

## Research Note/Note de recherche

### Estimation of Contributions of a Resource Sector to a Provincial Economy: The Case of Saskatchewan Potash

Surendra N. Kulshreshtha  
Department of Agricultural Economics  
University of Saskatchewan  
Saskatoon, Saskatchewan S7N 0W0

#### Introduction

With the declining relative contribution of the primary resources sector to the economy after World War II, there may be a tendency among public and private decision-makers to downplay the contributions made by such industries. The direct contribution of the mining sector to the Saskatchewan economy, for example, declined from 10.5 percent during 1961-65 to 7.5 percent during 1973-77, and only recently increased to the neighborhood of 11 percent (1981-85 average). Such decline, or lack of growth, in the most visible benefits of an industry may lead to misplaced policy emphasis by society as a whole and its elected leaders. The contribution of a sector, however, may not be accurately represented by these direct contributions alone.

Saskatchewan is a major producer of potash in the world market. According to the U.S. Bureau of Mines, the province has 74 percent of the world's reserves that can be recovered under current price and technological conditions.<sup>1</sup> Potash production is also the major non-fuel mining activity in Saskatchewan. During 1985, Saskatchewan potash production was estimated at 6,377 thousand tonnes, valued roughly at \$621.5 million. This constituted 53 percent of the value of mineral

<sup>1</sup>According to Searls (1983), there are known reserves of 19 billion metric tonnes (equivalent  $K_2O_3$ ), of which Canada has 14 billion tonnes. The only other major reserves, in the USSR, are 3 billion tonnes.

production excluding fuels.<sup>2</sup> However, like any other primary resource sector, this sector's fortunes change from time to time. Production of potash peaked during 1980 at slightly over a billion dollars, as shown in Figure 1. At its peak, the potash sector's direct contribution was 44 percent of total non-fuel mining production, and about 5.5 percent of the provincial economy.<sup>3</sup>

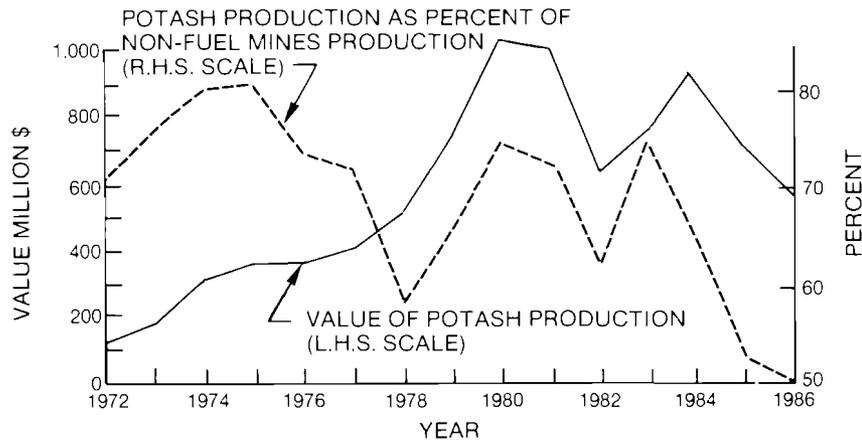


Figure 1  
TRENDS IN SASKATCHEWAN POTASH MINING SECTOR,  
1972-1986

Potash production, like any other primary production, makes contributions beyond the mine sites. In fact, all direct sales and direct employment by the mines result in some indirect impact on the provincial economy and on the rest of Canada. Including these indirect contributions provides a more realistic evaluation of the economic role played by a primary sector.

The principal objective of this study is to assess the total contributions made by a primary production sector to the Saskatchewan and Canadian economy (using potash production as an example). This

<sup>2</sup>Data obtained from Government of Saskatchewan (1986).

<sup>3</sup>This direct contribution of the potash sector is arrived at as follows: The gross domestic product (GDP at factor cost) for the mining sector was 12.3 percent of the Saskatchewan total GDP. Since the value of potash production constituted 44.8 percent of the value of total mineral production in the province, its contribution to the provincial GDP is 5.51 percent.

assessment will, it is hoped, shed some light on the issue of the appropriate measure of contributions of a primary resource sector.

### Conceptual Model

Contributions made by a sector can be broadly divided into two types—direct and indirect.<sup>4</sup> Frequently, indirect effects (or impacts)<sup>5</sup> are also referred to as “secondary” effects. Total contributions of an industry (sector)<sup>6</sup> are the sum of its direct and indirect (secondary) contributions. Direct contributions can be measured in several ways, such as contribution to value of production, employment, exports, gross domestic product, household incomes, and so forth. Each of these measures portrays the significance of that sector differently. Secondary contributions are based on the second, third, fourth, and subsequent rounds of economic ripples created by the direct contribution. These rounds of effects are created through two types of inter-industry linkages that exist in an economy: backward linkages, and forward linkages. As a result, impacts upon a sector resulting from these linkages are known as “induced by” and “stemming from” impacts.<sup>7</sup>

Change in the output level of a sector has a multiplier effect upon the rest of the economy through the two types of linkages. For each of these linkages two types of multipliers can be identified. The Type I multiplier takes into account direct and indirect<sup>8</sup> changes in the econ-

<sup>4</sup>The terminology of “indirect” (versus direct) has been borrowed from the literature in project evaluation and benefit-cost analysis. Indirect benefits (or costs) in the context of a project are those that stem indirectly from, or are induced by, the project in question; see Sewell, Davis, Scott and Ross (1965, 548). Another nomenclature commonly used in project appraisal is primary and secondary benefits (or costs). In the literature dealing with impact analysis both nomenclatures have been adopted to a certain extent.

<sup>5</sup>In this paper, the terms contributions, impacts, and effects are used interchangeably. Nonetheless some distinction among these terms does exist. “Impacts” is generally used in the context of a program or policy change, and is a term very commonly used in input-output analysis (see Richardson 1972). “Effects” of a program resulting from a change in economic magnitude is also used interchangeably with impacts in the context of impact analysis (see Zygodlo and Niehaus 1978, 14). “Contributions” is a concept that is based on netted out effects or impacts of a program (policy).

<sup>6</sup>In this study, the terms “industry” and “sector” are used interchangeably.

<sup>7</sup>For more details on these linkages, readers are referred to Miller and Blair (1985, 323-325).

<sup>8</sup>In the literature there appears to be some ambiguity in the usage of the term “indirect” changes. Sometimes it is used to denote all changes (excluding the

omy. The Type II multiplier includes the above indirect changes plus induced changes in the rest of the economy. Since households (consumers) earn incomes as payment for their labour inputs to the production process, the effects of this altered household behaviour are termed the induced effects.<sup>9</sup>

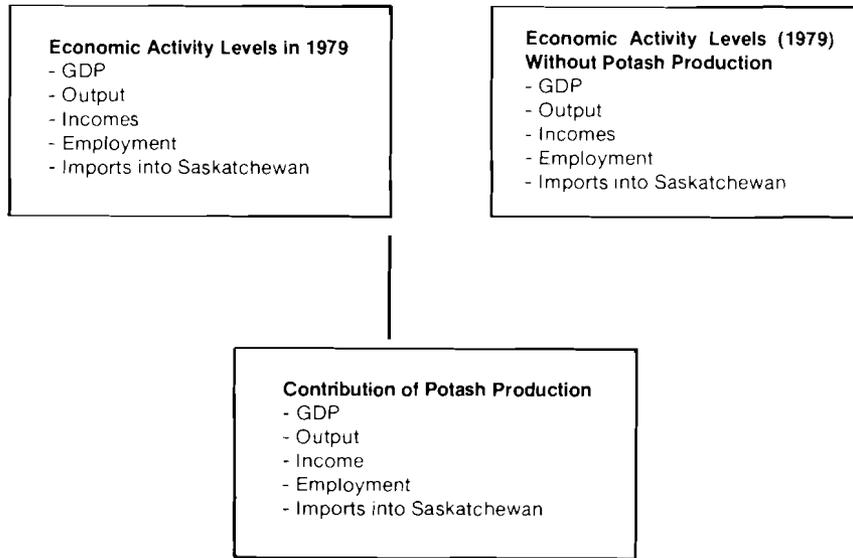


Figure 2

#### THE WITH AND WITHOUT PRINCIPLE OF ASSESSING THE MARGINAL CONTRIBUTION OF A SECTOR

Estimation of secondary economic impacts requires knowledge of the way economic transactions take place among various economic units in the complex economic system. These complexities are captured through the use of an input-output model. To determine the total contribution of a sector, the economic model may simulate a situation where the economic activities associated with that sector cease to exist. This simulated economy can then be compared with the actual economy. This is called the "with-without" principle of impact analysis, as shown in Figure 2. In this study, the level of output of various industries, gross domestic product at market prices, imports into Saskatchewan, and employment levels in various industries are calculated for two situations: (i) an assumed situation where Saskat-

direct changes), whereas Miernyk (1965) uses the term to indicate only the changes due to indirect requirements of various industries.

<sup>9</sup>In addition to the above two types of changes (indirect and induced), there may be another effect of a resource sector upon the regional economy. This can be

chewan has no potash production; and (ii) the actual Saskatchewan situation final demand for the appropriate time period. The difference in the levels of various measures between the two situations is the contribution of the potash sector.

#### Research Design

The total contributions of the potash production in Saskatchewan were measured in terms of four criteria: (i) contributions to economic activity of various industries; (ii) contributions to gross domestic product (GDP) at market prices; (iii) imports into Saskatchewan from other parts of the world; and (iv) employment generated. No agglomeration impacts are included here, since most potash sales are destined for the export market.<sup>10</sup>

The input-output model used for this study was based upon the 1979 level of transactions for Saskatchewan presented in a rectangular input-output model accounting framework.<sup>11</sup> An important feature of a rectangular input-output model is that each industry is not forced to produce only one commodity (or one type of goods and services). The model used in this study is based on a transactions table containing 63 goods and services producing industries (called sectors), and 71 commodities representing goods and services produced, plus eight primary inputs.<sup>12</sup> In addition, imports into the province were identified separately by province, and from foreign sources.

The transaction table was manipulated to create a multiplier matrix. In the model used in this study, household income and expenditures were endogenized. The model yields the following output generation relationship:

$$G = (I - DB)^{-1} DF \quad (1)$$

where  $G$  is a  $64 \times 1$  vector of sector output,

labeled as agglomeration effects. The agglomeration effects changes resulting from creation or expansion of industries that use, as a major raw material, products of the direct contribution sector. Such creation or expansion are explained through location theory, where entrepreneurs locate their plant to minimize transportation costs plus cost of production.

<sup>10</sup>Virtually all of the potash produced in the province is destined for points outside the provincial boundaries.

<sup>11</sup>This model for Saskatchewan is a part of the PRARIE—Prairie Regional Input-Output and Employment—Model, as described by Kulshreshtha and Yap (1985).

<sup>12</sup>These primary inputs include five different sources of personal income, other operating surplus of incorporated business, indirect taxes, and subsidies.

D is a 64 x 78 matrix of market share coefficients,

B is a 78 x 64 matrix of sector direct technical coefficients, and

F is a 78 x 1 vector of final demand for various commodities.

Both the D and B matrices above are based on the 1979 transactions table for the province.

The contributions of the potash sector were estimated by using the following equation:

$$\text{Total contributions} = G_0 - G_1 \quad (2)$$

$$\text{where } G_1 = (I - D^* \cdot B^*)^{-1} D^* (F^*) \quad (2.1)$$

$$\text{and } G_0 = (I - DB)^{-1} DF \quad (2.2)$$

The matrices  $D^*$ ,  $B^*$ , and vector  $F^*$  are now defined as net of (or excluding) the potash production sector. This is done by exogenizing the sector producing potash.

Exogenization of a sector can be illustrated as follows. Let us re-write the equation generating sectoral output in a rectangular input-output model as:

$$G = (DB) G + DF \quad (3)$$

Let  $DB = \Pi$ , and

$$G = \Pi G + f \quad (3.1)$$

and be identical to a square input-output model. Let  $m$  sectors in the economy have their output determined endogenously. Let subscript 1 refer to these industries. Let subscript 2 refer to that sector whose output is exogenous. Equation (3.1) can now be written as:

$$\begin{bmatrix} g_1 \\ g_2 \end{bmatrix} = \begin{bmatrix} \Pi_{11} & \Pi_{12} \\ \Pi_{21} & \Pi_{22} \end{bmatrix} \begin{bmatrix} g_1 \\ g_2 \end{bmatrix} + \begin{bmatrix} f_1 \\ f_2 \end{bmatrix} \quad (4)$$

In the above scenario  $g_2$  and  $f_1$  are known, but  $g_1$  and  $f_2$  are unknown. Solving for  $g_1$ , one obtains:

$$g_1 = (I - \Pi_{11})^{-1} (\Pi_{12} g_2 + f_1) \quad (5)$$

If the production levels of a sector are exogenously determined (such as is the case with  $g_2$ ), then  $\Pi_{21} = 0$ , and  $f_2 = 0$ . In other words, production level of  $g_2$  has already taken into account intermediate sales to other sectors, and to its final demand sectors. Thus, equation (4) can be rewritten for an exogenized sector as:

$$\begin{bmatrix} g_1 \\ g_2 \end{bmatrix} = \begin{bmatrix} \Pi_{11} & \Pi_{12} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} g_1 \\ g_2 \end{bmatrix} + \begin{bmatrix} f_1 \\ 0 \end{bmatrix} \quad (6)$$

Solving for the level of output, we obtain

$$G^* = [I - \Pi^*]^{-1} f^* \quad (7)$$

where  $\Pi^*$  is  $\begin{bmatrix} \Pi_{11} & \Pi_{12} \\ 0 & 1 \end{bmatrix}$  in equation (6), and  $G^*$  is  $\begin{bmatrix} g_1 \\ g_2 \end{bmatrix}$ .

Now equation (7) is equivalent to equation (2.1) above. Thus, the procedure involves creation of an economy without potash production, creating multipliers and determining the level of output by various sectors in the absence of any final demand (exports and new investment) by the potash sector.

The above analysis requires creation of an economy without potash production, since the current economy was taken as that with potash production. Three types of economic activities were identified as associated with potash production: (i) purchase of inputs for potash production; (ii) sales of potash in final demand outlet; and (iii) new investment by the potash industry. The information for inputs required for potash production were estimated using a proportional share of potash in "other non-metal mines". Since potash production constitutes 94.5 percent of total value of goods and services produced by the other non-metal mines sector, all inputs purchased were apportioned accordingly. Purchases of the other non-metal mines sector were obtained from the 1979 transactions table of Saskatchewan as provided by Statistics Canada. This information was used in re-estimating the market share ( $D^*$ ) and technology ( $B^*$ ) matrices in equation (2.1). The creation of final demand without potash production ( $F^*$ ) required information described under (ii) and (iii). These data were also obtained from the transactions table.

Employment of labour resources by an industry was determined using an employment production function for different sectors. Only the workers involved with production-related activities were assumed to be adjusted according to the level of output. The employment production function relationships were estimated by regressing the annual equivalent number of workers against the constant dollar value of production, plus a proxy variable for technological change. Earlier attempts included an aggregate output-labour ratio as this proxy variable. Results were not satisfactory, with frequent inconsistent signs for the estimated coefficients. In later attempts, a "time" variable was included where necessary. Estimated coefficients for the change in employment triggered by change in the output level of the sector are shown in the Appendix, Table A.1.

## Results

What does Saskatchewan potash production contribute to the provincial and Canadian economy? This discussion is divided into four parts: 1) contributions to gross value of goods and services produced by various industries in the province; 2) contributions to the value-added activities in the province; 3) contributions to the provincial employment level; and 4) contributions to other Canadian regions through importation of their goods and services.

### Contributions to Value of Output

The total value of goods and services produced during 1979 by Saskatchewan industries was estimated at \$15.5 billion. If there had been no potash production in the province, this level of output would be reduced to \$14.2 billion—or \$1.3 billion less than actual, Table 1. Thus, approximately 8.4 percent of the value of goods and services produced in the province is, directly or indirectly, related to potash production.

Table 1  
SELECTED MEASURES OF TOTAL CONTRIBUTIONS OF THE  
POTASH SECTOR TO SASKATCHEWAN ECONOMY, 1979

	Value		Contribution of the Potash Sector
	With Potash Sector	Without Potash Sector	
	— Millions of Dollars —		
Total Value of Goods and Services Produced	15,542	14,242	1,300
Household Income	7,886	7,545	341
Total Value of Gross Domestic Product	10,615	9,867	748
	— No. of Full-Time Equivalent Workers —		
Total Sectoral Employment	303,815	295,956	7,859

Besides the mining sector, which drops in value of output by \$762 million, the transportation and financial services sectors experience a significant reduction in the value of their own goods produced. The loss in the output of the transportation sector is 9.1 percent of the 1979 level, whereas that of the financial services sector is 8.7 percent,

see Appendix, Table A.2. A significant portion of the loss in the financial sector is in terms of royalties collected by various levels of government.

### Contributions to Saskatchewan Gross Domestic Product

In this study, gross domestic product was measured in market prices. During 1979, various Saskatchewan industries contributed a total of \$10.6 billion as value-added or GDP, Table 1. A significant proportion of the GDP is in the form of household incomes. If there were no potash production, a total of \$341 million would be lost as household (personal) incomes, and another \$406 million as operating surplus of businesses and net indirect taxes received by various levels of government. Thus, potash production accounts for \$748 million of gross domestic product in Saskatchewan—some 7 percent of the actual 1979 level.

### Contributions to Provincial Employment

Some 7,800 jobs in the Saskatchewan economy are estimated to be directly or indirectly related to potash production, Table 1 and Table A.3. This constitutes about 2 percent of the total provincial employment of 411,000 workers in 1979. If potash production were to cease, besides the loss of employment in the mining industry there would be major losses in the services sector (1,077 workers), the trade sector (881 workers), and the transportation and communication sector (766 workers), see Appendix, Table A.3. For every 100 jobs lost in the mining sector, another 82 jobs would be lost in other Saskatchewan industries; that is, for the economy as a whole, almost one other job is dependent upon each job in the potash industry.

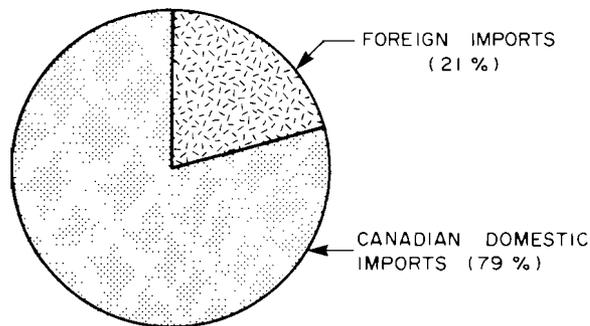
### Impact of Saskatchewan Potash Production Upon Other Regions

The impacts of potash production and related activity are not confined to the province of Saskatchewan. Various Canadian provinces plus other regions outside Canada also feel the impacts of such activities. Noteworthy among these are: first, many of the goods purchased by the consumers are imported into the province; for example, 27 percent of the total personal expenditure by Saskatchewan households of \$5,617 million is satisfied through importing goods and services from other regions. Second, a significantly large portion of new capital investment on machinery and equipment is imported. And third, each industry's input requirements are met partly from imports. Imports into the province for any of the above reasons become a source of growth for the region where these imports originate.

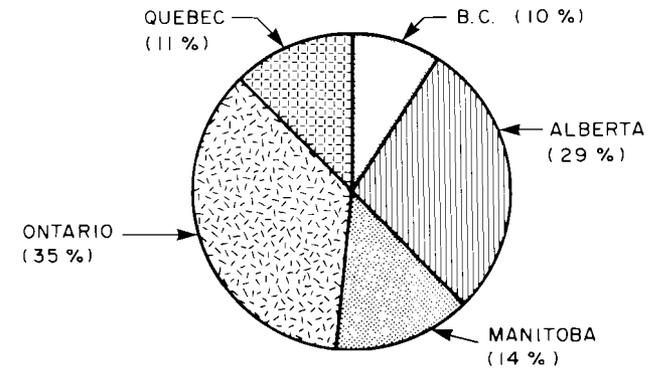
Contributions of Saskatchewan potash production to imports into the province are shown in Table 2. About \$573 million, or 8.6 percent of the total imports, are linked with potash production, directly or indirectly. Let us review where these imports originate in an attempt to answer the question: Who benefits from potash production activity? About 21 percent of the total imports are from regions outside Canada, Figure 3A. Thus, about one-fifth of these import-related benefits leak out of Canada. Of the remaining Canadian imports, almost two-thirds of the total are obtained from Ontario and Alberta, Figure 3B. Thus, the major benefits of increased potash production in Saskatchewan are shared with Ontario and Alberta.

**Table 2**  
CONTRIBUTION OF POTASH PRODUCTION IN SASKATCHEWAN TOWARDS IMPORTS INTO THE REGION, 1979

	Level		Contribution of Potash Production
	With Potash Sector	Without Potash Sector	
— Millions of Dollars —			
Direct Imports	1,004	678	326
Secondary Imports	5,635	5,388	247
Total Imports	6,639	6,066	573



**Figure 3A**  
DISTRIBUTION OF BENEFITS TO OUTSIDE SASKATCHEWAN REGION BY CANADA AND NON-CANADA REGIONS



**Figure 3B**  
DISTRIBUTION OF BENEFITS TO CANADIAN REGION BY PROVINCE

**Summary**

Saskatchewan potash production contributes to the provincial and Canadian economies in more ways than just the value of potash produced. Although in 1979 potash production was valued at \$733 million, it contributed about \$1,300 million to the value of industrial output in Saskatchewan. About 7 percent of Saskatchewan's gross domestic product and 2 percent of its total employment is directly or indirectly related to potash production. Furthermore, the impacts of potash production related activity are also felt by other Canadian provinces, notably Ontario and Alberta. This suggests that the contributions of this sector, like those of any other primary goods producing industry, are significantly higher than just the direct contribution. For the potash sector, total contributions were estimated to be 1.77 times the volume of its output, 2.04 times the personal (household) incomes paid, 1.88 times its own gross domestic product (at market prices), and 1.82 times its direct employment.

In addition to the above measured impacts, there may also be non-quantifiable impacts of potash production upon the Saskatchewan society. For example, a majority of farm families derive their family income from off-farm sources.<sup>13</sup> During periods of low net farm income, off-farm employment income is used as a measure to "float" over the bad times. Employment in potash mines has helped many farm families enhance the viability of their farm operations. Proximity

<sup>13</sup>For example, in 1986 one-third of all farms in Saskatchewan reported off-farm work in non-agricultural sectors (based on unpublished data obtained from Statistics Canada).

to centres of potash production may also induce growth and stability in local communities and improve the level of local government finances, and thus have significant fiscal implications for these local communities. Stability and economic prosperity in the primary resource industries affects more than those directly employed by them.

### References

- Government of Saskatchewan. 1986. *Economic Review 1986*. Regina: Bureau of Statistics.
- Isard, W. and R. E. Kuenne. 1953. "The impact of steel upon the greater New York-Philadelphia industrial region: A study in agglomeration projection", *Review of Economics and Statistics*, 35, November.
- Johnson, T. G. and S. N. Kulshreshtha. 1982. "Exogenizing agriculture in an input-output model to estimate relative impacts of different farm types", *Western Journal of Agricultural Economics*, 7:2; 187-198.
- Kulshreshtha, S. N. and M. T. Yap. 1985. *The Prairie Regional Input-Output and Employment Model—A User's Handbook*. Regina: Prairie Farm Rehabilitation Administration.
- Miernyk, W. H. 1965. *The Elements of Input-Output Analysis*. New York: Random House.
- Miller, R. E. and P. D. Blair. 1985. *Input-Output Analysis: Foundations and Extensions*. Englewood Cliffs, New Jersey: Prentice Hall, Inc.
- Richardson, H. W. 1972. *Input-Output and Regional Economics*. New York: John Wiley and Sons.
- Searls, James P. 1983. "Potash", in *Minerals Commodity Profiles*. Washington: U.S. Bureau of Mines.
- Sewell, W. R. D., John Davis, A. D. Scott, and D. W. Ross. 1965. "A guide to benefit-cost analysis", in I. Burton and R. W. Kates (eds.), *Readings in Resource Management and Conservation*. Chicago: The University of Chicago Press.
- Yan, C. *Introduction to Input-Output Economics*. 1969. New York: Holt, Rinehart and Winston.
- Zygadlo, L. and R. Niehaus. 1978. *Regional Development and Plan Evaluation—The Use of Input-Output Analysis*. Chapter IV, Handbook No. 530. Washington, D.C.: U.S. Department of Agriculture.

### Appendix

Table A.1

#### ESTIMATED REGRESSION COEFFICIENT FOR CHANGE IN EMPLOYMENT, BY SECTORS, SASKATCHEWAN

Sector	Change in Employment per \$1,000 of Output
Agriculture	0.00122
Metal Mines	0.01411
Mineral Fuels	0.00083
Non-Metal Mines	0.00075
Slaughtering and Meat Processing	0.00351
Poultry Processors	0.00738
Dairy Factories	0.00360
Fruits and Vegetables	0.00937
Feed Manufacturers	0.00464
Flour and Breakfast Cereals	0.00253
Bakeries	0.03096
Vegetable Oil Mills	0.00129
Misc. Food Products	0.00761
Soft Drink Manufacturers	0.00716
Distilleries	0.00639
Rubber and Plastics Industry	0.00842
Leather Industry	0.01738
Textiles Manufacturers	0.00824
Clothing Manufacturers	0.02437
Wood Products Manufacturers	0.00907
Furnitures and Fixtures	0.02837
Paper and Allied Products	0.00543
Printing and Publishing	0.01428
Primary Metal Industry	0.00345
Metal Fabrication	0.01193
Machinery	0.01415
Transportation Products	0.01395
Electrical Products	0.01302
Non-Metallic Mineral Products	0.06365
Petroleum Refining	0.00114
Other Petroleum and Coal Products	0.00064
Chemical Products	0.00460
Miscellaneous Manufacturing	0.00785
Construction	0.00843
Trade	0.01614
Finance	0.00573
Services	0.02365
Transportation Margins	0.00445

Table A.2  
CONTRIBUTION OF POTASH PRODUCTION IN SASKATCHEWAN  
TOWARDS LEVEL OF INDUSTRIAL OUTPUT, 1979

Sector or Industry	Level of Output		Contribution of Potash Production
	Actual	Without Potash	
— Millions of Dollars —			
Agriculture, Forestry, Fisheries	2,975	2,968	7
Mining	1,945	1,183	762
Food and Beverage	728	716	12
Non-Food Manufacturing	1,170	1,159	11
Construction	2,121	2,071	50
Transportation and Communication	1,538	1,398	140
Utilities	311	283	28
Trade (wholesale and retail)	1,502	1,420	82
Financial Services	1,840	1,686	154
Business and Personal Services	1,412	1,358	54
Total	15,542	14,242	1,300

Table A.3  
CONTRIBUTION OF POTASH PRODUCTION TO SASKATCHEWAN  
EMPLOYMENT LEVELS, 1979

Sector	Full-Time Equivalent Workers		Contribution of Potash Production
	Actual	Without Potash	
Agriculture, Forestry, Fisheries	26,277	26,268	9
Mining	9,121	4,801	4,320
Food and Beverage	4,843	4,760	83
Non-Food Manufacturing	13,658	13,643	15
Construction	25,678	25,149	529
Transportation and Communication	59,014	58,248	766
Utilities	3,453	3,391	62
Trade	67,380	66,499	881
Financial Services	19,214	19,097	117
Business and Personal Services	75,177	74,100	1,077
Total	303,815	295,956	7,859
Other*	107,185*	**	**
Total	410,980	**	**

\* Includes farm operators, public administration workers, and other self-employed workers in the services industry.

\*\* Not estimated.