Exogenizing Agriculture in an Input-Output Model to Estimate Relative Impacts of Different Farm Types

Thomas G. Johnson and Surendra N. Kulshreshtha

In this study, aggregate, provincial level impact for various farm types are estimated for Saskatchewan based on an input-output table constructed for the province. The input-output table is rectangular with the agriculture sector including 12 farm subsectors, treated exogenously. Results indicate that in 1978 agriculture contributed 13.8 percent of the provincial gross domestic product directly, and another 18.2 percent indirectly. Among the farm types, the grain farms generated the highest output multipliers while cow-calf, dairy and irrigation generated the lowest. The income and value added pseudo-multipliers were almost a complete reversal of the output multipliers. Although irrigation generated low pseudo-multipliers, the dairy and cow-calf sectors generated higher pseudo-multipliers.

Agricultural policy in Saskatchewan has often had as its objective, the diversification of the agricultural sector.[1] This objective suggests a change in the enterprise mix of agriculture. Until recently, this policy, and others, such as intensification, development of new crops, irrigation development, etc., have been designed on the basis of micro-level economic analyses of the enterprises involved, but have ignored the aggregate economic impact of resulting changes in the enterprise composition of the industry. Since each farm enterprise will, in general, have unique interrelationships with other sectors of the economy, changes in the enterprise mix should generate different levels of economic activity in the province.

The objective of the research reported in this paper was to determine the relative impact of different farm types on the provincial economy. Information such as this can be used (and has been used) to determine the effects of irrigation development, droughts, changes in energy prices, and various agricultural policies [Johnson and Kulshreshtha; Thomas G. Johnson; Kulshreshtha, Tewari, and Johnson]. In this study, the aforementioned impacts were estimated by employing input-output analysis.

Input-output analysis is ideally suited to the analysis of economic impacts of changing final demands. Sectoral output multipliers indicate the relative impact of changes in final demand for the various products of an economy. However, when the analysis relates not to a change in final demand but rather to the impact of intra-sectoral changes, such as a change in the mix of farm types,

Thomas G. Johnson is an assistant professor in the Department of Agricultural Economics at Virginia Polytechnic Institute and State University, and Surendra N. Kulshreshtha is a professor in the Department of Agricultural Economics at the University of Saskatchewan, Saskatoon, Canada. Agricultural Economics Contribution Number 1034.

The authors wish to thank Professor K. Rosaasen of the Agricultural Economics Department for his comments and suggestions on an earlier draft. Also valuable suggestions were received from three anonymous reviewers. The authors accept sole responsibility for any remaining errors and ommissions.

[1]Although diversification in the context of agriculture refers to a growing proportion of non-grain enterprises, in the overall context, this also implies diversification of the primary and secondary production.

input-output analysis is somewhat awkward to use. The problem is comparable to that addressed by Petkovich and Ching, in which the level of sectoral output is, because of some exogenous constraint, predetermined rather than simultaneously determined by final and intermediate demand. Petkovich and Ching have suggested a linear programming solution of the input-output model as one method of handling constraints on sectoral output. The problem addressed in the present study is somewhat more general in that it involves any case in which sectoral output and its expenditure pattern is predetermined. The study employs a more direct method of incorporating changes in sectoral output. The approach involves the redefinition of the sector in question as a final demand sector rather than an endogenous sector. This approach is employed in this study to estimate the differential impacts of various farm types on the Saskatchewan economy.

Objectives and Scope of the Study

The primary objective of this study was to design an analysis capable of estimating the impact of change in agricultural enterprise mix on the aggregate economy of Saskatchewan. The impact of a change was assessed by estimating both the direct and indirect (including induced) effects of different types of farms. This objective was carried out with the help of a 1974 transactions matrix for the province.[2] The model is rectangular[3] with 59 endogenous sectors and 73 commodities. The household sector is endogenous and the agricultural sector is exogenous.

[2]The Canadian input-output model is interregional with tables for each province based on what is essentially a census of firms. The transactions upon which this model is based were all those involving Saskatchewan firms. The model is, therefore, a survey (as opposed to non-survey) model of the Saskatchewan economy. The 1974 transactions data were aggregated in such a way as to reflect the Saskatchewan economy which is quite different from the total Canadian economy. Resource and agricultural related industries are highlighted in the model while manufacturing and most service sectors are quite highly aggregated.

The Model

In a typical economy, the agriculture industry relies on other sectors in at least two ways: (1) it procures, from the economy, certain farm inputs, such as fertilizer, machinery, labor, etc. and (2) it provides inputs to non-agricultural industries. Although it may be easy to visualize the direct changes in the economic health of the agricultural industry as a result of a policy measure, it is not as easy to visualize the effects that these direct changes in the industry may subsequently have on other sectors. For example, if a government program is initiated which encourages the establishment of certain intensive livestock operations, the effects on producers and the industry are readily identifiable. The benefits and costs to other sectors or to households are not as obvious. The answers to questions of indirect impacts lie in an understanding of the intersectoral relationships in an economy.

The Rectangular Input-Output Framework

The primary objective of the study was carried out with the help of a 1974 transaction matrix for the province of Saskatchewan which basically describes the flow of commodities from one sector to another. The rectangular input-output model differs from the square model in that sectors and commodities are identified separately with no requirement regarding the correspondence between the two classifications. The model may recognize any number of commodities — either greater than, less than or equal to the number of sectors. The important difference between the square and rectangular models is that in the latter, any industry may produce a positive level of any commodity.

The rectangular model is based on the following accounting equations:

[3]The rows in the input-output tables are the commodities being bought whereas the columns stand for industries or sectors in the provincial economy. For more details on the rectangular system, see Statistics Canada, or Chossudousky.

$$q = Bg + e, \quad (1)$$

where,

- q = $m \times 1$ vector of the values of total commodity output,
- B = $m \times n$ matrix of industry technology coefficients (value of commodity inputs per \$1 of industry output),
- g = $n \times 1$ vector of the value of total sectoral (industry) outputs,
- e = $m \times 1$ vector of final demand (less imports),
- m = number of commodities,
- n = number of industries.

Equation (1) requires that total output equals the sum of intermediate and final demand. The difference is that B relates output levels of industries to intermediate demands for commodities.

Commodity output levels are further related by the market shares equation,

$$g = Dq, \quad (2)$$

where,

- D = $n \times m$ matrix of market share coefficients

The matrix D relates the output levels of industries to the sum of its share of each commodity,

$$g_i = d_{i1}\, q_1 + d_{i2}\, q_2 + \ldots + d_{im}\, q_m. \quad (i = 1, \ldots, n) \quad (3)$$

Substituting equation (2) into equation (1) gives

$$q = BDq + e \quad (4)$$

which has the solution,

$$q = (I - BD)^{-1} e. \quad (5)$$

Alternatively one could substitute equation (1) into equation (2) and solve for the level of industry output, as shown by equation (6).

$$g = (I - DB)^{-1} De. \quad (6)$$

Using the above solutions two multiplier matrices can be defined. From equation (5), one obtains

$$M_C = (I - BD)^{-1}, \quad (7.1)$$

and from equation (6), one has

$$M_I = (I - DB)^{-1} D. \quad (7.2)$$

The matrix M_C contains the direct plus indirect effects on each commodity of a one dollar change in demand for each commodity. Thus, the element m_{Cij} is the direct plus indirect output of commodity i required to produce one dollar of commodity j for final demand. Similarly m_{Iij} in the matrix M_I is the direct plus indirect output of sector i required to produce one dollar of commodity j.

The major advantage of such a model is that it allows the industrial definitions to be developed independently of considerations about the commodities produced.[4] This framework is particularly useful for treating the agriculture industry which can be best viewed as a multi-product industry. The rectangular scheme is therefore a more realistic representation of industrial structure. Furthermore, the model allows the analyst to measure the effects of market shares and their changes on the interrelationships between sectors.

The model used in this study was developed in terms of producer prices. This was done using coefficients which decompose purchaser prices into producer prices and various margins, using the base year relationships.

[4]In reality, of course, most sectors are identified by a range of products such as "leather and textile products" or "other petroleum and coal products". The firms included in these sectors are defined as those whose major products (50 percent of value) come from the definition in question.

Exogenizing Agriculture

Input-output analysis implicitly assumes that all endogenous sectors can produce any level of output required to meet final demands. Given this assumption, changes in final demand can be introduced to the input-output model and the total effects on each sector calculated. As Petkovich and Ching point out, in some cases, the output of a certain sector is not determined by demand but by capacity constraints. Under these circumstances simple final demand driven solutions to the input-output model are inadequate. Petkovich and Ching propose and demonstrate an iterative linear programming solution to the model which allows the incorporation of predetermined levels for the sector in question.

The capacity reduction scenario above is really a special case of the more general scenario in which the output of a given sector is, in the short run at least, restricted to some predetermined level. This more general scenario includes those cases where output is reduced because of policy changes [Bromley, Blanch, and Stoevener], depletion of raw materials [Petkovich and Ching; Jones, Casey and Lacewell], or drought [Hoppe]. On the other hand, it also includes those cases where production is increased because of irrigation, weather modification, etc. [Mamer, Goldman and Wallace, 1973a and 1973b; Maki, *et al.*; Jerome E. Johnson; Burris; Bark; Bark, Buller and Vanderlip; and Thomas G. Johnson]. In fact, this scenario includes all those cases where the objective is to determine the impact, not of changes in final demand, but changes in total output.

The approach used in the present study is much more direct than the Petkovich and Ching solution in that it sets the level of a sector's output at the exogenously determined level and then solves the input-output model in a more or less normal fashion.

For simplicity define the $m \times m$ matrix A as follows

$$A = BD. \tag{8}$$

Then

$$q = Aq + e, \text{ or} \tag{9}$$

$$q = (I - A)^{-1}e. \tag{9.1}$$

If a subset of the sectors are, as described above, restricted to some predetermined level we may partition the matrices as follows:

$$\begin{bmatrix} q_1 \\ q_2 \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} q_1 \\ q_2 \end{bmatrix} + \begin{bmatrix} e_1 \\ e_2 \end{bmatrix} \tag{10}$$

where the subscript 1 refers to those sectors whose outputs are endogenously determined while subscript 2 refers to those whose outputs are exogenous. In this scenario, e_1 and q_2 are known but q_1 and e_2 are unknown. Solving for these unknowns

$$q_1 = (I - A_{11})^{-1} (A_{12}\, q_2 + e_1) \tag{11}$$

and,

$$e_2 = (I - A_{22})\, q_2 - A_{21}\, q_1. \tag{12}$$

If, as in the present paper, one is interested in the impact of some known level of sector output in a given sector, e_1 can be assumed to be zero. Then

$$q_1 = (I - A_{11})^{-1} A_{12} q_2. \tag{13}$$

Final demand, e_2, is then calculated as a residual. Total economy wide output is $q_1 i_1 + q_2 i_2$ where the i's are the appropriately dimensioned identity vectors.

Notice that once e_2 is known, the input-output model can be solved in the usual fashion resulting in estimates of q_1 and q_2 equivalent to those above. However, in the scenario described above, e_2 and not q_2 are the unknowns.

In general, if the predetermined level of q_2 (or even a predetermined change in q_2) is incorrectly multiplied by the multiplier matrix, as is often done, the estimated impact is exaggerated, by the amount $(I - A)^{-1}(q - e)$.

Notice that $A_{12}q_2$ in equation (13) is simply the first round expenditures of the sectors in question. In the following sections, the input-output model is "open" with respect to agriculture and the sector's expenditures are treated like final demand.[5]

Calculation of Multipliers

Input-output allows the analyst to develop many different types of multipliers — output multipliers, income multipliers, value added multipliers, employment multipliers and others. Each of these may be refered to as Type I — direct plus indirect effects, or Type II — direct plus indirect plus induced effects. Direct effects are the initial shock or disturbance being studied. The indirect effects include all subsequent changes which result from the several rounds of purchases of intermediate outputs, but exclude purchases which result from the respending of incomes earned as a result of the initial shock. This latter effect is called the induced effect and can be measured only if households are endogenous to the input-output model.

Many analysts use different names for the same multiplier (i.e. final demand versus output) while others use the same name for different multipliers (i.e. income multiplier is used to indicate total change in income caused by a one dollar change in income or a one dollar change in demand).[6] As a result, there is a great deal of misunderstanding surrounding the concept of multipliers.

In this study five multipliers (all type II) are defined. The *output multiplier* is defined as the ratio of total (direct plus indirect plus induced) output to direct output (or final demand). This multiplier, when multiplied by a given level of final demand will indicate total production required to deliver that final demand. The *income* (and *valued added) multipliers* are defined as the ratio of total income (value added) to direct income (value added). These multiplier must be multiplied by income (value added) rather than output. Because it is easier to multiply multipliers by direct output (as opposed to direct income or value added), two additional psuedo-multipliers[7] can be identified. The *income* (value added) *psuedo-multiplier* is defined as the ratio of total income (value added) to direct output. These multipliers are designed to be multiplied by direct output, in contrast to final demand.

Sources of Data for the Agricultural Sector

In the 1974 Canadian input-output tables, the agricultural industry is treated as a single sector. For studies related to agriculture, such a model is of limited value. In this study, therefore, the agricultural sector was divided into 12 sub-sectors, based on enter-

[5]The effect of exogenizing agriculture is not unlike that of exogenizing the household sector. When the level of household expenditure is known or for some reason not expected to change (i.e., it is exogenous), then it is appropriate to include it in final demand. When its level is not known *ex ante*, but is determined by the levels of other sectors, it should be endogenous. While households are frequently made exogenous when appropriate, the approach has seldom (if ever) been extended to production sectors.

[6]A common error committed is to calculate the Type II output multipliers by simply adding all elements in the appropriate column of the multiplier matrix including the household sector. The problem with this approach is that if the value is compared with the type I multiplier, the entire household income level is attributed to the induced effect, when in reality most of it is direct and indirect.

[7]The term pseudo-multiplier is coined and offered here to distinguish those multipliers which have the same units in the denominator and numerator, from those "multipliers" which have different units, as in the case of the pseudo-multipliers in this study. Considerable confusion is possible when a term such as "income multiplier" refers to both types. Schaffer, for example, reports income multipliers whose units are total *income* per dollar of direct *output*. The unsuspecting reader may be surprised to find that essentially all of these multipliers fall between 0.0 and 1.0. Furthermore, the distinction should alert the users of these multipliers to consider which of the alternatives is the appropriate one for their purposes. The authors are undoubtedly not alone in having their income multipliers misused by practitioners who multiply them by a direct output change rather than a direct income change.

prise type and soil zone.[8] The cross-classification by soil types was carried out to increase the homogeneity of the farms within each enterprise type. The criterion for this cross-classification was a non-statistical evaluation of differences in coefficients.[9] The final classification included: (1) Mixed farms — Brown and dark brown soil zones; (2) Mixed farms — Black soil zones; (3) Cow-calf; (4) Feeder; (5) Dairy; (6) Hogs; (7) Cereal — Brown soil zone; (8) Cereal — Dark brown soil zone; (9) Cereal — Black soil zone; (10) Oilseed; (11) Poultry; and (12) Irrigation — South Saskatchewan Irrigation project.

The major data source was a magnetic tape containing the 1978 consumption and production records kept by the CANFARM system (a national farm record keeping service). There is reason to believe that the distribution of CANFARM subscribers and the distribution of Saskatchewan farmers by size are dissimilar. This led to the need for some test of the sample as compared with the population. These tests resulted in support of the above contention. As a result, the CANFARM data were categorized on the basis of size, and weights calculated from the 1976 Census of Agriculture.[10]

The next task was to calculate input and output coefficients from the weighted data. These expenditures were classified into Statistics Canada input-output classifications (see Table 1).

Coefficients for poultry farms are based on cost of production formulas provided by the various marketing agencies involved. The irrigation farm coefficients are based on budgets prepared by the Outlook Irrigation Branch of the Saskatchewan Department of Agriculture.

Empirical Results

From the agricultural input-output coefficients in Table 2, 1979 final demand levels were calculated for each type of farm. This information was used to calculate relevant multipliers for the twelve farm types, which are shown in Table 2. The output multipliers indicate the total provincial production arising from each dollar of production in any of the twelve subsectors. The output multiplier of 2.03 for the total sector is reasonably large for an economy as open as that of Saskatchewan. Of the subsectors, irrigation farms (in the Outlook, Saskatchewan, area) have the smallest output multiplier (1.95) while oilseed farms have the highest (2.09).

The value-added multiplier for agriculture is estimated at 2.42. This indicates that for each dollar of value added generated in agriculture, $1.42 of additional value added is generated elsewhere in the economy. The cow-calf farms generate the lowest multiplier of this type (2.25) while poultry farms generate the highest (3.47). These multipliers convey very little comparative information however. The poultry farms have the highest value simply because they generate the lowest direct value added.

[8]The classification was based on the same criterion used by Statistics Canada to classify industries. Cereal farms received at least 50 percent of total revenues from cereal grains sales, cow-calf farms received at least 50 percent of total revenues from the sale of cows, bull, calves and feeder animals, feeder operations received at least 50 percent of total revenues from slaughter steers and heifers, etc. Mixed farms were those which did not have a dominating enterprise. Irrigation farms from the South Saskatchewan Irrigation Project (the only major concentration of irrigated acreages in the province) have a range of products but receive a major portion of total revenue from irrigated crops.

[9]Livestock farms, for example, had similar coefficients regardless of soil type. Oilseed farms were almost all located in the black soil zone and were therefore not cross-classified by soil zone. The cross-classification of mixed farms would have left the sample size unacceptably low and the brown and dark brown were therefore left undistinguished.

[10]The test referred to was a Hotellings T^2 test of seven average attributes of the provincial farms versus the CANFARM sample. After weighting the sample for farm size, the T^2 statistic was very insignificant indicating no difference between the population and the sample.

TABLE 1: Input-Output Coefficients for Agriculture Subsectors by Commodity Type. (Mixed and Livestock Farms)

	Mixed					
Commodity Type	Br.-D.Br.	Black	Cow-Calf	Feeder	Dairy	Hogs
4. Poultry	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5. Wheat	0.001784	0.001372	0.001046	0.000320	0.000000	0.002000
6. Other Grains	0.001784	0.001372	0.001046	0.000320	0.000000	0.002000
10. Oilseeds, Nuts and Kernels	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
11. Other Ag. Products	0.007544	0.019482	0.023374	0.015649	0.031990	0.006325
12. Forestry Products	0.001341	0.000232	0.000234	0.001419	0.001248	0.000398
27. Feeds	0.027272	0.017773	0.026312	0.025128	0.089596	0.217563
35. Leather & Textile Products	0.000864	0.000712	0.000816	0.001352	0.000770	0.000103
36. Lumber, Plywood & Other Woods	0.004639	0.002494	0.003334	0.005002	0.004239	0.003419
41. Metal Fabricated Products	0.017037	0.007736	0.009862	0.018903	0.015623	0.009592
42. Ag. Machinery	0.095930	0.078669	0.087484	0.092123	0.060850	0.047694
51. Gas & Fuel Oil	0.099456	0.079440	0.074923	0.077374	0.053358	0.051328
52. Other Pet. & Coal Products	0.011051	0.008827	0.008325	0.008597	0.005929	0.005703
54. Fertilizers	0.064995	0.074351	0.033441	0.046270	0.017668	0.039017
55. Pharmaceuticals & Other Chemical Products	0.039569	0.045152	0.020026	0.032283	0.011779	0.019865
59. Communications	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
60. Electrical Power	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
65. Real Estate, Financial Services	0.062312	0.112720	0.096630	0.096348	0.062163	0.062234
66. Insurance & Workmen's Compensation	0.054576	0.051103	0.034919	0.062440	0.022856	0.040451
67. Non-Res. Rent	0.027321	0.030194	0.022429	0.008986	0.039704	0.016828
69. Business Services	0.010413	0.007935	0.013730	0.011855	0.045264	0.024406
73. Households	0.470187	0.465839	0.540684	0.494698	0.576707	0.435516
75. Indirect Taxes	0.032545	0.034452	0.026021	0.023639	0.011462	0.013895
76. Subsidies	−0.030622	−0.039854	−0.024634	−0.022708	−0.041206	−0.008336
80. Other Operating Surplus	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Total	0.999998	1.000001	1.000002	0.999998	1.000000	1.000001

TABLE 1. Continued. (Grain, Poultry and Irrigation Farm)

	Cereal (Grain)					
Commodity Type	Brown	Dark Brown	Black	Oilseed	Poultry	Irrigation
4. Poultry	0.000000	0.000000	0.000000	0.000000	0.174745	0.000000
5. Wheat	0.001017	0.001620	0.001235	0.001074	0.000000	0.008528
6. Other Grains	0.001095	0.001864	0.001667	0.001074	0.000000	0.005366
10. Oilseeds, Nuts and Kernels	0.000000	0.000000	0.000000	0.000000	0.000000	0.002588
11. Other Ag. Products	0.019446	0.014687	0.015701	0.022003	0.000000	0.023283
12. Forestry Products	0.000292	0.000133	0.000232	0.000173	0.006351	0.000000
27. Feeds	0.009298	0.004472	0.006351	0.001610	0.517748	0.000000
35. Leather & Textile Products	0.000340	0.000456	0.002466	0.000211	0.000000	0.000179
36. Lumber, Plywood & Other Woods	0.004928	0.005078	0.003722	0.003230	0.004313	0.010556
41. Metal Fabricated Products	0.013082	0.013021	0.010234	0.008507	0.004332	0.000000
42. Ag. Machinery	0.081753	0.081342	0.094805	0.078448	0.000000	0.055096
51. Gas & Fuel Oil	0.079088	0.082192	0.103165	0.084590	0.024501	0.040656
52. Other Pet. & Coal Products	0.008788	0.009133	0.011463	0.009399	0.000000	0.003426
54. Fertilizers	0.035142	0.060444	0.084326	0.093096	0.000000	0.056449
55. Pharmaceuticals & Other Chemical Products	0.027560	0.050562	0.050136	0.071796	0.001523	0.036306
59. Communications	0.000000	0.000000	0.000000	0.000000	0.000000	0.004222
60. Electrical Power	0.000000	0.000000	0.000000	0.000000	0.000000	0.036372
65. Real Estate, Financial Services	0.080465	0.074008	0.097402	0.076613	0.046606	0.279180
66. Insurance & Workmen's Compensation	0.084054	0.071193	0.070376	0.067735	0.009705	0.000000
67. Non-Res. Rent	0.023767	0.022289	0.020867	0.076477	0.000000	0.000000
69. Business Services	0.003926	0.004936	0.006939	0.003005	0.032917	0.005430
73. Households	0.528268	0.500561	0.429929	0.407965	0.157244	0.258484
75. Indirect Taxes	0.035806	0.037873	0.041307	0.031517	0.020015	0.054521
76. Subsidies	−0.038116	−0.035866	−0.050322	−0.038530	0.000000	0.000000
80. Other Operating Surplus	0.000000	0.000000	0.000000	0.000000	0.000000	0.119357
Total	0.999999	0.999998	1.000001	1.000001	1.000000	0.999999

TABLE 2. Various Input-Output Multipliers by Agriculture Subsectors.

Agriculture Subsector	Output Multiplier	Value Added Multiplier	Value Added Pseudo-Multiplier	Income Multiplier	Income Pseudo-Multiplier
Mixed Br.-D.Br.	2.03256	2.41609	1.18674	1.61256	0.758207
Mixed Black	2.04274	2.50715	1.19390	1.62205	0.755626
Cow-Calf	1.96809	2.24792	1.24974	1.51941	0.821513
Feeder	2.01984	2.37808	1.21474	1.59240	0.787743
Dairy	1.98067	2.25649	1.25800	1.49883	0.864450
Hogs	2.05863	2.44437	1.10292	1.62395	0.707264
Cereal, Br.	1.99493	2.29443	1.24107	1.54893	0.818248
Cereal, D.Br.	2.00816	2.34568	1.21797	1.57469	0.788229
Cereal, Black	2.07666	2.63044	1.15976	1.69218	0.727517
Oilseed	2.08864	2.72862	1.14298	1.71977	0.701595
Poultry	2.01422	3.46913	0.63133	2.26510	0.356255
Irrigation	1.94842	2.48804	1.09880	1.98241	0.512301
Total (All Farm)	2.02556	2.41782	1.19736	1.60136	0.770025

The value added pseudo-multipliers are perhaps the most meaningful among the various multipliers. The aggregate multiplier of 1.20 indicates that agriculture has an exceptionally large impact on the economy. It suggests that for each dollar of production in agriculture, $1.20 in value added occurs in the province. A multiplier of this magnitude is possible only if the sector in question is closely related to the household sector. Under-scoring the ambiguity of the value added multiplier, the cow-calf subsector, with a value added pseudo-multiplier of 1.25 is second only to the dairy farms with 1.26. The lowest is the poultry subsector with 0.63.

The income multipliers, like the value added multipliers must be interpreted carefully. The aggregate income multiplier of 1.60 indicates that for each dollar of farm income, $0.60 of income is generated elsewhere. The income pseudo-multiplier of 0.77 indicates that for each dollar of production in agriculture provincial income rises $0.77. In terms of the last multiplier, the dairy and cow-calf subsectors again rank high (0.86 and 0.82) while poultry is the lowest (0.36).

The multipliers indicate only the relative effects per dollar of output. In absolute terms the cereal farms predominate, as Table 3 indicates. From the provincial economy's position, the direct plus indirect value added levels are the best indicators of a subsector's importance. Overall, the model predicts that nearly $3 billion dollars of the provincial gross domestic product can be directly or indirectly attributed to agriculture. To put this in perspective, consider that the provinces gross domestic product (at factor cost) in 1978 was 8,865 million. Therefore, while agriculture contributed only 13.8 percent of gross domestic product directly, indirectly it contributed another 18.2 percent for a total of 33.4 percent.[11] This indicates, vividly, the relative importance of the industry in the province of Saskatchewan.

A Comparison of the Agricultural Subsectors

The first major observation regarding the agriculture subsectors is that, with the exception of poultry, the subsectors are relatively similar. The rather incongruous results displayed by the poultry subsector may be due

[11]Using the Saskatchewan Bureau of Statistics estimate of agriculture's contribution to GDP and the IO estimate of the value added multiplier the direct and total contributions are 18.0 percent and 43.4 percent respectively.

TABLE 3. Direct Plus Indirect Levels of Key Variables Due to Agriculture by Agriculture Subsectors.

	Mixed					
	Br.-D.Br.	Black	Cow-Calf	Feeder	Dairy	Hogs
	Thousands of Dollars					
Imports	31,899.70	54,446.80	128,171.00	35,474.30	20,691.50	19,571.70
Taxes	17,752.50	32,291.20	74,553.70	19,738.60	11,545.20	10,089.92
Subsidies	−3,324.62	−6,830.64	−11,414.47	2,990.25	−2,451.93	−1,070.49
Wages and Salaries	14,607.10	25,701.30	57,575.00	16,546.30	9,378.53	9,079.76
Supplementary Labour Income	1,135.24	1,957.50	4,344.02	1,272.65	655.53	663.05
Net Income of Unincorporated Business	2,980.65	5,605.29	12,879.10	3,428.02	2,250.23	1,895.17
Other Operating Surplus	12,189.50	23,041.40	47,217.40	13,109.30	7,261.21	7,491.45
Total Household Income	49,288.00	86,739.00	218,805.00	57,112.90	36,910.30	30,290.00
Value Added[b]	77,145.22	137,048.97	332,860.75	88,071.08	53,714.08	47,234.75

TABLE 3. Continued.

	Cereal						
	Brown	Dark Brown	Black	Oilseed	Poultry	Irrigation	Total[a]
	Thousands of Dollars						
Imports	215,439.00	317,170.00	326,435.00	38,521.90	8,423.95	2,538.99	1,198,780.00
Taxes	128,113.00	187,109.00	188,395.00	22,254.00	3,675.14	1,863.28	697,379.00
Subsidies	−24,785.61	−35,634.10	−48,063.80	−4,850.09	−351.24	−132.29	−141,899.50
Wages and Salaries	98,117.60	145,629.00	155,174.00	18,536.30	4,140.74	1,458.83	555,943.00
Supplementary Labour Income	7,499.55	11,163.40	12,168.10	1,430.85	111.66	111.66	42,682.10
Net Income of Unincorporated Business	20,662.00	30,113.10	31,562.40	4,023.49	771.89	345.96	116,517.00
Other Operating Surplus	74,293.20	116,909.00	135,215.00	17,192.40	3,732.79	1,725.30	459,377.00
Total Household Income	356,327.00	512,134.00	486,263.00	57,321.70	9,298.25	3,867.19	1,904,350.00
Value Added[b]	540,456.19	791,349.21	775,168.50	93,383.75	16,477.77	8,293.74	2,961,201.70

[a]Due to rounding error the sum of the figures in a row may not equal the total.
[b]Provincial gross domestic product at factor cost.

to one or more of the following reasons. First, the input-output coefficients are not based on empirical observations as are those for most other sub-sectors, but rather on cost of production formulas used in pricing poultry. Actual costs may be lower and net incomes higher than what the data indicated. Second, the subsector is highly concentrated with large gross revenues per farm. This results in relatively low net returns per dollar of production. Third, unlike the other subsectors, the poultry subsector does not produce a mixture of products. The mixture of products in the other subsectors tend to keep the multipliers homogeneous.

In general, the grain farms generated the highest output multipliers while cow-calf, dairy and irrigation generated the lowest. This is most likely because the grain farms tend to purchase more goods and services (particularly goods) from domestic sources. This is probably because the grain farm input supply sectors are highly developed in the prairie provinces. The dairy, cow-calf and irrigation subsectors are somewhat smaller. This is probably because these two sectors purchase more inputs than any others from other farms. Since agriculture is not assumed to respond to increased demand, the multiplier effect is low. The hogs subsector on the other hand purchases more prepared feeds which gives it a higher multiplier.

The income and value added pseudo-multipliers are almost a complete reversal of the output multipliers. Irrigation generates quite low multipliers as before, but the dairy and cow-calf sectors generate somewhat higher pseudo-multipliers than any of the others. One explanation for this may be that cow-calf and dairy generate higher levels of income per dollar of sales than other subsectors.[12] This contributes directly to household and to income and value-added. The above comparisons should not be extended beyond their valid ranges. For instance, one should not conclude from this that irrigation should be discouraged. On the contrary, earlier applications of this model to irrigation budgets suggest very important secondary effects from this development strategy. If one was to generate ratios of direct plus indirect income or value added per acre, it would be noted that irrigation has a much larger impact than any dryland farm since a larger value of production is generated per acre relative to dryland farming. Similarly, the hog, dairy and poultry subsectors would be favoured in such a comparison. If one was to compare the direct plus indirect income or value-added per dollar of investment one would get yet another ranking.

Conclusions

This paper demonstrates the inappropriateness of introducing changes in the level of sectoral output through the final demand vector. A simple method is proposd and used to introduce the changes in output directly into the solution. The method is a convenient way of comparing the aggregate impact of various types of farms on the Saskatchewan economy.

The analysis above allows one to draw several conclusions regarding the impact of different types of farms. First, the various farm types do not have profoundly different effects on the aggregate levels of output, income or value added when compared on a per dollar of output basis. Poultry is the only subsector whose multipliers are considerably different from that of the overall mean. The differences displayed by this subsector, while large in relative terms, are small in absolute terms because of the relatively small number of producers in the group. Overall, the multipliers for agricultural subsectors are large in comparison with those of other sectors.

The study leaves many questions unresolved, however. A comparison of aggregate effects per dollar of output is only the first step in comparing the impact of various subsectors. While the aggregate multipliers for agriculture are similar, their impact on specific sectors may not be. The preliminary

[12]Income here includes return to operator labour and management, hired labour, land ownership and certain land rentals.

findings have not indicated the relative impact that different sectors have on specific non-agricultural sectors such as finance, trade, feed manufacturers, etc. In addition, more research is needed to determine the impact of replacing an extensive enterprise such as cow-calf with a more intensive feeder operation. Before it is possible to guide government policy related to diversification, intensification and similar structural changes, more comparative research is necessary. The model does, however, provide the necessary tool.

References

Bark, L. Dean, *A Study of the Effects of Altering the Precipitation Pattern on the Economy and Environment of Kansas*. Department of Physics, Kansas State University Agricultural Experiment Station. Manhattan, Kansas. Departmental Report 5-425, October, 1978.

Bark, L. D.; O. H. Buller; and R. L. Vanderlip. *Cloud Seeding. Potential Benefits for Kansas Agriculture*. Agricultural Experiment Station, Kansas State University, Manhattan, Bulletin #628, May, 1979.

Bromley, D. W.; G. E. Blanch; and H. H. Stoevener. *Effects of Selected Changes in Federal Land Use on a Rural Economy*. Station Bulletin #604, Agricultural Experiment Station, Oregon State University, March, 1968.

Burris, Martin J. *Impacts of Induced Rainfall on the Great Plains of Montana*. Montana Agricultural Experiment Station, Montana State University, Bozeman. Bulletin 670, August, 1973.

Chossudousky, Michel. *Input Output Analysis*. Research Paper No. 7708. University of Ottawa, March, 1977.

Hoppe, Robert. *Building a Non-Metropolitan Input-Output Model: Minnesota's Region Six East*. Agricultural Experiment Station, University of Minnesota, Technical Bulletin #313, 1978.

Johnson, Jerome E. *The Effects of Added Rainfall During the Growing Season in North Dakota*. Agricultural Experiment Station, North Dakota State University, Fargo, Number 52, August, 1974.

Johnson, Thomas G. *The Environmental and Economic Effects of Weather Modification in Saskatchewan*. Research Bulletin BL:82-02. Saskatoon: Department of Agricultural Economics, University of Saskatchewan, March, 1982.

Johnson, Thomas G. and S. N. Kulshreshtha, *Nature of Intersectoral Relations of Saskatchean Agriculture: An Input-Output Analysis*, Department of Agricultural Economics, University of Saskatchewan, Research Report 81-06, November, 1981.

Jones, Lonnie L.; James E. Casey and Ronald D. Lacewell. "Use of an Integrated Input-Output and Optimization Model to Estimate the Regional Economic Effects of Resource Depletion." Mimeo, Texas Agriculture Experiment Station, Texas A&M (Undated).

Kulshreshtha, S. N.; D. D. Tewari; and Thomas G. Johnson. "Impact of Rising Energy Cost Upon Agricultural Production and Regional Economy: A Case Study of Saskatchewan," Prepared for Presentation at the International Conference of Agricultural Economists, Jakarta, September, 1982.

Maki, Wilbur R.; Leonard A. Laulainen, Jr.; Mason Chen, and Donald R. Newell. *Economic Impact of Irrigated Agriculture in West Minnesota*. Minneapolis Agricultural Experiment Station, University of Minnesota.

Mamer, John W.; George Goldman; and L. T. Wallace.(a) "Economic Effects of the Expansion or Irrigation in Colusa County." Publication I-O 6. Cooperative Extension, University of California, September, 1973.

Mamer, John W.; George E. Goldman; and L. T. Wallace.(b) "Economic Impact of the Expansion of Irrigation in Glenn County." Publication I-O 7. Cooperative Extension, University of California, November, 1973.

Petkovich, M. D. and C. T. K. Ching, "Modifying a One Region Leontief Input-Output Model to Show Sector Capacity Constraints", *Western Journal of Agricultural Economics*, 3(1978):173-79.

Schaffer, William A., ed. *On the Use of Input-Output Models for Regional Planning*. Leiden, Netherlands: Martinus Nyhoff Social Science Division, 1976.

Statistics Canada, *The Input-Output Structure of the Canadian Economy, 1966*, Ottawa, August, 1969.