DEVELOPMENT PERSPECTIVES ON AND A DECISION SUPPORT SYSTEM FOR ABORIGINAL COMMUNITY-BASED ECONOMIES: THE CASE OF THE MOOSE CREE FIRST NATION, NORTHERN ONTARIO

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INFORMATION REPORT NOR-X-390

Canadian Forest Service
Northern Forestry Centre

2003

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Catalogue No. Fo46-12/390E
ISBN 0-662-35318-8
ISSN 0831-8247

This publication is available at no charge from:

Natural Resources Canada
Canadian Forest Service
Northern Forestry Centre
5320 – 122 Street
Edmonton, Alberta T6H 3S5

A microfiche edition of this publication may be purchased from:

Micromedia Ltd.
240 Catherine Street, Suite 305
Ottawa, Ontario K2P 2G8

National Library of Canada cataloguing in publication data

Ghebremichael, A.

Development perspectives on and a decision support system for Aboriginal community-based economies : the case of the Moose Cree First Nation, Northern Ontario

(Information report ; NOR-X-390)
Includes an abstract in French.
Includes bibliographical references.
ISBN 0-662-35318-8
Cat. No. Fo46-12/390E

1. Native business enterprises – Ontario, Northern – Case studies.
2. Native peoples – Ontario, Northern – Economic conditions.
3. Economic development projects – Ontario, Northern.

I. Kubursi, A. A., 1941- .
II. Northern Forestry Centre (Canada)
III. Title.
IV. Series: Information report (Northern Forestry Centre (Canada)) ; NOR-X-390.

E78.05C3G33 2003 338.7'089'9707131 C2003-980322-8

This report has been printed on Canadian recycled paper.

Ghebremichael, A.; Kubursi, A. 2003. *Development perspectives on and a decision support system for Aboriginal community-based economies: the case of the Moose Cree First Nation, northern Ontario.* Nat. Resour. Can., Can. For. Serv., North. For. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-390.

ABSTRACT

The socioeconomic fabric of Aboriginal communities is distinct from that of non-Aboriginal communities. The unique sociocultural aspects of Aboriginal communities and their close attachment to nature ought to form the broad foundations of scientific inquiries into sustainable development. This paper highlights the main challenges in fostering sustainable development of Aboriginal community-based economies. The various asymmetries and anomalies in the relation between Aboriginal and modern economies are discussed. Applications of a decision support system, Aboriginal Community Development Impact Model: Moose Cree 2000, are demonstrated, with data from a planned development project in northern Ontario. It is argued that removing the anomalies and asymmetries in the relation between Aboriginal economy and the broad-based modern Canadian economy could lead to socioeconomic stability of the Moose Cree First Nation or any Canadian First Nation community. Compensation, transfer payments, or other injections of money that do not build capacity and economic infrastructure in the Aboriginal economy will have only temporary effects, most of which will seep out of the local economy.

RÉSUMÉ

Les communautés autochtones ne sont pas formées du même tissu socioéconomique que les communautés non autochtones. Les études scientifiques sur le développement durable de ces communautés doivent donc être fondées sur les particularités de la structure sociale et de la culture des peuples autochtones, ainsi que sur le lien étroit qui les unit à la nature. Le présent document met l'accent sur les principaux défis que pose l'adoption de mesures pour le développement durable des économies autochtones axées sur la communauté. Il traite des nombreuses différences qui existent entre l'économie autochtone et l'économie moderne, ainsi que des anomalies qui caractérisent la relation entre ces deux économies. Il montre également les applications d'un système d'aide à la décision, le Modèle d'impact du développement communautaire autochtone : Moose Cree 2000, au moyen des données relatives à un projet de développement qui doit être réalisé dans le Nord de l'Ontario. Le document soutient que l'élimination des différences entre l'économie autochtone et l'économie canadienne moderne à grande échelle, ainsi que des anomalies qui caractérisent la relation entre ces deux économies, pourrait permettra la stabilité socioéconomique de la Première nation crie de Moose et de toutes les communautés autochtones du Canada. Les indemnisations, les paiements de transfert et les autres injections de capitaux qui ne contribuent pas au renforcement des capacités des Autochtones et de l'infrastructure de leur économie n'ont qu'un effet temporaire; de plus, la majeure partie de cet argent ne rapporte pas à l'économie locale.

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INTRODUCTION

The socioeconomic fabric of Aboriginal communities is distinct from that of non-Aboriginal communities. The unique sociocultural aspects of Aboriginal communities and their close attachment to nature ought to form the broad foundations of any scientific inquiries into sustainable development. For economic development purposes, people have been moved out of their ancestral lands, landscapes have been changed, and the contributions of indigenous people have been undervalued. Such development has been one of the more valued objectives of the modern state. However, its dominant framework has not taken into account traditional ecological knowledge, styles of living, local preferences, and meaningful alternatives. It is widely acknowledged that Aboriginal peoples could do better than they are able to achieve today. In Canada, there is general consensus that Aboriginal communities do not play an integral role in decision-making processes that deal with the development of their local economies. In short, there is a pressing need for a clear understanding of all the elements that constitute the sociocultural, economic, and ecological building blocks of sustainable development within Aboriginal community-based economies.

We have two broad objectives here: to describe various perspectives that focus on the development of Aboriginal and non-Aboriginal rural community-based economies, considering the Moose Cree First Nation of northern Ontario, as a case study; and to demonstrate the applications of a decision support system (DSS) developed for the Moose Cree First Nation.

To pursue these objectives, we follow a three-step approach. First, we present the nature, structure, and dynamics of the relation between the Aboriginal economy and the broad-based, modern Canadian economy and discuss the various asymmetries and anomalies in that relation, as well as the way in which they influence the future course of the Aboriginal economy. We also explain the costs associated with persistent asymmetry in the relation between the Aboriginal economy and the modern economy and the opportunities that could be realized from a harmonized relation. We argue that removal of these anomalies and asymmetries is a prerequisite for an economic infrastructure that will promote social and economic harmony. Second, we describe the technical structure of ACDIM: Moose Cree 2000 and demonstrate its applications. Third, we use theoretical insights and quantitative results from a case study to make suggestions about approaches to fostering sustainable development within Aboriginal community-based economies.

Including this introduction, the paper consists of eight sections. The second section deals with the challenges associated with harmonizing the Aboriginal economy and the modern Canadian economy. The third section presents a theoretical analysis of free trade between unequal economies, and the following section profiles the socioeconomic fabric of the Moose Cree First Nation. The fifth section highlights the technical features of the DSS developed for the Moose Cree First Nation (*see* Appendix 1 for detailed descriptions and mathematical derivations). The sixth section describes a case study demonstrating the applications of the DSS, the results of which are discussed in the seventh section. The paper ends with our concluding remarks.

CHALLENGES IN HARMONIZING UNEQUAL ECONOMIES

In this section, we outline a theoretical framework within which the Aboriginal economy (also called "traditional economy" and "underdeveloped economy" in this report) and the broad-based, modern Canadian economy can be analyzed. We identify the main challenges that impede harmonization and use the theories of dualism and dependence, the basic needs approach (Thirlwall 1994), and the important role of Aboriginal traditional knowledge in fostering sustainable development as illustrative tools to highlight these challenges.

Dualism

Malthus, who saw any given economy as consisting of agricultural and industrial sectors, originally outlined the theory of dualism (Pearce 1992). The agricultural sector is characterized by subsistence farming based on primitive techniques. In an economy where this sector is dominant, the standard of living and wages are very low. The industrial sector, on the other hand, is characterized by modern technology, high productivity, and higher wages. According to this theory, studying the interactions between these two sectors should increase the understanding of economic development.

Development economists identify three types of dualism: spatial, social, and technological (Thirlwall 1994). Spatial dualism refers to unequal development patterns between regions. In a national economy with geographic duality, labor migration, mobility of capital, and trade retard growth of the underdeveloped region's economy, which subsequently affects the national economy as a whole. Social dualism refers to differences in sociocultural values, preferences, and attitudes between developed and less developed economies. In this circumstance, obstacles to development arise when people within the indigenous subsistence economy are reluctant to alter their traditional way of life and to respond positively to development incentives. Social dualism is commonly viewed as an inevitable consequence of development rather than as a basic cause of underdevelopment. Technological dualism occurs where technological differences exist between an underdeveloped local or regional economy and a technologically advanced, industrialized, monetized modern economy. The underdeveloped Aboriginal economy, for example, is characterized by labor-intensive production techniques and variable technical coefficients, whereas production processes in the modern economy are capital intensive, with fixed technical coefficients.

The advanced technology of the modern economy may impede the progress of the underdeveloped economy on which the rapid development of the total (i.e., national) economy partially depends (Thirlwall 1994). First, relatively fixed technical coefficients (i.e., a low elasticity of substitution between factors) means that labor can only be absorbed from the Aboriginal economy into the modern economy as fast as the growth of capital. Second, capital intensity itself will restrict employment opportunities in the modern economy, contributing to higher unemployment in major cities and perpetuating underdevelopment in Aboriginal and non-Aboriginal rural communities. Stiglitz (1999), who considered duality as an endogenous variable that can be explained and changed by policy actions, explored the effects of several sources of the vicious circle of poverty. He argued that disparities in wages, productivity, access to capital, education and health services, and environmental degradation perpetuate underdevelopment. It is commonly accepted that proactive government intervention can remove each of these sources of disparity.

Dependence

Development economists view dependence as a conditioning situation in which the growth of an underdeveloped economy is conditioned by development and expansion of an advanced, modern economy. Thirlwall (1994) identifies three forms of dependence: colonial dependence, which is based on trade and exploitation of natural resources; financial–industrial dependence, which is a result of structural changes in the advanced economy; and technological–industrial dependence, which occurs with inflow of investment capital from the advanced economy to the underdeveloped economy having the sole motive of profit maximization. These and similar forms of dependence create highly dualistic national economic structure, inequality, psychological effects of a dependence mentality, and the habit of seeking government handouts.

From the early 20th century onward, the Aboriginal economy has been integrated into Canada's modern market economy. The size of the market economy in the early 1900s was several times that of the Aboriginal economy, its diversification was much greater, and the manufacturing sector's share in gross domestic product (GDP) was infinitely larger. Through these differences in size and structure, the relation between the two economies was effectively one between a large, advanced, rich economy and a small, underdeveloped, poor economy. Both theoretical analysis and empirical studies suggest that the dynamics of such a relation always generate two opposing forces that affect and shape the development directions of the second (smaller) economy. Favorable repercussions include an increased demand for the products of the smaller economy and possible diffusion of technology and knowledge, as well as other spread effects resulting from the geographic proximity of the smaller economy to the larger economy. These effects may typically lead to subcontracting, joint ventures, and coordination in several sectors. Unfavorable repercussions arise from the disappearance of many activities and income sources in the smaller economy and its confinement to producing labor-intensive and low-skilled labor goods, as well as the emigration of a sizeable segment of its labor force to the neighboring advanced economy. These effects are known in the literature as backwash effects or polarization effects. They arise from the capability of efficient, large-scale industries in the advanced economy to out-compete the inefficient, small-scale, industries in the underdeveloped economy and to attract both their labor and their capital (for a good analysis of these effects, *see* Krugman and Obstfeld [1994] and Thirlwall [1994]).

From the discussion to this point, two crucial questions arise: What is the net balance between the two opposing forces? To what extent do they foster development of the Aboriginal economy? Economic theory suggests that removal of barriers to trade between the two economies would increase the exports of the Aboriginal economy to its neighbor. However, this is realized only if the trade is based on comparative advantage (discussed in the section "Exchange between Unequal Partners"). The level of exports will not be sustained if the modern economy imposes trade barriers on Aboriginal products. Such protectionism would increase the price of intermediate and capital goods imported by the Aboriginal economy, and thus raise the cost of production within that economy in a way that would compromise its comparative advantage. Further integration between the two economies, such as allowing free movement of labor and capital, would significantly reduce the export of goods from the small to the large economy, as the export of labor services would be substituted for the export of goods. In other words, free trade and free mobility of factors of production would gradually wipe out trade based on perceptions of comparative advantage and would confine the Aboriginal economy to trade based on absolute advantage. This would lead to a condition where the underdeveloped Aboriginal economy exports low-skilled labor goods and imports high-skilled labor goods, which are relatively expensive. The Aboriginal economy would therefore remain backward in an advanced country. The notion of labor mobility is used here only for illustrative purposes. We understand that the theory of labor mobility is difficult to apply to the mobility of Aboriginal labor. In most cases, Aboriginal workers are reluctant to relocate, because of their attachment to the Aboriginal lifestyle. We also realize that unique Aboriginal artifacts—what one of our reviewers calls "exotic Aboriginal goods"—are sources of income for only very limited number of households. This meager income does not have any impact on the structure and strength of the local and national macroeconomies to the extent of changing market prices.

However, if integration of the two economies proceeds slowly and systematically, the Aboriginal economy can be expected to be able to use its natural resources effectively. Then free trade and free mobility of factors of production may allow producers in that economy to expand their production. This would be partially due to economies of scale and an enhanced comparative advantage. In short, a slow pace of integration and control of locally based natural resources could allow the Aboriginal economy to benefit from spread effects. By contrast, hasty integration would produce polarization effects. The theoretical implications of these contentions are best exemplified by the simple model described in the section "Exchange between Unequal Partners".

Basic Needs Approach

Since the 1970s, the basic needs approach to sustainable development has been gaining momentum. This approach focuses on the provision of the essentials of life: health services, education, adequate nutrition, housing, clean water, and a sanitation system. As Thirlwall (1994) has put it, the rationale for this approach is that direct provision of such goods and services eliminates absolute poverty more quickly than alternative strategies, which simply attempt to accelerate expansion of the production sector, focusing only on raising total factor productivity and economic efficiency.

Proponents of the basic needs approach base their arguments on the following principles: economic growth strategies usually fail to benefit the disadvantaged sector of society; the productivity and incomes of the poor depend on the direct provision of the basic needs of life; it takes time to raise the incomes of the poor so that they can afford to meet basic needs; and it is difficult to help all the poor uniformly in the absence of a strategy for provision of basic needs. They further argue that provision of basic needs is a form of investment in human capital, which can be as productive as investment in the industrial sector. Thus, it should be obvious that a properly designed and implemented strategy for basic needs provision, which ensures productivity and equity, enhances industrial output, thereby raising national wealth.

Aboriginal or Traditional Knowledge

Knowledge is perhaps the major factor determining whether humankind will be able to create a sustainable future on this planet (Serageldin 1993). Aboriginal, traditional, or indigenous knowledge (terms used interchangeably in this report) is a way of life and a way of relating to nature, rather than simply an accumulated set of knowledge about ecological systems (Brubacher and McGregor 1998). It is an integral part of the sociocultural system of Aboriginal people, who are more aware of its importance than any others. Indigenous knowledge is transmitted from generation to generation via traditional or oral socialization. The transmission mechanisms include story-telling, behavioral modeling, learning from individual experiences, singing, dancing, engaging in craft work, and appreciating and preserving natural resources as inherent sources of spiritual renewal and livelihood.

Experience has shown that Aboriginal community-based development initiatives that do not integrate indigenous knowledge into planning and decision-making processes are bound to fail. The World Commission on Environment and Development (1987), also known as the Brundtland Commission, recognized the importance of indigenous knowledge for sustainable development. The commission emphasized that tribal and indigenous peoples would need special attention as the modern technological forces of economic development disrupted their traditional lifestyles. It also recognized that traditional lifestyles can in turn offer modern societies many lessons in the management of natural resources in complex forest, mountain, and dryland ecosystems. Generally, social scientists agree that Aboriginal communities are repositories of vast accumulations of traditional knowledge and experience that links humanity with its ancient origins. Modern society can learn a great deal from their traditional skills in the sustainable management of complex ecological systems.

In Canada, policymakers, development planners, and the public at large have become increasingly aware of the important role that the traditional knowledge of indigenous peoples can play in fostering sustainable development. For example, Indian and Northern Affairs Canada (2001), in its strategic plan *Sustainable Development Strategy 2001–2003*, emphasizes the importance of Aboriginal communities participating in federal decisionmaking. The department has committed itself to conducting analyses and to developing guidelines on how to assist Aboriginal communities in the use and control of their traditional knowledge base.

Nonetheless, Aboriginal community-based development strategies must be designed on the basis of firmly founded principles. Gilday (1993), for example, outlined the following principles of the Department of Renewable Resources, Government of the Northwest Territories, Canada:

- Preservation and promotion of Aboriginal or traditional knowledge is a primary responsibility of Aboriginal people.
- Government programs and services should be administered in a manner consistent with the beliefs, customs, knowledge, values, and language of the people being served.
- Traditional knowledge should be considered in the design and delivery of government programs and services.
- The primary focus of traditional knowledge research should be the Aboriginal community.
- Traditional knowledge is best preserved through its continued use and practical application.

- Oral information is a reliable source of information about traditional knowledge.

Thus, interdepartmental strategic approaches to the use and control of indigenous knowledge will help in harmonizing the Aboriginal and advanced economies of Canada. To develop a credible and useful Aboriginal or traditional knowledge base, long-term multidisciplinary research programs are warranted.

EXCHANGE BETWEEN UNEQUAL PARTNERS

This section focuses on trade between a large, advanced, well-connected modern economy and a small, poor, disarticulated economy. The analysis is based on the formulations of Myrdal (1989), Krugman (1995), and others. Here we discuss, both the positive effects, known as spread effects, and the negative consequences, referred to as backwash effects. To illustrate these two possible outcomes of trade between unequal economies, we use a simple mathematical trade model and a diagram, under increasing returns to scale. Increasing returns to scale is one the properties of a production technology, which exhibits rising output by proportionally more than the aggregate amount of all inputs. This characteristic implies that proportional increases in output require less than proportional increases in inputs, mostly because of to technical efficiency.

Economic theory suggests that at equilibrium, under specified conditions, the long-term outcome of exchange is equal advantages throughout the world factor-price equalization (this and other specialized terms are defined in Appendix 2): the less-skilled workers in poor countries will be paid the same wages as their counterparts in advanced countries and likewise for skilled workers. But does factor-price equalization, appropriately qualified to fit an n factor, n good world, capture economic reality? For years, many trade theorists have rejected equal advantages from trade and factor equalization as a description of the world. The wide, and in some cases increasing, variation in pay levels within and among countries seemed to make it a textbook proposition of little relevance. Reflecting this view, Bhagwati and Dehejia (1994) have enumerated some of the "extraordinary demanding" assumptions needed to establish factor-price equalization and even simpler propositions about the gains of trade. These include existence of the same level of technological advances, the same production functions, the identical tastes, similar ranking of sectors by skilled to unskilled labor and by capital intensity at all prices, absence of economies of scale, and lack of complete specialization at the country level, i.e., all countries produce the full set of traded goods. Furthermore, Norman and Venables (1995) stressed that in a Heckscher–Ohlin model, where the cost of trade is negligible, trade in goods does not equalize factor prices; flows of capital and labor would also be needed. Hence, many trade theorists today believe that trade is exacerbating factor-price divergence.

We start with a model first developed by Murphy et al. (1989). We use the model to characterize the present asymmetrical relation between the Aboriginal economy and the broad-based, modern Canadian economy and to highlight the likely consequences of trade between unequal partners. For illustrative purposes, we begin with an economy of two sectors, functioning with a fixed endowment of labor (L). This input can be employed in either of two sectors: the Aboriginal sector, characterized by constant returns to scale, or the modern sector, characterized by increasing returns to scale. Labor is not paid the same wage in the two sectors. It is reasonable to assume that the modern economy is capable of paying premium wages to attract labor from the Aboriginal economy. Thus, the modern economy has productivity, economies of scale, and other advantages over the underdeveloped Aboriginal economy.

Accordingly, let ω (where $\omega > 1$) be the ratio of the wage rate that must be paid in the modern economy to that paid in the Aboriginal economy:

$$\omega = \frac{W_m}{W_A} \qquad (1)$$

where

W_m = the wage rate in the modern economy; and

W_A = the wage rate in the Aboriginal economy.

The modern economy is assumed to produce N goods, where N is perceived to be a large number. Units are chosen such that labor productivity within the Aboriginal economy is unity in all goods. For the modern economy, we assume increasing productivity of labor in all goods, i.e., decreasing costs, which can be presented as follows:

$$L_i = F_i + \alpha Q_i \qquad (2)$$

where

Q_i = the production of good i in the modern economy;

F_i = the fixed amount of labor needed to produce Q_i, irrespective of the amount of i; and

α = marginal requirement of labor, with $\alpha < 1$.

For simplicity, we assume that the demand for N goods is Cobb-Douglas and symmetric. That is, each good receives a constant expenditure share, $1/N$. Many producers, who are assumed to be price takers, populate the Aboriginal economy. Perfect competition prevails in this sector. Each good has a perfectly elastic supply at the marginal cost of production of unity, given the choice of units. In the modern economy, given the assumption of decreasing cost, a single entrepreneur can produce each good. This unconstrained monopolist in the modern economy cannot, of course, price his or her products above unity, because he or she will face competition from the Aboriginal economy. So, the question becomes, Will production take place in the modern economy or the Aboriginal economy?

Figure 1 can help to answer this question. On the horizontal axis is the labor, L_i, used to produce good i. On the vertical axis is the total output of the two economies, Q_i. The heavy solid lines represent the production technologies of the two economies. The broken 45° line is a ray representing premium wage. The line for the modern economy has a slope of $1/\alpha$.

Figure 1 allows us to conceptualize what each economy would produce if all labor were allocated to it. In either case, L/N workers would be employed in the production of each good. If all the goods were produced in the Aboriginal economy, Q_1 of each good would be produced, whereas if all the goods were produced in the modern economy, Q_2 would be produced. Q_2 is always greater than Q_1, provided Equation 3 is satisfied:

$$\frac{L/N - F}{\alpha} < \frac{L}{N} \qquad (3)$$

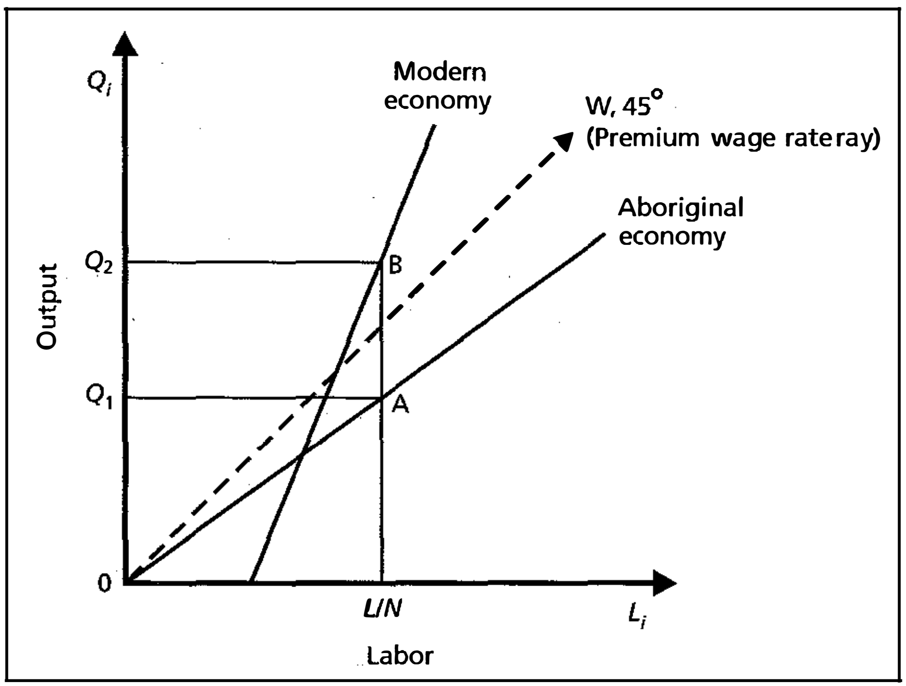

Figure 1. Conceptual relationship between Aboriginal and modern economies (source: Krugman 1995).

That is, as long as the marginal cost advantage in the modern economy is sufficiently large, or fixed costs are large or both, Equation 3 is satisfied. Because of marginal cost advantages over the Aboriginal economy (i.e., α being very small), the modern economy will have comparative advantage and will absorb most of the labor force.

Thus, it is believed that such conditions encourage migration of labor to the modern economy. But there is a catch. Even if the Aboriginal economy could produce goods using modern technology, it cannot necessarily compete with the modern economy, which pays premium wages. Suppose that only one firm starts producing with modern technology, while all other producers continue to use traditional techniques. The firm using modern technology must still charge the same price as all the other producers and sell the same amount. Since there are many goods, we can safely ignore income effects.

Referring to Figure 1, let Q_1 be the quantity of each good that continues to be sold by two firms, A and B. If firm A starts producing at point A, using traditional technology, are this firm's production operations profitable? Keep in mind that it must pay a premium wage. The ray, 0W in the diagram represents the premium wage. Firm A will be profitable only if 0W passes below point A. But it does not, and the production operations of firm A are therefore unprofitable. By contrast, if we begin with a situation in which most of the firms are using modern techniques and are able to produce Q_2 at the input-output combination point B, the production operations of all firms are profitable, because the wage premium ray passes below point B.

There are three distinct outcomes possible here. If the wage premium is low, the modern economy will prevail; if it is high, the modern economy will falter; and if it takes an intermediate value, it is safe to posit that the two economies will coexist (for analytical purposes, the 45° ray is just a guide to the intermediate value of the premium wage). The modern economy can continue specializing in manufactured goods, while the Aboriginal economy produces traditional goods.

It is worth posing a question at this point. What impediments inhibit the normal operations of the Aboriginal economy? Three main conditions necessary for the dominance of the modern economy can help to answer this question. First, there must be economies of scale in production in the modern economy. Second, the modern economy must be able to draw labor from the Aboriginal economy, which pays lower wages; in other words, there must be an elastic supply of labor to the modern economy. Third, there must exist a wage premium to attract labor from the Aboriginal economy. In effect, the interaction of the internal economies of scale with the elastic supply of labor generates external economies in the modern economy that allow it to prosper while the Aboriginal economy falters.

In summary, the following economic conditions—among many other possible conditions—create a pattern of dependence of the Aboriginal economy on the modern economy. First, the modern economy operates under conditions of increasing returns to scale. Second, the modern economy can offer a wage premium to Aboriginal workers, ensuring an elastic supply of labor to its industries. Third, the influx of Aboriginal labor at a fraction of total labor cost reduces the wage premium in the modern economy, making firms operating in that economy more profitable and sustainable. Fourth, the cash incomes earned by Aboriginal migrant workers are typically spent in the consumption of the modern economy's products; thus, the modern economy not only captures an elastic supply of labor at relatively low wages, but it also experiences a sufficiently large effective demand for its products in both economies. Fifth, the geographic proximity of the two economies reduces the costs of distributing goods produced in the modern economy.

To close this discussion of the theoretical background to the DSS, a linking statement on the DSS itself is in order. Accordingly, we summarize the nature of the DSS, describe the extent to which this paper is a coherent whole, and outline the way in which and the extent to which the quantitative calculations reflect the mathematical model.

The Aboriginal economy is a special case of a developing economy within a mature and advanced economy. It is in the class of dual economies, where formal and informal sectors operate side by side and interact within a common framework. The major problems for the Aboriginal economy are the loss of labor and other resources to the advanced economy; the underestimation of the value added, because a good deal of the economy's outputs do not pass through the market; and the nature of interdependence and interactions between the advanced and the Aboriginal economies.

The DSS captures many of the salient features of the Aboriginal economy, including the following:

- valuation of the output of the Aboriginal economy according to a labor theory of value;

- identification of the dual nature of the Aboriginal economy;

- quantification of the intricate nature of the interactions between the two economies; and

- operation of a demand-constrained system with an output-adjusting vector, which is characteristic of an economy with high levels of unemployment, low supply elasticity, and "sticky" wages and prices.

Clearly, the economic manifestations of a dual economy, the elaboration of traditional activities, and the agglomeration of formal and informal activities indicate that the spirit that the Aboriginal economy is a distinct economy, reflecting social and spiritual choices and differences. The DSS demonstrated in the following sections was developed with these sociocultural and economic complexities in mind.

In recognition that these complexities cannot be captured and analyzed by a single model, the next section presents a brief socioeconomic profile of the specific Aboriginal community for which the DSS was developed. This is followed by a description of the technical structure of the DSS and its applications.

SOCIOECONOMIC PROFILE OF MOOSE CREE FIRST NATION

Quantitative measures are required to explain the pattern and degree of dependence of the Aboriginal economy on the broader, modern economy. In collaboration with the Canadian Forest Service and the Moose Band Development Corporation (MBDC), Econometric Research Ltd. designed a DSS for the analysis of socioeconomic impacts. The system's technical name is ACDIM: Moose Cree 2000, which stands for *Aboriginal Community Development Impact Model for Moose Cree Developed in the Year 2000.*

Because it is imperative that the economic base of the community be embedded in the model, we conducted an extensive survey of the local socioeconomic infrastructure and developed a comprehensive profile of the community (available from the first author). As background to the structure of ACDIM: Moose Cree 2000 (detailed in Appendix 1), the following two subsections highlight the natural resource base and the socioeconomic infrastructure of the Moose Cree First Nation and its environs.

Renewable Natural Resource Base

Aquatic Life

Moose River, which supports a variety of fish species, including river sturgeon *(Acipenser fulvescens)*, pickerel *(Esox americanus americanus)*, pike *(Hoplunnis diomedianus)*, whitefish *(Carcharodon carcharias)*, and sucker *(Catostomus commersoni)*, is important to the local economy in terms of both fishery and tourism. The tributaries that empty into the Moose River also support brook trout *(Lampetra appendix)*, whitefish, pickerel, and sucker. Particular to spring and fall are the sightings of many seal (*Phoca* sp.) feeding on the whitefish. Farther to the north, in James Bay, it is possible to spot the occasional beluga whale *(Delphinapterus leucus)* coming into warmer waters from the Arctic Ocean.

Wildlife

The most common types of wildlife found in the area are black bears *(Ursus americanus)*, wolves *(Canis lupus)*, muskrat *(Ondatra zebethicus)*, fox (*Vulpes* sp.), marten *(Martes americana)*, beaver *(Castor canadensis)*, moose *(Alces alces)*, rabbits (*Lepus* sp.), and the occasional caribou *(Rangifer tarandus)*. Waterfowl contribute much to the local subsistence economy. The species found in the area include Canada geese *(Branta canadensis)*, blue geese *(Chen caerulescens)*, ducks (*Anas* sp.), and ospreys *(Pandion haliaetus)*.

General Vegetation and Forest Resources

This area is typical of subarctic forests, with varieties of lichen and bogs supporting cranberries *(Vaccinium* sp.), blueberries *(Vaccinium* sp.), choke cherries *(Prunus virginiana)*, raspberries *(Rubus idaeus)*, fiddleheads (ostrich fern) *(Matteuccia struthiopterus)*, black spruce *(Picea mariana)* and balsam poplar *(Populus balsamifera)*. The habitat within the Moose River district includes extensive areas of muskeg typical of the Hudson Bay lowlands.

The dominant forest cover is black spruce and tamarack *(Larix laricina)*, which inhabits poorly drained areas. In better-drained areas, white spruce *(Picea glauca)*, balsam poplar, trembling aspen *(Populus tremuloides)*, and white birch *(Betula papyrifera)* are found.

With the allocation of a sustainable forest license from the Ontario Ministry of Natural Resources to MBDC, a complete forest inventory of the Moose River Basin area was undertaken. Moose Band Development Corporation hired a consulting firm, Petersen Consulting, to evaluate the feasibility of developing a forest management unit for 1.1 million ha of land in the traditional territory of the Moose Cree First Nation in the area between Cochrane and Moose Factory, Ontario. The consulting firm reported the potential for an annual harvest allocation of 204 818 m^3 (K. Petersen, Petersen Consulting, 23 November 2000, E-mail). Annual revenues that could be generated from the sale of the wood at a mill-gate price ranging from \$42.52 to \$51.36/m^3 were estimated at between \$8.7 million and \$10.5 million.

Socioeconomic Infrastructure

Social service organizations and administrative institutions are currently the major sources of income for the Moose Cree First Nation.

Health Institutions

The Weeneebayko General Hospital is one of the major local employers.

Administration

Several organizations offer jobs in the field of administration, including the Moose Cree First Nation, the MBDC, the Moose Cree Education Authority, and the Mushkegowuk Tribal Council.

Industry

A gravel-hauling operation by the MBDC is the main industry on the island. It offers temporary employment to approximately 20 people for approximately 6 weeks each year.

Construction

There is no major construction industry in the area. However, the Moose Cree First Nation builds new homes and renovates older ones, thereby creating some seasonal jobs.

Retail

There is some retail on reserve. The shops, most of which are located in the Moose Cree Complex, include the Northern Store, The Gift Basket, Cree Cultural Craft Shop, and The Craft Room. There are a number of small convenience stores. Neeyan Crafts is a speciality shop of the community.

Social Services

The Moose Cree First Nation is the major employer on the reserve. Employees provide a variety of services in health clinics, facilities for senior citizens, and day-care facilities, as well as offering social assistance services.

Economic Transfers

On average, between 200 and 300 band members are reported to depend on social assistance annually.

STRUCTURE OF THE ACDIM: MOOSE CREE 2000 SYSTEM

This section presents an overview of the ACDIM: Moose Cree 2000 system. Detailed explanations of the conceptual foundations and mathematical structure are provided in Appendix 1. The mathematical structure and theoretical framework of ACDIM are based on our original, peer-reviewed Community Development Impact Model, a community-based, economy specific model that was developed for and is being used by five northern Ontario communities.

Aboriginal economies are distinctive, for a variety of reasons. They are space intensive, and they involve a rich mix of Aboriginal, nonmarket activities combined with less-developed commercial and industrial activities. Obviously, this is not the typical economic mix found in relatively urbanized communities. For analytical purposes, we classified the economic activities of the Moose Cree First Nation into four categories: formal (on-reserve) activity (e.g., administration, extraction, and transfers), informal (on-reserve) activity (e.g., fishing, hunting, and craft or artisan), off-reserve activity (e.g., administration, agriculture, and processing), and recreation activity (e.g., sportfishing, cottaging, and sport hunting). This type of economic structure requires different analytical approaches.

Typically, Aboriginal economies are not well understood. Their contributions and outputs are not appropriately considered within the current national accounting framework, are rarely quantified, and they are typically not counted in the usual estimates of GDP because most of their products are not tradable (i.e., they do not pass through the market). But being nontradable does not mean that these products do not yield value in the sense that they create utility for their consumers and use scarce resources in their production. The first challenge in dealing with an Aboriginal economy is therefore to create the capacity to value those economic activities generating products that do not pass through the marketplace. These include reserve-based hunting, logging, fishing, trapping, craft-making, and products of medicinal products. ACDIM: Moose Cree 2000 uses parallel parameters from the modern economy for valuing such traditional outputs. For example, time spent trapping is valued at its opportunity cost in creating similar products that are traded in the modern economy.

There are also many linkages between the Aboriginal (reserve) and the non-Aboriginal (nonreserve) economies that are not well understood or quantified. ACDIM: Moose Cree 2000 explores these linkages by identifying the forward and backward linkages between the two economies. The input-output framework embedded in the model is particularly well suited to deal with this problem. The typical treatment of these linkages assumes that they are unidirectional, from the modern economy to the Aboriginal economy. This truncated view of the complex relations between the two economies underestimates the contributions of the Aboriginal economy to the modern economy. This is a different problem from that of simply quantifying non-Aboriginal activities, in that it relates to the type of interdependence between the two economies. Many activities outside the Aboriginal economy owe their sustenance to it.

A crucial feature in ACDIM: Moose Cree 2000 allows the user to examine the implications of dependence on transfer payments versus the development of alternative productive activities. These alternatives are not necessarily in the Aboriginal economy. They may involve the development of non-Aboriginal activities within the Aboriginal economy and investments outside it. The system defines and traces the linkages between the two economies and calculates the feasibility of these linkages and their economic consequences on both economies. These consequences are defined in terms of several indicators, including employment, labor income, value added (also referred to as gross provincial income [GPI]), tax revenues, and gross outputs.

APPLICATIONS OF ACDIM: MOOSE CREE 2000—A CASE STUDY

The ACDM: Moose Cree 2000 DSS was used to help the MBDC determine whether it would be appropriate to develop a forest management unit in its traditional territory.

This brief background section is based on information received from the consulting firm. The desire for a sustainable socioeconomic contribution to the development of the Moose Cree First Nation was the driving force behind the project. In the short term, the Moose Creek First Nation is expected to build skills related to sustainable forest management by undertaking projects such as harvesting and silvicultural operations. This is considered as a capacity-building aspect of the project. Petersen Consulting estimated that 100 direct and 200 indirect jobs would be generated by the project.

To commence the development project in the traditional area of the Moose Cree First Nation, an estimated $10 million worth of equipment would be required. Individual entrepreneurs from the Moose Cree First Nation would be encouraged to purchase the equipment to harvest the trees. The companies that process and convert timber into various products would assist in financing the project, and MBDC would forge partnerships with these companies.

Both Tembec and Abitibi Consolidated have the capacity to consume additional wood fiber, provided that demand for their products remains stable. At the time of assessment, all companies operating in northern Ontario were facing shortage of timber supply, partly because Lands for Life, an ecosystem preservation initiative of the Ontario government, was removing old-growth forestlands from commercial timber management. Consequently, additional supply from the proposed project would alleviate the shortage while creating employment opportunities for the Aboriginal labor force.

It is estimated that MBDC would receive $1/m^3 or $204 818 per year in management fees. The Moose Cree First Nation would generate a variable amount of revenue depending on the value of minimum stumpage. At the official rate in effect in January 2000, the minimum stumpage fees would be $4.03/ m^3 or $825 417.

RESULTS

This section summarizes the socioeconomic impacts of the proposed timber-harvesting operation. Province-wide and local impacts were computed under two scenarios—a low scenario and a high scenario. The two scenarios were based on the lower and higher ranges of estimates of the major variables in the database (Table 1).

Table 1. Anticipated start-up expenditures and sources of start-up funds for a forest management unit, to be operated by the Moose Cree First Nation

Expenditure or Income	Amount ($)
Start-up expenditures	
Environmental assessment	236 000
Land resource inventories	365 650
Access development	188 500
Other information collection	150 000
Aboriginal ecological knowledge	510 000
Wildlife studies	300 000
Human resources	175 000
Land use plan and forest management plant	428 000
Monitoring and inventory verification	150 000
Project management and consulting fees (various activities)	627 500
Legal (review of contracts)	25 000
Total	3 155 650
Potential sources of funds	
Living Legacy Trust (or other provincial sources)	1 408 792
Indian and Northern Affairs Canada	1 408 792
Cash and in-kind donations	338 065
Total	3 155 650
Infrastructure	
Bridge	2 000 000
Roads	8 500 000–15 000 000
Total	10 500 000–17 000 000

Source: Petersen Consulting, Timmins, Ontario.

The analysis results generated by ACDIM: Moose Cree 2000 are organized into four tables. Tables 2 and 3 present the impacts at the provincial level for the low and high scenarios, respectively, whereas Tables 4 and 5 present the corresponding impacts at the local level, respectively. For the sake of simplicity, we discuss here only the high scenario results reported in Tables 3 and 5. The following is a summary of the general interpretations of the key findings.

- The impacts differ by type of expenditure. Start-up expenditures and expenditures on equipment and infrastructure are considered

Table 2. Province-wide socioeconomic impacts, low scenario (year 2000 dollars)

Impact measures	Startup funds	Equipment	Infrastructure	Revenue
Initial expenditure or revenue ($)	3 155 650	10 000 000	10 500 000	8 708 861
Impacts				
Gross output ($)				
Direct	3 155 650	10 000 000	10 500 000	8 708 861
Indirect and induced	4 526 051	11 339 873	14 736 967	14 894 735
Total	7 681 701	21 339 873	25 236 967	23 603 596
Multiplier	2.43	2.13	2.4	2.71
Value added ($)				
Direct	1 935 507	4 327 304	4 207 990	3 137 355
Indirect and induced	3 937 910	10 745 349	13 878 258	11 429 209
Total	5 873 417	15 072 653	18 086 248	14 566 564
Multiplier	1.86	1.51	1.72	1.67
Employment (PYs)				
Direct	28	49	51	47
Indirect and induced	43	91	127	149
Total	71	140	178	196
Multiplier	2.54	2.86	3.49	4.17
Labor income ($)				
Direct	1 619 169	2 595 190	3 814 061	2 630 366
Indirect and induced	1 525 714	3 412 511	4 839 419	4 195 592
Total	3 144883	6 007 701	8 653 480	6 825 958
Taxes ($)				
Federal	209 048	1 973 805	1 162 669	1 396 946
Provincial	210 685	937 970	847 838	890 977
Local	86 916	242 790	304 625	300 240
Total	506 649	3 154 565	2 315 132	2 588 163
Imports ($)				
From other provinces	224 692	575 093	885 146	833 453
From other countries	575 258	2 242 884	2 065 084	1 816 661
Total	799 950	2 817 977	2 950 230	2 650 114
Selected comparative indicators				
Total jobs per million dollars	22.5	14	16.95	22.51
Direct jobs per million dollars	8.87	4.9	4.86	5.4
Effective direct wage rate ($/PY)	57 827	52 963	74 786	55 965
Effective induced wage rate ($/PY)	35 482	37 500	38 106	28 158
Effective total wage rate ($/PY)	44 294	42 912	48 615	34 826

Note: PY = person-year.

to have only temporary effects, whereas recurrent revenues and expenditures generate sustainable benefits, although not as large as those of the temporary expenditures.

- The temporary impacts of the high-scenario expenditures are substantial (Table 3, columns 2-4). These expenditures would generate a province-wide total impact of $50.2 million in value added, commonly referred to as GPI (Fig. 2). The corresponding

Table 3. Province-wide socioeconomic impacts, high scenario (year 2000 dollars)

Impact measures	Startup funds	Equipment	Infrastructure	Revenue
Initial expenditure or revenue ($)	3 155 650	10 000 000	17 000 000	10 519 542
Impacts				
Gross output ($)				
Direct	3 155 650	10 000 000	17 000 000	10 519 542
Indirect and induced	4 526 051	11 339 873	23 859 852	17 991 293
Total	7 681 701	21 339 873	40 859 852	28 510 835
Multiplier	2.43	2.13	2.40	2.71
Value added ($)				
Direct	1 935 507	4 327 304	6 812 937	3 789 618
Indirect and induced	3 937910	10 745 349	22 469 560	13 805 367
Total	5 873 417	15 072 653	29 282 497	17 594 985
Multiplier	1.86	1.51	1.72	1.67
Employment (PYs)				
Direct	28	49	83	57
Indirect and induced	43	91	204	179
Total	71	140	287	236
Multiplier	2.54	2.86	3.46	4.14
Labor income ($)				
Direct	1 619 169	2 595 190	6 175 147	3 177 225
Indirect and induced	1 525 714	3 412 511	7 835 249	5 067 864
Total	3 144 883	6 007 701	14 010 396	8 245 089
Taxes ($)				
Federal	209 048	1 973 805	1 882 416	1 687 375
Provincial	210 685	937 970	1 372 690	1 076 214
Local	86 916	242 790	493 202	362 661
Total	506 649	3 154 565	3 748 308	3 126 250
Imports ($)				
From other provinces	224 692	575 093	1 433 094	1 006 730
From other countries	575 258	2 242 884	3 343 469	2 194 349
Total	799 950	2 817 977	4 776 563	3 201 079
Selected comparative indicators				
Total jobs per million dollars	22.5	14	16.88	22.43
Direct jobs per million dollars	8.87	4.9	4.88	5.42
Effective direct wage rate ($/PY)	57 827	52 963	74 399	55 741
Effective induced wage rate ($/PY)	35 482	37 500	38 408	28 312
Effective total wage rate ($/PY)	44 294	42 912	48 817	34 937

Note: PY = person-year.

employment impacts would also be relatively large: 160 direct and 498 total (direct + indirect + induced) person-years (PYs) (Fig. 3). The labor income effect associated with the temporary expenditures is $23.2 million, whereas the labor income effect associated with recurrent (sustainable) revenues is $8.2 million (Fig. 4).

- All levels of government would collect considerable tax revenues: $4.1 million (roughly 50%), $2.5 million (roughly 37.5%), and $823 000 (roughly 12.5%) to the federal, provincial, and local governments, respectively (Fig. 5).
- The recurrent impacts of the revenues generated at a mill-gate price of $51.36/m^3 (Table 3, last column) are slightly lower than the temporary impacts. But it should be kept in mind that these impacts are sustainable over the lifetime of the project. They include $17.6 million in value added and 57 direct and 236 total PYs in employment. In terms of annual tax revenues, the federal, provincial, and Ontario-wide local governments would

Table 4. Local socioeconomic impacts, low scenario (year 2000 dollars)

Impact measures	Startup funds	Equipment	Infrastructure	Revenue
Initial expenditure or revenue ($)	3 155 650	10 000 000	17 000 000	8 708 861
Impacts				
Gross output ($)				
Direct	3 155 650		10 500 000	8 708 861
Indirect and induced	1 744 823		2 398 605	1 655 023
Total	4 900 473	1 894 241	12 898 605	10 363 884
Multiplier	1.55		1.23	1.19
Value added ($)				
Direct	1 935 507		4 207 990	3 137 355
Indirect and induced	2 071 435		5 096 891	1 223 815
Total	4 006 942	1 322 920	9 304 881	4 361 170
Multiplier	1.27		0.89	0.5
Employment (PYs)				
Direct	28		51	47
Indirect and induced	18		25	15
Total	46	14	76	62
Multiplier	1.64		1.49	1.32
Labor income ($)				
Direct	1 619 169		3 814 061	2 630 366
Indirect and induced	798 673		896 159	420 000
Total	2 417 842	551 572	4 710 220	3 050 366
Imports ($)				
From other provinces	137 884	54 872	499 647	245 064
From other countries	348 882	185 758	1 116 237	524 903
Total 486 766 240 630 1 615 884 769 967				
Selected comparative indicators				
Total jobs per million dollars	14.58	1.4	7.24	7.12
Direct jobs per million dollars	8.87		4.86	5.4
Effective direct wage rate ($/PY)	57 827		74 786	55 965
Effective induced wage rate ($/PY)	44 371		35 846	28 000
Effective total wage rate ($/PY)	52 562	39 398	61 977	49 199

Note: PY = person-year.

collect $1.7 million, $1.1 million, and $363 000, respectively.

- The province-wide impacts are much larger than the local impacts. The rest of Ontario would derive the lion's share of both the temporary and sustainable or recurrent impacts. The local economy is too highly disarticulated (disjointed) to retain a significant share of the impacts ofthe project (Figs. 2 to 4).

- The Moose Cree community would retain a total of $20.4 million in value added and 184 PYs in total employment on the temporary impacts (Table 5, columns 2–4). The corresponding sustainable local impacts include $5.3 million in value added and 74 PYs in total employment (Table 5, last column).

- Multipliers are unitless measures that indicate the impacts of unit-dollar initial

Table 5. Local socioeconomic impacts, high scenario (year 2000 dollars)

Impact measures	Startup funds	Equipment	Infrastructure	Revenue
Initial expenditure or revenue ($)	3 155 650	10 000 000	17 000 000	10 519 542
Impacts				
Gross output ($)				
Direct	3 155 650		17 000 000	10 519 542
Indirect and induced	1 744 823		3 883 456	1 999 196
Total	4 900 473	1 894 241	20 883 456	12 518 738
Multiplier	1.55		1.23	1.19
Value added ($)				
Direct	1 935 507		6 812 937	3 789 618
Indirect and induced	2 071 435		8 252 108	1 478 249
Total	4 006942	1 322 920	15 065 045	5 267 867
Multiplier	1.27		0.89	0.5
Employment (PYs)				
Direct	28		83	57
Indirect and induced	18		41	17
Total	46	14	124	74
Multiplier	1.64		1.49	1.3
Labor income ($)				
Direct	1 619 169		6 175 147	3 177 225
Indirect and induced	798 673		1 450 923	476 000
Total	2 417842	551 572	7 626 070	3 653 225
Imports ($)				
From other provinces	137 884	54 872	808 953	296 013
From other countries	348 882	185 758	1 807 241	634 032
Total	486 766	240 630	2 616 194	930 045
Selected comparative indicators				
Total jobs per million dollars	14.58	1.4	7.29	
Direct jobs per million dollars	8.87		4.88	
Effective direct wage rate ($/PY)	57 827		74 399	
Effective induced wage rate ($/PY)	44 371		35 388	
Effective total wage rate ($/PY)	52 562	39 398	61 501	

Note: PY = person-year.

expenditure on a given variable. For example, for the start-up funds in Table 2, dividing the reported total value added by the total expenditure gives a value-added (i.e., GPI) multiplier of 1.86. Similarly, the gross output multiplier of 2.43 is calculated by dividing the total output by the total expenditure. The employment multiplier of 2.54 is a ratio of the reported total employment to direct employment (Table 2, second column).

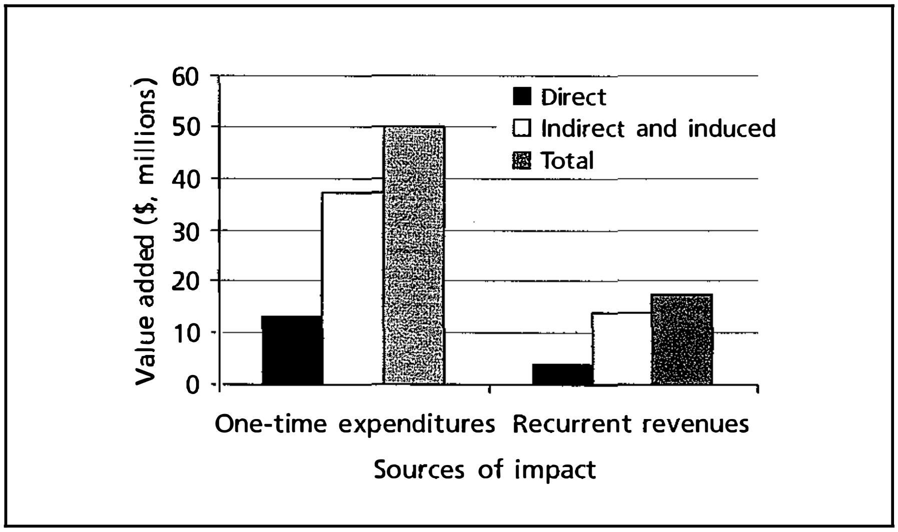

Figure 2. Province-wide impacts in terms of value added, high scenario.

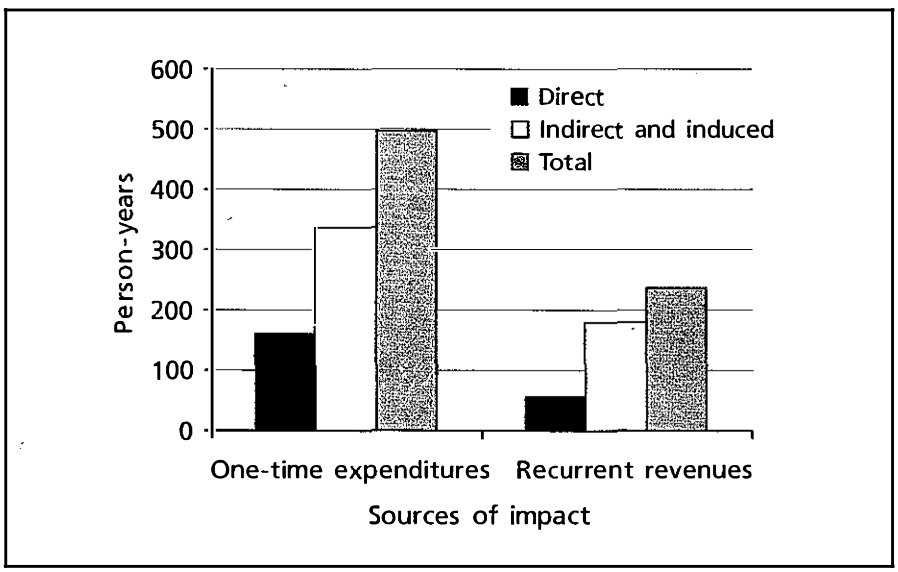

Figure 3. Province-wide impacts in terms of employment, high scenario.

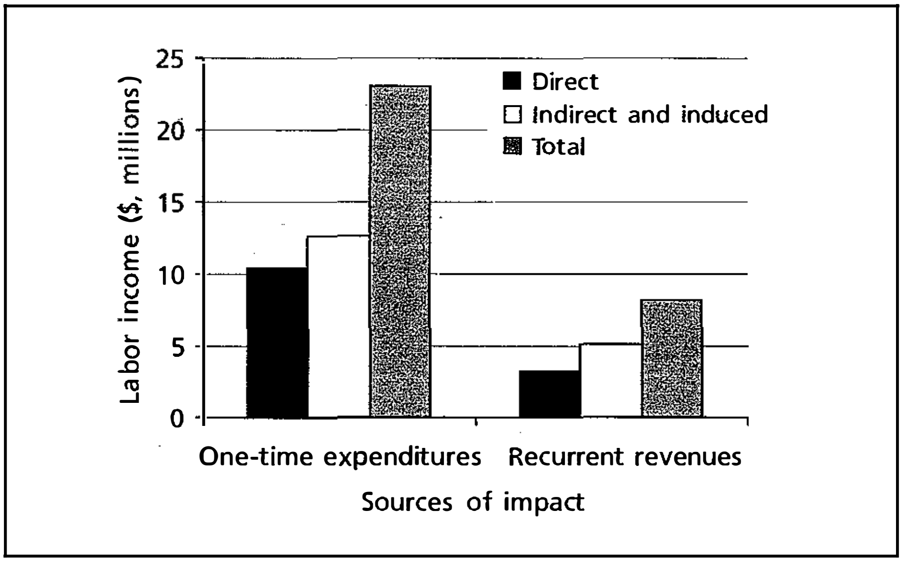

Figure 4. Province-wide impacts in terms of labor income, high scenario.

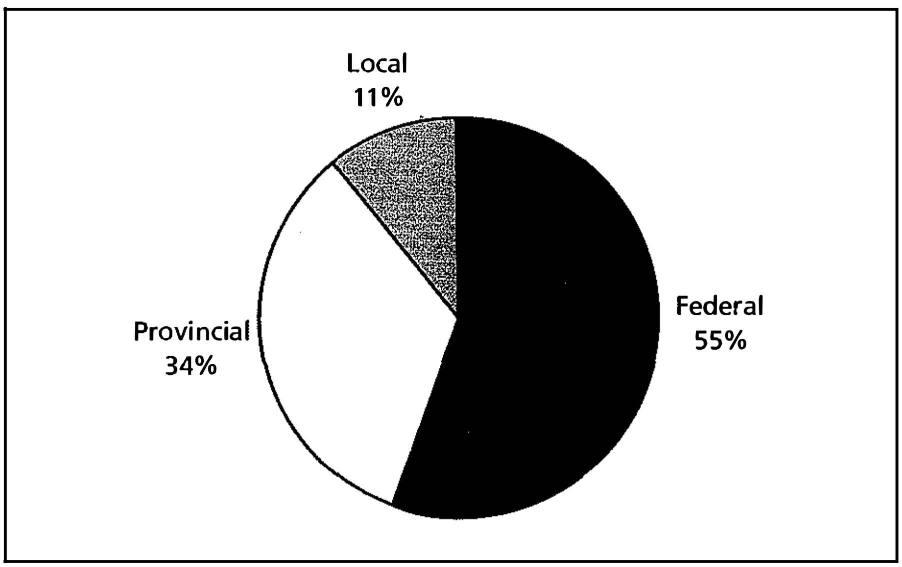

Figure 5. Distribution of total tax impact of temporary expenditures, high scenario.

CONCLUDING REMARKS

We began this paper by highlighting the general concepts dealing with the nature, structure, and dynamics of the relation between the Aboriginal economy and the modern Canadian economy, as they have evolved over time. We have argued that removing the anomalies and asymmetries in this relation could lead to socioeconomic stability of any Canadian First Nation community. For example, compensations or transfer payments will not help much unless they build capacity and infrastructure in the Aboriginal economy. The results of the case study reveal that injection of money that does not build capacity and economic infrastructure will have only temporary effects on the Aboriginal economy, and most of these effects will seep out.

What impediments should be removed so that the disjointed Aboriginal economy is integrated into the modern economy? The poor structure and performance of the Aboriginal economy and its growing dependence on the modern economy are the major forces creating a gap between the two economies. These forces block the positive spread effects and bolster the negative backwash effects. Moreover, three major conditions enable the modern economy to retain its dominance: economies of scale in production; ability to pay premium wages that draw labor from the Aboriginal economy, which pays lower wages; and existence of an elastic supply of labor to the modern economy.

The interaction of the internal economies of scale with the elastic supply of labor generates the external economies that allow the modern economy to prosper while the Aboriginal economy falters. There is yet another factor: the ability of the modern economy to sell its expanded outputs. The negative impacts of these and similar conditions could be profound. Thus, Aboriginal peoples should be able to do better than they have achieved to date. To do so, they must be able to manage their natural resource base and to derive value from their culture and Aboriginal ecological knowledge. They also need appropriate infrastructure, models, and decision support tools, such as ACDIM: Moose Cree 2000. This model provides the community of the Moose Cree First Nation with a balanced view of its Aboriginal economy and its relations with the modern economy and a quantitative base for the evaluation of alternative investment options.

The results of the case study (Tables 2 to 5) demonstrate the usefulness of decision support tools. For example, the annual recurrent revenue of \$10.5 million from the sale of 204 818 m^3 roundwood, at an estimated mill-gate price of \$51.36/m^3, would generate province-wide impacts of 236 PYs in total employment, \$8.2 million in labor income, and \$17.6 million in value added (Table 3). The corresponding impacts of this revenue at the local level would be 74 PYs, \$3.7 million in labor income, and \$5.3 million in value added (Table 5). In addition, that annual revenue would generate \$3.1 million in taxes. Out of this total tax revenue, the local government's share would amount to 12.5%, whereas 50% and 37.5% would accrue to the federal and provincial governments, respectively.

In closing, we recommend the following principles: understanding the traditional ecological knowledge of Aboriginal peoples and the values they place on ecosystems; giving priority to the merits of the basic needs approach to sustainable development; building an Aboriginal community vision and action plans through participatory decision making; encouraging the establishment of a small-scale manufacturing infrastructure for value-added products within the Aboriginal economy (e.g., medium-size sawmills and joinery mills); and integrating the Aboriginal economies into the modern Canadian economy at a slower pace, through systematic elimination of the social, spatial, and technological forms of duality.

ACKNOWLEDGMENTS

This paper is part of a package of deliverables of the ACDIM: Moose Cree 2000 research project, which was funded by the Lake Abitibi Model Forest (LAMF) and the Moose Band Development Corporation (MBDC). We thank Sue Parton, general manager of LAMF, and George Beasely, general manager of MBDC who were both instrumental in the project's success. We acknowledge Deborah Woodman's excellent job in developing the database and in drafting the community profile. The helpful comments of Dr. Bill White and Mr. Joseph De Franceschi, both of the Canadian Forest Service, Dr. Cliff Hickey of the University of Alberta, and Dr. David Butterfield of McMaster University are gratefully acknowledged.

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APPENDIX 1
Theoretical Foundations and Mathematical Structure of ACDIM: Moose Cree 2000

Introduction

Econometric Research Ltd. developed the decision support system ACDIM: Moose Cree 2000. Here we provide an overview of the conceptual foundations and mathematical structure of the model.

The Aboriginal economy is distinct from the modern Canadian economy. It comprises a constellation of sectors cam be readily categorized as formal (traded) and informal (nontraded). Activities in the informal sectors are also known as Aboriginal activities and they typically include labor-intensive or resource-intensive activities, often operating under diminishing returns to the variable inputs. The formal sectors are usually replicas of the modern economy sectors; they coexist with the informal sectors but are rarely interconnected with them.

The calculation of economic impact indicators for Aboriginal communities in Ontario is based on the latest input-output tables for Ontario, which were obtained from Statistics Canada (1996). However, the activity expenditures to be evaluated by the model occurred in 2000 or later and the calculated impacts should therefore refer to the same period. To deal with this incompatibility between parameters in the model and the value units for the input data, all calculations of impacts are done in three stages. First, purchased inputs are converted from current values to 1996 values. Second, all impacts are calculated in 1996 values. Finally, the calculated impacts are converted to current values. Each of these three steps is described below.

Conversion of Inputs to 1996 Values

The conversion of inputs to 1996 values is the simplest part of the model. Each commodity input in 2000 values, $F_{i,00}$, is divided by a corresponding price index, $\mathrm{PI}_{i,00}$ (with a 1996 base), to convert the input to a 1996 value, $F_{i,96}$.

$$F_{i,96} = F_{i,00} / \mathrm{PI}_{i,00} \qquad (1)$$

The labor income input, $W_{f,00}$, must also be converted to a 1996 value, $W_{f,96}$, by dividing by a wage index $\mathrm{WI}_{f,00}$.

Here and elsewhere in the model, where price adjustments are based on published indexes of price changes, a value for 2000 should be understood as one adjusted for price changes up to the end of 2000.

Calculation of Impacts in 1996 Values: The Provincial Input–Output Data System

The impact model is based on the provincial input–output system. This system is made up of three input–output matrices: a "make" matrix, **V**; a "use" matrix, U; and a final demand matrix, **F**.

The typical element of the make matrix, V_{ji}, is the value of commodity i produced by industry j (there are 48 commodities and 36 industries in the system). Thus each industry may, and typically does, produce more than one commodity. The make matrix has as many columns as there are commodities and as many rows as there are industries.

The typical element of the use matrix, U_{ij}, represents the value of commodity i used in production by industry j. Additional rows of the use matrix are organized into a primary input matrix, **Y**, whose typical element, Y_{kj}, represents the value of each primary input k used in industry j. (The primary input categories are noncompetitive imports, indirect taxes, labor income including benefits, net income of unincorporated businesses, and other operating surplus.) These entries describe all the inputs used by each industry in the system.

The final demand matrix, with typical element F_{is}, defines the deliveries of commodities to the various categories of final demand: consumption, investment, government expenditure, exports to other provinces, exports to the rest of the world, and imports from other provinces and the rest of the world. Primary input rows of the final demand matrix are grouped into a matrix **YF**, with typical elements, YF_{ks}.

The organization of these matrices and the corresponding row and column totals may be represented by relation 2:

	Commodities	Industries	Final demand	Row total
Commodities		**U**	**F**	q_i
Industries	**V**			g_i
Primary inputs		**Y**	**YF**	Y^T
Column total	q_i	g_j	f^T	

(2)

The row and column totals designated q_i represent the total value of domestic production of each commodity, the totals designated g_j represent the value of gross domestic output (value of sales) of each industry, the total designated y_{kT} represents the total value of each primary input, and the total designated f_{st} represents the total value of each final demand category.

The row and column totals imply the following accounting relation.

Commodity Balances

$$\sum_j U_{ij} + \sum_s F_{is} = q_i \qquad i = 1, 2, \ldots, n \qquad (3)$$

The value of intermediate and final demand use equals the value of domestic production for each commodity.

Industry Output

$$\sum_i V_{ji} = g_j \qquad j = 1, 2 \ldots, m \qquad (4)$$

The sum of all the values of commodities produced equals the value of gross output of each industry.

Commodity–Industry Composition

$$\sum_j V_{ji} = q_i \qquad i = 1, 2, \ldots, n \qquad (5)$$

The sum of the domestic production of commodity i by all industries equals the total domestic production of commodity i.

Input Structure by Industry

$$\sum_i U_{ij} + \sum_k Y_{kj} = g_j \qquad j = 1, 2, \ldots, m \qquad (6)$$

The sum of intermediate and primary inputs equals the value of gross output of each industry. This follows from the fact that other operating surplus is treated as a residual payment.

Primary Inputs by Type

$$\sum_j Y_{kj} + \sum_s \mathrm{YF}_{ks} = y_{kT} \qquad k = 1, 2, \ldots, p \qquad (7)$$

The sum of industry and final demand uses of each primary input equals total use.

Final Demand Input Structure

$$\sum_i F_{is} + \sum_k \mathrm{YF}_{ks} = f_{sT} \qquad s = 1, 2, \ldots, t \qquad (8)$$

The sum of the values of commodity inputs and primary inputs equals the total value of each final demand category. In addition, the combination of these identities implies two further identities.

Commodity–Industry Totals

$$\sum_i q_i = \sum_i \sum_j V_{ji} = \sum_j \sum_i V_{ji} = \sum_j g_i \qquad (9)$$

The total value of commodity production is equal to the total value of industry gross output.

Final Demand, Primary Input Totals

Because

$$\sum_i \left(\sum_j U_{ij} + \sum_s F_{is} \right) = \sum_i q_i$$

and

$$\sum_j \left(\sum_i U_{ij} + \sum_k Y_{kj} \right) = \sum_j g_j$$

the equality of commodity and industry totals implies

$$\sum_i \left[\sum_j U_{ij} + \sum_s F_{is} \right] = \sum_j \left(\sum_i U_{ij} + \sum_k Y_{kj} \right)$$

or

$$\sum_j \sum_k Y_{kj} = \sum_i \sum_s F_{is} \qquad (10)$$

The sum of the value of all primary inputs over all industries is equal to the sum of the value of all commodities used in final demand. Adding primary inputs used in final demand to each side of the above equation we obtain

$$\sum_k y_{kT} = \sum_k \sum_j Y_{kj} + \sum_k \sum_s \mathrm{YF}_{ks} =$$

$$\sum_s \sum_i F_{is} + \sum_s \sum_k \mathrm{YF}_{ks} = \sum_s f_{sT} \qquad (11)$$

The total value of all primary inputs equals the total value of all final demands.

Input–Output Model

The input–output data system described above can be converted into a macroeconomic model by making assumptions about the relations of various matrix elements to row or column totals.

Market Share Matrix

Assuming that the share of commodity i produced by industry j is fixed, we may write

$$V_{ji} = d_{ji} q_i \qquad (12)$$

where $d_{ji} = \frac{V_{ji}}{q_i}$ represents the proportion of commodity i produced by industry j. This assumption, together with the industry-output identity (Equation 4), implies that industry gross outputs can be calculated from commodity outputs.

$$g_j = \sum_i V_{ji} = \sum_i d_{ji} q_i \qquad j = 1, 2, \ldots, m \quad (13)$$

This commodity–industry composition may also be represented by a market share matrix, $\mathbf{D} = \| d_{ji} \|$, so that the vector of industry gross outputs, $\{g\}$, is related to the vector of commodity gross outputs, $\{q\}$, by the following matrix equation:

$$\{g\} = [D]\{q\} \qquad (14)$$

where { } indicates a column vector and [ ] indicates a matrix.

Thus, the fixed market share assumption implies that the production of the jth (multiproduct) industry is a weighted sum of the commodity outputs that it produces, where the weights are the coefficients d_{ji}. These weights sum to 1 across industries. The relation

$$q_i = \sum_j V_{ji} = \sum_j d_{ji} q_i$$

implies

$$\sum_j d_{ji} = 1 \qquad \text{for } i = 1, 2, \ldots, n \quad (15)$$

Industry–Technology Matrix

The production function underlying the production process is assumed to be of the fixed-proportion type (generally known as a Leontief production function).

$$g_j = \underset{i}{\mathrm{MIN}} \left[\frac{U_{ij}}{b_{ij}} \right] \qquad \text{for } i = 1, 2, \ldots, n; \quad j = 1, 2, \ldots, m \quad (16)$$

where $b_{ij} = \frac{U_{ij}}{g_j}$ is the amount of commodity i needed to produce one unit of output j.

Thus the use of each commodity is assumed to be a fixed proportion of industry gross output:

$$U_{ij} = b_{ij} g_j \qquad (17)$$

This assumption allows the total intermediate use of each commodity to be calculated from the industry gross outputs:

$$\sum_j U_{ij} = \sum_j b_{ij} q_j \qquad (18)$$

If we arrange the input-proportion coefficients in a matrix, $\mathbf{B} = \| b_{ij} \|$, the vector of total intermediate uses of each commodity can be calculated from the vector of industry gross outputs.

$$[\mathbf{U}]\{1\} = [\mathbf{B}]\{g\} \qquad (19)$$

If we let $F_i = \sum_s F_{is}$ represent the total final demand use of each commodity and arrange these in a final demand vector, $\{f\}$, the commodity-balance identities (Equation 3) can be represented in matrix form.

$$\{q\} = \{\mathbf{B}\}[g] + \{f\} \qquad (20)$$

The matrix equation forms of the commodity-industry model (Equation 14) and the commodity-balance model (Equation 20) form the core of the input–output model. These allow the commodity outputs and industry gross outputs to be calculated from a given vector of final demand commodity uses. Substituting Equation 14 into Equation 20, we have

$$\{q\} = \{\mathbf{B}\}\{\mathbf{D}\}[q] + \{f\} \qquad (21)$$

This matrix equation can then be solved for the commodity output vector:

$$\{q\} = [I - \mathbf{BD}]^{-1}\{f\} \qquad (22)$$

The analogy between Equation 22 and the familiar Leontief system $\{q\} = [\mathbf{A}]\{q\} + \{f\}$ is immediately apparent. The matrix **[A]** would be equivalent to the matrix **[B]** if the matrix **[D]** were an identity matrix, which implies that every industry produces only one commodity. In this respect the "square" Leontief framework is inadequate, as changes in the matrix **[A]** may correspond either to a technological change in input proportions or to a shift in market shares. The "rectangular" framework separates these effects.

By premultiplying Equation 22 by the market share matrix, **[D]**, we can solve for industry outputs.

$$\{g\} = [\mathbf{D}]\{g\} = [\mathbf{D}][I - \mathbf{BD}]^{-1}\{f\} \qquad (23)$$

An equivalent mathematical expression to Equation 23 may be obtained directly by first premultiplying the commodity-balance model (Equation 20) by the market share matrix **[D]**:

$$\{g\} = [\mathbf{D}]\{q\} = [\mathbf{D}][\mathbf{B}]\{g\} + [\mathbf{D}]\{f\} \qquad (24)$$

and subsequently solving Equation 23 for the industry gross output vector:

$$\{g\} = [I - \mathbf{DB}]^{-1}[\mathbf{D}]\{f\} \qquad (25)$$

Output–Income Relationship

To calculate the income associated with a given forestry activity vector, further assumptions must be made concerning the primary input matrices. Five basic components define the elements of the matrices **Y** and **YF**. First, there is labor income, which includes the wage payments and benefits in each industry j, W_j, and in each category of final demand s, W_s. Labor income is assumed to be a constant proportion of industry gross output.

$$W_j = w_j g_j \qquad (26)$$

Second, there is net unincorporated business income in each industry j, E_j, and each final demand category s, E_s. Net unincorporated business income in each industry is also assumed to be a constant proportion of industry gross output.

$$E_j = e_j g_j \qquad (27)$$

Third, there is other operating surplus for each industry j, OOS_j, and each final demand category s, OOS_s. Again, this element is assumed to be a constant proportion of gross output in each industry.

$$\mathbf{OOS}_j = \mathbf{oos}_j g_j \qquad (28)$$

Fourth, there are indirect taxes less subsidies in each industry j, T_j, and each final demand category s, T_s. This element is also assumed to be a constant proportion of gross output in each industry.

$$T_j = t_j g_j \qquad (29)$$

Finally, there are noncompetitive imports in each industry j, MNC_j, and final demand category s, MNC_s. As for the other four elements, this element is assumed to be a constant proportion of gross output in each industry.

$$MNC_j = mnc_j g_j \qquad (30)$$

These assumptions allow the calculation of primary inputs associated with a given final demand vector. Once the vector of industry outputs, {g}, has been calculated, it can be used to calculate the corresponding primary inputs. Thus labor income in an industry, W, can be calculated from

$$W = \langle w \rangle \{g\} = \sum_j w_j g_j \qquad (31)$$

where $\langle w \rangle$ denotes a row vector of labor income coefficients, w_j. The total wage bill in the economy, W_T, is then given by

$$W_T = W + W_F \qquad (32)$$

where $W_F = \sum_s W_s$, the total wage income associated with final demand. In a similar manner we can calculate total net unincorporated business income, UIC, and total other operating surplus, OOS.

$$UIC = \langle e \rangle \{g\} + UIC_F = \sum_j e_j g_j + UIC_F \qquad (33)$$

where $UIC_F = \sum_s UIC_s$, the total net unincorporated business income associated with final demand.

$$\text{OOS} = \langle \text{oos} \rangle \{g\} + \text{OOS}_F = \sum_j \text{oos}_j g_j + \text{OOS}_F \quad (34)$$

where $\text{OOS}_F = \sum_s \text{OOS}_s$, the total other operating surplus associated with final demand.

The calculation of total taxes, T, is more complicated, since this equals the sum of indirect taxes less subsidies on industry output and final demand, import duties on competitive imports, and direct taxes on wages, unincorporated business income and profits.

$$T = \langle t \rangle \{g\} + T_F + \langle \text{tm} \rangle \{\text{mc}\} + \text{tax}_1 \times (W_T + \text{UIC}_T) + \langle \text{dt} \rangle \{g\} \quad (35)$$

where

$\langle t \rangle$ is a row vector of indirect tax coefficients, t_j;

$T_F = \sum_s T_s$ is the total indirect tax less subsidies associated with demand;

$\langle \text{tm} \rangle$ is a row vector of import tax coefficients (tariffs), tm_i;

$\{\text{mc}\}$ is a column vector of competitive domestic imports of each commodity, MC_i;

tax_1 is the average income tax rate; and

$\langle \text{dt} \rangle$ is a row vector of average corporate profit tax rate for each industry, dt_j.

There are two types of imports in the model, competitive and noncompetitive. Competitive imports, which make up the larger portion, are imports for which there exist domestically produced counterparts. Noncompetitive imports have no corresponding domestic production. They include items such as coffee beans and tropical fruits. Competitive imports are assumed to represent a constant fraction of total industry and final demand use (exclusive of imports) for each commodity.

$$\text{MC}_i = m_i \left[\sum_j b_{ij} g_j + F_{oi} \right] \quad (36)$$

where m_i is the fraction of total domestic use of commodity i supplied by imports and F_{oi} is the final demand use of commodity i exclusive of imports. In matrix form Equation 36 becomes

$$\{\text{mc}\} = [m][[\mathbf{B}]\{g\} + \{f_o\}] \quad (37)$$

where $[m]$ is a diagonal matrix of m_i values. Noncompetitive imports by industries are related to industry outputs and are added to noncompetitive imports in final demand to calculate total noncompetitive imports, MNC.

$$\text{MNC} = \langle \text{mnc} \rangle \{g\} + \text{MNC}_F \quad (38)$$

where $\text{mnc} = \langle \text{mnc}_j \rangle$ represents the fractions of noncompetitive imports per unit of gross output in each industry j, and $\text{MNC}_F = \sum_s \text{MNC}_s$.

Total imports are the sum of competitive and noncompetitive imports.

$$M = \langle 1 \rangle \{\text{mc}\} + \text{MNC} \quad (39)$$

Domestic Output and Imports

The assumption that competitive imports are proportional to domestic commodity use, as in Equations 36 and 37, requires modification of the commodity balance model (Equation 20). Equation 20 states that

$$\{q\} = [\mathbf{B}]\{g\} + \{f\}$$

where the final demand vector, $\{f\}$, includes negative entries for competitive imports. If we redefine final demand to exclude competitive imports and denote this new value F_{oij}, then

$$\{f\} = \{f_o\} - \{\text{mc}\} \quad (40)$$

and the commodity balance model can be rewritten as

$$\{q\} = [\mathbf{B}]\{g\} + \{f_o\} - \{\text{mc}\} \quad (41)$$

Substituting the competitive import equation (Equation 37) eliminates competitive imports from the commodity balance model.

$$\{q\} = [\mathbf{B}]\{g\} + \{f_o\} - [m^{\wedge}][[\mathbf{B}]\{g\} + \{f_o\}] \quad (42)$$

or

$$\{q\} = [I - m^{\wedge}][[\mathbf{B}]\{g\} + \{f_o\}]$$

Now, use of the commodity–industry model allows calculation of commodity outputs and industry gross outputs from final demand excluding competitive imports. Using the commodity–industry model

$$\{q\} = [I - m^{\wedge}][[\mathbf{B}][\mathbf{D}]\{q\} + \{f_o\}] \quad (43)$$

which implies

$$\{q\} = [I - [I - m^{\wedge}]\mathbf{BD}]^{-1}[I - m^{\wedge}]\{f_o\} \quad (44)$$

and

$$\{g\} = \mathbf{D}\left[I - [I - m^{\wedge}]\mathbf{B}\mathbf{D}\right]^{-1}[I - m^{\wedge}]\{f_o\} \qquad (45)$$

Alternatively, the vector of industry gross outputs can be calculated by premultiplying the commodity-balance model by the "make" matrix.

$$\{g\} = [\mathbf{D}]\{q\} = [\mathbf{D}][I - m^{\wedge}][[\mathbf{B}]\{g\} + \{f_o\}] \qquad (46)$$

which implies

$$\{g\} = \left[I - [\mathbf{D}](I - m^{\wedge})[\mathbf{B}]\right]^{-1}[\mathbf{D}][I - m^{\wedge}]\{f_o\} \qquad (47)$$

Closing the Model

Equation systems 44 and 45 solve only for initial and indirect domestic commodity and industry output. Final demand components are treated as exogenous to the system. This treatment is inadequate because consumption can be expected to be linked to the level of labor income. Thus, a final demand vector that implies a larger labor income should also imply more consumption. When consumption is related to income, the solution of the system includes not only direct and indirect effects, but also "income-induced" effects. Thus the model is completed by adding a relation linking consumption, C, to "income", N:

$$C = bN \qquad (48)$$

where b is the average propensity to consume out of income.

Income is defined as the sum of labor income, W, and net income of unincorporated business, UIC. Thus, income is related to gross industry outputs by the vectors of primary input coefficients w and e.

$$N = \sum_j \left(w_j + e_j\right)g_j + \left(w_c + e_c\right)C + W_{\mathrm{F}} \qquad (49)$$

$$= [\langle w\rangle + \langle e\rangle]\{g\} + \left(w_c + e_c\right)C + W_{\mathrm{F}}$$

where W_{F} is the sum of labor income associated with all final demand components except consumption and competitive imports.

The integration of consumption into the model is completed by assuming that the values of commodities and primary inputs that enter into consumption expenditure are fixed proportions of the total value of consumption:

$$C_i = c_i C \qquad i = 1,2, ..., n \qquad (50)$$

or, in matrix form,

$$\{f_c\} = \{c\}C$$

where c_i is the proportion of consumption used to purchase commodity i and $\{c\}$ is the column vector for values of c_i. A second assumption is also required:

$$W_c = (w_c + e_c)C \qquad (51)$$

where w_c is the proportion of the total value of consumption spent on labor and e_c is the proportion of the total value of consumption that generates net income of unincorporated business.

The income concept defined in Equation 49 does not include dividends, government and private transfers, or income taxes and other direct taxes and may therefore not accurately represent personal income. On the other hand, the inclusion of dividends, government transfers, and direct taxes would require information about the distribution of dividends and other private transfers between Ontario, the other provinces, and abroad, information that is not available.

The inclusion of consumption within the system modifies its structure, which assumes the following configuration:

$$\begin{bmatrix} \dfrac{I - [\mathbf{D}][I - m^{\wedge}][\mathbf{B}]}{-(\langle w\rangle + \langle c\rangle)} - \dfrac{[\mathbf{D}][I - m^{\wedge}]\{c\}b}{1 - \left(w_c + e_c\right)b} \end{bmatrix} \begin{bmatrix} \dfrac{g}{N} \end{bmatrix} = \begin{bmatrix} \dfrac{[\mathbf{D}][I - m^{\wedge}]\{f\}}{W_{\mathrm{F}}} \end{bmatrix} \qquad (52)$$

Calculation of Impacts

The province-wide impacts of forestry-related expenditures are computed by replacing the vector $\{f\}$ in Equation system 52 by the vector of commodity demands associated with a particular type of expenditure, $\{P\}$, where P_{ir} is the demand for commodity i associated with expenditure vector r, and W_{F} by W_r, the direct labor income associated with expenditure vector r. The resulting values of $\{q\}$, $\{g\}$, and N (income) represent the changes associated with these expenditures. Note that Equation system 52 assumes that a constant fraction of each consumption input, P_{ir}, is supplied by competitive imports. For the projects considered in this report, however, it is more reasonable to assume that these commodity inputs are supplied by the Ontario economy. Thus, the terms $[I - m\hat{}]\{f\}$ are replaced by $\{P\}$ in calculating the impacts of forestry activities.

This calculation makes three assumptions: that "marginal" impacts are governed by the fixed proportion and fixed market share assumptions in the model described above, that the marginal impacts are governed by the average numeric values used to specify the input–output model, and that there are sufficient primary resources available to supply the additional demands without leading to changes in primary input prices.

Conversion of 1996 Outputs to 2000 Outputs

As noted at the beginning of this appendix, the input–output table for Ontario that is currently available reflects 1996 prices. Thus, according to the system so far described, the model calculates the 1996 values of project impacts on the basis of input values that have been deflated from 2000 values. These 1996 outputs must be readjusted to 2000 values to obtain an accurate measure of the impacts of activities undertaken in 2000. In the description that follows, "2000 values" for outputs should be understood as values adjusted to account for average price changes from 1996 to the end of 1999.

The basic data required for this adjustment are a set of industry selling price indices, $\text{PG}_{j,00}$ and industry wage indices, $\text{WI}_{j,00}$, which have 1996 as their base year. In addition, price indices for noncompetitive imports, PMNC00, and for consumption, PC00, are required.

Commodity price indices can be calculated from the "make" matrix and the industry price indices using the fixed market share assumption. This assumption implies that commodity price indices are weighted averages of the selling prices of the supplying industries.

$$\text{PQ00}_i = \sum_j d_{ji}\text{PG00}_j \qquad i = 1,2, \ldots, n \qquad (53)$$

Industry gross outputs are adjusted using the industry price indices:

$$g00_j = \text{PG00}_j g96_j \qquad j = 1, 2, \ldots, m \qquad (54)$$

similarly, commodity outputs are adjusted using the commodity price indices:

$$q00_i = \text{PQ00}_i q96_i \qquad i = 1, 2, \ldots, n \qquad (55)$$

The adjustment of labor income by industry is similarly straightforward, using the industry wage indices:

$$N00_j = \text{WI00}_j N96_j \qquad j = 1, 2, \ldots, m \qquad (56)$$

Labor income in consumption is adjusted in a similar manner using the wage index for the personal services industry. Noncompetitive imports in industry and in consumption are adjusted using a common price index for noncompetitive imports, PMNC00:

$$\text{MNC00}_j = \text{PMNC00} \times \text{MNC96}_j \quad j = 1, 2, \ldots, m \qquad (57)$$

$$\text{MNC00}_c = \text{PMNC00} \times \text{MNC96}_c \qquad (58)$$

Indirect taxes by industry and in consumption are calculated assuming that the 1996 indirect tax rates also apply in 2000. (This assumption can be modified to account for known changes to the tax system.) These rates are applied to 2000 values:

$$T00_j = t_j \times g00_j \qquad (59)$$

$$T00_c = t_c \times C00 \qquad (60)$$

where consumption in 2000 values has been calculated by applying the price index for consumption:

$$C00 = \text{PC00} \times C96 = \text{PC00} \times b \times N96 \qquad (61)$$

The only remaining element to adjust to 2000 values is other operating surplus. Following the practice used in calculating constant-price input–output tables, these elements are found residually for each industry and for consumption.

$$\text{OOS00}_j = g00_j - \sum_{i=1} \text{PQ00}_i b_{ij} g96_j - \text{MNC00}_j - T00_j - N00_j \qquad j = 1, 2, \ldots, m \qquad (62)$$

$$\text{OOS00}_c = C00 - \sum_{i=1}^{43} \text{PQ00}_i c_i b N96 - \text{MNC00}_c - T00_c - N00_c \qquad (63)$$

Aboriginal Economy Model

We start with a model first developed by Murphy et al. (1989), which offered a formalization of the Big Push theory set out by Rosenstein-Rodan in "Problems of Industrialisation of Eastern and South-eastern Europe" but which ultimately laid down the foundations of modern trade and growth theory. The model is used here to characterize the present asymmetrical relationship between the Aboriginal economy and the modern Canadian economy and the likely consequences of trade among unequal partners.

Let us begin with two economies or, better still and just to make the point, a single economy with two sectors and a fixed endowment of labor (L). Labor can be employed in either of the two sectors: the Aboriginal sector, characterized by constant returns to scale, or the modern sector, characterized by increasing returns to scale. Labor is not paid the same wage in the two sectors. It is reasonable to assume that labor must be paid a premium to move from Aboriginal to modern employment.

Let w, where $w > 1$, be the ratio of the wage rate that must be paid in the modern sector to that paid in the Aboriginal sector:

$$\omega = \frac{W_m}{W_A} \tag{64}$$

The economy is assumed to produce N goods, where N is a large number. nits are chosen such that labor productivity within the Aboriginal sector is unity in all goods. For the modern sector we assume increasing productivity of labor in all goods, i.e., decreasing costs, which can be presented as follows:

$$L_i = F_i + \alpha Q_i \tag{65}$$

where

Q_i = the production of good i in the modern sector;

F_i = the fixed amount of labor needed to produce Q_i, irrespective of the amount of i; and

α = marginal requirement of labor with $\alpha < 1$.

For simplicity, we assume that the demand for N goods is Cobb-Douglas and symmetric. That is, each good receives a constant expenditure share ($1/N$). Many producers, who are assumed to be price takers, populate the Aboriginal sector. Perfect competition prevails in this sector, and each good has a perfectly elastic supply at the marginal cost of production of unity, given the choice of units. In the modern sector, given the assumption of decreasing cost, a single entrepreneur can produce each good. This unconstrained monopolist in the modern sector cannot, of course, price his or her products above unity, because he or she will face competition from the Aboriginal sector. So, the question becomes, Will production take place in the modern sector or the Aboriginal sector?

Figure A1 can help to answer this question. On the horizontal axis is the labor, L_i, used to produce good i. On the vertical axis is the total output of the two economies, Q_i. The heavy solid lines represent the production technologies of the two economies. The broken 45° line represents the constant return in the Aboriginal economy, while the slope of the line for the modern economy has a slope of $1/\alpha$.

Figure A1 allows us to conceptualize what each economy would produce if all labor were allocated to it. In either case, L/N workers would be employed in the production of each good. If all the goods were produced in the Aboriginal economy, Q_1 of each good would be produced, whereas if all the goods were produced in the modern economy, Q_2 would be produced. Q_2 is always greater than Q_1, provided Equation 66 is satisfied:

$$\frac{L/N - F}{\alpha} < \frac{L}{N} \tag{66}$$

That is, as long as the marginal cost advantage in the modern economy is sufficiently large, or fixed costs are large or both, Equation 66 is satisfied. The modern economy will have a major advantage over the Aboriginal economy, since the marginal cost advantages of the modern economy (with α being very small) are so large that this economy will absorb most of the labor.

The sectors of the provincial model are divided into two groups: provincial and local. The supply of output from a provincial sector is first used to satisfy the regional demands where it is located, and any remaining output is allocated to other regions in declining order of geographic proximity. The closer a given region is to the supplying region, the larger will be its share of the supply of the provincial sectors in the supplying regions. These supplies are assumed to be fixed proportions in any

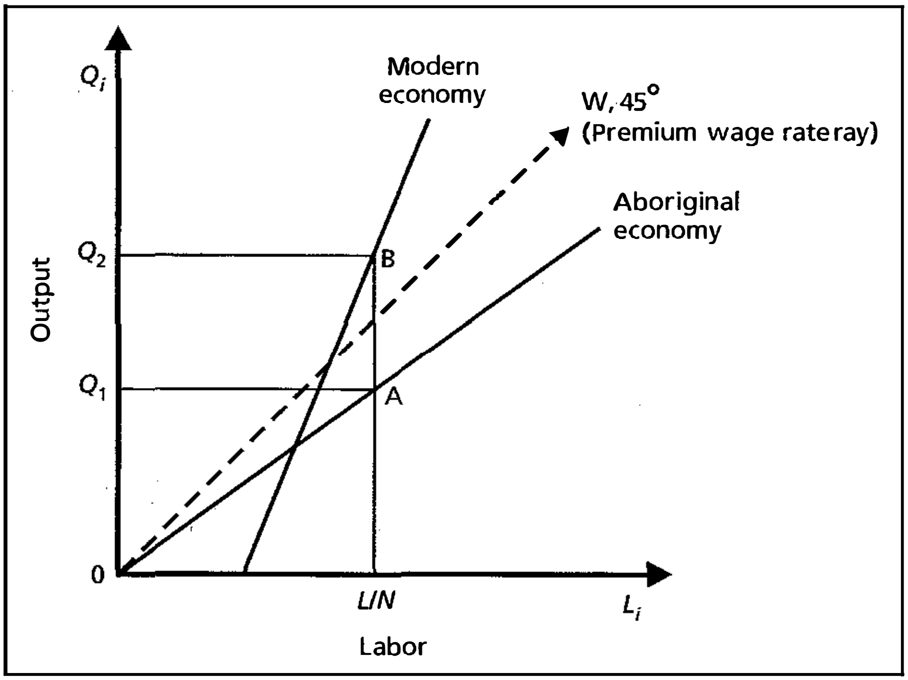

Figure A1. Conceptual relationship between Aboriginal and modern economies (source: Krugman, P.R. 1995. Development, geography, and economic theory. MIT Press, Cambridge, MA. 117 p.).

given region. However, they differ from one region to another for any given sector and from one provincial sector to another for any given region.

Thus, if g_j is the gross output of provincial sector j, then the gross output of sector j originating in region r, g_{jr}, is equal to a weighted sum of fixed proportions, k_{jr}, of g_j. In matrix-vector notation this becomes

$$\{g_r^P\} = [\mathbf{K}_r]\{g^P\} \qquad (67)$$

where

$\{g_r^P\}$ is the vector of industry outputs of provincial sectors in region r,

$\mathbf{K}_r$ is a matrix of coefficients k_{jr} for sector j in region r, and

g^P is the column vector of outputs of the provincial sectors.

The vector of outputs of provincial sectors, $\{g^P\}$, is computed from Equation 52. These outputs are then allocated across regions using Equation 67.

Regional sectors are of two kinds — formal and informal. Both types supply output only in their own region and are the only suppliers of regional output in their own region.

The demand for the output of the formal regional sectors comes from four sources (all net of imports): other final demand, consumption final demand, intermediate demand from other regional sectors, and intermediate demand from provincial sectors located in the region. Thus the demand–supply balance for regional commodities and sectors in region r (Northern Ontario region in this study) can be stated as follows:

$$q_{sr} = \sum_i u_{si} g_{ir} + \sum_j u_{sj} g_{jr} + C_s C_r + f_{sr} \qquad (68)$$

where

i is an index of provincial sectors,

j is an index of regional sectors, and

s and r are indices of regions.

The demand–supply balance for regional industries in a given region can be written as follows:

$$\{g_r^{\mathrm{L}}\} = [\mathbf{A}_{LP}]\{g_r^{\mathrm{P}}\} + [\mathbf{A}_{\mathrm{LL}}]\{g_r^{\mathrm{L}}\} + [\mathbf{D}]\{rC_{\mathrm{L}}\}C_r + [\mathbf{D}]\{rF_{\mathrm{L}}\} \quad (69)$$

where $[\mathbf{A}_{LP}]$ and $[\mathbf{A}_{LL}]$ are original partitions of the matrix in Equation system 52.

$$C_r = b_r Y_r \quad (70)$$

where b_r is the regional marginal propensity to consume.

In addition,

$$Y_r = \sum_{i=1}^{20}(w_i + e_i)(g_{ri}^{\mathrm{P}}) + \sum_{j=21}^{25}(w_j + e_j)(g_{rj}^{\mathrm{L}}) + w_c b_r Y_r + W_r$$

Rearranging the terms in Equations 67–70, we have

$$\left[\frac{A_{\mathrm{PP}}A_{\mathrm{PL}} + DC_{\mathrm{P}}\left(\frac{b}{1-w_{cb}}\right)(w+e)'_{\mathrm{P}}}{A_{\mathrm{LP}}A_{\mathrm{LL}} + D_{\mathrm{CL}}\left(\frac{b}{1-w_{cb}}\right)(w+e)'_{\mathrm{L}}}\right]\begin{bmatrix} g^{\mathrm{P}} \\ g_{\mathrm{L}}\end{bmatrix} + \left(\frac{bw_f}{1-w_{cb}}\right)\begin{bmatrix} c^{\mathrm{P}} \\ C_{\mathrm{L}}\end{bmatrix} + \frac{Df_{\mathrm{P}}}{Df_{\mathrm{L}}} = \begin{bmatrix} g^{\mathrm{P}} \\ g_{\mathrm{L}}\end{bmatrix} \quad (71)$$

Suppose that the initial spending I is initially in region r.

$$\begin{bmatrix} F_I^{\mathrm{P}} \\ F_I^{\mathrm{L}} \\ W_I \end{bmatrix}$$

Then in region r

$$g_r^{\mathrm{L}} = [\mathbf{A}_{\mathrm{LP}}]\{g_r^{\mathrm{P}}\} + \left[\mathbf{A}_{\mathrm{LL}} + \mathbf{D}_{\mathrm{CL}}\frac{b}{1-w_{cb}}(w+e)'_{\mathrm{L}}\right] \times \{g_r^{\mathrm{L}}\} + \frac{b}{1-w_{cb}}w_r\{c_{\mathrm{L}}\} + \{F_r^{\mathrm{L}}\}$$

or

$$\{g_r^{\mathrm{L}}\} = \left[I - [\mathbf{A}_{\mathrm{LL}}] - [\mathbf{D}]\{C_{\mathrm{L}}\}\frac{b}{1-w_{cb}}(w+e)'\right]^{-1} \times \left[[\mathbf{A}_{\mathrm{LP}}][\mathbf{K}]_r\{g^{\mathrm{P}}\} + \frac{bw_r}{1-w_{cb}}\{C_{\mathrm{L}}\} + \{F_r^{\mathrm{L}}\}\right] \quad (72)$$

for $s\langle\rangle r$, $F_s^{\mathrm{L}} = 0$, and $w_s = 0$.

In addition,

$$\{g_s^{\mathrm{L}}\} = \left[I - [\mathbf{A}_{\mathrm{LL}}] - [\mathbf{D}]\{C_{\mathrm{L}}\}\frac{b}{1-w_{cb}}(w+e)'_{\mathrm{L}}\right]^{-1} \times [[\mathbf{A}_{\mathrm{LP}}][\mathbf{K}]_s\{g^{\mathrm{P}}\}] \quad (73)$$

such that

$$\{g^L\} = \{g_r^{\mathrm{L}}\} + \sum_{s\langle\rangle r}\{g_s^{\mathrm{L}}\}$$

Alternatively,

$$\{g^{\mathrm{L}}\} = \left[I - [\mathbf{A}_{\mathrm{LL}}] - [\mathbf{D}]\{C_{\mathrm{L}}\}\frac{b}{1-w_{cb}}(w+e)'_{\mathrm{L}}\right] \times \left[[\mathbf{A}_{\mathrm{LP}}]\{g^{\mathrm{P}}\} + \frac{bw_r}{1-w_{cb}}\{C_{\mathrm{L}}\} + \{F_r^{\mathrm{L}}\}\right] \quad (74)$$

Upon proper substitution of terms, we end up with the following expressions:

$$\{g^{\mathrm{P}}\} = [\mathbf{M}]\left[([\mathbf{N}]\{C_{\mathrm{L}}\} + \{C_{\mathrm{P}}\})C\times_{\mathrm{F}} + [\mathbf{N}]\{F_r^{\mathrm{L}}\} + \{F_r^{\mathrm{P}}\}\right] \quad (75)$$

$$\{g_r^{\mathrm{L}}\} = [\mathbf{P}]\left[A_{\mathrm{LP}}K_r M(N_{\mathrm{CL}} + C_{\mathrm{P}}) + C_{\mathrm{L}}\right]C\times_{\mathrm{F}} + [A_{\mathrm{LP}}K_r MN + I]F_r^{\mathrm{L}} + [A_{\mathrm{LP}}K_r M]F_r^{\mathrm{P}} \quad (76)$$

$$\{g_s^{\mathrm{L}}\} = [\mathbf{P}]A_{\mathrm{LP}}K_s M[[N_{\mathrm{CL}} + C_{\mathrm{P}}]C\times_{\mathrm{F}} + NF_r^{\mathrm{L}} + F_r^{\mathrm{P}}] \quad (77)$$

where

$$\mathbf{M} = [I - A_{\mathrm{PP}} - A_{\mathrm{PL}\times}(I - A_{\mathrm{LL}\times}) - 1A_{\mathrm{LP}}]^{-1}$$

$$\mathbf{N} = A_{\mathrm{PL}\times}(I - A_{\mathrm{LL}\times})^{-1}$$

$$C\times_{\mathrm{F}} = \frac{bw_r}{1-w_{cb}}$$

$$A_{\mathrm{LL}\times} = A_{\mathrm{LL}} + D_{\mathrm{CL}}\frac{b}{1-w_{cb}}(w+e)'_{\mathrm{L}}$$

$$A_{\mathrm{LP}\times} = A_{\mathrm{PL}} + D_{\mathrm{CP}}\frac{b}{1-w_{cb}}(w+e)'_{\mathrm{P}}$$

Exports

We distinguish between two types of exports in much the same way we segregated imports into those originating in other provinces and those originating outside Canada. This distinction is useful inasmuch as it permits the proper calculation of the contribution of forestry activities to the overall balance of payments deficit in Ontario relative to the rest of the world. This deficit is significantly different from the balance of payments with the other provinces in that it does not involve the loss of foreign exchange and does not alter the value of the Canadian dollar.

Exports to other provinces and those to the rest of the world are both assumed to be a constant fraction of intermediate and final use of domestic commodities in Ontario.

$$EX_i^{P} = h_i^{P} q_i \qquad (78)$$

$$EX_i^{RW} = h_i^{RW} q_i \qquad (79)$$

where h_i^{P} and h_i^{RW} are the fractions of commodity i that Ontario exports to other provinces and to the rest of the world, respectively. The informal regional sectors satisfy local demand, and some of their products may be exported to the formal regional sectors or provincial sectors or both. Production in the informal regional sectors depends solely on labor.

The Aboriginal (informal) regional economy is assumed to produce *N* goods, where *N* is a limited number. Units are chosen such that labor productivity within the Aboriginal economy is unity in all goods, which signifies constant returns to labor.

There are no backward linkages among sectors in the Aboriginal regional economy. All of the sectors in this economy can be organized as a diagonal matrix. The amount of output in these sectors is just proportional to the labor inputs required to produce it. The values of these labor inputs are evaluated at their opportunity costs in the formal sectors, where the wage economy dominates and the labor market determines wages.

Social Impacts

The economic system does not operate in a vacuum. Rather, it is strongly connected to the social and environmental systems. For example, it is difficult to portray the community system fully in terms of purely economic indicators. There exists a host of social indicators that complement and substantiate the economic indicators discussed here. Furthermore, it is difficult to separate the social from the economic indicators. The two sets of indicators intersect and reinforce one another.

Two basic sets of social indicators are singled out in our study. The first pertains to wealth (property) variables that connect flow economic variables to property values and the local tax base. They also relate new economic values to their existing magnitudes. The second set of indicators attempts to measure the extent of dependency of the community on its dominant sectors. These measures reflect the stability and vulnerability of the community to outside shocks.

A special screen is devoted to the presentation of general social indicators. Among them are the average price of a house, the average annual wage, increases (or decreases) in house prices over current average, increases (or decreases) in wages over average annual wages, and increases (or decreases) in total property values.

The determination of the change in average house prices is based on an observed stable relation between housing prices and household incomes. This relation is complex but straightforward:

$$\mathrm{AHP}_t = \mathrm{AW}_t \times (\mathrm{AHP}/\mathrm{AW})_{t-1} \qquad (80)$$

where

AHP = average house price and

AW = average annual wage.

This is a simplified version of the equation we use, which entails relating mortgage values to appraised property value and relating maximum mortgage values to household incomes. The latter are also demographic multiples of average annual wages.

$$\mathrm{PV} = TLI \times (\mathrm{AHP}/\mathrm{AW})_{t-1} \qquad (81)$$

where

PV = total property value and

TLI = total labor income.

$$PT = MR \times PV \quad (82)$$

where

PT = total property taxes and

MR = mill rate.

$$BT = BTR \times GO \quad (83)$$

where

BT = local business taxes,

BTR = business tax rate, and

GO = gross sales.

With regard to dependency, two ratio measures were developed. The first attempts to measure the excess of local employment in a particular basic sector over the provincial average. To the extent that the community shows a higher share of employment in basic sector *j* than the province does, the community is said to be that much more dependent on this sector than the province is.

$$D_j = \frac{E_{rj} \Big/ \sum_j E_{rj}}{\left(\sum_r E_{rj} \Big/ \sum_r \sum_j E_{rj} \right)} \quad (84)$$

where

D_j = dependency ratio for sector *j*,

E_j = provincial employment in sector *j*, and

E_{rj} = community employment in sector *j*.

The share of direct employment in sector *j* may not be an appropriate measure of the extent of dependency and the importance of sector *j* in the local economic base. The closure of a mill not only deprives a community of direct employment in the mill but also involves contractions in other sectors linked indirectly to it. This is why we present the total added employment in the community as a multiple of the added direct employment in sector *j*. A value of, say, 2.0 for this multiplier suggests that the community derives one job outside sector *j* for every direct job in sector *j*.

Glossary

Employment Employment is explained in terms of person-years (PYs). In addition to direct PYs, it captures indirect and induced jobs associated with a given investment project, such as timber-harvesting operations. In some cases, direct employment may not be an important socioeconomic element of a given operation. The multiplier effects, revealed through the indirect and induced impacts, could have more significant policy implications.

Factor-price equalization Factor-price equalization is a proportion derived from the Heckscher-Ohlin approach to international trade, which argues, on a restrictive set of assumptions, that free trade is a perfect substitute for factor mobility and will have the effect of equalizing the rate of payment to any factor of production throughout the world, i.e., the wage rate should be the same in all countries. Apart from the obvious need for free trade and absence of transport costs, other crucial assumptions must be fulfilled, such as closeness in the factor endowments of countries and absence of factor reversals.

Gross output Gross output is the total value of goods and services sold by a business to sustain a given operation. Direct sales include the value of all goods and services bought for on-site operations. They include only a portion of the revenues of the activity, excluding taxes, depreciation, wages and salaries, and net profits. Total sales include the value of all goods and services needed to sustain the activity. Although it involves multiple double-counting (unlike value added), gross output is a good indicator, because it portrays the expected gross revenues to all business sectors within the economy. It is also used for calculating sales taxes and many other economic variables.

Labor income Labor income is the total bill of wages and salaries, which represents compensation for labor. It also includes benefits on incomes. The difference between total income and labor income provides a measure of property income. In this way, the ratio of labor income to total income and the ratio of labor income to property income are good indicators of the distribution of income in the economy. These ratios are also good measures of the intensity of labor use in the economy.

Multipliers Multipliers are unitless measures derived by adding direct, indirect, and induced effects (i.e., total effects) and dividing the total thus derived by the original expenditure (or gross revenue). For example, the income multiplier associated with a given activity is equal to income divided by the initial expenditure (i.e., gross revenue). Only the employment multiplier is calculated differently. It is computed by dividing total employment effect in person years (PYs) (direct + indirect + induced) by only direct employment. This is necessary because dividing total PYs by the dollar value of gross revenues (total initial expenditure) would not yield a unitless measure. However, there is another useful variant of the labor force related multiplier: the ratio of total employment effect to initial expenditures. This multiplier is a good indicator of the labor intensity of the project under review.

Opportunity cost The opportunity cost of an action is the value of the foregone alternative action. Opportunity cost can arise only where resources are scarce. If resources were limitless, no action would be at the expense of any other—all could be undertaken—and the opportunity cost of any single action would be zero. But in the real world of scarcity, opportunity cost is always positive. Thus, the term "cost" in economics refers to opportunity cost, and hence accountants and economists define the cost of an action quite differently.

Taxes ACDIM: Moose Cree 2000 generates estimates for several types of taxes, including personal income tax, provincial sales tax, goods and services tax, tariffs, corporate profit tax, property and business taxes, and tobacco and liquor taxes. The model displays the amount of each tax type collected by each level of government: federal, provincial, and local (municipal).

Value added Value added is a measure of net output within the economy. It avoids double-counting of products sold during the accounting period by including only the final value of goods and services. For example, if a farmer sells wheat to a mill, which in turn sells its flour to a bakery, the total value of bread sold by the bakery includes the value of wheat and flour sales, and the value of the flour sold by the mill includes the value of wheat sales. In this process, the value of wheat sales is included three times, first as wheat, second as flour, and third as bread. Conversely, only the value of bread is considered as value added, because this amount removes the double-counting of flour and the triple-counting of wheat. Value added for the provincial economy as a whole is equal to gross provincial income. It can be calculated by adding wages, interest, rent, and profits. Alternatively, it can be computed as a difference between total revenue and total cost of purchased inputs needed to sustain these sales. Value added is used to calculate the value of final products. It sums the net contribution to output at each stage of production.