 |
| FLA( 6) | 1.009 | 1.013 | 1.019 | 1.024 |
| FLA( 7) | 1.008 | 1.012 | 1.018 | 1.022 |
| FLA( 8) | 1.009 | 1.013 | 1.019 | 1.023 |
| FLA( 9) | 1.010 | 1.014 | 1.019 | 1.024 |
| FLA(10) | 1.009 | 1.013 | 1.019 | 1.023 |
| FLA(11) | 1.008 | 1.012 | 1.018 | 1.023 |
| FLA(12) | 1.009 | 1.013 | 1.019 | 1.023 |
| FLA(13) | 1.010 | 1.014 | 1.019 | 1.024 |
| FLA(14) | 1.008 | 1.012 | 1.018 | 1.023 |
| FLA(15) | 1.008 | 1.012 | 1.018 | 1.023 |
| FLA(16) | 1.008 | 1.012 | 1.019 | 1.024 |
| FLA(17) | 1.008 | 1.015 | 1.026 | 1.035 |
| FLA(18) | 1.008 | 1.012 | 1.018 | 1.023 |
| FLA(19) | 1.008 | 1.012 | 1.018 | 1.023 |
| FLA(20) | 1.009 | 1.013 | 1.021 | 1.026 |
| FLA(21) | 1.008 | 1.013 | 1.020 | 1.026 |
| FLA(22) | 1.008 | 1.013 | 1.020 | 1.026 |
| FLA(23) | 1.007 | 1.017 | 1.032 | 1.043 |
| FLA(24) | 1.031 | 1.033 | 1.035 | 1.036 |
| FLA(25) | 1.005 | 1.008 | 1.013 | 1.017 |
| FLA(26) | 1.003 | 1.039 | 1.077 | 1.099 |
| FLA(27) | 1.007 | 1.011 | 1.017 | 1.022 |
| FLA(28) | 1.008 | 1.012 | 1.018 | 1.023 |

*PRICES WERE IN CONSTANT-VALUE DOLLARS

TABLE(G-4)
************

*RESULTS FROM LINEAR WELLHEAD PETROLEUM PRICE PROFILES (HIGH CRUDE OIL)

| | CONSTANT GAS | LOW GAS | MEDIUM GAS | HIGH GAS |
|---|---|---|---|---|
| FLA( 1) | 1.015 | 1.021 | 1.030 | 1.037 |
| FLA( 2) | 1.019 | 1.022 | 1.027 | 1.032 |
| FLA( 3) | 1.018 | 1.021 | 1.027 | 1.031 |
| FLA( 4) | 1.017 | 1.021 | 1.026 | 1.031 |
| FLA( 5) | 1.015 | 1.023 | 1.033 | 1.042 |
| FLA( 6) | 1.016 | 1.020 | 1.026 | 1.030 |
| FLA( 7) | 1.015 | 1.019 | 1.024 | 1.028 |
| FLA( 8) | 1.016 | 1.020 | 1.025 | 1.030 |
| FLA( 9) | 1.019 | 1.022 | 1.027 | 1.031 |
| FLA(10) | 1.017 | 1.020 | 1.026 | 1.030 |
| FLA(11) | 1.015 | 1.019 | 1.025 | 1.029 |
| FLA(12) | 1.016 | 1.020 | 1.026 | 1.030 |
| FLA(13) | 1.018 | 1.022 | 1.027 | 1.031 |
| FLA(14) | 1.015 | 1.019 | 1.025 | 1.029 |
| FLA(15) | 1.015 | 1.019 | 1.025 | 1.029 |
| FLA(16) | 1.015 | 1.019 | 1.025 | 1.029 |
| FLA(17) | 1.015 | 1.022 | 1.032 | 1.040 |
| FLA(18) | 1.015 | 1.019 | 1.025 | 1.029 |
| FLA(19) | 1.015 | 1.019 | 1.025 | 1.029 |
| FLA(20) | 1.016 | 1.020 | 1.027 | 1.032 |
| FLA(21) | 1.015 | 1.020 | 1.026 | 1.032 |
| FLA(22) | 1.015 | 1.019 | 1.026 | 1.032 |
| FLA(23) | 1.012 | 1.022 | 1.036 | 1.046 |
| FLA(24) | 1.055 | 1.056 | 1.058 | 1.059 |
| FLA(25) | 1.009 | 1.012 | 1.017 | 1.020 |
| FLA(26) | 1.007 | 1.041 | 1.078 | 1.100 |
| FLA(27) | 1.014 | 1.018 | 1.023 | 1.028 |
| FLA(28) | 1.015 | 1.019 | 1.025 | 1.029 |

*PRICES WERE IN CONSTANT-VALUE DOLLARS

TABLE(G-5)
************

*RESULTS FROM NON-LINEAR WELLHEAD PETROLEUM PRICE PROFILES (LOW CRUDE OIL)

| | CONSTANT GAS | LOW GAS | MEDIUM GAS | HIGH GAS |
|---|---|---|---|---|
| FLA( 1) | 1.016 | 1.027 | 1.039 | 1.049 |
| FLA( 2) | 1.019 | 1.026 | 1.033 | 1.039 |
| FLA( 3) | 1.019 | 1.025 | 1.033 | 1.039 |
| FLA( 4) | 1.018 | 1.025 | 1.032 | 1.039 |
| FLA( 5) | 1.016 | 1.030 | 1.044 | 1.056 |
| FLA( 6) | 1.017 | 1.024 | 1.032 | 1.038 |
| FLA( 7) | 1.016 | 1.023 | 1.030 | 1.036 |
| FLA( 8) | 1.017 | 1.024 | 1.031 | 1.038 |
| FLA( 9) | 1.020 | 1.026 | 1.033 | 1.039 |
| FLA(10) | 1.018 | 1.024 | 1.032 | 1.038 |
| FLA(11) | 1.016 | 1.023 | 1.031 | 1.037 |
| FLA(12) | 1.017 | 1.024 | 1.031 | 1.038 |
| FLA(13) | 1.019 | 1.026 | 1.033 | 1.039 |
| FLA(14) | 1.016 | 1.023 | 1.031 | 1.037 |
| FLA(15) | 1.016 | 1.023 | 1.031 | 1.037 |
| FLA(16) | 1.015 | 1.023 | 1.031 | 1.038 |
| FLA(17) | 1.016 | 1.028 | 1.042 | 1.053 |
| FLA(18) | 1.016 | 1.023 | 1.031 | 1.037 |
| FLA(19) | 1.016 | 1.023 | 1.031 | 1.038 |
| FLA(20) | 1.017 | 1.025 | 1.034 | 1.042 |
| FLA(21) | 1.016 | 1.024 | 1.034 | 1.041 |
| FLA(22) | 1.016 | 1.024 | 1.033 | 1.041 |
| FLA(23) | 1.013 | 1.031 | 1.049 | 1.063 |
| FLA(24) | 1.057 | 1.059 | 1.061 | 1.063 |
| FLA(25) | 1.009 | 1.015 | 1.021 | 1.027 |
| FLA(26) | 1.007 | 1.063 | 1.104 | 1.128 |
| FLA(27) | 1.014 | 1.021 | 1.029 | 1.035 |
| FLA(28) | 1.016 | 1.023 | 1.031 | 1.037 |

*PRICES WERE IN REDUCED-VALUE DOLLARS

TABLE (G-6)
***********

*RESULTS FROM NON-LINEAR WELLHEAD PETROLEUM PRICE PROFILES (HIGH CRUDE OIL)

| | CONSTANT GAS | LOW GAS | MEDIUM GAS | HIGH GAS |
|---|---|---|---|---|
| FLA( 1) | 1.025 | 1.035 | 1.046 | 1.055 |
| FLA( 2) | 1.030 | 1.036 | 1.043 | 1.048 |
| FLA( 3) | 1.030 | 1.035 | 1.042 | 1.047 |
| FLA( 4) | 1.029 | 1.034 | 1.041 | 1.047 |
| FLA( 5) | 1.025 | 1.037 | 1.051 | 1.061 |
| FLA( 6) | 1.027 | 1.033 | 1.040 | 1.046 |
| FLA( 7) | 1.026 | 1.031 | 1.038 | 1.043 |
| FLA( 8) | 1.027 | 1.033 | 1.040 | 1.045 |
| FLA( 9) | 1.031 | 0.036 | 1.043 | 1.048 |
| FLA(10) | 1.028 | 1.034 | 1.040 | 1.046 |
| FLA(11) | 1.025 | 1.031 | 1.038 | 1.044 |
| FLA(12) | 1.027 | 1.033 | 1.040 | 1.046 |
| FLA(13) | 1.030 | 1.036 | 1.042 | 1.048 |
| FLA(14) | 1.025 | 1.032 | 1.039 | 1.045 |
| FLA(15) | 1.025 | 1.031 | 1.039 | 1.045 |
| FLA(16) | 1.024 | 1.031 | 1.039 | 1.045 |
| FLA(17) | 1.025 | 1.036 | 1.048 | 1.059 |
| FLA(18) | 1.025 | 1.031 | 1.039 | 1.044 |
| FLA(19) | 1.025 | 1.031 | 1.039 | 1.045 |
| FLA(20) | 1.026 | 1.034 | 1.042 | 1.049 |
| FLA(21) | 1.025 | 1.033 | 1.041 | 1.048 |
| FLA(22) | 1.025 | 1.032 | 1.041 | 1.048 |
| FLA(23) | 1.020 | 1.036 | 1.053 | 1.067 |
| FLA(24) | 1.083 | 1.084 | 1.086 | 1.087 |
| FLA(25) | 1.015 | 1.020 | 1.026 | 1.032 |
| FLA(26) | 1.011 | 1.065 | 1.108 | 1.129 |
| FLA(27) | 1.023 | 1.029 | 1.036 | 1.042 |
| FLA(28) | 1.025 | 1.031 | 1.038 | 1.044 |

*PRICES WERE IN REDUCED-VALUE DOLLARS

TABLE(G-7)
************

*RESULTS FROM LINEAR WELLHEAD PETROLEUM PRICE PROFILES (LOW CRUDE OIL)

| | CONSTANT GAS | LOW GAS | MEDIUM GAS | HIGH GAS |
|---|---|---|---|---|
| FLA( 1) | 1.016 | 1.026 | 1.038 | 1.047 |
| FLA( 2) | 1.019 | 1.025 | 1.033 | 1.038 |
| FLA( 3) | 1.019 | 1.025 | 1.032 | 1.038 |
| FLA( 4) | 1.018 | 1.024 | 1.032 | 1.038 |
| FLA( 5) | 1.016 | 1.029 | 1.043 | 1.054 |
| FLA( 6) | 1.017 | 1.024 | 1.032 | 1.038 |
| FLA( 7) | 1.016 | 1.022 | 1.030 | 1.035 |
| FLA( 8) | 1.017 | 1.023 | 1.031 | 1.037 |
| FLA( 9) | 1.020 | 1.026 | 1.033 | 1.038 |
| FLA(10) | 1.018 | 1.024 | 1.031 | 1.037 |
| FLA(11) | 1.016 | 1.022 | 1.030 | 1.036 |
| FLA(12) | 1.017 | 1.024 | 1.031 | 1.037 |
| FLA(13) | 1.019 | 1.025 | 1.033 | 1.038 |
| FLA(14) | 1.016 | 1.023 | 1.031 | 1.037 |
| FLA(15) | 1.016 | 1.023 | 1.031 | 1.037 |
| FLA(16) | 1.015 | 1.022 | 1.031 | 1.037 |
| FLA(17) | 1.016 | 1.028 | 1.041 | 1.051 |
| FLA(18) | 1.016 | 1.023 | 1.030 | 1.036 |
| FLA(19) | 1.016 | 1.022 | 1.031 | 1.037 |
| FLA(20) | 1.017 | 1.024 | 1.034 | 1.041 |
| FLA(21) | 1.016 | 1.024 | 1.033 | 1.040 |
| FLA(22) | 1.016 | 1.024 | 1.033 | 1.040 |
| FLA(23) | 1.013 | 1.029 | 1.047 | 1.061 |
| FLA(24) | 1.057 | 1.059 | 1.061 | 1.063 |
| FLA(25) | 1.009 | 1.015 | 1.021 | 1.026 |
| FLA(26) | 1.007 | 1.063 | 1.104 | 1.128 |
| FLA(27) | 1.014 | 1.021 | 1.029 | 1.035 |
| FLA(28) | 1.016 | 1.022 | 1.030 | 1.036 |

*PRICES WERE IN REDUCED-VALUE DOLLARS

## TABLE(G-8)

************

*RESULTS FROM LINEAR WELLHEAD PETROLEUM PRICE PROFILES (HIGH CRUDE OIL)

| | CONSTANT GAS | LOW GAS | MEDIUM GAS | HIGH GAS |
|---|---|---|---|---|
| FLA( 1) | 1.025 | 1.034 | 1.045 | 1.054 |
| FLA( 2) | 1.031 | 1.036 | 1.043 | 1.048 |
| FLA( 3) | 1.030 | 1.035 | 1.042 | 1.047 |
| FLA( 4) | 1.029 | 1.034 | 1.041 | 1.046 |
| FLA( 5) | 1.025 | 1.037 | 1.050 | 1.060 |
| FLA( 6) | 1.027 | 1.033 | 1.040 | 1.045 |
| FLA( 7) | 1.026 | 1.031 | 1.038 | 1.043 |
| FLA( 8) | 1.027 | 1.033 | 1.040 | 1.045 |
| FLA( 9) | 1.031 | 1.036 | 1.043 | 1.048 |
| FLA(10) | 1.028 | 1.034 | 1.040 | 1.045 |
| FLA(11) | 1.025 | 1.031 | 1.038 | 1.044 |
| FLA(12) | 1.027 | 1.033 | 1.040 | 1.045 |
| FLA(13) | 1.030 | 1.036 | 1.042 | 1.047 |
| FLA(14) | 1.025 | 1.031 | 1.039 | 1.044 |
| FLA(15) | 1.025 | 1.031 | 1.038 | 1.044 |
| FLA(16) | 1.025 | 1.031 | 1.038 | 1.044 |
| FLA(17) | 1.025 | 1.036 | 1.048 | 1.057 |
| FLA(18) | 1.025 | 1.031 | 1.038 | 1.044 |
| FLA(19) | 1.025 | 1.031 | 1.038 | 1.044 |
| FLA(20) | 1.026 | 1.033 | 1.042 | 1.048 |
| FLA(21) | 1.025 | 1.032 | 1.041 | 1.047 |
| FLA(22) | 1.025 | 1.032 | 1.041 | 1.047 |
| FLA(23) | 1.020 | 1.035 | 1.052 | 1.065 |
| FLA(2[illegible] | 1.083 | 1.084 | 1.086 | 1.087 |
| FLA(25) | 1.015 | 1.020 | 1.026 | 1.031 |
| FLA(26) | 1.011 | 1.06[illegible] | 1.106 | 1.129 |
| FLA(27) | 1.023 | 1.029 | 1.036 | 1.042 |
| FLA(28) | 1.025 | 1.031 | 1.038 | 1.044 |

*PRICES WERE IN REDUCED-VALUE DOLLARS

TABLE(G- 9)
************

*REQUIRED REVENUES OF THE CHEMICAL INDUSTRY
(LOW CRUDE OIL PRICES , CONSTANT-VALUE DOLLARS)

| YEAR | CONSTANT GAS | LOW GAS | MEDIUM GAS | HIGH GAS |
|---|---|---|---|---|
| 1972 | 1.000 | 1.000 | 1.000 | 1.000 |
| 1973 | 1.009 | 1.037 | 1.057 | 1.099 |
| 1974 | 1.018 | 1.070 | 1.087 | 1.171 |
| 1975 | 1.029 | 1.089 | 1.108 | 1.202 |
| 1976 | 1.038 | 1.103 | 1.127 | 1.222 |
| 1977 | 1.047 | 1.116 | 1.149 | 1.236 |
| 1978 | 1.056 | 1.129 | 1.173 | 1.266 |
| 1979 | 1.064 | 1.140 | 1.197 | 1.329 |
| 1980 | 1.071 | 1.150 | 1.225 | 1.447 |
| 1981 | 1.081 | 1.163 | 1.254 | 1.459 |
| 1982 | 1.089 | 1.175 | 1.283 | 1.460 |
| 1983 | 1.097 | 1.187 | 1.312 | 1.474 |
| 1984 | 1.106 | 1.201 | 1.342 | 1.496 |
| 1985 | 1.112 | 1.213 | 1.373 | 1.514 |

*TABLES(G-9) TO (G-14) RESULTED FROM NON-LINEAR PROFILES

TABLE(G-10)
************

REQUIRED REVENUES OF THE CHEMICAL INDUSTRY
(HIGH CRUDE OIL PRICES , CONSTANT-VALUE DOLLARS)

| YEAR | CONSTANT GAS | LOW GAS | MEDIUM GAS | HIGH GAS |
|---|---|---|---|---|
| 1972 | 1.000 | 1.000 | 1.000 | 1.000 |
| 1973 | 1.011 | 1.039 | 1.059 | 1.101 |
| 1974 | 1.023 | 1.074 | 1.091 | 1.176 |
| 1975 | 1.036 | 1.097 | 1.115 | 1.209 |
| 1976 | 1.051 | 1.115 | 1.140 | 1.234 |
| 1977 | 1.067 | 1.135 | 1.168 | 1.256 |
| 1978 | 1.083 | 1.155 | 1.200 | 1.293 |
| 1979 | 1.098 | 1.174 | 1.232 | 1.363 |
| 1980 | 1.114 | 1.192 | 1.268 | 1.490 |
| 1981 | 1.131 | 1.214 | 1.305 | 1.510 |
| 1982 | 1.149 | 1.235 | 1.343 | 1.519 |
| 1983 | 1.167 | 1.257 | 1.382 | 1.544 |
| 1984 | 1.189 | 1.285 | 1.425 | 1.580 |
| 1985 | 1.215 | 1.315 | 1.475 | 1.617 |

TABLE(G-11)
************

REQUIRED REVENUES OF THE CROP FARMING INDUSTRY
(LOW CRUDE OIL PRICES , CONSTANT-VALUE DOLLARS)

| YEAR | CONSTANT GAS | LOW GAS | MEDIUM GAS | HIGH GAS |
|---|---|---|---|---|
| 1972 | 1.000 | 1.000 | 1.000 | 1.000 |
| 1973 | 1.011 | 1.028 | 1.040 | 1.065 |
| 1974 | 1.023 | 1.053 | 1.064 | 1.114 |
| 1975 | 1.035 | 1.072 | 1.083 | 1.139 |
| 1976 | 1.046 | 1.085 | 1.099 | 1.156 |
| 1977 | 1.056 | 1.097 | 1.116 | 1.169 |
| 1978 | 1.066 | 1.109 | 1.135 | 1.191 |
| 1979 | 1.076 | 1.121 | 1.155 | 1.231 |
| 1980 | 1.085 | 1.132 | 1.176 | 1.306 |
| 1981 | 1.097 | 1.146 | 1.199 | 1.320 |
| 1982 | 1.107 | 1.158 | 1.222 | 1.326 |
| 1983 | 1.117 | 1.170 | 1.244 | 1.339 |
| 1984 | 1.128 | 1.184 | 1.267 | 1.357 |
| 1985 | 1.137 | 1.196 | 1.290 | 1.372 |

TABLE(G-12)
*************

REQUIRED REVENUES OF THE CROP FARMING INDUSTRY
(HIGH CRUDE OIL PRICES , CONSTANT-VALUE DOLLARS)

| YEAR | CONSTANT GAS | LOW GAS | MEDIUM GAS | HIGH GAS |
|---|---|---|---|---|
| 1972 | 1.000 | 1.000 | 1.000 | 1.000 |
| 1973 | 1.014 | 1.030 | 1.042 | 1.067 |
| 1974 | 1.029 | 1.059 | 1.070 | 1.120 |
| 1975 | 1.045 | 1.081 | 1.093 | 1.149 |
| 1976 | 1.062 | 1.101 | 1.116 | 1.172 |
| 1977 | 1.081 | 1.123 | 1.142 | 1.195 |
| 1978 | 1.101 | 1.144 | 1.170 | 1.225 |
| 1979 | 1.120 | 1.166 | 1.199 | 1.276 |
| 1980 | 1.141 | 1.187 | 1.232 | 1.361 |
| 1981 | 1.162 | 1.211 | 1.265 | 1.385 |
| 1982 | 1.185 | 1.236 | 1.299 | 1.403 |
| 1983 | 1.209 | 1.262 | 1.335 | 1.430 |
| 1984 | 1.237 | 1.293 | 1.376 | 1.466 |
| 1985 | 1.270 | 1.329 | 1.423 | 1.505 |

TABLE(G-13)
************

REQUIRED REVENUES OF THE ELECTRIC POWER INDUSTRY
(HIGH CRUDE OIL PRICES , CONSTANT-VALUE DOLLARS)

| YEAR | CONSTANT GAS | LOW GAS | MEDIUM GAS | HIGH GAS |
|---|---|---|---|---|
| 1972 | 1.000 | 1.000 | 1.000 | 1.000 |
| 1973 | 1.009 | 1.054 | 1.085 | 1.153 |
| 1974 | 1.019 | 1.100 | 1.127 | 1.262 |
| 1975 | 1.030 | 1.126 | 1.156 | 1.305 |
| 1976 | 1.043 | 1.145 | 1.186 | 1.335 |
| 1977 | 1.057 | 1.166 | 1.220 | 1.359 |
| 1978 | 1.071 | 1.187 | 1.260 | 1.409 |
| 1979 | 1.083 | 1.204 | 1.298 | 1.514 |
| 1980 | 1.095 | 1.221 | 1.344 | 1.707 |
| 1981 | 1.109 | 1.242 | 1.390 | 1.723 |
| 1982 | 1.123 | 1.262 | 1.437 | 1.723 |
| 1983 | 1.137 | 1.283 | 1.485 | 1.749 |
| 1984 | 1.154 | 1.308 | 1.537 | 1.790 |
| 1985 | 1.173 | 1.337 | 1.596 | 1.830 |

TABLE(G-14)
************

REQUIRED REVENUES OF THE ELECTRIC POWER INDUSTRY
(HIGH CRUDE OIL PRICES , REDUCED-VALUE DOLLARS)

| YEAR | CONSTANT GAS | LOW GAS | MEDIUM GAS | HIGH GAS |
|---|---|---|---|---|
| 1972 | 1.000 | 1.000 | 1.000 | 1.000 |
| 1973 | 1.013 | 1.062 | 1.094 | 1.165 |
| 1974 | 1.027 | 1.120 | 1.148 | 1.291 |
| 1975 | 1.042 | 1.158 | 1.191 | 1.354 |
| 1976 | 1.060 | 1.192 | 1.237 | 1.406 |
| 1977 | 1.081 | 1.228 | 1.290 | 1.454 |
| 1978 | 1.103 | 1.266 | 1.352 | 1.533 |
| 1979 | 1.123 | 1.302 | 1.416 | 1.683 |
| 1980 | 1.145 | 1.338 | 1.492 | 1.954 |
| 1981 | 1.169 | 1.381 | 1.572 | 2.008 |
| 1982 | 1.195 | 1.426 | 1.658 | 2.050 |
| 1983 | 1.223 | 1.474 | 1.750 | 2.128 |
| 1984 | 1.256 | 1.531 | 1.851 | 2.228 |
| 1985 | 1.294 | 1.594 | 1.968 | 2.331 |

# APPENDIX H

# LISTING OF COMPUTER PROGRAM

PROGRAM LISTING

```
C THE MAIN PROGRAM ESTIMATES THE L(K,T) VALUES , FOR EACH
C YEAR FROM 1973 TO 1985 , WHICH RESULT FROM SPECIFIED
C RPO(T) AND RPG(T) PROFILES. THESE L(K,T) VALUES ARE THEN
C USED TO CALCULATE THE REQUIRED REVENUES OF EACH INDUSTRY
C IN 1985. SUBROUTINE AV THEN CALCULATES THE FLA(K) VALUES
C CORRESPONDING TO THE 1985 REQUIRED REVENUES.

      DIMENSION G(28),COMP(28,28),C(28,28),A(28,28),
     1U(28,28),AC(13),AI(13),AR(13),RL(28),B(28,28),L(28),
     1R(28),W(28),RPO(13),RPG(13),CC(3),DD(3),RL26(13),
     1 RUTH(28),RL14(14),RL15(14),FLA(28),M(28),H(28)

C THE 1972 VALUES OF COMP(J,K) ARE READ IN.

      DO 102 K=1,28
      READ(5,103)(COMP(J,K),J=1,28)
  103 FORMAT(14F5.3)
  102 CONTINUE

C G(K)=1.0-PROF(K,1972)-BIE(K,1972)

      READ(5,100)(G(K),K=1,28)
  100 FORMAT(14F5.3)

C AC(I) REPRESENTS AC(T) . AI(I) REPRESENTS AI(T). AR(I)
C REPRESENTS AR(T). AC(T),AI(T),AR(T) ARE READ IN FROM
C 1972 TO 1985

      READ(5,107)(AC(I),I=1,13)
      READ(5,107)(AI(I),I=1,13)
      READ(5,107)(AR(I),I=1,13)
  107 FORMAT(13F6.3)

C IN EQUATION (A-6) THE VALUE OF A(J,K) IS 0.0 , THE VALUE
C OF B(J,K) IS 1.0 , AND THE VALUE OF C(J,K) IS 1.0.

      DO 108 J=1,28
      DO 109 K=1,28
      A(J,K)=0.0
      C(J,K)=1.0
      B(J,K)=1.0
  109 CONTINUE
  108 CONTINUE

C SPECIFICATION OF A(J,K) AND B(J,K) VALUES USED IN
C EQUATION (A-7). A(J,K) REPRESENTS Z(J,K)

      A(14,2)=9.0
      A(14,3)=9.0
```

PROGRAM LISTING ...(CONT'D)

```
      A(14,4)=9.0
      A(14,7)=39.0
      A(14,23)=19.0
      A(14,25)=19.0
      A(14,26)=39.0
      A(14,28)=19.0
      A(15,27)=14.0
      B(14,2)=10.0
      B(14,3)=10.0
      B(14,4)=10.0
      B(14,7)=40.0
      B(14,23)=20.0
      B(14,25)=20.0
      B(14,26)=40.0
      B(14,28)=20.0
      B(15,27)=15.0
      READ(5,2000)(RPO(I),I=1,13)
      READ(5,2000)(RPG(I),I=1,13)
 2000 FORMAT(13F5.3)

C RL(J) IN YEAR T REPRESENTS L(J,T).
C SPECIFICATION OF RL(J) FOR 1972

      DO 3053 J=1,28
      RL(J)=1.0
 3053 CONTINUE

C RUTH(J) IS USED TO DETERMINE THE VALUE OF P(J) IN 1985
C DIVIDED BY P(J) IN 1972.
C RUTH(J)=L(J,1985)*L(J,1984)*----*L(J,1973)

      DO 6270 J=1,28
      RUTH(J)=1.0
 6270 CONTINUE

C CALCULATION OF CC(I),I=1,3 FOR 1973.
C CC(I)IS C(E) IN EQUATION (A-8).

      CC(1)=AC(1)/(3.2+0.695)
      CC(2)=AI(1)/(3.2-1.305)
      CC(3)=AR(1)/(3.2+2.395)

C CALCULATION OF DD(I),I=1,3 FOR 1973
C DD(I) IS D(E) IN EQUATION (A-8).

      DD(1)=3.2/(3.2+0.695)
      DD(2)=3.2/(3.2-1.305)
      DD(3)=3.2/(3.2+2.395)

C R(K)=RO(K)/P(K)
```

PROGRAM LISTING ...(CONT'D)

```
C  W(K)=RG(K)/R(K)
C  SPECIFICATION OF R(K) AND W(K) FOR 1972

      DO 1000 K=1,28
      R(K)=0.0
      W(K)=0.0
 1000 CONTINUE
      R(24)=0.582
      W(26)=0.348
      LL=1
      T=1973.0

C  RL(14) AND RL(15) AT TIME T-1 ARE REQUIRED FOR SOME K
C  VALUES (CAPITAL COSTS) WHEN APPLYING EQUATION (A-22)TO
C  YEAR T
C  RL14(LL) IS USED TO STORE THE VALUES OF RL(14) FOR
C  DIFFERENT YEARS
C  RL15(LL) IS USED TO STORE THE VALUES OF RL(15) FOR
C  DIFFERENT YEARS

      RL14(1)=1.0
      RL15(1)=1.0

C  LL IS USED TO STORE THE VARIATION OF VARIABLES WITH TIME
C  FOR EXAMPLE IF LL=2 THEN RPD(LL) REPRESENTS RPD(1974)

    1 CONTINUE

C        ESTIMATION OF C(J,K) AND A(J,K) FOR YEAR T
C        ONLY C(26,K) AND A(26,K) CHANGE WITH TIME
C        THE OTHER C(J,K) AND A(J,K)VALUES REMAIN
C        THE SAME AS WHEN THEY WERE READ IN

      A(26,1)=CC(2)
      A(26,5)=CC(2)
      A(26,6)=CC(2)
      A(26,17)=CC(2)
      DO 32 I=20,24
      A(26,I)=CC(2)
   32 CONTINUE
      A(26,16)=CC(1)
      A(26,19)=CC(1)
      A(26,28)=CC(1)
      A(26,27)=CC(3)
      C(26,1)=DD(2)
      C(26,5)=DD(2)
      C(26,6)=DD(2)
      C(26,17)=DD(2)
      DO 33 I=20,24
      C(26,I)=DD(2)
```

PROGRAM LISTING ...(CONT'D)

```
   33 CONTINUE
      C(26,16)=DD(1)
      C(26,19)=DD(1)
      C(26,28)=DD(1)
      C(26,27)=DD(3)

C CALCULATION OF H(K)
C H(K)=THE SUM OF (A(J,K)/B(J,K))*COMP(J,K) OVER J

      DO 3 K=1,28
      HO=0.0
      DO 2 J=1,28
      H(K)=(A(J,K)/B(J,K))*COMP(J,K)+HO
      HO=H(K)
    2 CONTINUE
    3 CONTINUE

C CHANGE C(J,K) AND H(K) FOR THOSE INDUSTRIES WHERE
C CONSTRUCTION IS TREATED AS A CAPITAL COST AND IS
C REPRESENTED BY EQUATION (A-7). IN EQUATION (A-7) L(J) IS
C AT TIME T-1 AND NOT TIME T.  HENCE IT IS MOVED TO THE
C RIGHT HAND SIDE OF EQUATION(A-19) AND IS INCLUDED IN H(K)
C RATHER THAN U(K,J).

      DO 91 K=1,28
      DO 3002 J=1,28
      IF(J-14)3020,3001,3020
 3020 IF(J-15)3002,3021,3002
 3021 IF(K-27)3002,3051,3002
 3001 IF(K-2)3003,3051,3003
 3003 IF(K-3)3004,3051,3004
 3004 IF(K-4)3005,3051,3005
 3005 IF(K-7)3006,3051,3006
 3006 IF(K-23)3007,3051,3007
 3007 IF(K-25)3008,3051,3008
 3008 IF(K-26)3009,3051,3009
 3009 IF(K-28)3002,3051,3002
 3051 C(J,K)=0.0
      H(K)=H(K)+(RL(J)*COMP(J,K))/B(J,K)
 3002 CONTINUE
   91 CONTINUE

C CALCULATION OF U(K,J)
C IN NEW NOMENCLATURE EQUATION (A-19) IS
C THE SUM OF (U(K,J)*RL(J)) OVER J IS EQUAL TO
C H(K)+RPD(LL)*R(K)+RPG(LL)*W(K)

      DO 9 K=1,28
      DO 8 J=1,28
      IF(J-K)18,6,18
```

PROGRAM LISTING ...(CONT'D)

```
   18 U(K,J)=-(C(J,K)/B(J,K))*COMP(J,K)
      GO TO 8
    6 U(K,J)=G(K)-(C(J,K)/B(J,K))*COMP(J,K)
    8 CONTINUE
    9 CONTINUE
C       INVERSION OF U
      N=28
      CALL ARRAY(2,N,N,N,N,U,U)
      CALL MINV(U,28,D,L,M)
      CALL ARRAY(1,N,N,N,N,U,U)
C ESTIMATION OF RL(K)
      DO 12 K=1,28
      RLO=0.0
      DO 11 J=1,28
      RL(K)=U(K,J)*(H(J)+RPO(LL)*R(J)+RPG(LL)*W(J))+RLO
      RLO=RL(K)
   11 CONTINUE
   12 CONTINUE
      RL14(LL+1)=RL(14)
      RL15(LL+1)=RL(15)
C RL26(LL) IS USED TO STORE THE VALUES OF RL(26) FOR EACH
C YEAR FROM 1973 TO 1984 .  THESE VALUES ARE REQUIRED IF
C CC(I) AND DD(I) ARE TO BE CALCULATED UP TO 1985.
      RL26(LL)=RL(26)
C CALCULATION OF RUTH(J)
      DO 6271 J=1,28
      RUTH(J)=RUTH(J)*RL(J)
 6271 CONTINUE
C CALCULATION OF COMP(J,K)   EQUATION(A-22)
      DO 14 K=1,28
      DO 5002 J=1,28
      IF(J-14)4020,4001,4020
 4020 IF(J-15)4002,4021,4002
 4021 IF(K-27)4002,4052,4002
 4001 IF(K-2)4003,4051,4003
 4003 IF(K-3)4004,4051,4004
 4004 IF(K-4)4005,4051,4005
 4005 IF(K-7)4006,4051,4006
 4006 IF(K-23)4007,4051,4007
 4007 IF(K-25)4008,4051,4008
```

PROGRAM LISTING ...(CONT'D)

```
4008 IF(K-26)4009,4051,4009
4009 IF(K-28)4002,4051,4002
4051 COMP(J,K)=((A(J,K)+RL14(LL))/B(J,K))*(COMP(J,K)/RL(K))
     GO TO 5002
4052 COMP(J,K)=((A(J,K)+RL15(LL))/B(J,K))*(COMP(J,K)/RL(K))
     GO TO 5002
4002 COMP(J,K)=((A(J,K)+C(J,K)*RL(J))/B(J,K))*(COMP(J,K)
    1/RL(K))
5002 CONTINUE
  14 CONTINUE

C CALCULATION OF R(K)  EQUATION(A-25)
C CALCULATION OF W(K)  EQUATION(A-26)

     DO 15 K=1,28
     R(K)=(RPO(LL)*R(K))/RL(K)
     W(K)=(RPG(LL)*W(K))/RL(K)
  15 CONTINUE

C AB=L(26,T-1)*L(26,T-2)*-----*L(26,1972)*3.2
C CALCULATION OF AB

     ALO=1.0
     DO 31 I=1,LL
     AL=RL26(LL)*ALO
     ALO=AL
  31 CONTINUE
     AB=AL*3.2
     LL=LL+1
     T=T+1.0

C CALCULATION OF CC(I) FOR YEAR T (FROM DEFINITIONS AFTER
C EQUATION (A-6)).

     CC(1)=AC(LL)/(AB+AC(LL-1))
     CC(2)=AI(LL)/(AB+AI(LL-1))
     CC(3)=AR(LL)/(AB+AR(LL-1))

C CALCULATION OF DD(I) FOR YEAR T (FROM DEFINITIONS AFTER
C EQUATION(A-6)).

     DD(1)=AB/(AB+AC(LL-1))
     DD(2)=AB/(AB+AI(LL-1))
     DD(3)=AB/(AB+AR(LL-1))
     IF(T-1986.0)1,20,20
  20 CONTINUE

C FLA(K) IS THE INFLATION WHICH IF APPLIED EVERY YEAR FROM
C 1973 TO 1985 WILL BRING THE PRICE OF K FROM ITS
C 1972 VALUE TO THE 1985 VALUE PREDICTED BY THE MODEL
```

PROGRAM LISTING ...(CONT'D)

```
      CALL AV(RUTH,FLA)
      WRITE(6,6957)
 6957 FORMAT(1H ,30X,'VECTOR FLA')
      WRITE(6,6958)(FLA(K),K=1,28)
 6958 FORMAT(7F10.6)
      STOP
      END
```

```
          SUBROUTINE AV

C THIS SUBROUTINE CALCULATES FLA(K) VALUES IF GIVEN THE
C REQUIRED 1985 REVENUES OF EACH INDUSTRY K
C A TRIAL AND ERROR PROCEDURE IS USED IN THIS SUBROUTINE

      DIMENSION RUTH(28),FLA(28),X(14)
      DO 1 K=1,28
      FLA(K)=1.0
      YOY=1.0
      N=14
      R=0.01
      X(1)=1.0
    7 CONTINUE
      DO 5 J=2,N
      X(J)=FLA(K)*X(J-1)
    5 CONTINUE
      HOH=(X(N)-RUTH(K))*(YOY-RUTH(K))
      IF(HOH)21,1,22
   21 R=R/10.0
   22 YOY=X(N)
      IF(ABS(RUTH(K)-X(N))-0.001)1,1,9
    9 IF(RUTH(K)-X(N))12,1,11
   11 FLA(K)=FLA(K)+R
      GO TO 7
   12 FLA(K)=FLA(K)-R
      GO TO 7
    1 CONTINUE
      RETURN
      END
```