Urban Implications of Regional and Interregional Efficiency in Agricultural Production*

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As early as 1960 Isard [6, p. 491] commented that the value of interregional linear programming as a technique for use in regional analysis was dependent on further development which would enable it to:

...embrace household behaviour as approximated by consumption functions, agglomeration economics (including economies of scale, localization, and urbanization), etc. ...more adequately depict a truly general interregional equilibrium system, and at the same time remain operational.

Despite such comments, little has been done to utilize this technique in the estimation of regional equilibrium. In fact, interregional programming studies of agricultural adjustment have concentrated almost solely on the production and transportation dimensions of agricultural development.

Linear programming study results and techniques have strong potential to serve as an integral component of regional development models. The purpose of this paper is to indicate their potential use in the estimation of urban job and income impacts of agricultural adjustment in rural regions.

The Problem

Development in rural regions is characterized by a dependence on an agricultural export base. Economic activity in such regions contains two major components. Those components are the production of agricultural products and the provision of goods and services utilized in agricultural production and consumed by households. Regional analyses of the agricultural industry conducted in the past (Heady and Whittlesey [5], and Eyvindson [3] have dealt almost exclusively with only one of those components, namely, the implications of interregional competition for regional levels and the interregional distribution

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of production. The associated demands for goods and services and hence implications for jobs and incomes in urban centers, the other component, have received limited attention.

Heady's [4, p. 108] statement that: "...we turn to the economic variables and public policy instruments causing changes in farming structure for the basic explanation of changes in rural communities..." indicates an understanding of potential implications of the changing structure of agriculture and agricultural policy for urban places among individuals involved in interregional programming studies of agriculture. However, the task of studying the relationships between resource-based industries (agriculture, forestry, mining, etc.) and other economic activity in a regional context has been left to others. Some valuable work has been done. In their contribution to the book Benefits and Burdens of Rural Development, Tweeten and Schreiner [12] present research results regarding employment in two predominantly rural counties of Oklahoma. Through analysis of county employment characteristics they establish trends on the composition of employment, associated with changes in regional industry mix. More recent research conducted by Schreiner and Muncrief [11] utilizes to-from analysis in the development of a Regional Information System to aid in public decisions. The system provides a detailed sectoral analysis of employment and unemployment inter-relationships for the eight counties in Planning Region Nine of South Central Oklahoma. The spatial-economic structure of rural-urban regions is the topic of research conducted by MacMillan [7]. In that research, town size specific input-output tables are employed to estimate the magnitude of development impacts accruing to public investment in large towns as against smaller towns.

As a result of the heavy emphasis on consideration of the interregional distribution of agricultural production and the limited number of studies like those by Schreiner [11] and his colleagues, there is a need for:

1. Further research on the implications of agricultural adjustment for urban places in agricultural regions.
2. Information to aid rural policymakers facing the need for an urban adjustment policy for agricultural regions.

Interregional studies of the agricultural industry involving the utilization of linear programming techniques can contribute to the resolution of this situation and an improved understanding of the implications of changes in farm structure for development in agricultural regions.

Changes in farming structure are one component basic to explanation of changes in rural regions. The spatial-economic structure (size, number, and distribution) of urban places and linkages between urban places in rural regions is also basic to the explanation of changes in rural regions. This presentation deals only with the farm component.
Objectives

The objectives of this paper are:

1. To specify an analytical approach which utilizes results of inter-regional linear programming analysis in the estimation of urban impacts of changes in rural demands for goods and services required in agricultural production and for household consumption (urban demand for goods and services provided by regional centers).

2. To present illustrative results of the model's application to the measurement of regional demands for goods and services in an agricultural region of Manitoba.

The Nature of Linear Programming's Contribution to the Model

Linear programming techniques are applicable to problems which involve the maximization or minimization of a linear objective function subject to a set of linear constraints. The minimization of cost of satisfying specified regional demands for crop and livestock commodities given regional land, labor and capital availability constraints and explicit commodity production alternatives is typical of the format for interregional programming analyses of agricultural production. Consider the following simple illustrative example:

Each of two agricultural regions is involved in the production of wheat, two wheat production alternatives (wheat production on summer fallow or stubble land) are present in each region, and production is constrained by available land in each region and total wheat demand. The objective is to maximize regional net revenue through the efficient allocation of wheat production between regions and production alternatives.

Stated algebraically the problem is as follows:

Maximize the objective function

\[ Y = \sum_{i=1}^{2} \sum_{j=1}^{2} y_{ij} X_{ij} \]

subject to

\[ \sum_{i=1}^{2} \sum_{j=1}^{2} a_{ij} X_{ij} = W \]

\[ \sum_{j=1}^{2} b_{ij} X_{ij} \leq B_i \text{ for all } i \text{ and } j \]
\[ X_{ij} \geq 0 \] for all \( i \) and \( j \)

where

\[ i = 1, 2 \]

\[ j = 1, 2 \]

In the formulation:

\[ Y = \text{total net revenue} \]

\[ y_{ij} = \text{net revenue from wheat produced in region } i \text{ utilizing production alternative } j \]

\[ x_{ij} = \text{level of wheat production in region } i \text{ produced utilizing production activity } j \]

\[ W = \text{total wheat demand} \]

\[ a_{ij} = \text{the region } i, \text{ production alternative } j \text{ yield of wheat} \]

\[ B_i = \text{land available in region } i \]

\[ b_{ij} = \text{region } i \text{ and production alternative } j \text{ land requirement per unit of production alternative } x_{ij} \text{ introduced.} \]

Given the existence of a combination of the production alternatives available which satisfy the specified demand within the land constraints delineated (a feasible solution), the solution to the above problem indicates the maximum profit (optimum) combination of production activities for each of the two regions.

The implications of the above solution to the estimation of urban job and income impacts are derived from:

1. The matrix \( A \) of production function coefficients associated with the optimum level of regional production and the distribution of production among regions and production alternatives.

2. The number and income level of farm households involved in the production of each region's wheat output given the optimum solution.

3. The estimated changes in production of agricultural commodities in each region.

First, elements of the matrix \( A \) correspond to elements of production functions of the form \( W_{ij} = \sum_{k=1}^{n} b_{ijk} x_{ij} \) present in the optimum solution where the subscript \( k \) identifies factors of production. Each \( b_{ijk} \) represents a single factor.
input or a combination of factor inputs and is specified on the basis of analyses to determine the magnitude of the input or combination of inputs required for the production of each unit of $X_{ij}$ produced. Given explicit delineation of the input components of each $b_{ijk}$, the total set of factor inputs required per unit of $X_{ij}$ is known. As a result the aggregate demand for each factor input (good or service demanded) can be determined simply by multiplying the $X_{ij}$ per unit requirements by the number of units of $X_{ij}$ produced.

Second, household demand for goods and services associated with agricultural production can be derived in the following manner. Utilizing regional farm size distribution information determined exogenously or within the linear programming model for models which are farm size specific, the number of farms and, given commodity prices, income per farm can be determined. Given that information and consumption function analyses, per farm and regional household consumption of goods and services can be determined.

Third, changes in regional production can be determined directly through comparison of present regional levels and distribution of production with the optimal patterns indicated in the linear programming solution.

The Model

Alternative approaches are available for the estimation of the urban impacts of agricultural adjustments indicated by the linear programming solution including:

1. Use the changes in regional production (changes in final demand) contained in the linear programming solution to measure the direct, indirect and induced urban job and income impacts on the basis of results of complementary input-output analysis.

2. Use the linear programming results to re-estimate: (a) the elements of the agriculture sector cells of a complementary input-output table, and (b) final demand. Calculate new interdependence matrix values (multipliers) based on modifications made to the agricultural sector entries. Employ the adjusted input-output model results and estimated changes in final demand to determine urban job and income impacts.

\footnote{For example, specification of the coefficient $b_{ijk}$ associated with operating capital requires identification of requirements for fertilizer, pesticides, herbicides, transportation services, fuel supplies, etc. While all the $k$ factor inputs are not explicitly identified as individual factors in most regional programming models, they are explicitly dealt with in the delineation of factor costs (returns) and are implicit in the specification of the coefficients values of the objective function.}
3. Estimate derived demand for urban goods and services on the basis of the linear programming solution and utilize those as inputs to a model developed to simulate urban place hierarchies under alternative sizes and distributions of urban places.

Alternative 1 was employed in this analysis.

The model (Alternative 1) employed in the analysis to develop the results presented is summarized together with identified alternatives in Figure 1. It contains the traditional regional and interregional agriculture production analysis. However, the unique element is its inclusion of estimates of urban job and income impacts together with the estimation of adjustments in agricultural production.

As indicated in Figure 1, analysis of agricultural adjustment and associated urban impacts begins with the specification of provincial demand requirements and regional factor input and output constraints. These may be estimated through quantitative analysis or given assumed values. In this study, they were estimated through quantitative analysis.

Following specification of provincial and regional constraints, a linear programming model was utilized to estimate changes in regional production associated with an optimal distribution of agricultural production. This was done through comparison of the optimal interregional distribution of production with current patterns. Subsequently, urban job and income impacts were measured through utilization of a regional input-output model (MacMillan, Lu, and Framingham [9]).

The reader will note that the model as such provides for the estimation of regional tax revenue. The provision of urban and regional infrastructure by government is constrained by the local tax base (public revenue generation capacity). The levels and distribution of agricultural output and level of urban demands serve as the basis for the estimation of public tax revenue available to a region. Given tax revenue projected on that basis and employment estimated utilizing established techniques (MacMillan and Lu [8]), the model measures components necessary for analysis of urban dimensions of regional development.

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3 Craddock [2] contains a Canadian example.
4 Since the derived demand for goods and services is not substituted for the original transaction matrix coefficients in the input-output model, this approach requires the assumption that the production function relationships present in the input-output model and for the optimal solution of the linear programming model are identical.
5 Refinement of the approach to include the spatial-economic component (i.e., a settlement function) would permit allocation of tax revenue among regional centers (Blase, MacMillan, and Tung [1]).
FIGURE 1: Diagrammatic Representation of Alternative Models for Estimation of Urban Job and Income Impacts of Interregional Adjustments in Agriculture

Regional Input-Output Model

Agricultural

FDI

in

land

Changes in Regional Production

Provincial Demand for Agricultural Commodities

Regional Factor Input and Output Constraints

Interregional Linear Programming Analysis

Derived Demand for Urban Goods and Services

Urban Place Hierarchy Simulation Model

Urban Job and Income Impacts

Farm Job and Income Impacts

Agricultural Tax Revenue

Rural and Urban Job and Income Impacts

Total Tax Revenue Impacts

Alternative 1

Alternative 2

Alternative 3
Application of the model (Alternative 1, Figure 1) to analysis of urban impacts of the interregionally competitive distribution of production among Manitoba regions required prior specification of provincial regions. The criteria employed in that specification were: (1) the concept of functional economic areas, and (2) compatibility with established administrative regions of the provincial government's Department of Agriculture. Given the regional analysis research results developed by Maki and MacMillan [10] and the recently specified boundaries for each of the five administrative regions of the Manitoba Department of Agriculture, the study regions illustrated in Figure 2 were specified. Given the intraregional variability in production practices and soil productivity, subregions corresponding to Manitoba crop reporting districts were identified in each region in order to provide for identification of small area differences in costs of production and factor input requirements.

Given delineation of regions and producing subregions, an interregional linear programming model was formulated. This necessitated specification of agricultural commodity demand categories, corresponding production alternatives, regional production constraints and an objective function. The categorization of demand and specification of production alternatives was based on: (1) analysis of past agricultural production in Manitoba and identification of that set of commodities accounting for 95 percent of total agricultural production, and (2) specification of production activities related to each commodity on the basis of the knowledge of study participants concerning agricultural production in Manitoba. To enhance the usefulness of the model for purposes of policy analysis, size-specific production activities for each of three crop and three livestock enterprise sizes were included in the model.

The production constraints included were minimum and maximum production levels for each commodity to be produced, farm size specific land bounds, farm size specific minimum income requirements and provincial commodity demand levels. The objective function to be maximized was a net revenue function.

An algebraic statement of the agricultural production analysis model is as follows:

\[ Y = \sum_{i=1}^{14} \sum_{j=1}^{3} \sum_{k=1}^{3} \sum_{p=1}^{40} r_{ijkp} x_{ijkp} - \sum_{i=1}^{14} \sum_{v=1}^{16} \sum_{p=1}^{14} t_{vip} T_{vip} \]

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7 The Manitoba Department of Agriculture is the government department primarily responsible for agriculture and rural development in the province. Therefore, the ultimate usefulness of the study results is dependent on the ability of departmental staff to utilize the results in the context of their administrative regions.
8 Income constraints have been included in the model to provide for the analysis of the implications of alternate farm income distribution policy decisions.
FIGURE 2: Study Regions and Descriptive Information Indicative of Current Conditions and Trends

\[+5.0\text{%} \quad +9.5\text{%} \quad +17.7\text{%} \quad +17.5\text{%} \quad +27.4\text{%} \quad +53.9\text{%} \quad -57.7\text{%} \quad +85.7\text{%} \quad +9.3\text{%} \quad +14.5\text{%} \]

Combined Incorporated Centres

1971 population
- less than 500
- 500 - 1,000
- 1,000 - 2,000
- 2,000 - 5,000
- 5,000 - 10,000
- 10,000 - 33,000

1971 other population 1961-1971
16864 (-13\%)

- less than 10\% decrease
- 10 - 20\% decrease
- more than 20\% decrease

The five study regions corresponding to administrative regions of the Manitoba Department of Agriculture are indicated by the wide boundary lines. The other regions and related demographic information are those delineated by Maki and MacMillan [10] and are included to provide the reader with descriptive background information.
\[ \sum_{i=1}^{14} \sum_{v=1}^{14} \sum_{p=1}^{41} c_{vip} A_{vip} \]

subject to the following constraints:

**Land Availability**

\[ \sum_{j=1}^{3} \sum_{p=1}^{40} a_{ijkp} X_{ijkp} \leq L_{ik} \text{ for all } i \text{ and } k \]

**Regional and Provincial Commodity Maximums and Minimums**

\[ \sum_{k=1}^{3} b_{ijkp} X_{ijkp} \geq R_{ijp} \text{ for all } i \text{ and } j \text{ and for } p = 1-9, 18-20, 26-28, 33, 34, 36-40 \]

\[ \sum_{k=1}^{3} b_{ijkp} X_{ijkp} \leq R_{ijp} \text{ for all } i \text{ and } j \text{ and for } p = 1-9, 18-20, 26-28, 33, 34, 36-40 \]

\[ \sum_{i=1}^{14} \sum_{j=1}^{3} \sum_{k=1}^{3} b_{ijkp} X_{ijkp} \geq P_{p} \text{ for } p = 1-9, 17, 20, 25, 34, 36-40 \]

\[ \sum_{i=1}^{14} \sum_{j=1}^{3} \sum_{k=1}^{3} b_{ijkp} X_{ijkp} \leq P_{p} \text{ for } p = 1-9, 17, 20, 25, 34, 36-40 \]

**Income Constraints**

\[ \sum_{k=1}^{3} \sum_{p=1}^{40} Y_{ijkp} X_{ijkp} \geq Y_{ij} \text{ for all } i \text{ and } j \]

**Labor Constraints**

\[ \sum_{k=1}^{3} \sum_{p=1}^{40} l_{ijkp} X_{ijkp} \geq L_{i} H_{ij} \text{ for all } i \text{ and } j \]

**Livestock Feed Supplies**

\[ \sum_{j=1}^{3} \sum_{k=1}^{13} m_{p} b_{ijkp} X_{ijkp} - \sum_{j=1}^{16} f_{p} X_{ij3p} + \sum_{p=14}^{14} m_{p} \sum_{v=1}^{14} T_{ivp} \]

\[ - \sum_{p=14}^{16} m_{p} \sum_{v=1}^{14} T_{ivp} = 0 \text{ for all } i \]
Intermediate Livestock Commodity Supplies

\[ (14) \quad \sum_{j=1}^{3} s_{ij3pq} x_{ij3p} - \sum_{j=1}^{3} s_{ij3pq} x_{ij3p} + \sum_{v=1}^{14} A_{vip} - \sum_{v=1}^{14} A_{ivp} = 0 \text{ for all } i \text{ and } q \text{ and for } p = 17-41 \]

Supplies of Feed Grain for Sale

\[ (15) \quad \sum_{j=1}^{3} \sum_{k=1}^{2} b_{ijkp} x_{ijkp} - \sum_{v=1}^{14} T_{ivp} = 0 \text{ for all } i \text{ and for } p = 14, 15, 16 \]

Minimum Oats in Livestock Rations

\[ (16) \quad \sum_{j=1}^{3} \sum_{k=1}^{2} m_{12} b_{ij} k_{12} x_{ijkl2} - \sum_{p=17}^{40} f_{1p} x_{ij3p} + m_{15} T_{iv15} - m_{15} T_{vi15} > 0 \text{ for all } i \text{ and } v \]

Minimum Barley in Livestock Rations

\[ (17) \quad \sum_{j=1}^{3} \sum_{k=1}^{2} m_{13} b_{ijk13} x_{ijkl3} - \sum_{p=17}^{40} f_{2p} x_{ij3p} + m_{16} T_{iv16} - m_{16} T_{vi16} > 0 \text{ for all } i \text{ and } v \]

Hay Supplies

\[ (18) \quad \sum_{j=1}^{3} b_{ij3,10} x_{ij3,10} - h_{p} x_{ij3p} = 0 \text{ for all } i \text{ and for } p = 17-32, 36, 37 \]

with the subscripts identified as follows:

- \( i \) and \( v \) = regions 1-14
- \( j \) = farm and enterprise sizes 1-3
- \( k \) = soil types; 1-2 are crop land; 3 is pasture land
- \( p \) = commodity produced; \( p = 1-9 \) are crops produced for sale to final provincial demand or for export; \( p = 10 \) is hay;
  \( p = 11-13 \) are cereals produced for feed within a region;
  \( p = 14-16 \) are cereals produced for sale as feed in other regions; and \( p = 17-41 \) are livestock commodities
q = intermediate livestock commodities 1-6
r = cereal feed types 1-2

and with the variables identified as follows:

\[ Y = \text{net revenue} \]

\[ r_{ijkp} = \text{net revenue from the production of one unit of commodity } p \]
\[ \text{in region } i \text{ on farm size } j \text{ and soil quality } k \]

\[ X_{ijkp} = \text{the quantity of commodity } p \text{ produced in region } i \]
\[ \text{on farm size } j \text{ and soil quality } k \]

\[ t_{vip} = \text{transportation cost per unit of crop commodity } p \]
\[ \text{transported from region } v \text{ to region } i \]

\[ T_{vip} = \text{quantity of crop commodity } p \text{ transported from region } v \]
\[ \text{to region } i \]

\[ c_{vip} = \text{transportation cost per unit of livestock of commodity type } p \]
\[ \text{produced on farms in region } v \text{ transported to farms in region } i \]

\[ A_{vip} = \text{number of livestock animals of commodity type } p \]
\[ \text{produced on farms in region } v \text{ transported to farms in region } i \]

\[ L_{ik} = \text{land with soil quality } k \text{ available in region } i \]

\[ a_{ijkp} = \text{the commodity } p \text{ per unit requirement for land in region } i \]
\[ \text{on farm size } j \text{ and soil quality } k \]

\[ R_{ijp} = \text{the minimum level of production of commodity } p \]
\[ \text{allowed in region } i \text{ on farms with enterprise size } j \]

\[ R_{ijp}^{'} = \text{the maximum level of production of commodity } p \]
\[ \text{allowed in region } i \text{ on farms with enterprise size } j \]

\[ b_{ijkp} = \text{per unit yield of commodity } p \text{ in region } i \]
\[ \text{on farms of size } j \text{ and soil quality } k \]

\[ P_{p} = \text{minimum provincial consumption plus export demand for commodity } p \]

\[ P_{p}^{'} = \text{maximum provincial consumption plus export demand for commodity } p \]

\[ Y_{ij} = \text{minimum income requirement for farms of size } j \text{ in region } i \]

\[ Y_{ijkp} = \text{net revenue from commodity } p \text{ produced in region } i \]
\[ \text{on farms of size } j \text{ and soil quality } k \]

\[ LH_{ij} = \text{minimum labor hours required on farms of size } j \text{ in region } i \]
\( l_{ijkp} \) = labor hours required per unit of commodity \( p \) produced on soil of quality \( k \) on farms of size \( j \) in region \( i \)

\( m_p \) = metabolizable energy provided per unit of commodity \( p \) produced

\( f_p \) = metabolizable energy required per unit of commodity \( p \) produced

\( s_{ijkpq} \) = supply of intermediate livestock inputs of type \( q \) produced per unit of commodity \( p \) produced on soil quality \( k \) on farms of size \( j \) in region \( i \)

\( s'_{ijkpq} \) = amount of intermediate livestock inputs of type \( q \) required per unit of commodity \( p \) produced on soil quality \( k \) on farms of size \( j \) in region \( i \)

\( f_{rp} \) = minimum requirement for feed of type \( r \) per unit of commodity \( p \) produced

\( h_p \) = hay requirement per unit of commodity \( p \) produced.

As indicated earlier, input-output techniques were employed to measure the urban job and income impacts of changes in regional production and hence exports of agricultural products. The total impact on regional output associated with changes in exports was calculated by multiplying the interdependence (inverse) matrix \((I-A)^{-1}\) times the dollar value of the estimated change in exports. Stated algebraically the procedure was as indicated below.

\[
\Delta X^0 = (1-A^0)^{-1} \Delta P^0.
\]

\[
\Delta x^0_{ij} = c_{ij} \Delta P_j
\]

where

\( \Delta X^0 \) = vector of total changes in sector sales

\( (I-A^0)^{-1} \) = matrix of interdependence coefficients including households\(^9\)

\( \Delta P_j \) = the change in exports in sector \( j \)

\( c_{ij} \) = the direct, indirect and induced production requirement from sector \( i \) per dollar of delivery to final demand by sector \( j \)

\( \Delta x^0_{ij} \) = the total direct, indirect and induced sales of sector \( i \) due to the exports of sector \( j \).

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\(^9\)Ideally, the production coefficient matrix, \( A \), would be re-estimated for each LP solution.
Total employment impact associated with the estimated changes in final demand was obtained by multiplying sector change in total sales by the corresponding direct employment coefficients. In algebraic terms

(21) \[ \Delta e_{ij} = \Delta x_{ij} \left( e_i \right) \]

where

\( e_{ij} = \) the additional employment generated in sector \( i \) due to change in exports of sector \( j \)

\( e_i = \) the direct employment requirement per dollar of output produced in sector \( i \).

Since the input-output table employed includes production-consumption linkages (households are an endogenous sector), sectoral income impacts were taken directly from the household sector results obtained from calculation of equation (20).

Results

Illustrative results are presented for Region II. They relate to a programming solution where all farms are in the medium crop and small livestock size class and demand levels enabling farmers to maximize profit at 1971 prices exist. The only constraints imposed were available land and the requirement that commodity production levels not be allowed to fall below 80 percent or rise above 120 percent of 1971 levels in the case of hog, beef and milk production or outside the range of the historic minimum and maximum of the past five-year period (1966-1971) in the case of all other commodities. They were chosen on the assumption that they reflect the nature of adjustment possible over the next five years given current demand conditions and the flexibility in agriculture as measured from past experience.

The results of that analysis are presented in Table 1. They indicate that increases of $260 thousand of income and 46 urban jobs respectively would accompany the $3.8 million increase in crop production. The estimated $10.4 million increase in livestock production would similarly be accompanied by urban income and job increases of $606 thousand and 115 jobs respectively.

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10 For more detailed discussion of the impact measurement procedure and coefficients used see MacMillan, Lu, and Framingham [9, pp. 144-147, and related tables].
11 See Figure 2.
TABLE 1: Estimated Changes in the Level of Agricultural Crop and Livestock Exports, Rural Incomes\(^a\) and Employment and Regional Urban Jobs and Income\(^b\)

<table>
<thead>
<tr>
<th>Agricultural Sector</th>
<th>Production</th>
<th>Income Impacts</th>
<th>Job Impacts(^c)</th>
<th>Change in Government Revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Estimated Change in Production</td>
<td>Farm</td>
<td>Urban</td>
</tr>
<tr>
<td></td>
<td>1971</td>
<td>Constrained Optimum</td>
<td>per Mil Total</td>
<td>per Mil Total</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$1,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agricultural Crops</td>
<td>18,099</td>
<td>21,918</td>
<td>3,819</td>
<td>313</td>
</tr>
<tr>
<td>Agricultural Livestock</td>
<td>23,308</td>
<td>33,748</td>
<td>10,441</td>
<td>295</td>
</tr>
<tr>
<td>Total</td>
<td>41,407</td>
<td>55,666</td>
<td>14,260</td>
<td>4,275</td>
</tr>
</tbody>
</table>

\(^a\)The estimates presented in this table are indicative of the magnitude of urban impacts and further refinement is necessary before these results should be used for other than illustrative purposes.

\(^b\)Regional urban impacts are reduced due to the absence of any large urban place from the region and the region's proximity to metropolitan Winnipeg.

\(^c\)It is assumed that the effect of changes in agriculture livestock and crop production will reduce current underemployment in the industry, rather than creating new jobs.
Total government tax revenue would rise by some $559 thousand.\textsuperscript{12}

Implications and Suggestions for Further Research

A number of large research programs have employed interregional programming models to analyze the interregional distribution of agricultural production. The data and results associated with the application of those models are a latent source of information on which to base studies of the urban impacts of agricultural adjustment in Canada and the United States.

In instances where complementary input-output models are available, the approach employed in this study (Alternative 1) or Alternative 2 involving the re-estimation of the input-output model's interdependence matrix based on demand for goods and services derived from linear programming results could be employed. In cases where no such model is available, Alternative 3 could be pursued, wherein demands for goods and services derived from results of linear programming analysis would serve as inputs to a model designed to simulate alternate urban hierarchies.

Two key dimensions of adjustment in rural-urban regions are spatial-economic interrelationships affecting urban places and time (the dynamics of adjustment). Further research is required to determine the affect of changes in the number, distribution and size of urban places in rural regions over time. Such research would complement the model presented here and contribute a further component critical to an understanding of development in rural-urban regions.

The addition of urban impact analyses to interregional research on agricultural adjustment impacts would provide information on a critical component of development and change in agricultural regions. The future of urban places in rural regions is a critical policy issue related to agricultural adjustment and regional change. Hence, further knowledge of the interrelationships between agricultural adjustment, urban development and increased analytical support for public decision-making are important benefits from such research. Those benefits alone are ample to justify its pursuit.

\textsuperscript{12}Since the present model is static in nature, the time frame of such adjustments cannot be specified on the basis of the current analysis.
REFERENCES


