Transportation Issues in Canadian Agriculture I: Regional Modelling For Policy Analysis

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The Federal Minister of Agriculture launched a review of agricultural policies in Canada in the spring of 1989. Industry stakeholders became involved in the review process at a conference held in Ottawa in December 1989. The need for a thorough review of policies stemmed from the changed circumstances in the agricultural industry as well as from a perception that either current policies were not as effective in meeting their objectives throughout the 1980s as they had been in previous decades or that the objectives of agricultural policy had changed. The Canada-U.S. Trade Agreement (FTA) which went into effect in January 1989 created opportunities and challenges for the Canadian agri-food industry. Canada, along with over 100 other countries, was involved in intense

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negotiations in the Uruguay Round of the GATT; Canadian agriculture had a big stake in reducing barriers to agricultural trade around the world. Growing consumer awareness of food safety and environmental issues created new demands on primary producers and food processors. Hovering like a dark cloud over all the new challenges to the industry was the severely depressed market situation for most grains and oilseeds which was brought on by worldwide overproduction. An export subsidy battle between the United States and the European Community depressed market prices even further. High real interest rates during the 1980s contributed to farm financial problems across Canada. Even record level subsidies to Canadian producers from 1986 to 1989 failed to stop farm bankruptcies and quit claims on land across Canada.

Many observers of the Canadian agri-food industry believed that existing institutions and policy instruments were obscuring the true market signals to primary producers, thus inhibiting their abilities to adjust to new market opportunities. The ad hoc nature of many farm programs made the government presence unpredictable and interfered with decision making by producers. Many government interventions in the market place were increasingly recognized as being potentially susceptible to countervail actions from the United States.

The goal of the policy review process was to develop a new set of agricultural policies based on increased market responsiveness, greater self-reliance in the agri-food sector, recognition of regional diversity and increased environmental sustainability (Agriculture Canada 1989).

Following a conference in Ottawa in December, 1989, a number of government-industry task forces were created to examine the implications of various agricultural policy options. One of the committees was given the mandate of studying three agricultural transportation programs: Western Grain Transportation Act (WGTA), Feed Freight Assistance (FFA), and Minimum Compensatory Rates (MCR) for canola products. This group consisted of representatives from the federal and provincial governments, grains industry, livestock industry, grains and oilseeds processing industry, farm organizations and transport carriers.

The Minister of Agriculture requested the 44-member Transportation Committee to examine the following issues with respect to the WGTA (Agriculture Canada 1990):

1. method of payment of the Crow Benefit;
2. options that would contribute to reduced costs and improved efficiency of the grain handling and transportation system;
3. amendments to the WGTA and other legislation or regulations.

The Transportation Committee was also asked to consider the following options for the FFA:

1. removal of restrictions on access to feed grains supplies;
2. replacement of FFA with resource-neutral development programs;
3. payment of the FFA benefit to livestock producers directly;
4. enhancement of FFA to compensate for transportation cost increases;
5. amendments to the FFA and other legislation or regulation.

The Transportation Committee began meeting in March 1990 and reported to the Minister of Agriculture in July 1990 (Agriculture Canada 1990). Because of the extremely short time interval, the Transportation Committee was unable to provide more than a qualitative assessment of various policy options for resolution of these difficult political issues. The composition of the Committee also ensured that all sides of the issues would be vigorously debated and consensus on likely impacts of policy changes would be difficult to achieve.

This study was conducted separately from the Transportation Committee review process and had no influence on the Transportation Committee report. This was an independent economic analysis of the major policy options debated by the Transportation Committee. Although not all options considered by the Transportation Committee were analyzed, all major types of options were included in this economic study.

Since proposed changes to the WGTA and the FFA Act are so politically divisive, it was considered highly desirable to develop very disaggregated estimates of possible impacts on such variables as:

1. patterns of crop production in each of the provinces;
2. total levels of production for major crops in each of the provinces;
3. summerfallow in the prairie provinces;
4. net margins to the crops sector in each of the provinces;
5. land values in each region of the prairie provinces;
6. exports of grain from western Canada;
7. beef cattle populations in each province of Canada;
8. gross margins to the beef sector in each province;
9. hog populations in each province;
10. gross margins to the hog sector in each province;
11. household incomes in each of the prairie provinces;
12. industrial activities in each of the prairie provinces;
13. government payments to crop and livestock producers in each province;
14. total economic welfare in Canada.

Due to the need for such disaggregated estimates, it was decided that the main analysis would be conducted on a linear programming model of Canadian agriculture. Such a model was available; the Canadian Regional Agriculture Model (CRAM) had been developed a few years earlier (Webber et al. 1986). Although analysis of the transportation policy options would require many modifications to CRAM as well as revisions to almost all data coefficients, it was concluded that using CRAM as the main analytical tool was preferable to building a completely new model.

The estimation of the impact on total economic welfare in Canada implied capturing all down-stream effects of changes in the transportation policy. Therefore, in addition to CRAM, Statistics Canada's Interprovincial Input-Output Model was employed to estimate impacts of changes in the WGTA on industrial activities and household incomes in the prairie provinces.

A team of agricultural economists from across Canada was assembled to conduct this study. In addition, an Advisory Committee composed of Federal Government employees oversaw the study and monitored its progress. Four working papers on the study results were issued (Klein et al. 1991a; Kerr et al. 1991; Klein et al. 1991b; and Klein et al. 1991c).

The study was too comprehensive to be reported in a single paper. For this reason, the contents of this paper relate only to a description and justification of the modelling procedures employed. A description of policy options studied and their estimated impacts are presented in Klein et al.(1993).

In order to estimate the nature of the impacts, two types of changes were identified. First were the changes in the agriculture sector resulting from the change in transportation policy. These changes are called the direct impacts of the policy change. Second were changes in other economic sectors, triggered by the direct changes. These changes are called secondary impacts of the policy change. The first type of impacts were estimated using CRAM, whereas the second type of impacts were estimated using the inter-provincial input-output model.

This paper is organized into two parts: the first part includes a description of the structure, data, validation and limitations of CRAM; the second part includes a description of the Statistics Canada Input-Output model, the manner in which it was used in the analyses, and the nature of data transformation from CRAM to the Input-Output (IO) model.

The Canadian Regional Agricultural Model (CRAM)

Overview

The agricultural industry in Canada is very diverse, containing many interrelationships among commodities and regions. Quantitative models of the agricultural and secondary industries in Canada are required to capture these interrelationships and to project the likely magnitudes of any changes in production, resource use and income in the various regions of Canada.

The Canadian Regional Agriculture Model (CRAM)[1] was used to estimate the aggregate farm level consequences of each policy option for each province, including changes in crop production and exports, changes in livestock production and shipments, changes in gross margins and changes in land values.

CRAM is a regional linear programming model of Canadian agriculture. It simulates production, marketing and transportation of the major agricultural commodities produced in Canada. It optimizes production of these commodities for a single year within the constraints of agricultural resources and final demands for the products.

The model represents the crop sector of the Canadian agricultural industry with production occurring in 29 separate regions having different soil and climatic conditions: seven in Alberta, nine in Saskatchewan, six in Manitoba and one in each of the other seven provinces as shown in Figure 1.

Crops in the model include four grades of wheat, barley/oats, flax, canola, corn (for grain and silage), soybeans, tame hay, pasture and other crops. The category called "other crops" differs by region and represents historic production levels of minor crops such as pulses, sunflowers, potatoes, buckwheat and canary seed. The model permits choices to be made among the available crops, including the planting of crops in western Canada on either summerfallow or stubble. The model selects the most profitable crops to be grown in each region within the specified constraints.

Crops produced in each region can be used to meet the demands for livestock feed, domestic consumption or export. Domestic consumption is assumed to be fixed at the provincial level. Excess supplies of each crop are transported to terminal locations (Thunder Bay or west coast) for export, with freight costs assessed on the sales of the products.

CRAM selects the optimum amount of summerfallow in each region of the prairie provinces on the basis of the relative profitabilities of available crops planted on summerfallow and stubble, with the constraint that the area of summerfallow must equal the area of summerfallow crop in each region.

Only the variable costs of crop production are included in the model. Fixed costs such as depreciation, interest on investment, owned labour and management costs are not taken into account.

Livestock production is modelled at the provincial level. Livestock commodities in the model are beef, hogs, dairy and poultry. Low and high quality beef are produced, with low quality beef coming from the slaughter of mature dairy and beef cows as well as bulls. Pork primal cuts are produced in the hog sector of the model. Fluid and industrial milk products are represented in the dairy sector of the model. The production of eggs, broiler meat and turkey meat are represented in the poultry sector of the model.

1. A complete description of CRAM is provided in Webber et al. (1986). Modifications to CRAM and data used in this study are available in Klein et al. (1991).

FIGURE 1 Map of Prairie Provinces Showing Study Sub-Regions

Animals are fed grains that are grown in the crops sector of the model: stored forage, pasture, barley and corn for beef and dairy animals, barley for hogs and wheat for poultry. Protein supplements are treated as a cash cost in the model. Substitute feed rations for the beef animals are permitted in the model. Based on relative profitability, feeder animals can be fed different ratios of feed grains and forages. The model also chooses the optimal rate of growth of feeder animals, within specified constraints. Similarly, the breeding herd of beef cattle can be fed different proportions of feed grains, pasture and stored forage.

The opening stocks of all categories of livestock are specified exogenously. When analyzing a policy option that would change the farm level price of feed grain and thus the relative profitability of livestock production, changes are made to the opening stocks of animals. Replacement ratios for each class of livestock are specified to ensure that closing stocks equal opening stocks in a

no growth situation.

Domestic level demand is specified in the form of downward sloping demand functions for low and high quality beef, pork, final dairy products, eggs, broilers and turkeys. Excess supplies can be exported. Both meat and livestock animals can be transported to other provinces and to export locations. Beef (in the form of either live animals or dressed meat) can be imported into Canada. Live animals can be imported either for feeding or for slaughter purposes.

Poultry and dairy production are constrained by quotas on provincial levels of production as mandated by marketing boards. Production of these commodities is used to satisfy domestic demands.

The objective of the model is to maximize the sum of consumer and producer surpluses. Consumer surplus is increased when the price of food falls due to greater production. Producer surplus measures the difference between gross agricultural income and costs of production and transportation. Commodities traded internationally are valued on an export basis. Farm level grain prices are derived by subtracting handling and transportation costs from the in-store prices at the terminals.

Accounting in the model is done on a regional basis by tracking gross revenues, cash costs and farm created value. Grains fed to livestock are valued at their opportunity costs with revenues to the crops sector being offset by equivalent costs to the appropriate livestock sectors. Since only variable costs of production are included in the model, returns to the crop and livestock sectors are calculated as gross margins above variable costs.

CRAM generates a series of "shadow prices" for farm land in each of the 22 regions of the prairie provinces. A shadow price for land is defined as the net rental value of one extra hectare in its best possible agricultural use, within the demand constraints of the model. Since CRAM is a comprehensive model, the shadow price incorporates the simultaneous effects of extra variable costs of production, summerfallow and transportation as well as the possible lower overall price level of the most profitable crop that could be grown on one extra hectare in that region.

Stepped Demand Functions

The price of farm products is generally dependent on the quantity produced and offered for sale as well as on demand for the product. The higher the quantity produced, the lower is the price, *ceteris paribus*. This effect is captured in CRAM through a series of demand functions which are downward sloping for the major categories of final agricultural products.

Since Canada trades all categories of grains and oilseeds, as well as beef and hogs, producers face an import and export price for these commodities. The small country assumption is used in CRAM; this means that changes in

Canadian production will have no effect on world price levels. Thus, domestic prices must be between an export price floor and an import price ceiling. The downward-sloping demand functions in CRAM for wheat, barley, canola, high quality beef, low quality beef, primal cuts of pork, major final dairy products, broilers, eggs and turkeys represent price levels between the floors and the ceilings.

Since CRAM is a linear programming model, the downward slopes to the demand functions must be approximated in a series of linear segments or steps. Each step represents a distinct price range for a stated quantity of output. By increasing the number of steps and decreasing the quantity increments associated with each step, the stepped demand curve can be made almost smoothly downward sloping. Unfortunately, each additional step increases the overall size of the model, thereby increasing the computing requirement for solving it. For this reason, ten steps were used for each of the demand functions in the model. This represents a compromise between accuracy of representing the demand functions and manageable size of the model.

Retention Functions

Inventories of beef animals and hogs are responsive to changes in variables which affect the profitability of production in these sectors. They are particularly responsive to changes in their own prices as well as prices of feed grains. Opening stocks of breeding and feedlot animals in the beef, hog, dairy and poultry sectors of CRAM are determined exogenously on the basis of estimated retention functions. Optimization occurs within the constraints imposed by the opening stocks of breeding animals for each class of livestock.

Retention of beef animals and hogs will be affected not only by changes in the farm-level price of feed grains, but also by changes in direct government payments for feeding these grains. For example, a change in freight rates for transporting grains as a result of a change in a government program will directly change the farm level price of feed grains. The elasticity of retention is an estimate of the percentage increase in herd size for a one percent decrease in feed grain prices.

The retention functions used for the analysis are long run elasticities of herd size with respect to changes in either feed grain prices or the price of feeder steers, as estimated by Agriculture Canada (Charlebois 1987). They range from -0.20 to -0.40 in the different parts of the country. This means that if feed grain prices decrease by one percent, the beef and hog breeding herds will increase (in the long run) by 0.2 to 0.4 percent. From the same Agriculture Canada study, a retention elasticity of beef and hog breeding animals with respect to output prices of 0.5 was used in this study.

Government Programs

Existing government programs have affected cropping and livestock practices. Therefore, the base case, against which all policy options are compared, is somewhat dependent on past and current government programs.

All major federal and provincial programs that affect resource allocation in Canadian agriculture are included in CRAM. A separate accounting is made for government expenditures in each of the ten provinces. In general, the types of programs that are included are:

1. credit programs and interest subsidization;
2. crop insurance and crop damage payments;
3. subsidies on inputs (except for farm fuel rebates, since the value of these rebates has already been taken into account in calculating the variable costs of production);
4. grants;
5. deficiency payments.

Supply Managed Commodities

The production of dairy and poultry products is limited under the authority of the Farm Products Marketing Agencies Act. Producers in each province are allocated quotas on either output or some input. Prices for these commodities are set according to formulas that are designed to cover all costs of production.

Changes to farm level prices for feed grains as a result of changes to a government transportation program would affect the cost of producing these supply managed commodities. However, cost of production formulas are used to establish farm level prices for most of these products. If input costs are reduced, prices for these products would also be reduced, leaving the producers of these commodities unaffected from a profit perspective, to the extent that formula prices accurately reflect costs of production.

In this study, it was assumed that fluid milk prices in each province would change to keep gross margins in the fluid milk enterprise at the same level as in the base case. However, it was assumed that prices of industrial milk and poultry produced in the Atlantic provinces would not be affected by changes in prices for feed grains since industrial milk and poultry production in these provinces is small relative to the Canadian total. If farm level prices of feed grains increase as a result of a different government policy, it was assumed that producers of industrial milk and poultry in these provinces would suffer reduced gross margins.

Data in CRAM

CRAM maximizes the difference between gross agricultural income and costs of production and transportation of agricultural commodities, within the constraints of resource availabilities and wholesale-level demand. Data are required for each of the variables that can affect the maximization of the objective function. Data in CRAM are much too voluminous to be reported in this paper. Rather, a brief description of the types of data in CRAM is provided in this section. Actual data, as used in the study, are available from the authors upon request.

On the gross income side, data are required on either fixed farm level prices for output or, for those products where prices are determined within the model, demand schedules for the output. In the study of these transportation programs, 1988-89 final realized prices for grain in-store Vancouver and Thunder Bay are used. Farm level prices are reduced from these levels by the costs of transporting the grains or oilseeds.

Livestock prices, except for supply managed commodities, are endogenously determined. They are based on downward sloping, stepped demand functions and will change slightly every time beef and pork production levels change.

Grain yields are specified for each grain, oilseed, forage and other crop in each of the 29 regions in the model. In Western Canada, yields are also differentiated between summerfallow and stubble cropping programs. In this study, crop yields used were average levels for each crop during the 1982-88 period.

Livestock yields are dependent on feeding programs, rates of gain and type of animal. CRAM contains several categories of each in each of the ten livestock producing regions.

Variable costs of producing crops and animals were developed from survey data obtained from Agriculture Canada, as well as from other published and unpublished sources. Costs reflect 1989 cost conditions in the WGTA part of the study and 1990 in the FFA part of the study. Variable costs of livestock production do not explicitly include the cost of feed grains and forage. These intermediate products are purchased from the crops sector at their opportunity costs.

The cost of transporting agricultural products from province to province or from province to export terminal are very important data in this study. Current WGTA and projected compensatory costs of transporting grains from each of the 22 producing regions in Western Canada to Vancouver and Thunder Bay were obtained from the Grain Transportation Agency. Producers' costs for receiving, elevation, loading-out, removal of dockage and terminal cleaning were obtained from the Canadian Grain Commission.

Availability of crop land, forage land and pasture land in each region constrain the optimal solution. These data, obtained from Statistics Canada, Ontario Ministry of Agriculture and Food, Manitoba Agriculture, Saskatchewan Agriculture and Alberta Agriculture, represent 1988 inventories of land.

Various other data, including those that represent constraints on rotations and summerfallow, are also contained in CRAM.

Validation of CRAM

Validation of a model is important for lending credibility to any analysis for which it is used. The base case must be realistic so that meaningful comparisons can be made to it. Validation of CRAM included checks on:

1. areas planted to major crops in each province;
2. total production of major crops in each province;
3. summerfallow area in each province;
4. exports of major crops from the prairie provinces;
5. domestic disappearance and exports of beef animals, dressed beef and pork primals;
6. movements of feeder cattle and calves from province to province.

The base case was not expected to duplicate the agricultural production in any one year. After all, CRAM is an optimizing model; it finds the solution with the highest objective function value across the whole country's agricultural industry. CRAM does not incorporate the uncertainty of information on yields, prices and costs that face producers in the real world; in CRAM, all coefficients are known with certainty. There are many constraints on producers' activities which are not captured by the model: Canadian Wheat Board delivery quota constraints, rotational constraints based on soil and climatic conditions, as well as many others. Some minor crop and livestock activities available to producers are not included in CRAM (for example, sheep and horses). Furthermore, crop yields used in the base case do not conform to any single year; averages for the 1982-88 period were used to preclude biasing the results from unusually high or low yields in a particular region.

Given the above caveats, the base case developed by CRAM seemed reasonable. The areas planted to all crops were within the bounds of actual crop plantings between 1982 and 1988. The area planted to wheat in Alberta was near the top end of the range while the area planted to wheat in Saskatchewan was at the bottom end of the range. The area planted to barley was at the bottom end of the ranges for each of the prairie provinces. Flax and canola plantings were within the ranges of actual crop plantings between 1982 and 1988.

Production of all major crops was within the range of actual production for the 1982-88 period, except for canola in Saskatchewan, which was about twenty percent higher in the base run than the highest actual level of production during those years. This was due to the fact that the highest level of canola planting in Saskatchewan over this time period was in 1988, a year when canola yields were much lower than normal. The choice of a relatively large area on which to plant canola combined with average 1982-88 yields resulted in the high production of canola in Saskatchewan in the base.

Summerfallow ratios in each of the prairie provinces were well within their recorded ranges over the 1982-88 period.

Exports of major crops in the CRAM base case were within the ranges of actual exports over the 1982-88 period. Exports of barley were near the low end of the range due to the relatively low plantings of barley in each of the provinces. Exports of canola in the base case were near the top of the range due to the relatively high production of canola in the base.

Domestic disappearance and exports of beef and pork were close to actual levels in 1989. Exports of beef in the CRAM base case were marginally higher than recorded levels; however, actual levels of beef exports in 1989 were lower than in previous years.

The movements of feeder cattle from Western Canada to Ontario in the base were quite close to actual published movements in 1989. The difference between 1989 actual shipments and CRAM shipments in the base case was less than one percent.

Overall, it was judged that the base case was reasonable and could be appropriately compared to results from specific transportation policy alternatives.

Limitations of CRAM

Aside from the well known limitations of a linear programming model (linear relationships known with certainty, non-integer variables, imposition of optimizing behaviour), CRAM has some additional shortcomings for examination of grain transportation policy options. First, it is a static model. It cannot analyze the dynamic mechanisms required to move from one equilibrium to another. Second, although CRAM includes the major crop and livestock commodities grown in Canada, it does not include some commodities that may be important in specific regions. In fact, only 86 percent of the crop movements which qualify for WGTA rates are captured by the model. Third, since accounting in CRAM is on a calendar year basis, any intra-year changes in prices cannot be analyzed. Fourth, market prices for intermediate products are not established in CRAM. There is no price for hay; there are no prices for feeder calves in the various provinces; there are no local or regional prices for feed grains. All products are free to move from region to region in response to market opportunities.

The lack of capability for analyzing intra-year changes in prices may be a matter of concern in the local feed grain markets. Shortages of feed grains in some regions can occur following years of drought, especially late in the crop year before a new crop has reached maturity. Feed grains may have to be imported from other regions, thus increasing local prices of feed grains in the importing regions. There is plenty of evidence to show that dynamic local feed grain markets do exist within Canada, but the peculiarities of local markets are difficult to capture in an aggregate model. They could be better addressed in a farm level model. CRAM is designed to analyze regional impacts in the various agricultural sectors on an annual basis.

CRAM develops a general equilibrium set of prices and quantities for the major agricultural commodities in Canada. Export prices are fixed at world price levels, less the costs of handling and transportation to terminal locations. The farm level price of barley destined for the export market is the opportunity cost for feed used in livestock expansion decisions. Once the livestock herd is determined (on the basis of herd retention functions), the animals must be fed. The livestock herd in each province draws feed to meet nutritional requirements from the least expensive sources. The only prices established by the general equilibrium solution are for final products.

Analysis of expected impacts from changes in transportation policies requires some assumption about expectations of grain and livestock producers. CRAM does not have provision for analyzing decisions that are not profit maximizing.

There is no doubt that the limitations of CRAM increase the difficulty in interpreting the results. However, the strengths of CRAM to analyze the impacts of changes in transportation policies should not be underestimated. CRAM is a general equilibrium model of Canadian agriculture that encompasses the production and transportation alternatives for the vast majority of Canadian agriculture. The advantages of using a general equilibrium model like CRAM far outweigh its disadvantages. A general equilibrium model forces arbitrage to occur. In CRAM, agricultural commodities are produced in regions where they have a comparative advantage, within the constraints imposed by resource availabilities and government policies.

The Interprovincial Input - Output Model

Conceptualization of Secondary Impacts

Changes in the transportation policy in Canada can be postulated to have a major effect on the agricultural industry through their impact on the level and composition of output, marketing, and on the other economic activities leading to regional, social and environmental (ecological) effects. The secondary impacts that would emanate from these direct changes could be several and varied. Many other industries in the region of impact, or those situated outside, may be affected through the interrelationships between agricultural and non-agricultural industries. Depending upon the magnitude of these changes, development of the region as a whole may be affected. Some of these economic changes may also lead to social impacts. For example, lower economic activity in agriculture may affect the economic viability of smaller rural communities. Alternatively, if economic changes are such that the local region's industries are supported more, the rural communities in the region may grow and become stronger social institutions. Environmental impacts may also be created through the changes in the transportation policies. An increase in the farm-level processing of cereals, through livestock production, may have some detrimental impacts on the surface water and groundwater pollution. Similarly, a change in the use of farm inputs (such as fertilizer, herbicides, etc.), triggered by a corresponding change in cultural practices, may also lead to different levels of non-point source pollution of water bodies, as well as different impact on soil degradation. Although some of the social and environmental impacts may be significant, the focus of this study was limited to economic impacts.

The secondary economic impacts of a change in the transportation policy are, to a major extent, conditioned by the nature and magnitude of the direct impact of the policy change. For example, a change in transportation policy resulting in a different freight rate structure could change the regional agricultural production mix, and its ultimate destination. These changes in grain and livestock production may lead to other changes in the region through changes in industrial production, personal disposable income, gross domestic product, government revenues, and regional employment. A change in regional employment may lead to a further change in demand for products produced by various local industries, and thereby cause another round of adjustments in output, personal disposable incomes, gross domestic product, trade, and employment. These changes in an economic system are often called secondary impacts of a policy change and may, in some instances, be as important as direct impacts.

Changes in the enterprise mix on farms in various regions will have two types of impacts: those that are induced by the backward linkages and those that stem from forward linkages. The backward linkages refer to those transactions necessary for meeting the intermediate goods requirements of an industry. Forward linkages are present when outputs of one industry are used as inputs by another industry. For example, changes in the crop area or size of livestock enterprise will result in different levels of inputs demanded by farmers. A decrease in crop production will lead to decreased demand for fertilizer, machinery repairs, fuels and lubricants, as well as other inputs. Similarly, an increase in livestock production in a region will increase demand for inputs such as purchased feeds, pharmaceutical supplies, and veterinary services. Therefore, different enterprises will have different secondary impacts, both in terms of the industries affected and the magnitudes of impacts on the affected industries. Both of these are examples of backward linkages of agriculture. An example of a forward linkage is the use of live animals for further processing within the region. Thus, livestock production can have both backward and forward linkages. With higher freight rates, there may exist opportunities for increased production of processed oilseed and livestock products. Availability of relatively cheaper raw materials may spur processing of oilseeds through existing or new oilseed crushers. Similarly, provinces, such as Saskatchewan, may be able to compete in the production of meat, rather than exporting both feed grains and feeder animals, thereby increasing livestock slaughtering activities in that province.

Secondary impacts can be further identified into two types. First, changes in the enterprise pattern will lead to a different impact on different industries present in the region since various farm enterprises interact differently with local industries. Second, each crop or livestock enterprise will result in different returns to primary factors of production. The most important of these are wages and salaries as well as incomes of unincorporated businesses. These payments constitute a major share of regional personal income. Changes in the income level may lead to different current expenditures by consumers as well as different expenditures on durable and semi-durable goods. Lower consumer expenditures would lead to lower output by various industries with an eventual decrease in gross domestic product, trade, and employment. Thus, secondary impacts can be divided into two types: indirect impacts and income induced impacts.

The secondary impacts of a change in the economic activity of a sector are estimated using an input-output model, which is the methodology followed in this study. The description of the model used in the study is described next.

Overview of the Input-Output Model

The impact analysis in this study was carried out using Statistics Canada's 1984 Interprovincial Input-Output Model. The model is capable of tracing the propagation of demand throughout the Canadian economy that is provincially as well as industrially disaggregated. This is because the intermediate and final demands throughout the economic system are disaggregated both regionally (provincially) and industrially. The structure of this model is similar to that described by Leontief-Strout (1963) and Isard (1951). This model is an extension of the national input-output model, in that it uses a commodity-by-industry or "rectangular" accounting framework of the national model. The rectangular accounting framework for input-output models is superior to the traditional square accounting framework since it allows for joint production.

The model is disaggregated into eleven regions -- ten provinces and the two territories which are combined to form the eleventh region. It distinguishes among approximately 200 industries and 650 commodities. International imports and exports are treated at the national level. The model treats households as exogenous; in other words, the model is open. Therefore, the estimated secondary impacts include only the indirect impacts. One of the strong features of the model is its ability to capture feedback effects.

The main assumptions of the interprovincial input-output model are similar to those of the national model. These include:

1. commodity-based fixed technology assumption, which implies that an industry's total output is made up of commodities in fixed proportions;
2. industry-based fixed technology assumption, which suggests that the total output of a commodity is provided by industries in fixed proportions.

These assumptions are supplemented by: (i) the consumption functions are linear with fixed proportions, and remain stable during the period of impact analysis; (ii) the share of locally produced goods to the imported goods remains unchanged during the period of impacts from that in the base period; (iii) new technologies are not assumed to affect the technological coefficients used in the model to any appreciable extent; and, (iv) there are no capacity constraints in the economic system. Furthermore, the input-output model is timeless and static. All the changes are assumed to take place in a timeless economic system, with no explicit recognition for the time period when these impacts are realized.

The interprovincial input-output model was extended to develop linkages with the level of employment in each of the eleven regions. The relationship between the level of employment and the level of output of a given industry was region-specific, as well as industry-specific. The relationship was also linear with fixed proportions, which implicitly assumes away economies of size, particularly in terms of labour costs.

Procedure for Impact Analysis

The estimation of secondary impacts of changes in transportation policy involves four steps:

1. estimation of the direct impacts of the policy changes using CRAM;
2. preparing the output from CRAM for use as input into the input-output model;
3. creating the appropriate system to estimate the impacts of the direct change;
4. estimation of the secondary impact.

The direct impact of a change in transportation policy was estimated in terms of changes in various regions' agricultural activity. This included: area under various crops, total production and marketing of various grains. These estimates became the basis for estimating the provincial level of gross farm income and net farm income from grains and cereals. In addition, the direct impact estimation included estimates of beef cattle and hog enterprises in each province. Gross revenues and costs of production from these enterprises, combined with the estimates above, led to the estimation of the provincial gross and net incomes.

The estimated direct impacts were used in the estimation of secondary impacts. This process involved several steps:

1. changes in the area under crops, beef cattle and hog enterprises for a region were translated in terms of changes in commodity requirements of these production processes. Various inputs were classified according to the Standard Commodity Classification Code;
2. since the above set of estimates were in purchasers' prices, these were converted into producers' prices, using a set of margins;
3. since the change in 2 was in terms of the total change (that is, local and imported), these quantities were expressed in terms of locally supplied demand;
4. the changes in beef and hog enterprises were assumed to be processed locally, since a situation of under-capacity existed in the prairie slaughtering and meat processing plants. A change in final demand of the slaughtering and meat processing sector was estimated. Adjustments were made in the data to avoid double-counting between this type of impact and those based on 3 above.

The third task in the procedure was to create an appropriate multiplier matrix to generate the secondary impacts of the direct change in the agriculture industry. This step was carried out by Statistics Canada. The multipliers referred to the open model; thus, the resulting impacts include only the industry-support impacts and not consumption-induced impacts. The final task in the procedure was that of estimation of the secondary impacts. In this step, direct impacts in step two were used in conjunction with the multipliers to arrive at the level of secondary impacts for various regions of Canada.

The economic impacts of proposed changes in the method of payment of the Crow Benefit were assessed by comparing the results of a model simulation to reflect as closely as possible the situation in Canadian agriculture at the end of the 1980s with simulations calibrated to represent the various policy options.

Limitations of the Input-Output Model

The major limitations of the input-output model stem from the various limitations of the tool as described above. One of the major assumptions that may affect the results of this analysis is that of no structural change during the period of impact. This would imply that the technological coefficients have remained constant; the market share of various industries in producing a commodity has remained unchanged from the base period; the sources of supply as well as their relative magnitudes would not undergo any major shift during the period of impact; and consumers' spending patterns, as portrayed in the model, have remained stable. The assumption of no major structural change is a reasonable one in the context of the change in the transportation policy, particularly in light of the magnitude of the direct changes.

References

Agriculture Canada. 1989. *Growing Together*. Agriculture Canada, Ottawa.

______. 1990. Report of the Transportation Committee, *Agri-Food Policy Review*, Agriculture Canada, Ottawa, Ontario.

Charlebois, P.R. 1987. *Modelé Économétrique du Boeuf*. Working Paper, Policy Branch, Agriculture Canada, Ottawa.

Isard, W. 1951. "Interregional and Regional Input-Output Analysis: A Model of a Space Economy", *The Review of Economics and Statistics*, 33: 318-328.

Kerr, W.A., G. Fox, J.E. Hobbs and K.K. Klein. 1991. "A Review of Studies on Western Canadian Grain Transportation Policies". Working paper 6/91. Policy and Grains and Oilseeds Branches, Agriculture Canada, Ottawa.

Klein, K.K., G. Fox, W.A. Kerr, S.N. Kulshreshtha and B. Stennes. 1991a. "Regional Implications of Compensatory Freight Rates for Prairie Grains and Oilseeds". Working Paper 3/91. Policy and Grains and Oilseeds Branches, Agriculture Canada, Ottawa.

______. 1991b. "Summary of Regional Impacts of Compensatory Freight Rates for Prairie Grain". Working Paper 4/91. Policy and Grains and Oilseeds Branches, Agriculture Canada, Ottawa.

Klein, K.K., J. Corman and S. Russell. 1991c. "Feed Freight Assistance: An Analysis of Policy Options". Working Paper 11/91. Policy Branch, Agriculture Canada, Ottawa.

Klein, K.K., S.N. Kulshreshtha, W.A. Kerr, G. Fox, B. Stennes and J. Corman. 1993. "Transportation Issues in Canadian Agriculture II: A Regional Analysis of the Western Grain Transportation and Feed Freight Assistance Acts", *Canadian Journal of Regional Science*, 16: forthcoming.

Leontief, W. and A. Stout. 1963. "Multiregional Input-Output Analysis", in T. Barns (ed.). *Structural Interdependence and Economic Development*. London: Macmillan. 119-150.

Webber, C.A., J.D. Graham and K.K. Klein. 1986. *The Structure of CRAM: A Canadian Regional Agricultural Model*. Marketing and Economics Branch, Agriculture Canada, Ottawa.