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Applied General Equilibrium Analysis Of Customs Unions And Interregional Labour Mobility

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Canada

Applied General Equilibrium Analysis of Customs Unions and Interregional Labour Mobility

by

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Department of Economics

Submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy

Faculty of Graduate Studies
The University of Western Ontario
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Abstract

This thesis develops various extensions and applications of applied general equilibrium modelling techniques. Essay I deals with the modelling of labour migration and builds on the regional numerical general equilibrium model of Canada developed by Jones and Whalley (forthcoming). Their limited migration decision rule is extended to involve a comparison of relative utility levels across regions. The major implication for model results is that measured migration responses may be dampened under certain policy simulations; this can result in different conclusions being drawn from simulation exercises.

Essay II considers the application of this model to the study of the Canadian equalization system and its influence on interregional labour migrations in Canada. While authors such as Courchene (1984) have argued that equalization may result in labour allocation inefficiencies in Canada, Boadway and Flatters (1982) have proposed that due to the existence of regionally concentrated resource rents, properly allocated equalization may result in increased efficiency in the allocation of labour in Canada. Simulations are performed to assess the effects of equalization payments and regional resource rents on labour allocation efficiency in Canada. The results suggest that the interactions required by the Boadway and Flatters's analysis may not exist; equalization may be reducing gains which could arise from the migration incentives of the regional resource rents.

The analysis of Essay III involves numerical simulations using a pure exchange model with three countries and three goods. Non-cooperative strategies are characterised by Nash retaliatory tariffs and customs union formation is analysed for the case when the union's external tariffs are strategically set to benefit the union and lump-sum intra-union transfers are not available. The use of non-zero intra-union tariffs as an alternative transfer mechanism is explored. Results presented here suggest that the presence of non-zero intra-union tariffs may reduce the gains which can arise from union formation. More importantly though, these tariffs can alter the strategic options available to the trading nations. Non-zero intra-union tariffs can allow a union to be the optimal strategy for all its members, whereas in the intra-union free trade case the union is an inferior strategy for some.

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On a more personal level, I would like to thank my family for tolerating this portion of my life. I have missed many days in the lives of my children: Emillie, Lorien, and Christopher. Most of all, I want to thank my wife, Sherill Enns, for her unmeasurable love, support, endurance, and forgiveness through all of this.

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INTRODUCTION AND OVERVIEW OF THESIS

In recent years, the techniques of applied general equilibrium modelling have been used to analyze a wide range of economic problems. This thesis considers two further applications/extensions of this modelling. Essay I deals with the modelling of labour migration in a regional numerical general equilibrium model of Canada. Essay II considers the application of this model to the study of the Canadian equalization system and its influence on interregional labour migrations in Canada. Essay III describes a small-scale numerical general equilibrium model for the analysis of issues of customs union formation. In particular, the influence of non-zero intra-union tariffs on the distribution of the gains from union formation is considered.

Essay I builds on the regional numerical general equilibrium model of Canada developed by Jones and Whalley (forthcoming). This model was developed chiefly for the analysis of the regional impacts of Canadian federal government policies. The influence of federal and provincial policies on labour migrations in Canada has been considered an important issue since at least Courchene (1970), when he analyzed the effects of the federal government's system of equalization payments and unemployment insurance on labour migration. In their numerical general equilibrium model of Canada, Jones and Whalley employ a novel labour migration decision process by which labour distributes itself across the regions of Canada. Migration decisions in the Jones–Whalley model are influenced by both economic and non-economic factors so that changes in economic variables such as wages will invoke only "partial" migration responses. The non-economic factor involves location specific preferences.

The Jones–Whalley implementation of the underlying migration decision rule is not entirely satisfactory. For example, labour's decision to migrate is based upon the relative values of only three economic variables: regional wage rates, regional receipts of transfer payments from the federal government, and regional resource rents. Essay I describes an extended version of the Jones–Whalley model in which the migration decision process involves a comparison of relative utility levels across regions. While computational problems required that a less than ideal migration rule be used, a more general modelling framework for the analysis of regional issues in Canada has been developed. The major implication for model results is that measured migration responses may be dampened under certain policy simulations. As is described in essay II, this can result in different conclusions being drawn from simulation exercises.

Essay II describes an application of this enhanced model to an important Canadian issue: the effect of the Canadian system of equalization payments to the provinces on the efficient distribution of labour across Canada. A considerable amount of theoretical analysis has been devoted to this topic and various competing theories have been presented. Courchene (1984) has argued that equalization payments to a region will interfere with the labour market clearing capabilities of wage rates in Canada and, therefore, introduce inefficiencies through the misallocation of labour in Canada. Boadway and Flatters (1982) have proposed that equalization may, in certain circumstances, result in increased efficiency in the allocation of labour in Canada. They argue that regionally concentrated natural resources may interfere with the market clearing capabilities of wage rates across Canada and result in inefficient migrations from the resource-poor to the resource-rich regions. They propose that equalization, when properly implemented, may be used to counter the migration incentives presented by natural resources, thereby preventing the inefficient migration and improving welfare. Courchene (1984) and Dales (1983) have argued that the economic scenario required for the Boadway/Flatters analysis to work does not exist and, furthermore, the current equalization system does not satisfy the conditions required for it to lead to increased labour allocation efficiency under such a scenario. Both Courchene and Dales have suggested that an improperly implemented equalization scheme aimed at following the Boadway/Flatters theory may result in larger losses to Canada.

The first set of simulations presented in this essay attempts to assess the possible welfare impacts on Canada of the equalization system. These simulations suggest that while equalization may result in labour allocation inefficiencies, the income effects of the actual transfers can result in an overall gain to Canada. Simulations are also performed to assess the effects of regional resource rents on labour allocation efficiency in Canada. The results suggest that the migrations induced by the presence of these rents may increase labour allocation efficiency and yield a welfare gain for Canada. This presents ~~a~~ scenario which is substantially different from that considered by Boadway and Flatters and suggests that the interactions required by their analysis may not exist; if equalization does, in fact, retard out-migration from equalization receiving regions, then it may be reducing the gains to Canada which could arise under the migration incentives of the regional resource rents. Furthermore, results are presented which suggest that an equalization scheme aimed at removing the migration incentives of resource rents could remove these gains almost completely.

The final essay of this thesis deals with the formation of customs unions between nations. Kemp and Wan (1976) have shown that if transfers could be made between countries then a customs union solution (defined by a set of common external tariffs and a system of lump-sum transfers) would exist which would make all members better off relative to a non-cooperative state. Furthermore, they showed that a solution would exist which would make enlarging the union better for all members, so that a set of transfers must exist which makes all countries better off under complete free trade. While this model presents an important argument for the movement to freer trade between nations, Kemp and Wan have outlined the reasons why their model is not directly applicable to the real world. McMillan (1986) presents two clear arguments. Firstly, tariffs are set passively even though as a union gets bigger its ability to strategically influence its terms-of-trade increases. Secondly, lump-sum transfers between nations may not be politically feasible.

The analysis in this essay attempts to study the possibility of gains to all members from union formation when the union's external tariffs are strategically set to benefit the union and lump-sum intra-union transfers are not available. While the inability to use intra-union lump-sum transfers should restrict these possibilities, Dixit and Norman (1980) have suggested that non-lump-sum transfers might be used to redistribute gains between members of a customs union. The use of non-zero intra-union tariffs as such a transfer mechanism is explored.

The analysis involves numerical simulations using a pure exchange model with three countries and three goods. Non-cooperative strategies are characterized by Nash retaliatory tariffs and, due to the modelled capability for customs union formation, a mixture of cooperative and non-cooperative strategies can occur in an equilibrium. The modelling of Nash retaliatory tariffs is based on Johnson's (1958) work on optimal tariffs and retaliation. Since the model is an extension of Johnson's 2x2 analysis to a higher dimensional case, his observations on the possible gains from cooperative and non-cooperative trading strategies can be considered for the case of customs union formation. For the simple examples examined here, these observations appear to hold.

Results presented here suggest that the presence of non-zero intra-union tariffs may reduce the gains which can arise from union formation. More importantly though, these tariffs can alter the strategic options available to the trading nations. Non-zero intra-union tariffs can allow a union to be the optimal strategy for all its members, whereas in the intra-union free trade case the union is an inferior strategy for some. Details of the possible consequences of alternative intra-union tariff specifications are explored.

ESSAY I

LABOUR MIGRATION MODELLING IN A REGIONAL MODEL OF CANADA

1. INTRODUCTION

In some earlier work, Jones and Whalley (forthcoming) develop a regional numerical general equilibrium model of Canada for the analysis of federal and regional government policies in Canada. A novel feature of this model is the process by which labour migrates between regions: while the decision to migrate is influenced by economic factors, non-economic factors are also an important determinant of any migration. In particular, labour is assumed to have a preference for the region in which it was located before any policy simulations were initiated in the model. These location specific preferences allow labour to be associated with a particular region so that the impacts of policies on a region's population can be identified and analyzed. In many models of international trade, the effects of policy changes on a region's population are analyzed under an assumption of complete labour immobility across regions. However, this would not be appropriate for the study of policy in Canada since interregional labour migrations could also be an important consequence of any policy. The Jones-Whalley formulation of partial migration responses and location specific preferences allows both of these important areas of policy impact to be considered.

Whalley and Trela (1986) employ the Jones-Whalley model for the analysis of Canadian federal and regional government policies. One feature of this model that their analysis highlights is that the degree to which labour responds to economic incentives to migrate can be an important determinant of the measured welfare impact of some policy change. The accuracy of any estimated impact is dependent, in part, on two features of the modelling of the migration process: the parameters chosen for the functional forms of the migration functions, and the functional forms themselves.

Most important to the Jones–Whalley model are certain elasticities which determine the responsiveness of labour migrations to changes in economic factors. Whalley and Trela report the welfare impacts of various policies for a range of these elasticity values; they do not, however, alter the functional form of the migration decision rules.

The Jones–Whalley implementation of the underlying migration decision rule has not been well documented, so one goal of this essay is to present a full description of this process. More importantly though, their modelling of this process is not entirely satisfactory. Labour's decision to migrate between regions is based upon the relative values of only three economic variables: regional wage rates, regional receipts of transfer payments from the federal government, and regional resource rents. Important factors such as relative price levels are not considered. Since the Jones–Whalley model of Canada contains completely specified utility functions, a migration decision process could involve a comparison of relative utility levels across regions. Such an approach would provide a more generalized modelling of the influence of changes in economic factors on labour's migration decision. This essay describes a model which is an extension of the Jones–Whalley formulation to this case.

Another unsatisfactory feature of the Jones–Whalley migration process is the fixed coefficient function by which migrating labour is distributed over the set of recipient regions. One problem with this approach is that incentives for migration between regions may still exist even though model solution criteria have been met. A more general approach would be to allow labour to migrate to the region in which the highest utility level can be achieved. While procedures employing this latter formulation were implemented, computational problems required that the less-than-ideal migration rule of the Jones–Whalley model be used.

In extending the Jones–Whalley model so that an increased number of factors influence the migration decision, the measured out-migration response induced by certain policy changes was expected to be dampened. In particular, the influence of the Canadian equalization system on migration decisions was expected to be reduced. To test this, a set of simulations performed by Whalley and Trela was rerun under the new formulation. A comparison of the results supports the above conjecture. As will be seen in essay II of this thesis, one result of this change is that some arguments made by Whalley and Trela concerning equalization are not strongly supported.

2. THE JONES–WHALLEY REGIONAL MODEL OF CANADA

This section provides a brief description of the structure of the Canadian regional model (CRM) as found in Jones and Whalley (forthcoming). This description provides some necessary background for the discussion of the issues involved in modelling labour migration in a regional numerical general equilibrium (NGE) model. A more detailed description of the CRM is presented in Appendix I.

In the Canadian regional model, Canada is divided into six regions: Atlantic Canada, Quebec, Ontario, Manitoba/Saskatchewan, Alberta, and British Columbia. A seventh region, the rest of the world (ROW), represents Canada's largest trading partner, the United States.

Each region produces six goods which, due to the use of the "Armington assumption" (Armington (1969)), are different from the goods produced by any other region. Thus, forty-two goods are produced in the world. In Canada, production of non-energy goods involves capital, labour, and intermediate products (other goods) as inputs. The energy industry uses natural resources, labour and intermediate products. Intermediate use is determined through constant elasticity of substitution (CES) functions which are nested over all sources of goods. In ROW, only capital and labour are used in production, and no intermediate use is modelled.

Each region contains a single consumer type which maximizes nested CES utility functions subject to the region's budget constraint. All goods except the public services good in each region are traded, so the consumer's choice set involves the six locally produced goods and thirty imports. Except for a small portion of the capital stock which is owned by the federal government, the initial endowments of labour, capital, and natural resources in a region are all owned by the initial residents of the region. Consumer income arises from these sources and also from the two levels of government which are modelled. Various types of taxes are levied by each regional government and the revenue that is collected is returned lump-sum to the consumers in the region and appears as part of their income. Each Canadian region also receives intergovernmental transfers from the federal government, which are also distributed lump-sum to the consumers. Regional government expenditures and services are represented by consumer purchases of the non-traded regional public services good in each region.

The federal government levies taxes and subsidies on all Canadian regions and collects income from its capital ownership in each region. Portions of the collected revenues are distributed to the regional governments as intergovernmental transfers and to the consumers as interpersonal transfers. The remainder is used for the purchase of goods and services from the regions since, unlike the regional governments, the federal government is modelled as an individual which maximizes its utility subject to a budget constraint. Note that this implies that federal expenditures have no direct effect on regional welfare.

As mentioned above, factors initially within a region are assumed to be owned by the initial inhabitants of the region. Lack of data on interregional capital and resource ownership patterns forces this simplistic assumption to be made. Capital is assumed to be intersectorally, interregionally, and internationally mobile. Natural resources are assumed to be only interregionally mobile. Labour is assumed to be intersectorally mobile, internationally immobile, and interregionally partially mobile. This latter feature will be discussed in more detail later.

The 1981 data set used by Jones and Whalley is described in detail in St-Hilaire and Whalley (1983,1985). This data set and a set of model elasticity values provide the key inputs to the first stage of the policy simulation process. This step is called model calibration and can be described as the use of model equilibrium conditions and equilibrium data to solve for parameter values used to represent the model equations.

That is, a set of parameters is selected for the equations of the model such that data which characterise an observed equilibrium can be reproduced as a model equilibrium solution. Only when the model is fully specified and a policy change incorporated is the model solved for a new equilibrium. The observed equilibrium to which the model is calibrated is called the "benchmark" equilibrium, while the new equilibria calculated after policy changes are called "counterfactual" equilibria.

Elasticity estimates enter the calibration process by serving as identifying restrictions, allowing the other parameter values to be calculated. Different elasticities produce changed values for the other parameters of the model, so selecting the appropriate elasticity values is central to the model specification process. Most important to the simulations presented here are the labour migration elasticities and these will be discussed in detail in later sections.

3. MODELLING LABOUR MIGRATION IN THE CRM

As discussed in the Introduction, the model described in this essay extends the migration decision rules of the Jones–Whalley CRM to a more general case. This new modelling provides a more satisfactory solution to just one of the numerous issues which must be addressed when interregional labour migration is to be implemented in a NGE model such as the CRM. These issues are discussed in this section, while the modelling procedures required to address them are described in the following section.

Given that individual utility functions are completely specified in the CRM, then individual utility levels could be directly used as the basis for the migration decision process. For example, if individual i in a region is deciding whether to migrate to an outside region, he migrates only if the utility available in the outside region, U_i^L, is greater than that from remaining, U_i^R. Extending this simple example to a large scale NGE model such as the CRM raises the following issues:

1. If the original inhabitants of a region are modelled as having a utility function which is different from that of individuals in other regions, does a migrating individual retain his original utility function or does he adopt that of the receiving region?

   If the utility level available in some outside region is greater than that of the home region, what will determine which of the identical individuals will migrate? Furthermore, if utility is greater in more than one outside region, what will be the migration pattern to these regions?

   Most NGE models involve one of two polar assumptions—either perfect labour mobility between regions, or complete labour immobility. Neither of these is entirely appropriate in an evaluation of the regional impacts of federal policies in Canada. Under the assumption of perfect labour immobility, the effects of policies on labour migration are not captured. On the other hand, an assumption of perfect labour mobility does not allow the direct association of labour with any region. In this case, the issue of whether individuals in regions gain or lose from certain policies cannot be meaningfully addressed. Some process is needed which is capable of embodying partial labour mobility responses which are somewhere between the two extremes.

2. Migration function parameters will be calibrated to a benchmark data set which, following standard NGE modelling practices, is assumed to represent an equilibrium situation. Thus, incentives to migrate are assumed to be absent in the benchmark. Given the nested structure of the CES utility functions used in the CRM, benchmark utility levels will probably not be equal across regions. Furthermore, an individual in any region will not necessarily perceive that his utility level from residing in an outside region is equal to the home region level. The functional form for the migration function and the benchmark calibration of its parameters must, therefore, present these differences as a situation in which migration incentives are absent.

   Consider an example employing the simple case from above. In the benchmark, the individual should observe $U_i^R = \overline{U}_i^L$, where U_i^R is the utility available from goods consumption in the home region and $\overline{U}_i^L$ is the perceived utility from residing in the outside region. This latter value could be determined by the simple linear function $\overline{U}_i^L = a + b \cdot U_i^L$, where the perceived outside utility is determined from U_i^L, the utility received from goods consumption in the outside region. This function can thus represent some utility cost (or bonus) which would arise from migrating. The parameters a and b would be calibrated in the benchmark.

   Assume for now that $a = 0$. In the benchmark, if $U_i^R < U_i^L$ then $0 < b < 1$. If

$U_i^R > U_i^L$, then $b > 1$. The former case implies that the individual places a higher value on a unit of utility from goods consumption in the home region than on a unit of utility from goods consumption in the outside region. That is, some extra benefit arises from residing in the home region. The latter case implies that a lower value is placed on home region consumption utility. Thus, while extra benefits for residing in the outside region exist, the benchmark consumption utility in the home region outweighs the total benchmark utility for the outside region.

The choice of values for b is somewhat arbitrary for both cases and is even more so if the a value is also to be determined (i.e., is non-zero). However, if b is calibrated to some out-migration elasticity, then the parameter a could be determined so that the condition $U_i^R = \overline{U}_i^L$ is met. A set of these parameters must be determined for each region to which migration is possible; in the CRM, an individual in a region can migrate to any of five other regions. The migration decision process in Canada would then be characterized by two matrices of parameters.

This simple example does not address the issues raised in the previous item. For a more sophisticated model of the migration decision process, the migration function should also determine which members of a region's population migrate and how these out-migrants distribute themselves over the attracting regions.

3. If individuals initially within a region are identical and utility functions across regions are different, then any migration which occurred prior to the period under study can not be identified. This has important implications for the policy simulations which can be performed using the model.

   Consider the analysis of the Canadian equalization system. If equalization has prevented migration from the recipient regions to the higher income regions, then the benchmark populations of the former will contain members who, if equalisation had not been in place, would have migrated. In a simulation involving the removal of equalisation payments, labour which is endowed with the preference structure of the equalization-receiving regions will migrate to the higher income regions in a pattern which is consistent with the modelled migration functions of the home regions.

Now consider a simulation of the effects on labour migration of the large regional resource rents in Canada. The (conjectured) effect is that these rents have induced migration from the resource-poor regions to the resource-rich regions. However, in the benchmark all members of a region are modelled as having the preferences of that region, not those of any region from which the members may have previously migrated. While a simulation involving the removal of the influence of resource rents should reveal migrations from the resource-rich regions, the migration patterns will reflect the migration functions of these regions and, thus, will not yield an adequate approximation of the previous outflows from the non-resource regions.

4. THE MIGRATION DECISION PROCESS

This section describes the model formulation of the migration decision process which has been employed here. It should be noted that Kimbell and Harrison (1984) have proposed an alternative technique for the solution of models involving labour migration in a regional NGE model framework. The major difference between their approach and that used here is that they propose that a migration decision function be used which operates outside the utility maximizing process involved in the solution of a model equilibrium; the approach used here directly implements the migration decision process as part of an individual's utility-maximizing behaviour. While this approach may be more aesthetically pleasing to theoretical economists, problems arise in its implementation which may not occur in the Kimbell and Harrison approach.

With regard to the modelling issues raised in the previous section, the model formulation used here differs from that used in the CRM mainly in terms of issue two. That is, in terms of the functional form of the migration decision rule. While crucial differences will highlighted, a detailed description of the CRM approach is left to Appendix II.

To deal with the modelling issues discussed in the previous section, many assumptions have been made. As stated in the previous section, neither an assumption of perfect labour mobility nor an assumption of perfect labour immobility is entirely appropriate for the analysis of regional gains and losses. A novel feature of the modelling approach employed by Jones and Whalley is the use of location specific preferences to introduce a non-economic factor into labour's migration decision process. This feature is also used here and, as a result, changes in economic variables can be modelled to elicit only a partial labour migration response.

Obviously there exist economic factors which can result in partial labour mobility. In their analytical study of the Canadian equalization system and its influence on interregional labour migration, Boadway and Flatters (1982) discuss the influence of monetary migration costs on labour's decision to migrate. They conclude that if these involve out-of-pocket expenses that can be deducted for personal income tax purposes, then migration costs do not affect their basic arguments for equalization. While mentioning that migration costs might be some form of non-economic (psychic) costs, they do not elaborate on this.

Boadway and Flatters consider monetary migration costs under the assumption that for different persons there are different costs of migration and that those with the lowest costs would be the first to migrate. In other words, the greater the out-migration the higher the migration costs faced by the marginal person. The modelling technique which is about to be described employs basically the same approach. The migration costs, however, are non-monetary and arise due to locational preferences of the individuals in the regions.

Individuals initially within a region are assumed to have a preference for remaining in that region. Recall from the brief description of the CRM that individuals within a region all belong to the region's single consumer type. They are identical in that they each have the same consumption preferences and income. They are assumed to be different, however, in that each has a different strength of locational preference for the region. As will be seen, this difference is only visible in a person's decision whether to migrate or not. A further assumption is that an individual initially in region A who migrates to region B will retain the preference structure which initially characterizes the residents of the home region. The reason for this assumption is the pre-policy and after-policy utility comparison which is made for migrating individuals. If such an individual were to obtain a completely different preference structure (i.e., become a completely different economic individual), then a comparison of utilities for policy evaluation would be extra hard to justify. Furthermore, a "personal" utility comparison is the key to the labour mobility decision in the modelling here.

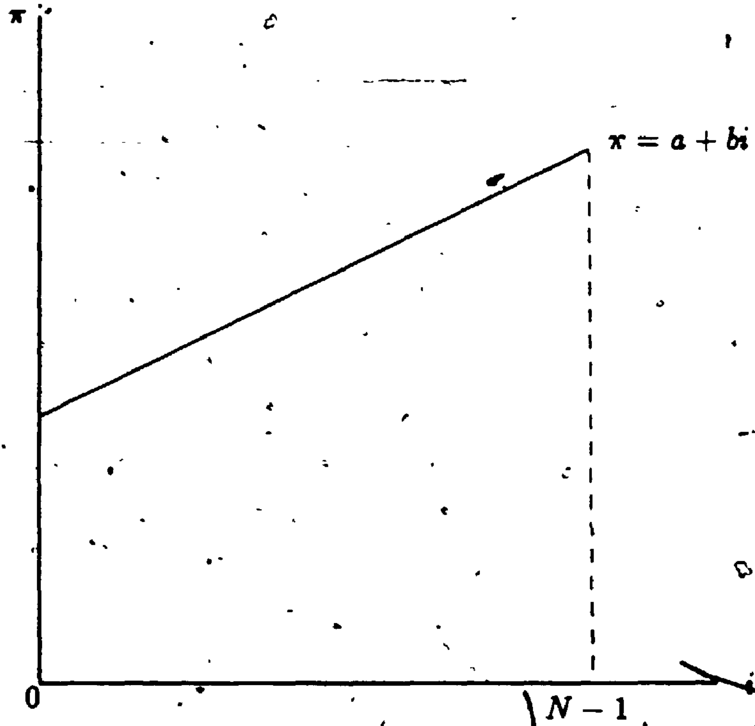
In the following description of the modelling technique, the additional assumptions made on the structure of the CRM will be described. Furthermore, features of the CRM described in section two will be temporarily modified in order to simplify the initial exposition of the migration process. Recall that in the benchmark, individuals in a region are identical in that each is a member of the single consumer type in the region and each has an equal income and claim on government expenditures in the region. To make the definition of an individual even more precise, each is also assumed to own a single unit of the homogeneous labour supply in the region. This assumption will be explained in more detail later. The individuals in a region are also assumed to be different in that each has a different degree of locational preference for the region. As will be shown next, this difference is visible only in a person's decision whether to migrate from the region.

An individual's preference for the home (benchmark) region is modelled as a utility penalty which is incurred when the individual leaves the home region. For simplicity of exposition, assume now that there exists only one other region to which the individual can migrate. Let U^L and U^R be the individual's consumption utilities for leaving and remaining in the home region, respectively. If π is the utility penalty the individual would face if he left the region, then he will leave only if

$$U^L - \pi > U^R. \tag{1}$$

If no differences existed between individuals in a region, then once the above condition held, all labour would migrate from the region. The difference in degree of strength of locational preference, however, introduces partial labour migration responses to differences in regional utilities. In other words, π varies over the labour units in the region. For simplicity, π is assumed to be a positive linear function over the labour set $[0, N-1]$, so the "penalty" function can be drawn as shown in Figure 1. N is the number of individuals residing in the home region in the benchmark and the exact definition of this value will be given later.

Figure 1

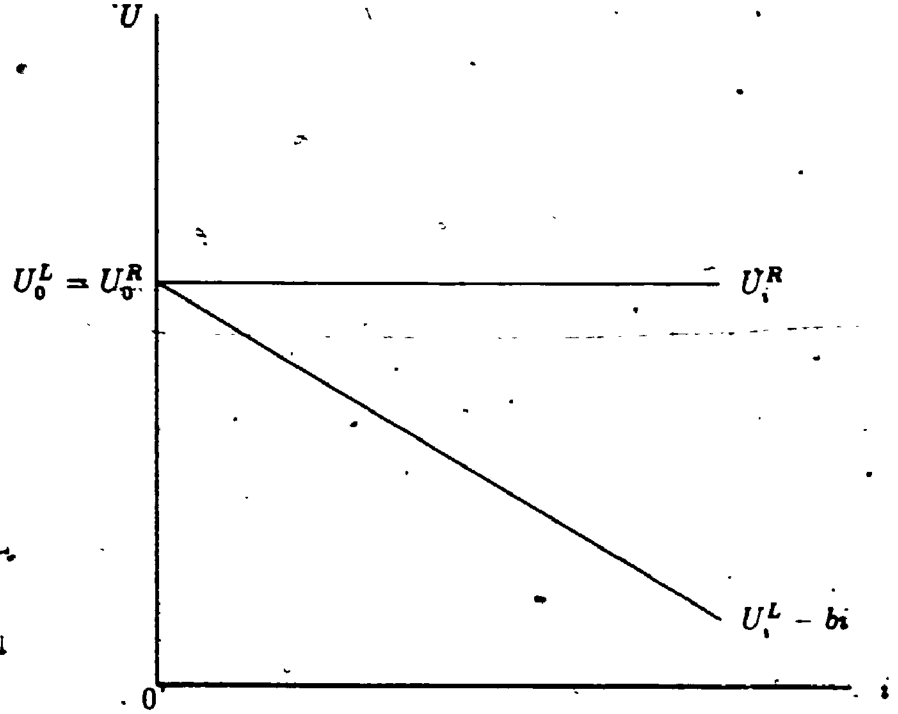


Assuming for now (without explanation) that $a = 0$, then the migration decision process for individual i becomes

$$\text{Decision} = \begin{cases} \text{leave}, & \text{if } U_i^L - bi > U_i^R; \\ \text{indifferent}, & \text{if } U_i^L - bi = U_i^R; \\ \text{stay}, & \text{if } U_i^L - bi < U_i^R. \end{cases} \tag{2}$$

This process can be described diagrammatically using Figure 2, which is drawn here for the benchmark case. But before the migration mechanism of Figure 2 is described, certain assumptions underlying the diagram must be explained.

Figure 2

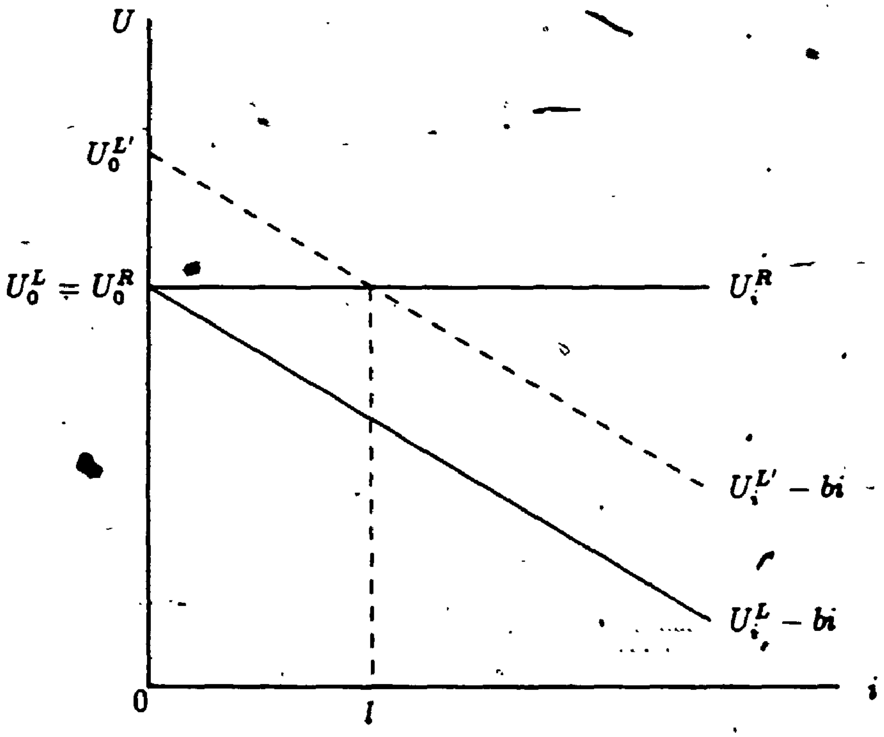


Given the assumption that a migrating individual retains the home region preferences, the functional form underlying the calculation of both the home region and out-of-region utilities is the same and the calculated levels can be validly compared. Since the diagram is supposed to represent the benchmark case, no incentives for migration must exist. For now, let this criterion be satisfied through an assumption that out-of-region consumption utility is equal to that in the home region. Individual $i = 0$, who faces no penalty for migration, is the marginal labour unit and is indifferent to residing in or out of the home region. All other individuals in the region have a preference for remaining there.

Consider some change outside the region such that U^L increases. In Figure 3, this results in the migration of l units of labour from the region. Similarly, a decrease in

U^R can induce an out-migration. Note that an increase in U^R or decrease in U^L alone would yield no change in the status of the home region labour supply as depicted in Figure 2. These effects can be shown using the outside region version of this diagram.

Figure 3

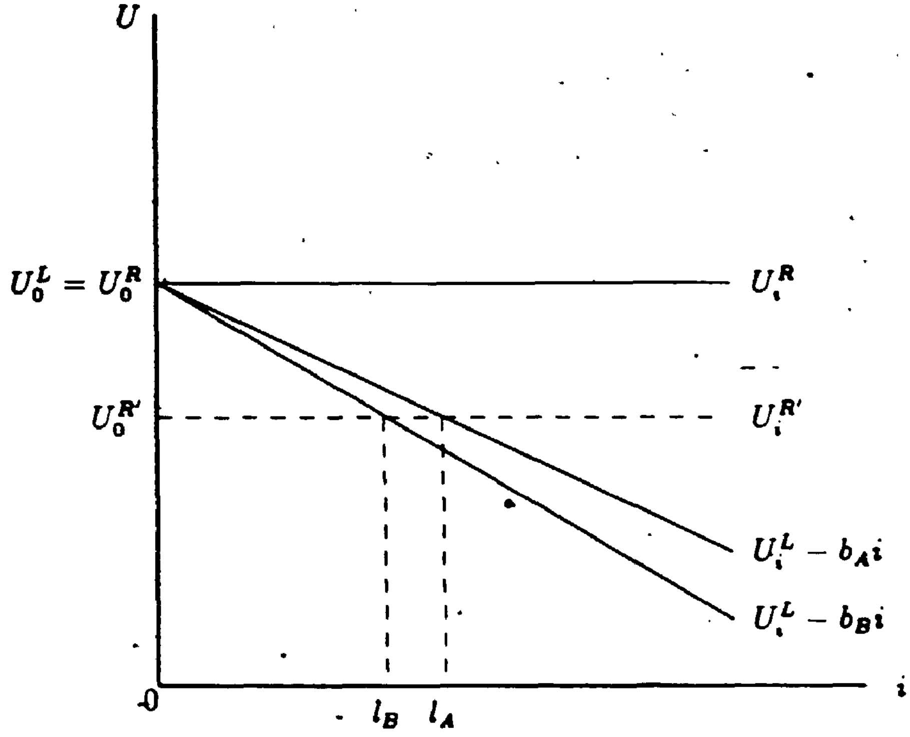


The strength of locational preference is determined by the parameter b. For a given decrease in home utility, the out-migration response in Figure 4 is smaller for b_B than for b_A. This is because $b_B > b_A$ represents a stronger locational preference in case B, which in turn implies a larger penalty for leaving the region. The choice of values for this parameter is discussed in the following section.

From Figure 2, the utility function for any individual i from the home region can be written as

$$U_i = max\left[\overline{U}_i^R(X^R), \overline{U}_i^L(X^L)\right] . \tag{3}$$

Figure 4



where $\overline{U}_i^R(X^R)$ is the utility to i from consuming the bundle of goods X^R in the home region, and $\overline{U}_i^L(X^L)$ is the utility from consuming X^L in the other region. Under the simple locational preference model described above, these values can be written as

$$\overline{U}_i^R(X^R) = U_i^R(X^R) \qquad \text{and} \qquad \overline{U}_i^L(X^L) = U_i^L(X^L) - bi \qquad (4)$$

where, from before, U_i^R and U_i^L are the utilities available to i in the respective regions solely from consumption. Recall, however, the discussion from issue two of the previous section concerning the relative utility levels an individual would perceive across the regions of the CRM. Outside region utility cannot be assumed to be equal to home region utility, so if Figure 2 is to be used to describe migration in the model, then the parameter a cannot be assumed to be zero. It is at this point that the major differences arise between the migration process used here and that used by Jones and

Whalley.

Jones and Whalley make the very strong assumption that an individual who migrates will face the same level of prices as exist in the home region. Given this assumption, U_i^R and U_i^L can be written as the indirect utility functions

$$U_i^R = g(P) \cdot I_i^R \qquad \text{and} \qquad U_i^L = g(P) \cdot I_i^L, \tag{5}$$

where $g(P)$ is the true cost of living (price) index for consumption in either region. I_i^R is the income to the individual from locating in the home region, while I_i^L is the income from locating in the other region. Based on the above functions, the analysis of Figure 3 can then be considered in terms of changes in income. Other modelling simplifications arise from this, such as the ability to assume that $a = 0$, and are discussed in detail in Appendix II.

A problem with the Jones–Whalley approach is that in the CRM an individual will not face identical price levels in different regions. Regional tax systems are not identical, so taxes such as a retail sales tax will cause the prices faced by each region to be different. Obviously, relative price levels across regions are a factor which should be considered in a model of the migration decision process.

Different price levels aren't the only change a migrant will face. The various sources of income available to an individual have to be considered and assumptions have to be made concerning their role in the migration process. Before this can be done, the exact definition of what constitutes an individual in this model must be stated more clearly than it has been so far.

As stated earlier, an individual initially within a region is assumed to belong to the single consumer type of that region. Members are assumed to have identical consumption preferences and incomes. While income consists of various components, the element which is the most important to the definition of an individual is labour income. In the modelling approach used here, an individual in a region is defined as the amount of labour which earns one dollar worth of wage income in the benchmark. Thus, actual population estimates for the regions are not used. The main justification for the use of efficiency units to represent individuals is model tractability. Model tractability is also the major argument for most of the assumptions made in the model.

What does the last assumption imply for the supply of labour in a region? Following standard NGE modelling techniques, all prices (including factor prices) are assumed to be equal to one in the benchmark equilibrium. Thus the wage rate in each region is equal to one. From this arise two characteristics of the labour in any region: each individual owns a single unit of labour (this was previously just assumed), and the benchmark labour supply in a region is equal to the benchmark wage bill for that region.

In the CRM, the supply of capital and resources in a region is assumed to be owned by the original inhabitants of that region. When an individual migrates, his share of these factors is not sold off and it remains in the region of origin. Returns to these factors accrue at the rates of the original region and a migrating individual has no claim on the new region's capital and resources.

Recall from the description of the CRM that regional government expenditures and services are represented by consumer purchases of the non-traded public services good. Given the complexity of the nesting structure underlying the consumer demands (see Appendix I), and the previously stated assumption that an individual's preferences do not change after migration, then the assumption is made that a migrant still consumes the public services good of the original benchmark region. The justification for this is, as usual, model tractability. Note that this implies that the public services goods are now traded goods. However, there are no tariffs on these goods and the public services good of a region is still consumed only by the original residents of that region.

An implication of the above assumption is that the purchase price of regional government services has no effect on the migration decision. However, regional government tax revenues are distributed to the individuals within a region and these do affect migration. Revenues from all sources are distributed on an equal per capita basis to all inhabitants of a region, including in-migrants. Through this, the migration incentives of regional government expenditure policies are captured. Of particular importance to the analysis here are the effects of the regionally concentrated resource tax revenues.

An in-migrant to a region faces the taxes imposed on that region by the federal government, and also receives a share of the federal transfers to that region. The assumption is made that federal transfer programs, both interpersonal and intergovernmental, are not distributionally neutral across regions. Since the individuals initially within a region are identical, interpersonal transfers from the federal government are assumed to be distributed on an equal per capita basis. Intergovernmental transfers to a region are assumed to be distributed in a similar manner, since no explicit local public good is provided by a regional government. Total transfers have been modelled like this in an attempt to capture the migration incentives of not only equalisation but also of other federal programs such as unemployment insurance.

When a change in any of the above factors occurs, this should be taken into account in the migration decision process which is used in the model. A two region model which incorporates these features could employ the utility function of equation (3), and the simple locational preference function:

$$\overline{U}_i^R = U_i^R \qquad \text{and} \qquad \overline{U}_i^L = U_i^L - (a + bi), \tag{6}$$

which implements the complete penalty function of Figure 1. Since the initial individuals within a region are identical in terms of their consumption utilities ($U_i^R = U_j^R$ and $U_i^L = U_j^L, \forall i, j$), then the parameter a can be calibrated in the benchmark to satisfy the condition that $U_i^L - a$ is equal to U_i^R for every $i = 0, \ldots, N-1$, where N is the home region supply of labour. This results in individual $i = 0$ being on the margin between staying or leaving, while the remainder of the individuals unambiguously prefer to stay. Since individuals initially within a region are identical, then equation (6) can also be rewritten as

$$\overline{U}_i^R = U_0^R \quad \text{and} \quad \overline{U}_i^L = U_0^L - (a + bi). \tag{7}$$

Figure 5

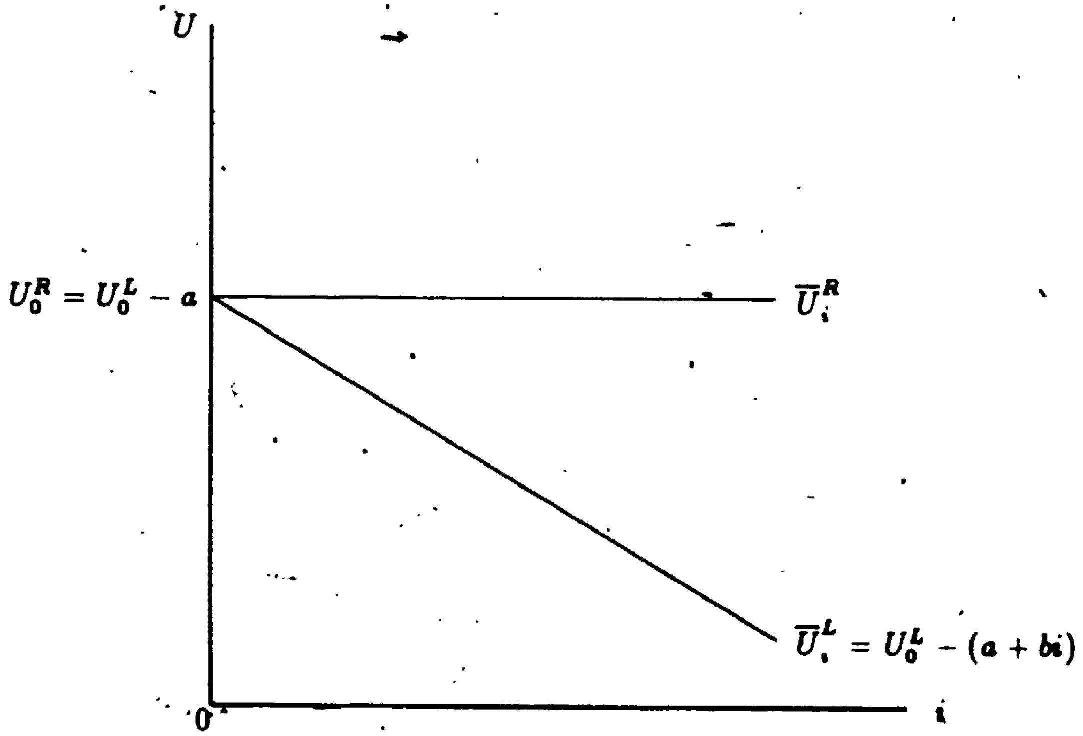


Figure 5 shows the benchmark situation for this function, which involves only a comparison of the utilities of the home region and a single outside region. While labour in a region in the CRM may migrate to any of the five outside regions, the migration process underlying Figure 5 can still be applied to this multi-region case. For each region, a separate migration decision function was calibrated in the benchmark for each of the five outside regions. Following some policy change, the six possible utility levels could be calculated for each unit of labour in a region. Labour would then be moved to (or remain in) the region which yielded it the maximum utility. Individual migration decisions would be employed and model equilibria would involve the absence of any further incentives to migrate.

When this form of migration process was implemented, however, the model could not be solved even for simple policy changes with very low migration elasticities (the specification of which will be discussed later.) For the policy experiments considered in this thesis, this model solution problem appears to result from the fact that under such a migration process only a single region receives most of the resulting out-migration from the other regions. Furthermore, as the model iterates towards a solution, this single "target" region can change. Some instability appears to be introduced into the model solution procedure by these features. As a result, an alternative approach to the migration process is used. Problems associated with this approach will be discussed later.

One goal in the implementation of this new approach was the maintaining of the simple locational preference model underlying equations (3) and (4). To achieve this, the strong assumption is made that rather than considering each outside region separately in the migration decision process, an individual in a region considers only a single comprehensive measure of out-of-region utility. For a region r, this measure, U_i^C, is defined as

$$U_i^C = \sum_s \alpha_s^r \cdot (U_i^s - a_s^r), \tag{8}$$

where s is an index over the number of regions and U_i^s is the consumption utility that

TABLE 1. Distribution of One Unit of Out-Migrating Labour Across Other Regions

	AC	Que	Ont	M/S	Alt	BC
Region from which unit of labour migrates						
Atlantic Canada	0	.109	.462	.074	.224	.131
Quebec	.098	0	.659	.033	.111	.099
Ontario	.192	.172	0	.119	.300	.217
Manitoba/Saskatchewan	.050	.027	.197	0	.495	.231
Alberta	.075	.032	.221	.203	0	.469
British Columbia	.063	.092	.297	.114	.434	0

SOURCE: See Whalley (1983). Calculated from data in Table 9, p.182. Calculation excludes Yukon, NWT, and intra-regional flows, ie., for example, flows between NFLD and PEI.

individual i would receive in region s. The α's are parameters in the benchmark data and show the share of a unit of labour leaving region r which goes to each region s. Table 1 lists the data used and it can be seen that for any region r (any row in Table 1), $\alpha_r^r = 0$ and $\sum_{s=1}^{6} \alpha_s^r = 1$. Some of the implications for the model results of the use of these parameter values are seen in the following section.

The parameter a_s^r is calibrated for each region r so that

$$a_s^r = U_0^r - U_0^s \qquad \forall s. \tag{9}$$

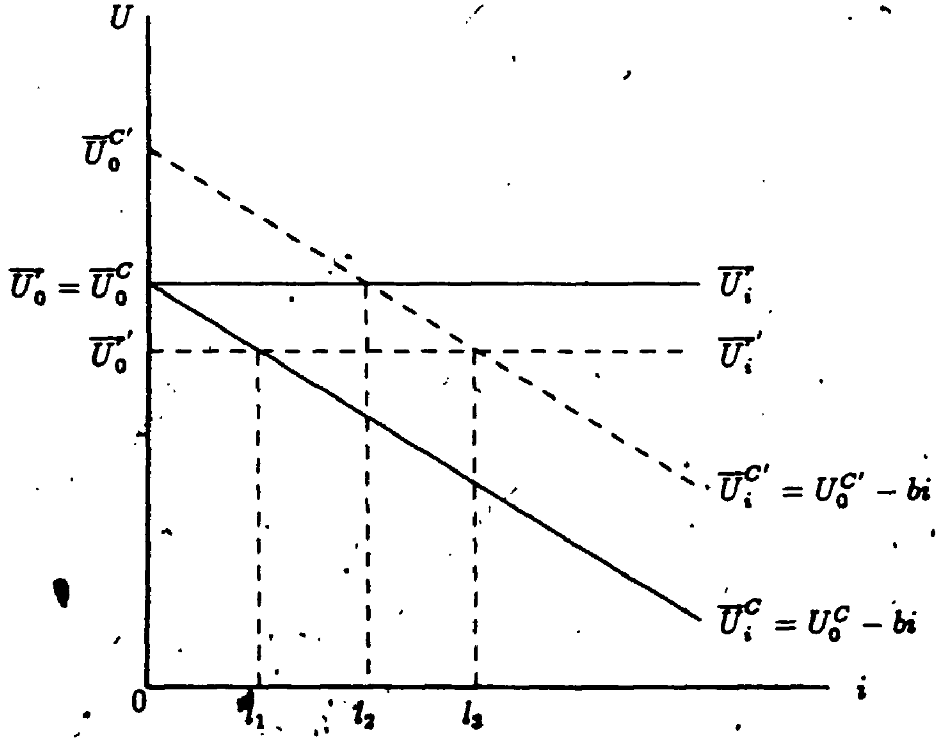
Since the individuals initially within a region are identical, then it must be true that $U_i^r = U_i^C = U_0^C$ for every $i = 0, \ldots, N^r - 1$, and that no incentives to migrate exist in the benchmark case. Given this, equation (4) can be used and can now be rewritten as

$$\bar{U}_i^r = U_0^r \qquad \text{and} \qquad \bar{U}_i^C = U_0^C - b_i, \tag{10}$$

with the solid lines in Figure 6 representing the benchmark case.

The number of out-migrants, l, can now be determined for a given change in the utility levels considered in this process. Four possible cases for out-migration responses and the corresponding marginal conditions are described in Figure 6. For the no out-migration case, individual 0 is on the margin and at that point $\overline{U}_0^r = \overline{U}_0^C$. For a change in home region utility, say a fall to $\overline{U}_0^{r\prime}$, the dashed horizontal line in Figure 6 shows that the individual on the margin is shifted beyond individual 0 and out-migration occurs. If l_1 is the number leaving, then individual l_1 is on the margin and $\overline{U}_0^{r\prime} = U_0^C - bl_1$ holds. If an increase in U_0^C to $U_0^{C\prime}$ were to induce an out-migration of l_2, then at the margin $\overline{U}_0^r = U_0^{C\prime} - bl_2$ would hold. Finally, if an out-migration of l_3 were induced by an increase in U_0^C to $U_0^{C\prime}$ and a decrease in $\overline{U}_0^r$ to $\overline{U}_0^{r\prime}$, then the condition $\overline{U}_0^{r\prime} = U_0^{C\prime} - bl_3$ would hold at the margin.

Figure 6



Thus, after out-migration the position at the margin can be described by the relationship

$$\hat{U}_0^r = \hat{U}_0^C - bl, \tag{11}$$

where l is the marginal individual. $\hat{U}_0^r$ and $\hat{U}_0^C$ can be either changed or unchanged from the original values, U_0^r and U_0^C, but must satisfy the condition that $\hat{U}_0^C - \hat{U}_0^r \geq 0$, so that $l \geq 0$ only. This condition applies because the diagram describes the region's out-migration function only; in-migration is determined from the other regions' out-migration functions.

New values for $\hat{U}_0^r$ and $\hat{U}_0^C$ which satisfy the above condition allow the quantity of out-migrating labour, l, to be calculated. l denotes this quantity since individuals 0 to l, not including l, migrate so that l is also the number migrating. Rewriting equation (11) yields

$$l = \frac{\hat{U}_0^C - \hat{U}_0^r}{b}. \tag{12}$$

In a two region model, if a policy change results in $\hat{U}_0^C > \hat{U}_0^r$ then $l > 0$ and out-migration occurs. For the multi-region case, a policy change may result in some outside regions having higher migration utilities than the home region, while for others it may be lower. Since out-migration should only occur to those regions in the first instance, the comprehensive out-of-region income measure must be more strictly defined. Therefore, define

$$\hat{U}_0^C = \sum_s \rho_s^r \cdot (\hat{U}_0^s - a_s^r), \tag{13}$$

where s is indexed over those regions for which $(\hat{U}_0^s - a_s^r) > \hat{U}_0^r$, and $\rho_s^r = \alpha_s^r / \sum_s \alpha_s^r$ so that $\sum_s \rho_s^r = 1$.

If $l > 0$ in the counterfactual case, then this out-migrating labour is distributed over the receiving regions according to the share parameters, ρ. That is, the amount of labour migrating from region r to region s is

$$N_s^r = \rho_s^r \cdot l. \tag{14}$$

As in the two region case, in-migration to any region r after a policy change is determined from the out-migration functions of the other regions. The after-policy labour supply in a region r is thus

$$\overline{N^r} = N^r - \sum_s N_s^r + \sum_m N_r^m, \tag{15}$$

where m is indexed over those regions for which out-migration to region r occurs.

An obvious problem with this fixed coefficient distribution function is that migration incentives may still exist even though a model equilibrium has been achieved. For example, suppose that two outside regions satisfy the conditions underlying equation (13). Utility maximization implies that all out-migrating labour would go to only one of these regions, however the distribution function of equation (14) would cause some labour to migrate to the other region. Thus, some migration incentives may still exist under what has been defined as an equilibrium in this model. Appendix III contains the results of some calculations which were performed to estimate how large these incentives might be.

The main justification for the use of this modelling approach is the elimination of the model solution problems discussed earlier. For most of the policy experiments considered here, in-migration to only a single region will no longer occur. As a result, the model solution procedure does not become unstable when an iteration over the solution variables results in different regions becoming the major recipients of in-migrants. It should be noted, however, that model solution problems have still been encountered for some of the larger policy simulations which have been attempted with this model (these are not described in this thesis).

As shown in Figure 4, an important determinant of a region's out-migration response is the value of the parameter b in equation (12). This value is determined in the calibration procedure as a function of the benchmark data and a specified elasticity value, η. This elasticity describes the responsiveness of the original labour units remaining in a region to a change in the comprehensive utility measure for the outside regions. Thus, this parameter will be related to migration elasticities which measure the responsiveness of regional populations to changes in relative incomes across regions. The choice of values for this parameter is discussed later.

For a region r, this elasticity is defined as

$$\eta^r = \frac{\partial \hat{N}^r}{\partial \hat{U}_0^C} \cdot \frac{\hat{U}_0^C}{\hat{N}^r}, \tag{16}$$

where $\hat{N}^r = N^r - l^r$ and is the number of original labour units remaining in the region. Since N^r is constant, then $\Delta \hat{N}^r$ must equal Δl^r. Now recall equation (11) which describes the marginal individual:

$$\hat{U}_0^r = \hat{U}_0^C - b^r l^r. \tag{11}$$

If $\Delta \hat{U}_0^r = 0$, then $\Delta \hat{U}_0^C = b^r \cdot \Delta l^r$. This can be written as

$$\begin{aligned} b^r &= \frac{\Delta \hat{U}_0^C}{\Delta l^r} \\ &= \frac{\Delta \hat{U}_0^C}{\Delta \hat{N}^r}, \end{aligned} \tag{17}$$

since from above, $\Delta \hat{N}^r = \Delta l^r$. Substituting (17) into (16) yields

$$\eta^r = \frac{1}{b^r} \cdot \frac{\hat{U}_0^C}{N^r - l^r}. \tag{18}$$

Substituting from (12) yields

$$\begin{aligned} \eta^r &= \frac{1}{b^r} \cdot \frac{\hat{U}_0^C}{N^r - ((\hat{U}_0^C - \hat{U}_0^r)/b^r)} \\ &= \frac{1}{b^r} \cdot \frac{\hat{U}_0^C}{(b^r N^r - \hat{U}_0^C + \hat{U}_0^r)/b^r} \\ &= \frac{\hat{U}_0^C}{b^r N^r - \hat{U}_0^C + \hat{U}_0^r}. \end{aligned} \tag{19}$$

In the benchmark $\hat{U}_0^C = \hat{U}_0^r$, which yields

$$\eta^r = \frac{\hat{U}_0^r}{b^r N^r}. \tag{20}$$

Given values of $\hat{U}_0^r$, N^r, and η^r for region r in the benchmark data set, the benchmark value for b^r can be solved for as

$$b^r = \frac{\hat{U}_0^r}{\eta^r N^r}. \tag{21}$$

This value gives the utility penalty which is incurred in varying degree by the residents of a region if they migrate. The larger the value, the stronger the preference of the individuals for their home region. Appropriately, the greater is the specified responsiveness of out-migration to changes in outside utility, the smaller is b. The property that a smaller benchmark labour supply implies a stronger locational preference might be explained by the argument that a higher population in a region results in a reduction of the non-economic (psychic) benefits of that region.

Whalley and Trela (1986) have discussed in detail the choice of values for the parameter η in the Jones–Whalley formulation of the migration process. They found no empirical estimates of elasticity parameters like η, so instead tried to use estimated values for Canadian interregional migration elasticities. One problem they encountered was that most empirical studies of Canadian data have dealt with changes in migration flows only; the measures required here have to pertain to changes in stocks. Since the results from studies such as that by Winer and Gauthier (1982) could not be directly related to the required elasticity parameters, an alternative approach was adopted: under the strong assumption that values are the same across regions, model results were presented for a range of values. Whalley and Trela report that the choice of these values can have an important influence on policy simulation results.

Since the η parameter used here is analogous to that of the Jones–Whalley model, the same approach is taken in choosing its values. Furthermore, the use of a similar range of parameter values allows a more accurate comparison of the two formulations of the migration decision process.

The migration decision process described in this section has addressed the model specification problems discussed in the first and second modelling issues of the previous section. Now recall the third modelling issue. While the migration-retarding effects of policies can be simulated using the standard modelling procedures, problems arise with the estimation of migrations which have already occurred. An alternative modelling approach must be employed for these latter simulations. This will now be described.

First consider an example of the standard approach. For the simulations involving the migration retarding effects of the equalization system, the model is first calibrated with all elements of benchmark income included. The counterfactual case then involves solving the model with the equalization payments removed from the calculation of consumer income in each region.

To simulate the migrations which are conjectured to have already occurred due to regional energy rents, the first step is to calibrate the model in the absence of the migration incentive component of these energy rents. To do this, equations (9) and (20) are determined using utility levels which have been calculated with the energy rent component of income set equal to zero. In this case, the benchmark equilibrium represents a situation where regional energy rents exist and are collected, but they have no direct effect on labour's migration decision process. For the counterfactual case, the migration incentives of the energy rents are then introduced by including the energy rent component back into the utility calculations underlying equation (12).

5. MODEL SIMULATIONS

The counterfactual equilibrium calculations reported in this section are used to illustrate the differences in model results which arise when the migration process employed in the Jones–Whalley CRM is replaced by the one described here. The policy simulations performed are the same as those used by Whalley and Trela to estimate the welfare impacts of the Canadian equalization system.[1] These simulations have been chosen because the differences that arise in the welfare results are an important factor in the analysis of the next essay. In this essay, the model's ability to simulate partial labour migration responses to changes in policy is discussed, and the migration results are compared to those of Whalley and Trela.

Two sets of results are reported for each of the simulations. First, Hicksian equivalent variations (EV's) in millions of 1981 dol[illegible] give the income equivalent of the regional welfare effects of the particular policy experiment under consideration. The welfare effects which are given for any region must be interpreted with some care since they are reported for the original inhabitants of the region. That is, for the single consumer type residing in the region prior to the policy change. The main justification for this convention is that the reporting of welfare results is simplified because utility comparisons for a region require only a single utility function. Furthermore, due to the partial labour mobility functions, migrations are not large (as will be seen) and so measured welfare changes for migrant groups are not large compared to those for the groups of individuals who do not migrate. Finally, the value for the total effect for Canada would be the same even if an alternative method were used for the individual regions. This value consists of the sum of the individual region welfare effects plus the impacts on the federal government.

The second set of results which are reported for each simulation are the net

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[1] See Table 5-13 in Whalley and Trela.

migrations into the regions which result from the policy change. These values give total labour inflow from other regions minus the outflow from the region and are in millions of the benchmark labour units described in the previous section.

The results presented in Table 2 involve the replacement of the federal equalization payments to the regions by an equal rate federal subsidy on final demands by all regions. This subsidy is designed to maintain federal government real expenditures at the benchmark level. As discussed in the previous section, empirical estimates of migration elasticity parameters such as η are not available, so instead simulations are performed over a range of these values. The range which was chosen was from 0.01 to 0.50. The lower value implies that a one percent increase in out-of-region utility will result in an outflow of one percent of the home region's labour. For the largest value, a fifty percent outflow would occur. The choice of this upper bound on the values to be tested arose from the observation that all of the policy experiments described in the following essay would solve for values less than or equal to this. Larger values introduced convergence problems into the solution for some policy changes.

In case 1, replacing the equalization system results in large welfare losses for the major recipients—Atlantic Canada, Quebec and Manitoba/Saskatchewan—while the other regions gain. Ontario gains the most from this policy change. The large losses can be explained by the income effects of removing the equalization payments, while the gains arise from the subsidy on final demand. The policy implications of these results are discussed more fully in the next essay of this thesis.

Due to the very inelastic value for the migration elasticity parameter, net migration flows are relatively small for case 1. Consider the more detailed description of these flows in Table 3. Column 1 gives the number of labour units (in millions) in each region in the benchmark. Columns 2, 3, 4 and 5 give the inflow, outflow, net inflow, and percentage change (Column 4 divided by Column 1 times 100), respectively.

TABLE 2. **Replace Federal Equalization Payments with a Subsidy on Final Demand Designed to Maintain Real Federal Expenditures Constant**

	Case 1	Case 2	Case 3	Case 4
Hicksian EV's ($ millions 1981)				
Atlantic Canada	-1310	-1283	-1252	-1086
Quebec	-1357	-1306	-1249	-980
Ontario	1760	1711	1657	1387
Manitoba/Saskatchewan	-179	-171	-162	-122
Alberta	479	464	449	375
British Columbia	556	547	536	471
Total	-29	-17	-5	48
Net Labour Migration (+ indicates inflow)				
Atlantic Canada	-10	-46	-88	-324
Quebec	-16	-75	-140	-457
Ontario	17	79	148	496
Manitoba/Saskatchewan	-2	-9	-17	-54
Alberta	6	28	51	164
British Columbia	5	24	46	175

Case 1: Migration elasticities equal to 0.01 for all regions.

Case 2: Migration elasticities equal to 0.05 for all regions.

Case 3: Migration elasticities equal to 0.10 for all regions.

Case 4: Migration elasticities equal to 0.50 for all regions.

TABLE 3. Details of Migration Flows[1] for Case 1 of Table 2

Region	Labour Supply[1]	Inflow	Outflow	Net Inflow	Percentage Change
AC	11533	0	9.6	-9.6	-0.08
Que	45300	1.0	16.9	-15.9	-0.04
Ont	73882	17.5	0.8	16.8	0.02
M/S	13422	1.3	3.3	-1.9	-0.01
Alt	19350	6.0	0.1	5.8	0.03
BC	22865	4.8	0.0	4.8	0.02

[1] Millions of 1981 benchmark labour units as defined in the text.

A comparison of these migration flows to the welfare effects in Table 2 reveals the intuitive result that the losing regions experience outflows while the gainers have inflows. Inflows to Atlantic Canada, the biggest loser per capita from the policy change, are zero while outflows are relatively large. Quebec and Manitoba/Saskatchewan, the other losing regions, have small inflows which are outweighed by larger outflows. The inflows can be attributed to the greater per capita loss to Atlantic Canada which results in some incentive for migration to these regions.

Outflows from the gaining regions are close to or equal to zero. While the per capita gains are almost equal for these regions, Ontario has the largest inflow. This can be explained by the share parameters listed in Table 1. A large portion of any labour leaving Atlantic Canada or Quebec will migrate to Ontario (providing the utility level in Ontario is high enough.)

Cases 2 to 4 of Table 2 involve migration elasticities of increasing size. Both net inflows and net outflows increase over the cases. Intuitively, a net outflow of labour from a region should result in an increase in the region's wage rate and, as a consequence, a smaller welfare loss than in the case where no migration is allowed. Regions experiencing a net inflow should have a drop in the wage rate and, consequently, a smaller welfare gain. A comparison of the welfare results over the four cases supports this intuition.

Note that the migration elasticity for case 2 is five times that of case 1 and that the net migration flows in case 2 are approximately five times those in case 1. A similar relationship exists between cases 2 and 3. Migration elasticities in case 4 are all equal to 0.5 and while this value is five times that of case 3, net flows have only increased by factor of 3. This suggests that actual labour migration does not increase proportionally to increases in the migration elasticities. The reason for this is that when the net outflow from a low utility region and the net inflow to a high utility region are both allowed to increase, the wage differential between the two regions will decrease even more and, therefore, dampen the possible migration response.

Table 4 contains the results reported by Whalley and Trela for the same set of policy experiments. Note that while the range of elasticity values is slightly different, the upper bound is the same as that used here. A comparison of the net labour migrations for the 0.5 elasticity case shows that while the Whalley–Trela results are qualitatively the same as those in Table 2, they are quantitatively different. In fact, they are nearly twice as large. A similar observation can be made for the results of the 0.05 cases. Note that the net migrations for case 2 of Table 4 are approximately the same as those for case 3 of Table 2. These results all suggest that the migration flows resulting from the Jones–Whalley formulation of the migration decision rule may be twice as large as they should be.

TABLE 4. Whalley–Trela Results[1] for the Simulation where Federal Equalization Payments are Replaced with a Subsidy on Final Demand Designed to Maintain Real Federal Expenditures Constant

	Case 1	Case 2	Case 3	Case 4
Hicksian EV's ($ millions 1981)				
Atlantic Canada	-1302	-1278	-1183	-1067
Quebec	-1354	-1300	-1150	-995
Ontario	1743	1704	1558	1396
Manitoba/Saskatchewan	-175	-167	-138	-107
Alberta	477	468	432	393
British Columbia	556	552	529	500
Total	-22	-5	56	117
Net Labour Migration (+ indicates inflow)				
Atlantic Canada	-37	-88	-381	-581
Quebec	-55	-130	-405	-702
Ontario	61	144	454	807
Manitoba/Saskatchewan	-8	-18	-56	-97
Alberta	21	50	158	283
British Columbia	17	42	150	290

Case 1: Migration elasticities equal to 0.02 for all regions.

Case 2: Migration elasticities equal to 0.05 for all regions.

Case 3: Migration elasticities equal to 0.20 for all regions.

Case 4: Migration elasticities equal to 0.50 for all regions.

[1] From Table 5-13 in Whalley and Trela (1986).

6. SUMMARY AND CONCLUSIONS

While the results presented here are qualitatively comparable to those of Whalley and Trela, they are quantitatively different. In particular, the net migration flows are smaller. This reflects the more detailed decision rule which is employed here. As shown in Appendix II, the migration decision process used by Whalley and Trela is only based only on changes in "migration income." This value is composed of federal transfers to regions, wages, and regional resource rents. Factors such as price changes are not considered. This suggests that under the Jones–Whalley model, changes in equalization will have a larger influence on the decision to migrate. The Whalley and Trela migration results support this conjecture and, as a consequence, their simulations reveal greater overall welfare effects for Canada at the higher migration elasticity levels. The implications of this for the conclusions made by Whalley and Trela concerning policy impacts are discussed in the next essay.

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APPENDIX I

ALGEBRAIC PRESENTATION OF THE STRUCTURE OF THE CRM

A. OVERVIEW AND NOTATION

Canada is modelled as six regions: Atlantic Canada, Quebec, Ontario, Manitoba/ Saskatchewan, Alberta, and British Columbia. Regions 1 to 6 refer to the above ordering, with r being the subscript denoting region. Each region contains agents with identical preferences towards goods; agents within a region differ only in their intensity of locational preference.

The federal government is modelled as a separate agent, although it is linked to the regions through its taxes, transfers, and expenditures. Federal income accrues from taxation and capital ownership. Some of this income is redistributed to the regions through intergovernmental transfers and transfers to persons; the remainder is spent on purchases of goods produced in the regions. Federal government activities are subscripted by G. The rest of the world is denoted by ROW. The modelling of ROW is essentially the same as for the Canadian regions, except that there are no links to the Canadian federal government through taxes and transfers.

The subscript j refers to industries, while K, L, and N refer to the factors capital, labour, and natural resources, respectively. Written without a bar, K, L, and N indicate use of factors by industries; written with a bar, they denote ownership of factors by a region (here region refers to $r = 1, \ldots, 6$, and ROW). Thus, K_j^r refers to the use of capital in industry j of region r. In this model, the strong assumption has been made that each region owns only the value of factors originally located in that region and appearing in the benchmark equilibrium data. $\overline{K}^r$ indicates the capital owned by region r, $\overline{K}^G$ denotes the federal government's capital ownership. Similarly,

N^r denotes ownership of natural resources in region r. Since resources are modelled as a factor which is specific to the energy industry in Canada, energy use in region r is simple denoted by N^r.

Due to the approach to labour mobility modelled here, somewhat different notation is needed for labour inputs. $\overline{L}^r_j$ is the use of labour in industry j of region r. $\overline{L}^r$ denotes the labour supply in region r, i.e., $\overline{L}^r$ is the initial population of region r. After a policy change, labour may migrate from one region to another; $\overline{L}^r_s$ denotes the amount of labour of type r locating in region s.

Y refers to value added originating in any industry in any region; G refers to the gross output for any industry in any region; H defines the vector of intermediate input requirements for any industry in any region; X is the vector of final purchases (including consumption) by any agent; U is the utility level attained by any agent; and P is the vector of world market prices for both goods and factors. The separate notation for other commodity and factor prices is discussed more fully below.

The solutions of behavioural functions that depend on prices endogenously determined in the model are represented as functions. $X(P)$ are final demands for products as a function of the prices P. $G(P)$ are gross outputs of commodities that meet the vector of final demands $X(P)$ and minimize costs.

The basic version of the model incorporates nine factors of production: one labour factor in each region ($r = 1, \ldots, 6, ROW$), the internationally and interregionally mobile capital factor, and one resource factor specific to Canadian energy industries. Each region produces 13 commodities referred to by the index i. The index j refers to industries, 13 in each region. Commodity 13 represents public services and is treated as non-traded. Index h refers to the 91 commodities produced in total.

a^r_{hj} indicates the per-unit use of good h in the production of good j in region r. ρ denotes substitution parameters on the production side, and σ denotes substitution parameters on the consumption side. $\overline{\rho}_j^r$ determines the elasticity of substitution among components of value added for industry j in region r, while ρ_j^s is used for substitution among intermediate goods in industry j in region s. δ and β are share parameters in the CES functions on the production side; b are the share parameters in the demand side functions.

B. PRICES AND POLICIES IN THE MODEL

Prices in the Model

The market price for labour in region r is P_L^r ($r = 1, \ldots, 6, ROW$). In the central case model variant, the market price of capital is P_K, while in the variant involving international capital immobility, the Canadian market price for capital is P_K^{CDN} and the ROW price is P_K^{ROW}. For the Canadian regions, the natural-resource price is P_N. These are the prices paid by domestic industries using these factors, net of factor taxes and after receipt of factor subsidies. They are also seller's prices received by factor owners (before income taxes).

$P^r = (P_1^r, \ldots, P_{13}^r)$ are the selling prices for producer outputs in region r, gross of domestic production taxes and subsidies. These are also f.o.b. world export prices received by exporters, and are the before-consumer-purchase-tax prices paid by domestic consumers for products produced in their own regions. $P_h = P_1, \ldots, P_{91}$ denotes these same producer prices indexed by the goods in all six Canadian regions and ROW.

For the central case variant of the model, P is the vector of endogenous model prices

$$(P_1, \ldots, P_{91}, P_K, P_N, P_L^1, P_L^2, P_L^3, P_L^4, P_L^5, P_L^6, P_L^{ROW}).$$

For the variant involving international capital immobility, $\hat{P}$ is the vector of endogenous world prices

$$(P_1, \ldots, P_{91}, P_K^{CDN}, P_K^{ROW}, P_N, P_L^1, P_L^2, P_L^3, P_L^4, P_L^5, P_L^6, P_L^{ROW}).$$

Policies in the Model

Regional government policy parameters are denoted by the terms t subscripted or superscripted as appropriate. Federal government policies are denoted by the terms τ, again with the appropriate subscripts and superscripts.

Trade Policies

Tariffs are modelled as ad valorem taxes on imports for both intermediate use and final demand. Tariffs imposed by the federal government are on international trade only so that τ^r_{Mh} is the federal tariff paid by consumers in region r on international imports of good h. Note that this vector of tariff rates is non-zero only for those h values which correspond to imports from ROW. The tariff rates on commodities are uniform across Canadian regions. Because trade barriers between regions are represented as ad valorem equivalent tariffs, t^r_{Mh} also denotes the tariff imposed by the region r government on imports of good h entering region r from other regions of Canada. t^{ROW}_{Mh} are the tariff rates on goods imported by ROW.

Factor Taxes and Subsidies

Canadian regional governments ($r = 1, \ldots, 6$) impose taxes t^r_{Lj} on labour in industry j ($j = 1, \ldots, 13$), on capital t^r_{Kj} ($j \neq$ energy), and on natural resources t^r_N used in the energy industry. The federal government similarly imposes taxes τ^r_{Lj}, τ^r_{Kj}, and τ^r_N on region r ($r = 1, \ldots, 6$). The ROW government imposes ad valorem tax rates t^{ROW}_{Lj}, t^{ROW}_{Kj} on the use of labour and capital in industry j ($j = 1, \ldots, 13$).

Intermediate Use Taxes and Subsidies

Each regional government, r, imposes ad valorem rates ${}^{I}t^{r}_{hj}$ on the purchase of commodity h for use in industry j in region r ($r = 1, \ldots, 6, ROW$). The federal government imposes similar taxes at rates ${}^{I}\tau^{r}_{hj}$ in regions $r = 1, \ldots, 6$.

Production Taxes and Subsidies

Each regional government, r, uses ad valorem tax rates $t^{r}_{P_j}$ on the production of the j^{th} industry located in region r ($r = 1, \ldots, 6, ROW$). Federal government tax rates τ_{P_j} also apply, with uniform rates across regions.

Consumption Taxes and Subsidies

Each regional government, r, uses ad valorem tax rates t^{r}_{i} on the consumption of good i in region r ($r = 1, \ldots, 6, ROW$). Federal government tax rates τ_i also apply.

Income Taxes

Each regional government, r, applies ad valorem average income tax rates t^{r}_{T} to taxable income of region r ($r = 1, \ldots, 6, ROW$). Federal government tax rates τ_T also apply.

C. PRODUCTION

Industry Value-Added Functions

The CES value-added function for any non-energy industry, j, in any region in Canada is

$$Y_j = \gamma_j \Big[\delta_j \cdot K_j^{-\bar{\rho}_j} + (1 - \delta_j) \cdot L_j^{-\bar{\rho}_j} \Big]^{-1/\bar{\rho}_j}, j \neq \text{energy industry}$$

where γ_j is a constant defining units of measurement, and Y_j is value added in industry j. This function also holds for any industry ($j = 1, \ldots, 13$) in ROW. For energy industries in Canada,

$$Y_j = \gamma_j \Big[\delta_j \cdot N^{-\bar{\rho}_j} + (1 - \delta_j) \cdot L_j^{-\bar{\rho}_j} \Big]^{-1/\bar{\rho}_j}, j = \text{energy industry.}$$

Factor demand functions for an industry reflect cost-minimizing behaviour. Minimizing CES value-added functions subject to a given level of output yields the appropriate cost functions.

For a given P, factor demands for each non-energy producing industry can be written as:

$$K_j^r(P) = \left\{ \delta_j^r \Big[\frac{(1 - \delta_j^r) \cdot \overline{P^r}_{L_j}}{\delta_j^r \cdot \overline{P^r}_{K_j}} \Big]^{\bar{\rho}_j^r/(\bar{\rho}_j^r + 1)} + (1 - \delta_j^r) \right\}^{1/\bar{\rho}_j^r} \cdot \frac{G_j^r(P)}{\gamma_j^r}$$

$$L_j^r(P) = \left\{ (1 - \delta_j^r) \Big[\frac{\delta_j^r \cdot \overline{P^r}_{K_j}}{(1 - \delta_j^r) \cdot \overline{P^r}_{L_j}} \Big]^{\bar{\rho}_j^r/(\bar{\rho}_j^r + 1)} + \delta_j^r \right\}^{1/\bar{\rho}_j^r} \cdot \frac{G_j^r(P)}{\gamma_j^r}$$

for $r = 1, \ldots, 6$ and $j \neq$ energy, and where

$$\overline{P^r}_{L_j} = P_L^r \cdot (1 + \tau_{L_j}^r + t_{L_j}^r)$$

$$\overline{P^r}_{K_j} = P_K^r \cdot (1 + \tau_{K_j}^r + t_{K_j}^r).$$

For the energy industry in each region the labour demand equation is identical to that above, while the natural resource factor demands are

$$N_E^r(P) = \left\{ \delta_E \Big[\frac{(1 - \delta_E^r) \cdot \overline{P^r}_{LE}}{\delta_E^r \cdot \overline{P^r}_N} \Big]^{\bar{\rho}_E^r/(\bar{\rho}_E^r + 1)} + (1 - \delta_E^r) \right\}^{1/\bar{\rho}_E^r} \cdot \frac{G_E^r(P)}{\gamma_E^r}$$

for $r = 1, \ldots, 6$, where $\overline{P}^r_N = P_N \cdot (1 + \tau^r_N + t^r_N)$.

In the *ROW*, there is no specific resource input to the energy industry and so factor demands for all industries in the *ROW* are similar to those for Canadian non-energy industries.

Intermediate Production Requirements

Five level nested CES functions are used in calibrating intermediate production requirements. As the model structure is different for *ROW* from that for regions in Canada, the regional structure will be described first, beginning with the bottom level.

–Level 5

First consider the use of composites of each of the traded goods (denoted by $l = 1, \ldots, 12$) in industry j in region s. The level 5 CES aggregation function is

$$^5C^s_{jl} = \left[\sum_{r \neq s} {}^5\beta^s_{jl(r)} \cdot \left(C^s_{jl(r)}\right)^{-^5\rho^s_j}\right]^{-1/^5\rho^s_j}$$

where $^5C^s_{jl}$ is the composite of the five types of good l produced in regions other than s. The superscript 5 denotes level 5, while the superscript s is region s; j is the industry subscript and l the good subscript. $l(r)$ denotes good l from region r; $C^s_{jl(r)}$ represents the intermediate use by industry j in region s of good l produced in region r. For notational simplicity, the level and region superscripts are dropped from the elasticities and share weights in the functions for subsequent levels.

–Level 4

This level describes the substitution between the use of the composite of good l available from other regions, $^5C^s_{jl}$, and the use of the good l available from the home region, $C^s_{jl(s)}$. $^4C^s_{jl}$ is therefore the intermediate use by industry j in region s of the composite of Canadian sources of good l.

$${}^4C_{jl}^s = \left[\beta_{jl}(C_{jl(s)}^s)^{-\rho_j} + (1-\beta_{jl})({}^5C_{jl}^s)^{-\rho_j}\right]^{-1/\rho_j}$$

–Level 3

Substitution at level 3 occurs between the use of the composite Canadian good l, ${}^4C_{jl}^s$, and good l from ROW, $C_{jl(ROW)}^s$. This defines ${}^3C_{jl}^s$, the intermediate use by industry j in region s of the composite good representing all sources of good l. ${}^3C_{jl}^s$ is defined for each of the traded goods, $l = 1, \ldots, 12$.

$${}^3C_{jl}^s = \left[\beta_{jl}(C_{jl(ROW)}^s)^{-\rho_j} + (1-\beta_{jl})({}^4C_{jl}^s)^{-\rho_j}\right]^{-1/\rho_j}$$

–Level 2

Substitution at level 2 occurs over the 11 non-energy traded-good composites and the non-traded local public services good for region s. The result defines a non-energy composite good.

$${}^2C_j^s = \left[\sum_{i \neq \text{energy}} \beta_{ji} \cdot ({}^3C_{ji}^s)^{-\rho_j}\right]^{-1/\rho_j}$$

–Level 1

Substitution at level 1 occurs over the non-energy composite good, ${}^2C_j^s$, and the energy composite good, ${}^3C_{jE}^s$, to yield a composite intermediate input for industry j in region s.

$${}^1C_j^s = \left[\beta_j({}^3C_{jE}^s)^{-\rho_j} + (1-\beta_j)({}^2C_j^s)^{-\rho_j}\right]^{-1/\rho_j}$$

The nesting structure used in the model to represent the ROW differs from the structure above only for levels 3 to 5, where substitution across goods produced in other regions occurs. For level 5, goods produced in all Canadian regions appear, i.e.

$${}^5C_{jl}^{ROW} = \left[\sum_{r=1}^{8} \beta_{jl(r)}^{ROW} \cdot (C_{jl(r)}^{ROW})^{-\rho_j}\right]^{-1/\rho_j}$$

for $l = 1, \ldots, 12$. The level 4 substitution does not apply for the *ROW*. Level 3 substitution involves the Canadian composite and the good produced in the *ROW*. This yields 12 traded-good composites, i.e.

$$ {}^3C_{jl}^{ROW} = \left[\beta_{jl}^{ROW}(C_{jl(ROW)}^{ROW})^{-\rho_j} + (1-\beta_{jl}^{ROW})({}^5C_{jl}^{ROW})^{-\rho_j}\right]^{-1/\rho_j}, $$

for $l = 1, \ldots, 12$. The next two levels are the same as for the Canadian regions.

Industry Production Levels to Meet Consumer Demands

Intermediate demand functions reflect cost-minimizing behaviour. Cost minimizing subject to the CES intermediate requirement functions at each nesting level yields the appropriate cost functions; for space reasons the derivation of these functions is not reproduced here. The cost functions for *ROW* industries differ from those of Canadian industries. The nesting structure at the first level is, however, the same for all industries over all regions and will be used to illustrate the basic structure.

Expenditure on intermediate goods by industry j in region r is denoted by M_j^r, where

$$ M_j^r = PD_j^r \cdot {}^1C_j^r. $$

${}^1C_j^r$ is the quantity of the intermediate use composite good at level 1 of the nesting structure, while PD_j^r denotes the price of this composite good.

The CES intermediate requirement subfunction underlying ${}^1C_j^r$ at level 1 yields the intermediate demand functions for the energy and non-energy composites, i.e., the demand function for the non-energy composite in industry j in region r is

$$ {}^2C_{jNE}^r = \frac{(1-\beta_j)^{1/(1+\rho)} \cdot M_j^r}{({}^1PD_{jNE}^r)^{1/(1+\rho)} \cdot {}^1PS_j^r}, $$

where the superscripts which denote level 1 and region r for the β's and ρ have been suppressed for simplicity of exposition. The term ${}^1PS_j^r$ is defined as

$$ {}^1PS_j^r = (\beta_j)^{1/(1+\rho)} \cdot ({}^1PD_{jE}^r)^{\rho/(1+\rho)} + (1-\beta_j)^{1/(1+\rho)} \cdot ({}^1PD_{jNE}^r)^{\rho/(1+\rho)}. $$

The price index for the composite good ${}^1C_j^r$ can then be written as

$$PD_j^r = ({}^1PS_j^r)^{1/(1+\rho)}.$$

Similarly, the price indexes ${}^1PD_{jNE}^r$ and ${}^1PD_{jE}^r$ are calculated using parameters from the lower levels of the intermediate requirement functions.

The CES subfunction for ${}^2C_j^r$ at level 2 yields the intermediate demand functions for each of the 11 non-energy traded good composites and for the public services good in r. Similarly, the appropriate demand functions are derived for each of the lower levels. At these lower levels, the price indexes are calculated from the domestic (gross of tax) prices of the individual goods, i.e.,

$$\overline{P}_{hj}^r = P_h \cdot (1 + \tau_{Mh}^r + t_{Mh}^r + {}^I\tau_{hj}^r + {}^It_{hj}^r)$$

is the price that industry j in region r pays for good h ($h = 1, \ldots, 91$).

The result of this cost-minimizing process is to yield the per-unit requirements a_{hj}^r, i.e. the per-unit requirement of good h in the production of good j in region r. Given $X(P)$, the vector of final demands for goods as a function of P, and $A(P)$, the matrix of elements a_{hj}^r, then

$$G(P) = [I - A(P)]^{-1} \cdot X(P)$$

yields the gross output of commodities that meets the vector of final demands and minimizes intermediate production costs.

D. CONSUMPTION

Demands for all agents in the model are based on utility-maximising behaviour subject to agent budget constraints, with nested CES utility functions used to represent agent preferences. The five level nesting structure for Canadian agents is identical to that used to represent Canadian intermediate requirements in production. At the top level, agent utility is a function of an energy and a non-energy composite, both of which are defined by the nesting structure used for the lower levels. Similarly, final demand preferences in the *ROW* follow the *ROW* intermediate requirement nesting structure. The federal government is modelled as a utility-maximizing agent and the preference structure used is similar to that for *ROW*.

Agent Budget Constraints

-Regions

The budget constraint for each region defines regional income I^r, where

$$I^r = P_K \cdot \overline{K^r} + P_L^r \cdot \overline{L^r} + P_N \cdot \overline{N^r} + TR^r + R^r - IT^r,$$

and P_K is the world price of capital, P_L is the wage received by labour in region r, P_N is the natural resource price in Canada, TR^r defines the federal government transfers to r, R^r is regional government net tax revenues (assumed redistributed in lump-sum form), and IT^r defines federal personal income taxes paid in r.

-Federal Government

The federal government budget constraint is represented by income I^G, where

$$I^G = P_K \cdot \overline{K^G} + R^G - \sum_{r=1}^{6} TR^r$$

and $\overline{K^G}$ is federal ownership of capital and R^G is federal net tax revenue.

-ROW

The budget constraint for the foreign agent, ROW, is given by the income term I^{ROW}, where

$$I^{ROW} = P_K \cdot \overline{K}^{ROW} + P_L^{ROW} \cdot \overline{L}^{ROW} + R^{ROW}$$

and R^{ROW} is the ROW net tax revenue.

Final Demands

The total final demand for any good is $X_h = \sum_r X_h^r$, where $h = 1, \ldots, 91$ and r refers to ROW, G, and all 6 regions in Canada. Maximizing the CES utility subfunctions at each level of the nesting structure yields the final demand functions for the composite goods, and at the lower levels the final demand functions for the individual goods. Since the nesting structure is the same as that used for the intermediate requirement functions in production, the derived final demand functions also have the same form as the intermediate demand functions.

Price indexes of the composites used in the functions are derived from the consumer prices of the individual goods. Consumer prices in each region r in Canada are denoted by

$$\overline{P}_h^r = P_h \cdot (1 + \tau_{Mh}^r + t_{Mh}^r + \tau_h^r + t_h^r)$$

for $r = 1, \ldots, 6$ and $h = 1, \ldots, 91$. The federal government pays no taxes and so

$$\overline{P}_h^G = P_h$$

For the ROW

$$\overline{P}_h^{ROW} = P_h \cdot (1 + t_{Mh}^{ROW} + t_h^{ROW})$$

Both the above hold for $h = 1, \ldots, 91$

E. TREATMENT OF FACTOR MOBILITY

The resource factor is specific to both Canada and the energy industry, so it is internationally and intersectorally immobile. Accordingly, the Canadian price for the energy factor is P_N, with the energy industry in region r facing the price

$$\overline{P}^r_N = P_N \cdot (1 + \tau^r_N + t^r_N).$$

Two versions of the model with different treatments of capital mobility are used. In the basic model variant, capital is intersectorally, interregionally, and internationally mobile. In this case there exists a single world price for capital. The other model variant has capital as intersectorally and interregionally mobile, but not internationally mobile. In this variant, the price of capital faced by an industry j in a Canadian region r is

$$\overline{P}^r_{Kj} = P_K^{CDN} \cdot (1 + \tau^r_{Kj} + t^r_{Kj}) \qquad \text{for } j \neq \text{energy},$$

while for the ROW, the price of capital is

$$\overline{P}^{ROW}_{Kj} = P_K^{ROW} \cdot (1 + t^{ROW}_{Kj}) \qquad \text{for } j = 1, \ldots, 13.$$

A further modification is necessary for this variant in the statement of the model equilibrium conditions.

A feature of the model which differentiates it from other applied general equilibrium models is the treatment of partial labour mobility between regions. This treatment is fully discussed in the main text.

F. MODEL EQUILIBRIUM CONDITIONS

Equilibrium in the model is characterized by a set of conditions:

Demand-Supply Equalities for Commodities and Factors

–for all commodities

$$X_h(P) = G_h(P) - \sum_{r=1}^{6,ROW} \sum_{j=1}^{13} a^r_{hj} G^r_j(P) \qquad \text{for } h = 1,\ldots,91.$$

–for capital

In the basic model variant:

$$\sum_{r=1}^{6,ROW} \sum_{j=1}^{13} K^r_j(P) = \sum_{r=1}^{6,ROW,G} \overline{K^r}.$$

In the international immobility variant:

$$\sum_{j=1}^{13} K_j^{ROW}(\dot{P}) = \overline{K}^{ROW} \qquad \text{and}$$

$$\sum_{r=1}^{6} \sum_{j=1}^{13} K^r_j(\dot{P}) = \sum_{r=1}^{6,G} \overline{K^r}.$$

–for labour

$$\sum_{j=1}^{13} L_j^{ROW}(P) = \overline{L}^{ROW} \qquad \text{and}$$

$$\sum_{j=1}^{13} L^r_j(P) = \overline{L^r} \qquad \text{for } r = 1,\ldots,6.$$

After migration has occurred, $\overline{L^r} = \overline{L^r_r} + (\sum_{s \neq r} \overline{L^r_s})$, where $\overline{L^r_r}$ is the number of original individuals in r who remain in r, and $\overline{L^r_s}$ is the number of individual from region s who migrate to r.

–for natural resources

$$\sum_{r=1}^{6} N^r(P) = \sum_{r=1}^{6} \overline{N^r}.$$

Zero-Profit Conditions for Industries (Basic Model Variant)

The producer price for industry j in region r (where the subscript (j, r) denotes the h value corresponding to j and r) covers production costs, including domestic production taxes and subsidies. Note that for ROW, τ_{Pj} is zero.

$$P_{(j,r)} = (1 + \tau_{Pj} + t^r_{Pj})\Big[\overline{P}^r_K \cdot \frac{K^r_j(P)}{G^r_j(P)} + \overline{P}^r_L \cdot \frac{L^r_j(P)}{G^r_j(P)} + \sum_{k=1}^{13} \sum_{s=1}^{6,ROW} a^r_{(k,s)j} \cdot \overline{P}^r_{(k,s)j}\Big]$$

Trade Balance (Basic Model Variant)

–for ROW

$$\sum_{r=1}^{6,G} \sum_{i=1}^{13} P_{(i,ROW)} \cdot X^r_{(i,ROW)}(P) = \sum_{r=1}^{6} \sum_{i=1}^{13} P_{(i,r)} \cdot X^{ROW}_{(i,r)}(P) + P_K \cdot \Big[(\sum_{j=1}^{13} K^{ROW}_j) - \overline{K}^{ROW}\Big].$$

–for each Canadian region, s

$$\sum_{r \neq s} \sum_{i=1}^{13} P_{(i,s)} \cdot X^r_{(i,s)}(P) + TR^s = \sum_{r \neq s} \sum_{i=1}^{13} P_{(i,r)} \cdot X^s_{(i,r)}(P) + P_K \cdot \Big[(\sum_{j=1}^{13} K^s_j) - \overline{K}^s\Big].$$

–for the Federal Government

$$I^G = R^G + P_K \cdot \overline{K}^G - \sum_{r=1}^{6} TR^r = \sum_{h=1}^{91} P_h \cdot X^G_h(P).$$

APPENDIX II

THE JONES-WHALLEY MIGRATION DECISION PROCESS

This appendix contains a description of the migration decision process used by Jones and Whalley (forthcoming) in their Canadian regional model. This model is also employed by Whalley and Trela (1986) in their analysis of the *Regional Aspects of Confederation*. Neither of these works presents the full details of the migration decision process. This appendix is intended to provide that missing detail and to also emphasize the improved migration process modelling which is described in the main text.

From Figure 2 of the main text and the assumptions underlying it, the utility function for any individual i in the home region can be written as

$$U_i = max[\hat{U}_i^R(X), \hat{U}_i^L(X)] \qquad (A.1)$$

where $\hat{U}_i^R(X)$ is the utility to i from consuming the bundle of goods X in the home region, and $\hat{U}_i^L(X)$ is the utility from consuming X in the other region. Under the simple locational preference model of Figure 2, these values can be written as

$$\hat{U}_i^R(X) = U_i^R(X) \quad \text{and} \quad \hat{U}_i^L(X) = U_i^L(X) - b_i \qquad (A.2)$$

where U_i^R and U_i^L are the utilities available to i in the respective regions solely from the consumption of X.

Assume, without explanation for now, that the prices which an individual faces in each region are equal. Due to this assumption, the price of the X bundle, P, is the same across regions. U_i^R and U_i^L can now be written as the indirect utility functions

$$U_i^R = g(P) \cdot I_i^R \quad \text{and} \quad U_i^L = g(P) \cdot I_i^L \qquad (A.3)$$

where $g(P)$ is the true cost of living (price) index for consumption in either region. I_i^R is the income to the individual from locating in the home region, while I_i^L is the income from locating in the other region. Based on the above functions, the analysis of Figure 3 in the main text can be considered in terms of changes in income.

This price assumption is very strong and obviously limits the model's ability to capture the "true" migration decision process. However, the use of this pricing assumption introduces some simplifications into the modelling of the migration function. Unequal utilities across regions imply that the constant, a, in the penalty function shown in Figure 1 of the main text will not necessarily be zero. Suppose that in the benchmark U_0^L is greater that U_0^R. In order for individual 0 in Figure 2 of the main text to perceive no incentives to migrate, then a must be greater than or equal to $U_0^L - U_0^R$. Assuming that within each region there exists an individual who is just on the margin, then this condition must hold with equality.

As will be shown, the model calibration process which arises under the above pricing assumption results in the parameter a being zero in every case. Individual 0 in each region is just on the margin and all others in a region have a unambiguous preference for remaining.

A further strong assumption is made. The only components of regional income which are considered in the migration decision are: wage earnings, interpersonal and intergovernmental transfers from ~~the federal~~ government, and resource tax revenues. Income from all other sources is assumed to be equal to that level which would arise if the individual were to remain in the home region. As discussed in the main text, the supply of capital and resources in a region is assumed to be owned by the original inhabitants of that region. When an individual migrates, his share of these factors is not sold off and, furthermore, remains in that region. Returns to these factors accrue at the rates of the original regions. The above assumption concerning the income included in the migration decision does, therefore, coincide with the modelling of capital and natural resource ownership; a migrating individual has no claim on the new region's capital and resources.

The assumption that a migrating individual still faces the home region prices implies that the same regional taxes are also paid. To be consistent with this, the migrating individual is assumed to pay the home region taxes and to collect a share of the home region non-resource based tax revenue as income. This yields a neutrality of non-resource based tax policies in terms of the labour migration decision.

In order to simulate their possible affect on labour allocation efficiency in Canada, regional revenues from resource taxation are modelled as being non-neutral in the migration decision. While an individual migrating to another region has no claim on the region's resource ownership, he does receive a share of the regional government's resource revenues (representing the government's provision of local public goods from resource based revenues). Thus, if a region is endowed with large quantities of resources, there can exist a migration incentive for labour in resource-poor regions to move to the resource-rich regions.

Total transfer payments to a region are included in the modelling in order to capture the migration incentives of not only equalization but also other federal programs such as unemployment insurance; this is done under the assumption that most federal transfer programs, both intergovernmental and interpersonal, are not distributionally neutral across the provinces. Since the individuals in a region are identical, interpersonal transfers from the federal government are assumed to be divided on an equal per capita basis. Intergovernmental transfers to a region are assumed to be distributed in a similar manner, since no explicit local public good is provided by a regional government.

Given all the above assumptions, the migration decision process can be reduced to a function of "migration income" differentials and locational preferences. For equation (A.3), I_i^R can now be split into two components: $\tilde{I}_i^R$ and $\bar{I}_i^R$. $\bar{I}_i^R$ is the "migration income" which an individual observes for the home region. $\tilde{I}_i^R$ is all other sources of income which the individual receives there. Similarly, I_i^L can be split into two components, $\tilde{I}_i^L$ and $\bar{I}_i^L$. Note that from the assumptions, $\tilde{I}_i^L = \tilde{I}_i^R$. Equation (A.3) can be rewritten as

$$\begin{aligned} U_i^R &= g(P) \cdot (\bar{I}_i^R + \tilde{I}_i^R) \\ &= g(P) \cdot \bar{I}_i^R + g(P) \cdot \tilde{I}_i^R \end{aligned} \tag{A.4}$$

and

$$\begin{aligned} U_i^L &= g(P) \cdot (\bar{I}_i^L + \tilde{I}_i^L) \\ &= g(P) \cdot \bar{I}_i^L + g(P) \cdot \tilde{I}_i^L. \end{aligned} \tag{A.5}$$

Now recall the migration decision rule from equation (2) of the main text, where individual i will migrate if $U_i^L - bi > U_i^R$. Given the assumptions underlying equations (A.4) and (A.5) above, this rule can be rewritten using (A.4) and (A.5) as

$$g(P) \cdot \bar{I}_i^L + g(P) \cdot \tilde{I}_i^L - bi > g(P) \cdot \bar{I}_i^R + g(P) \cdot \tilde{I}_i^R \tag{A.6}$$

which, since $\tilde{I}_i^L = \tilde{I}_i^R$, yields

$$g(P) \cdot \bar{I}_i^L - bi > g(P) \cdot \bar{I}_i^R. \tag{A.7}$$

By defining

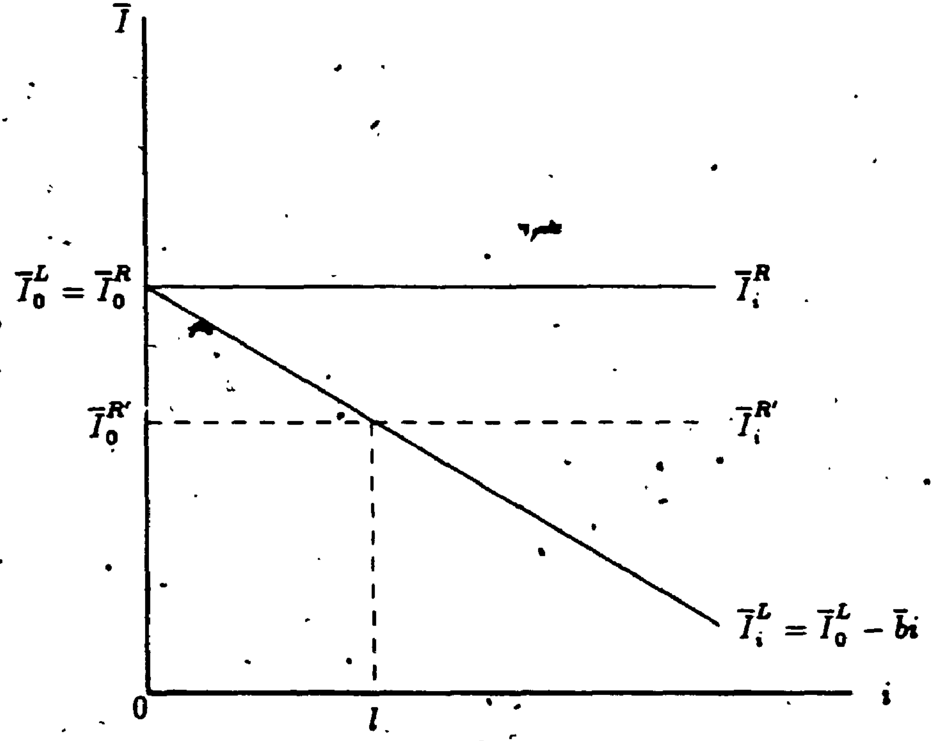
$$\bar{b} = \frac{b}{g(P)}, \tag{A.8}$$

then equation (A.7) can be rewritten to yield the following migration decision rule:

$$\text{Decision} = \begin{cases} \text{leave,} & \text{if } \bar{I}_i^L - \bar{b}i > \bar{I}_i^R; \\ \text{indifferent,} & \text{if } \bar{I}_i^L - \bar{b}i = \bar{I}_i^R; \\ \text{stay,} & \text{if } \bar{I}_i^L - \bar{b}i < \bar{I}_i^R. \end{cases} \tag{A.9}$$

As will be shown later, benchmark calibration yields the condition that $\overline{I}_i^L$ is equal to $\overline{I}_i^R$ for every $i = 0, \ldots, N$. This results in individual $i = 0$ being on the margin between staying or leaving, while the remainder of the individuals unambiguously prefer to stay. Using equation (A.9), Figure 2 of the main text can now be redrawn as Figure A.1; the solid lines represent the benchmark case. Note that the scaling of b to $\overline{b}$ changes the units of the locational preference parameters from utility to migration income.

Figure A.1



For a change in home region income, say a fall to $\overline{I}_0^{R'}$, the dashed line in Figure A.1 shows that the individual on the margin is shifted beyond individual 0 and out-migration occurs. Similarly, an increase in $\overline{I}_0^L$ ($= \overline{I}_i^L$ for $i = 0, \ldots, N$) would result in an upward shift in the line $\overline{I}_0^L - \overline{b}i$ and, therefore, some out-migration. Note that an increase in $\overline{I}_0^R$ or a fall in $\overline{I}_0^L$ will not yield any movement of the original inhabitants of the above region. In-migration to a region is determined from the out-migration functions of other regions.

The number of out-migrants, l, can now be determined for a given change in the relative migration incomes. Four possible cases for out-migration responses and the corresponding marginal conditions are described in Figure A.2. For the no out-migration case, individual 0 is on the margin and at that point $\overline{I}_0^R = \overline{I}_0^L$. For the change depicted in Figure A.1, if l_1 is the number leaving then individual l_1 is on the margin and $\overline{I}_0^{R'} = \overline{I}_0^L - \bar{b}l_1$ holds. If an increase in $\overline{I}_0^L$ to $\overline{I}_0^{L'}$ were to induce an out-migration of l_2 then at the margin $\overline{I}_0^R = \overline{I}_0^{L'} - \bar{b}l_2$ would hold. Finally, if an out-migration of l_3 were induced by an increase in $\overline{I}_0^L$ to $\overline{I}_0^{L'}$ and a decrease in $\overline{I}_0^R$ to $\overline{I}_0^{R'}$ then the condition $\overline{I}_0^{R'} = \overline{I}_0^{L'} - \bar{b}l_3$ would hold at the margin.

Thus, after out-migration the position at the margin can be described by the relationship

$$\hat{I}_0^R = \hat{I}_0^L - \bar{b}l \qquad (A.10)$$

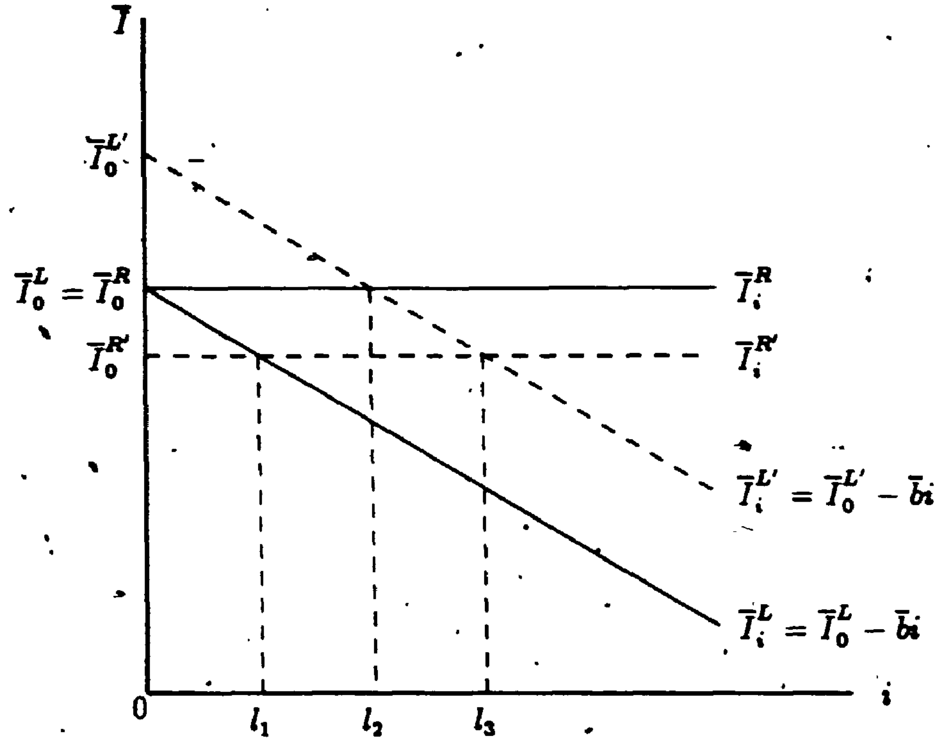
where l is the marginal individual. $\hat{I}_0^R$ and $\hat{I}_0^L$ can be either changed or unchanged from the original values, $\overline{I}_0^R$ and $\overline{I}_0^L$, but must satisfy the condition that $\hat{I}_0^L - \hat{I}_0^R \geq 0$. Again, this condition applies because the diagram describes the region's out-migration function only.

New values for $\hat{I}_0^R$ and $\hat{I}_0^L$ which satisfy the above condition allow the quantity of out-migrating labour, l, to be calculated. l denotes this quantity since individuals 0 to l, not including l, migrate so that l is also the number migrating. Rewriting equation (A.10) yields

$$l = \frac{\hat{I}_0^L - \hat{I}_0^R}{\bar{b}}. \qquad (A.11)$$

As should be obvious from this equation, the number of individuals (or units of

Figure A.2



labour) leaving the region is defined in some units of income. These units and the values used for other parameters in this labour migration modelling will be discussed below.

Calibration and Labour Mobility Parameters

So far the migration decision has only involved a comparison of home region income and outside region income. In the CRM, labour may migrate to any of five outside regions. The treatment of multiple regions and the calibration of migration function parameters will now be fully described.

The portion of own-region income considered by an individual in the migration decision process has been defined to consist of the region's wage rate plus per capita transfers from the federal government plus per capita regional resource tax revenues.

That is, the own-region migration income faced by an individual (a unit of labour) in a region r is

$$\overline{I}_i = w^r + \frac{TR^r}{N^r} + \frac{R^r}{N^r}, \tag{A.12}$$

and is the same for any individual i in region r. The total migration income for the region is thus

$$N^r \cdot \overline{I}_i = N^r \cdot w^r + TR^r + R^r. \tag{A.13}$$

The benchmark data contains observations on: a region's wage bill, $N^r \cdot w^r$; transfers to a region, TR^r; and a region's resource tax revenues, R^r. What is not known is: N^r, the number of units of labour in the region; w^r, the wage paid to a unit of labour in the region; and $\overline{I}_i$, the income to a unit of labour. Determining these values is part of the calibration process.

In order to satisfy the benchmark equilibrium conditions depicted in Figure A.1, the migration income which an individual receives in the home region must be equal to that available in any outside region. This value, a parameter of the initial model equilibrium, is chosen to be \$1. That is, in the benchmark case $\overline{I}_i$ = \$1 for any i in any region r. Equation (A.13) can now be written as

$$N^r = w^r \cdot N^r + TR^r + R^r, \tag{A.14}$$

which yields the number of labour units (or individuals) in a region, where a labour unit is defined in terms of the amount of labour which earns one dollar worth of migration income in the benchmark equilibrium.

Dividing equation (A.14) through by the wage bill, $w^r \cdot N^r$, yields

$$w^r = \frac{1}{1 + \left(\frac{TR^r + R^r}{w^r \cdot N^r}\right)}, \tag{A.15}$$

the benchmark wage rate for region r. Note that this is the wage to a unit of labour as defined above. Furthermore, note that in contrast to standard NGE modelling practices the benchmark prices of labour are not equal to one.

The assumption that $\overline{I}_i^r = 1$ for every region in the benchmark also plays a crucial role in the modelling of an individual's comparison of migration incomes across regions and his subsequent decision whether to migrate or not. It allows the decision process of Figure A.1 to be applied to the multi-region case. Assume that rather than considering each outside region separately in the migration decision process, an individual in a region considers only a single comprehensive measure of out-of-region income. This measure, F_i^r, is defined as

$$F_i^r = \sum_s \alpha_s^r \cdot \overline{I}_i^s, \qquad (A.16)$$

where s is an index over the number of regions. The α's are parameters in the benchmark data and show the share of a unit of labour leaving region r which goes to each region s. Table 1 of the main text lists the data used and it can be seen that for any region r (any row in Table 1), $\alpha_r^r = 0$ and $\sum_{s=1}^{6} \alpha_s^r = 1$. Given the benchmark assumption that $\overline{I}_i^r = 1$ for every r, then $F_i^r = 1$ must also hold for any region in the benchmark. Thus, the equilibrium condition that no migration incentives exist between regions holds for the benchmark case.

Equation (A.11) can now be used to describe total out-migration from a region. The migration income for the home region, referring to it as region H, is still $\overline{I}_0^R$ ($= \overline{I}_i^R$ for any i), while $\overline{I}_0^L$ ($= \overline{I}_i^L$, for any i) is now equal to the comprehensive out-of-region income measure, F_0^H ($= F_i^H$, for any i). Recall that $\hat{I}$ denotes income after a policy change has occurred and may or may not be different from $\overline{I}$.

In a two region model, if a policy change results in $\hat{I}_0^L > \hat{I}_0^R$ then $l > 0$ and out-migration occurs. For the multi-region case, a policy change may result in some outside regions having higher migration incomes than the home region, while for others it may be lower. Since out-migration should only occur to those regions in the first instance, the comprehensive out-of-region income measure must be more strictly defined. Therefore, define

$$\hat{I}_0^L = \sum_s \rho_s^H \cdot \hat{I}_0^s, \qquad (A.17)$$

where s is indexed over those regions for which $\hat{I}_0^s > \hat{I}_0^R$, and $\rho_s^H = \alpha_s^H / \sum_s \alpha_s^H$ so that $\sum_s \rho_s^H = 1$.

In the counterfactual case, if $l > 0$ then this out-migrating labour is distributed over the receiving regions according to the share parameters, ρ. That is, the amount of labour migrating from the home region to s is

$$N_s^H = \rho_s^H \cdot l. \qquad (A.18)$$

As in the two region case, in-migration to the home region after a policy change is determined from the out-migration functions of the other regions. The after-policy labour supply in a region is thus

$$\overline{N}^H = N^H - \sum_s N_s^H + \sum_r N_H^r, \qquad (A.19)$$

where r is indexed over those regions for which out-migration to the home region occurs.

An important determinant of a region's out-migration response is the value of the parameter b in equation (A.11). This value is determined in the calibration procedure as a function of the benchmark data and a specified elasticity value, η. This elasticity describes the responsiveness of the original labour units remaining in a region to a change in the comprehensive migration income measure for the outside regions. More formally, this elasticity is defined as

$$\eta = \frac{\partial \hat{N}^H}{\partial \hat{I}_0^L} \cdot \frac{\hat{I}_0^L}{\hat{N}^H}, \qquad (A.20)$$

where $\hat{N}^H = N^H - l$ and is the number of original labour units remaining in the region. Let $\Delta \hat{N}^H = 1$. Since N^H is constant, then Δl must equal 1. Now recall equation (A.10) which describes the marginal individual:

$$\hat{I}_0^R = \hat{I}_0^L - \bar{b}l. \tag{A.10}$$

If $\Delta \hat{I}_0^R = 0$, then $\Delta \hat{I}_0^L = \bar{b} \cdot \Delta l$. This can be written as

$$\begin{aligned} \bar{b} &= \frac{\Delta \hat{I}_0^L}{\Delta l} \\ &= \frac{\Delta \hat{I}_0^L}{\Delta \hat{N}^H} \end{aligned} \tag{A.21}$$

since from above, $\Delta \hat{N}^H = \Delta l$. Substituting (A.21) into (A.20) yields

$$\eta = \frac{1}{\bar{b}} \cdot \frac{\hat{I}_0^L}{N^H - l}. \tag{A.22}$$

Substituting from (A.11) yields

$$\begin{aligned} \eta &= \frac{1}{\bar{b}} \cdot \frac{\hat{I}_0^L}{N^H - ((\hat{I}_0^L - \hat{I}_0^R)/\bar{b})} \\ &= \frac{1}{\bar{b}} \cdot \frac{\hat{I}_0^L}{(\bar{b}N^H - \hat{I}_0^L + \hat{I}_0^R)/\bar{b}} \\ &= \frac{\hat{I}_0^L}{\bar{b}N^H - \hat{I}_0^L + \hat{I}_0^R}. \end{aligned} \tag{A.23}$$

In the benchmark $\hat{I}_0^L = \hat{I}_0^R = 1$, which yields

$$\eta = \frac{1}{\bar{b}N^H}. \tag{A.24}$$

Given values of N^H and η for region H in the benchmark data set, the benchmark value for $\bar{b}$ can be solved for as

$$\bar{b} = \frac{1}{\eta N^H}. \tag{A.25}$$

APPENDIX III

ESTIMATES OF POTENTIAL MIGRATION INCENTIVES IN THE COUNTERFACTUAL EQUILIBRIUM

This appendix reports results from calculations made to estimate the level of migration incentives which still exist after a counterfactual equilibrium has been determined. Recall that due to model solution problems, a less-than-ideal method for determining the destination of out-migrants was employed. Rather than having migrants go to the region which offered the highest utility to them, they are instead distributed in a fixed-coefficient manner over those outside regions which offer a higher utility than that available in the home region. While this approach allows the model to be solved, a problem with this method arises because incentives to migrate may still be present in what has been determined to be a model equilibrium.

TABLE 1. Percentage Differences in Potential Migrant Utility from Home Region Utility for Marginal Agents[1]

Home	Region of Migration					
Region	AC	Que	Ont	M/S	Alta	BC
AC	—	–7.7	–0.7	–1.9	–0.2	–1.6
Que	0.0	—	2.9	1.6	3.3	2.0
Ont	0.0	0.0	—	0.0	0.0	–1.0
M/S	0.0	0.0	–1.4	—	–0.9	–2.3
Alt	0.0	0.0	–0.3	0.0	—	–1.3
BC	0.0	0.0	0.0	0.0	0.0	—

[1] Calculation based on results in case 3, Table 2.

The results presented in Table 1 have been determined from the simulation in case 3, Table 2 of essay I. This case was chosen because it represents the situation where equalization has approximately a zero welfare effect for Canada as a whole and is therefore important to the analysis in essay II. The rows in the table give the regions from which labour could leave. The columns give the regions to which labour migrates. The values reported give the percentage differences in the utilities available to an out-migrant relative to that available in the home region. The out-migrant which is considered here is the marginal individual from the counterfactual equilibrium. That is, if the marginal individual in Atlantic Canada were to migrate to Quebec, then his utility would be 7.7 percent less than it would be in the home region.

The zero entries in the table show those cases in which no incentives to migrate to the region were created by the counterfactual experiment and so the marginal agent would not consider migrating there. Negative values indicate that the individual would be worse off from out-migration to the region. For each home region for which out-migration implies a loss to the marginal individual, a case exists where migration would result in a loss between 0 and 1 percent. This suggests that, as the theory predicts, the marginal individual is close to being indifferent between staying or leaving the home region.

An anomaly in these results is the set of all positive values for out-migration from Quebec. This suggests that the marginal individual in Quebec has an incentive to migrate to any of the other regions (except Atlantic Canada).

ESSAY II

EQUALIZATION AND LABOUR ALLOCATION EFFICIENCY IN CANADA

1. INTRODUCTION

This essay reports some numerical estimates of the effects of the Canadian federal government's system of equalization payments on labour allocation efficiency in Canada. The estimation of these effects is performed using an extended version of the Jones-Whalley (forthcoming) Canadian Regional Model (CRM). The extensions involve the modelling of labour migration decision rules and are described in the previous essay.

The analysis concentrates on three proposals made by Boadway and Flatter's (1982) in their study of the Canadian equalization system. Their first proposition is that labour allocation inefficiencies existed in Canada due to migration incentives arising from the regionally concentrated resource rents. They also propose that equalization payments might be used to offset these migration incentives and, as a result, remove the adverse effects on Canadian welfare. They conclude, however, that the equalization schemes currently in place would probably not act to promote efficiency in this manner.

Model simulations performed here using 1981 data suggest that the migration incentive effects of the equalization system resulted in a welfare loss for Canada. These losses could outweigh any gains which arose from the income effects of the transfers. Results are also presented which show that efficiency gains arise from the migration incentives of the regionally concentrated resource rents.

Courchene (1984) has documented the many arguments which have been used to show that: i) current equalization schemes need not be efficiency enhancing, and ii) that the presence of regionally concentrated resource rents need not introduce labour allocation inefficiencies. For the first case, Boadway and Flatters have themselves raised the two important issues of funding for the schemes and the difficulties which arise in attempting to design a scheme which accommodates the complex multi-regional and multi-policy structure of Canada. Predictably, the treatment of Ontario, the wealthiest region in Canada, is particularly important to both issues, and evidence of this is shown in the model results presented here.

Dales (1983) has highlighted the importance of also taking the complex multi-dimensional structure of Canada into consideration when analyzing the efficiency effects of regionally concentrated resource rents. The numerical general equilibrium (NGE) model used here captures some of this structure and the simulations show that the effects predicted by simple theory may not hold in a complex second-best situation. Again, Ontario is very important in determining the model results.

The results presented in this essay indicate that labour migration which was induced by the presence of regionally concentrated regional resource rents may have resulted in a welfare gain for Canada. Furthermore, the migration incentive effects of equalization may result in a welfare loss for Canada and, thus, could potentially eliminate the gains arising due to the regional resource rents. This presents a scenario substantially different from that considered by Boadway and Flatters and suggests that the interactions required by their analysis may not exist.

2. EQUALIZATION AND LABOUR ALLOCATION EFFICIENCY

Canada's first formal program of equalization payments was implemented in 1957 and since then the program has undergone many revisions. The importance of these payments to Canada should be evident from the fact that they are enshrined in the Canadian constitution. Subsection (2), Section 36 of Part III of the Constitution Act, 1982 states that:

> Parliament and the Government of Canada are committed to the principle of making equalization payments to ensure that provincial governments have sufficient revenues to provide reasonably comparable levels of public services at reasonably comparable levels of taxation.

A comprehensive history and evaluation of the Canadian equalization system is contained in Courchene (1984). This essay will concentrate on the influences of the equalization system on labour allocation efficiency in Canada.

Some empirical work performed by Courchene in the early 1970's was to provide the motivation for the more recent analyses of the effects of the Canadian equalization system on labour allocation efficiency. In this study, Courchene concluded that both equalization payments and unemployment insurance transfers did, for the period analyzed, dampen labour out-migration from the recipient regions. Since Courchene's analysis preceded the energy price increases of the early 1970's, no consideration was made of the influence of resource revenues on interregional labour migration.

These results led Courchene to propose (see, for example, Courchene (1978)) what has now been labelled the transfer dependency theory of equalization. Within the simple neoclassical framework where factors are paid their marginal products and labour is mobile, efficiency occurs when the marginal productivity of labour is the same across all regions. Courchene argues that equalization payments to a region may alter comprehensive income (wages, transfers, benefits from public goods) in the region so that labour will not respond to changing wages across regions in a manner which results in the above efficiency condition being satisfied. Labour will migrate until comprehensive incomes across regions are equal, but this does not necessarily mean that wages will be equal. This argument was presented in light of the large transfer payments to certain regions in Canada, particularly Atlantic Canada. The transfer dependency thesis suggests that payments to Atlantic Canada induce labour to remain there when normal market forces, operating through the wage system, should be luring this labour to other regions such as Ontario. As a result, labour allocation inefficiencies will arise and welfare losses will occur.

While Courchene's argument is generally accepted,[1] Boadway and Flatters (1982) have proposed an alternative scenario in which equalization could be used to improve labour allocation efficiency in Canada and, thereby, improve Canadian welfare. Underlying this analysis is the existence of the large and uneven distribution of natural resources, particularly energy, across Canada.

Boadway and Flatters propose that the comprehensive income in a region consists, in part, of the difference between the benefits a resident receives from provincial government activities and the cost that the resident bears in having these activities performed. These net fiscal benefits (NFB's) can vary across regions due to differences in resource-based tax collections of the regional governments. This can induce labour to migrate to the higher NFB regions and result in labour allocation inefficiencies. Boadway and Flatters argue that equalization payments to the low NFB regions will offset the incentives to migrate to the high NFB regions, and thereby enhance efficiency.

Boadway and Flatters present their argument through the use of a simple two-

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[1] See, for example, Vanderkamp (1982) and Winer and Gauthier (1982).

region model. If one region has higher NFB's than the other, then a self-financing scheme involving transfers from the high NFB region to the low NFB region is shown to equalise the benefits from the resource rents over the two regions. Incentives to migrate are eliminated and no labour allocation inefficiencies exist.

In analysing current equalization schemes relative to the above "rent-sharing" approach, Boadway and Flatters conclude that problems exist for justifying the current system in terms of improving labour allocation efficiency. Atlantic Canada and Quebec—both energy-poor regions in 1981—received the major portion of the equalisation payments made in that year. However, rather than having the high rent-collecting regions pay for equalization, payments were made out of the federal general revenues. Since the major contributions to these revenues came from federal taxes, the majority of the funding for equalization came from Ontario rather than from resource-rich Alberta. Furthermore, under the equalization scheme in place in 1981, Ontario received no equalization. Thus, while equalization may have discouraged labour from migrating from Atlantic Canada to Alberta, another effect might have been to cause distorting migrations to or from Ontario, also a resource-poor region in 1981.

Courchene (1984) has documented the many qualifications which must be made to the propositions that regionally concentrated resource rents will introduce labour allocation inefficiencies and that equalization can be used to enhance efficiency. Of particular interest here is Dales' (1983) use of the theory of the second-best to argue that, given the multi-regional and multi-policy structure of Canada, the existence of either of these effects is not guaranteed. This argument also applies to Courchene's transfer dependency thesis. According to Dales, the latter case has been presented in the form of a 'one-distortion' model which concentrates on the reduced incentives [illegible] migration from an equalization-receiving region. The proposed efficiency-retarding effects of resource rents have been presented as another one-distortion model in which incentives exist for in-migration to the resource-rich regions. By putting these two models together, the two distortions cancel each other out and equalization appears to promote efficiency.

As Dales notes, however, introducing further distortions and regions will wipe out the simple analysis. For example, if Atlantic Canada is the equalization-receiving region and Alberta is the resource-rich region, then a simple two-region, two-distortion model might show that a self-financing equalization scheme is efficiency enhancing. However, if Ontario (an energy-poor, but otherwise rich region) is introduced into the model, then determining what distorting forces exist is no longer very easy.

An empirical evaluation of the presence of the efficiency effects of either equalization or regionally concentrated resource rents should, therefore, be performed within a detailed model of Canada. The NGE model of Canada used in this essay presents a multi-region, multi-distortion structure for such an analysis. Before the model simulations are discussed, some previous empirical work in this area will be reviewed.

3. EMPIRICAL ANALYSIS

Two sets of empirical analyses have been performed which are relevant to the analysis performed here. The first deals with the testing of the assumption that fiscal factors do influence labour migration in Canada—an assumption which is crucial to the theories of both Courchene and Boadway–Flatters. The second set involves the analysis of the welfare impacts of the equalization system on Canada. Both of these analyses will be discussed below.

While many studies have been made of the non-fiscal forces which determine internal migration, only a few rigorous analyses of the relationship between fiscal activity and interregional labour migration have been performed. One such work was Courchene's 1970 regression analysis, upon which his transfer dependency argument was based. As discussed in the previous section, he concluded that both equalization payments and unemployment insurance transfers did, for the period analyzed, dampen labour out-migration from the recipient regions. Since Courchene's analysis preceded the energy price increases of the early 1970's, no consideration was made of the influence of resource revenues on interregional labour migration.

A more recent work by Winer and Gauthier (1982) was aimed at updating Courchene's analysis and extending it to cover a more complete set of fiscal variables, including provincial government resource revenues. Their empirical analysis attempts to determine what caused migration flows between pairs of regions for the period 1968–1977. This empirical analysis and the subsequent simulation exercises appear to provide evidence that both equalization and resource revenues affect the migration decision. In one simulation, Winer and Gauthier attempt to forecast what the migration rates for 1971 to 1977 would have been if resource revenues in western Canada had remained at their 1971 levels. The purpose was to approximate a situation in which the increases in resource revenues for these years were distributed on an equal per capita basis across Canada and, thus, would not introduce any differences in net fiscal benefits across regions. While based only on data samples for out-migration from Atlantic Canada to the rest of Canada and for in-migration to Alberta and British Columbia from the rest of Canada, the results suggest that the presence of resource rents may attract migrants to a region.

Another experiment performed by Winer and Gauthier involves the forecasting of 1971–77 migration rates for the case in which equalization payments were maintained at their 1971 level for this period. The simulations are performed for the same regions as in the above experiment and the results suggest that equalization may dampen out-migration from resource-poor to resource-rich provinces.

While the Winer–Gauthier experiments provide evidence that resource rents may induce out-migration from resource poor regions and that equalization to these regions may dampen this outflow, they have not been accepted as definitive proof that these forces exist. Courchene (1984), for example, advises that these results be treated with considerable caution. He notes that none of the westward migration is attributed to the productivity changes that are associated with energy price increases. Furthermore, Winer and Gauthier do not identify who is migrating; Courchene suggests that if the migrants are unemployed eastern Canadians, then while migration may occur, it may not be inefficient.

In their analysis, Winer and Gauthier make no attempt to determine the welfare impacts of the migrations induced by fiscal factors. Two studies of these effects have been performed: one by Watson (1986) which is based on partial equilibrium analysis, and the other by Whalley and Trela (1986) which employs general equilibrium analysis. Watson's analysis will be considered in some detail so that the features of his partial equilibrium approach can be compared to the NGE approach employed by Whalley and Trela. With the modifications described in essay I, this latter approach is also the one used here.

Under the premise that efficiency gains arise from the migration-retarding effects of equalization, Watson performs some calculations based on the Winer–Gauthier results in order to estimate the actual size of these gains. His results indicate that the overall welfare gain from the difference in equalization payments between 1971 and 1977 was $1.4 million (in $1971). Furthermore, he determines that the cost-benefit ratio of these payments is much greater than one. His conclusion is that while the pay-off in efficiency gains from the equalization system is very low, other gains arising from the program which have not been taken into account may, in fact, show the program to be of significant benefit to Canada.

To calculate his results, Watson chooses twenty-eight of the pairwise combinations of regions used by Winer and Gauthier in their simulations involving equalization payments. The data from the Winer–Gauthier results which is used by Watson is the change in the gross flow of migrants between the pair of provinces which was estimated to have resulted from the changes in equalization between 1971 and 1977. Of the twenty-eight cases, Watson rejects five because of 'perverse' results in which people were induced to leave a region even though equalization to the region was in their favour. For each remaining case, Watson estimates the income gain to the people who, because of the new (1977) levels of equalization, were induced not to migrate. This yields his estimate of the welfare gain to a region which arises from people not migrating to another region in response to differences in NFBs across the regions. To determine the welfare gain for Canada, Watson sums over the effects which were estimated between each of the pairs.

Obviously Watson's approach is unable to capture the distorting effects described by Dales (1983) in his discussion of the third region consequences of a policy targeted at eliminating distortions between any two regions. That is, Watson's estimates of the welfare impacts arising from the influence of equalisation on migration flows from Atlantic Canada to Alberta do not consider the presence of Ontario (or any other regions). As a consequence, while no consideration is given to the effects of the migration on the relative incomes in the pair of regions through factors such as wage adjustments, the effects of similar adjustments in the other regions are also not considered.

The regional numerical general equilibrium (NGE) model of Canada developed by Jones and Whalley (forthcoming), and employed by Whalley and Trela (1986) in their analysis of the regional aspects of Confederation, can capture the above effects, and more. For example, while Watson has no production in his analysis, the NGE model of Canada employs a detailed production structure. Furthermore, other policy elements of both the federal and regional governments are modelled, so the relationship between the equalization system and these policies, in particular federal and provincial resource policies, can be analyzed.

Another important feature of the analysis performed by Watson is that the effects of any migration on the non-migrating members of a region are not considered. Watson analyses (as did Winer and Gauthier) changes in interregional migration flows, not changes in the stock of labour in a region. As noted earlier, Courchene is concerned with the fact that Winer and Gauthier do not identify the migrants so that if they are, in fact, unemployed workers migrating to new jobs, then migration may be efficient. Underlying the Boadway–Flatters theoretical analysis is a general equilibrium framework in which labour is fully employed. Forces such as equalization and NFBs induce labour to change jobs over regions and, in doing so, introduce labour allocation inefficiencies. Simulations of this type of interaction can be best captured in a NGE modelling framework. Full employment can be explicitly specified and the Boadway–Flatters model can be studied within the bounds of this special case.

A NGE modelling approach also presents a solid economic structure for the modelling of labour migration and the migration decision process. While many authors admit that non-pecuniary migration costs should be modelled as playing a role in the migration decision process,[3] they usually then argue that if these costs are entered into the analysis in some monetary form the analysis will not be changed substantially by their presence. Since the utility functions are explicitly specified in a NGE model, these non-pecuniary migration costs can be directly incorporated. The modelling of location specific preferences is a feature of the Canadian regional model (CRM) which differentiates it from other modelling exercises.

The issues and problems associated with the implementation of labour migration and the migration decision process into a NGE model are described in essay I of this thesis.

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[3] See Watson (1986) and Boadway and Flatters (1982), for example.

4. MODEL SIMULATIONS

This section describes the results from simulations used to address the three issues raised by Boadway and Flatters (1982) in their study of the Canadian equalization system. Recall these issues from the introduction to this essay. The first involves the Boadway–Flatters proposition that labour allocation inefficiencies exist in Canada due to migrations induced by NFBs arising from the local taxation of regionally concentrated resources. The second involves the proposition that equalization payments might be used to offset these incentives and, as a result, remove the inefficiencies. The last issue involves the Boadway–Flatters proposition that the equalization schemes which were in place at the time would probably not act to promote efficiency.

The simulations are performed using the model described in the first essay of this thesis. As in the simulations presented there, two sets of results are presented for each simulation. The first set are Hicksian equivalent variations (EV's) in millions of 1981 dollars and give the income equivalent of the welfare effect on each region of the particular policy experiment under consideration. The second set shows the net migrations for the regions which result from the policy change. These values give total labour inflow from other regions minus the outflow from the region and are in millions of the benchmark labour units described in the previous essay. A more detailed description of the presentation and interpretation of the model results has already been given in the previous essay.

Current Equa[illegible]tion Schemes

The third issue described above will be dealt with first; that is, the effects of the equalization scheme which is in place will be analyzed. The simulations shown in Table 1 are the same as those in Table 2 of the previous essay. They involve the replacement of the federal equalization payments to the regions by an equal rate federal subsidy on final demands by all regions which is designed to maintain federal government real expenditures at the benchmark level. This change is performed over a range of migration elasticity values—from 0.01 to 0.5. The choice of these values is discussed in essay I of this thesis.

In case 1, replacing the equalization system results in large welfare losses for the major recipients—Atlantic Canada, Quebec and Manitoba/Saskatchewan—while the other regions gain. Ontario gains the most from this policy change. While the large losses can be explained by the income effects of removing the equalization payments, the gains arise from the subsidy on final demand.

Due to the very inelastic value for the migration elasticity parameter, net migration flows are relatively small for this case. A comparison of the migration flows to the welfare effects reveals the intuitive result that the losing regions experience outflows while the gainers have inflows. Cases 2 to 4 of Table 1 involve migration elasticities of increasing value. Both net inflows and net outflows increase over the cases. Intuitively, a net outflow of labour from a region should result in an increase in the region's wage rate and, as a consequence, a smaller welfare loss than in the case where no migration is allowed. Regions experiencing a net inflow should have a drop in the wage rate and, consequently, a smaller welfare gain. A comparison of the welfare results over the four cases supports this intuition.

While the results indicate that the equalisation-receiving regions gain through the income effects of these transfers, these gains are reduced as the dampening effect of equalisation on out-migration is increased. However, as is discussed in the previous essay, actual labour migration does not increase proportionally to increases in the migration elasticities. The reason for this is that when the net outflow from a low utility region and the net inflow to a high utility region are both allowed to increase, the wage differential between the two regions will decrease even more and, therefore,

TABLE 1. Replace Federal Equalization Payments with a Subsidy on Final Demand Designed to Maintain Real Federal Expenditures Constant

	Case 1	Case 2	Case 3	Case 4
Hicksian EV's				
($ millions 1981)				
Atlantic Canada	-1310	-1283	-1252	-1086
Quebec	-1357	-1306	-1249	-980
Ontario	1760	1711	1657	1387
Manitoba/Saskatchewan	-179	-171	-162	-122
Alberta	479	464	449	375
British Columbia	556	547	536	471
Total	-29	-17	-5	48
Net Labour Migration				
(+ indicates inflow)				
Atlantic Canada	-10	-46	-88	-324
Quebec	-16	-75	-140	-457
Ontario	17	79	148	496
Manitoba/Saskatchewan	-2	-9	-17	-54
Alberta	6	28	51	164
British Columbia	5	24	46	175

Case 1: Migration elasticities equal to 0.01 for all regions.

Case 2: Migration elasticities equal to 0.05 for all regions.

Case 3: Migration elasticities equal to 0.10 for all regions.

Case 4: Migration elasticities equal to 0.50 for all regions.

dampen the possible migration response. This suggests that the gains should still exist for the major recipients even if labour's responsiveness to changes in income is very high.

The gains listed in Table 1 arise due to the equal yield replacement in the policy change. This equal rate subsidy on final demand for all goods yields the highest benefits to the higher income regions. Since equalization is funded from general tax revenues and since the personal income tax is the greatest source of these revenues, this replacement rule should give a good approximation of the funding costs to the regions. The results in Table 1 indicate that the greater are the migration retarding effects of equalization, the lower are the welfare costs to the non-recipient regions from funding the program.

While the total welfare effects for Canada in cases 1, 2, and 3 show that Canada benefits from equalization, these gains decrease as the migration possibilities are increased. Furthermore, Canada loses under the relatively large net migrations of case 4. These results indicate that the migration retarding effects of equalization might result in overall welfare losses to Canada. This suggests that the current scheme may contribute to labour allocation inefficiencies in Canada.

While the results presented here are qualitatively comparable to those from a similar set of modelling simulations performed by Whalley and Trela (1986), they are quantitatively different.[3] As discussed in the previous essay, the more detailed decision rule which is employed here results in changes in equalization having a smaller influence on the decision to migrate. Consequently, the aggregate Canadian welfare gains shown here are less than one-half of those in the comparable Whalley-Trela cases, while the losses are more than double. While Whalley and Trela conclude from their results that equalization could easily be a welfare-losing program on efficiency

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[3] The Whalley-Trela results are presented in Table 4 in the previous essay.

grounds, the results presented here suggest that this statement is too strong.

Table 2 presents a set of simulations which are also similar to a set performed by Whalley and Trela.[4] The goal of these simulations is to analyse the migration effects of equalization without the large income transfer effects present. In the experiments performed here, actual transfers are not altered but the influences of equalization payments on labour's migration decision process are removed. That is, a counterfactual equilibrium is determined where the only model difference from the benchmark case is the removal of equalization payments from the calculation of the utility levels used in the migration decision process. The four elasticity cases considered are the same as those in Table 1.

For all cases, the qualitative pattern of gains and losses is the same as that of Table 1. Migration patterns are also the same, and as migration possibilities are increased both the welfare and migration effects are amplified. Consider case 1, where migration elasticities are 0.01 for every region. Removal of the migration incentives (or disincentives) of equalization causes labour from the three major equalization-receiving regions to migrate to Ontario, Alberta, and British Columbia. Ontario experiences the largest inflow, nearly three times that of Alberta.

The individual welfare effects reflect the changes in wage rates in the regions as labour migrates. Quebec, with the largest outflow, has the largest welfare gain, while Ontario, with the largest inflow, has the largest loss. For case 1, the total welfare result indicates that Canada shows an overall gain from the removal of the migration incentives of the federal equalization program. This suggests that the aggregate effect of the migration incentives of the current Canadian equalization scheme is a reduction in labour allocation efficiency and, subsequently, a welfare loss. As migration possibilities are increased (cases 2 to 4), the inefficiency is increased. This accounts

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[4] See Table 5-15 in Whalley and Trela.

TABLE 2. **Removal of Equalization from the Calculation of Utility Levels Used in Migration Decision Process; Actual Equalization Payments Unchanged**

	Case 1	Case 2	Case 3	Case 4
Hicksian EV's ($ millions 1981)				
Atlantic Canada	5	21	40	143
Quebec	11	39	72	232
Ontario	-12	-41	-76	-251
Manitoba/Saskatchewan	2	7	12	40
Alberta	-3	-12	-21	-67
British Columbia	-1	-6	-12	-52
Total	1	6	11	31
Net Labour Migration (+ indicates inflow)				
Atlantic Canada	-7	-32	-60	-220
Quebec	-10	-47	-87	-283
Ontario	11	53	99	331
Manitoba/Saskatchewan	-1	-7	-12	-40
Alberta	4	18	33	103
British Columbia	3	14	28	109

Case 1: Migration elasticities equal to 0.01 for all regions.

Case 2: Migration elasticities equal to 0.05 for all regions.

Case 3: Migration elasticities equal to 0.10 for all regions.

Case 4: Migration elasticities equal to 0.50 for all regions.

for the decreasing aggregate welfare gains from equalization which are seen in the Table 1 results.

What do the Table 2 results suggest about the effects of current equalization on labour allocation efficiency in Canada? While inefficiencies might be reduced by the dampening of incentives to migrate to Alberta, a much larger effect on migration to Ontario may be resulting in even bigger inefficiencies and thus a national welfare loss. Transfer dependency might be used to explain the effects of equalization on migration to Ontario.

The above observations are similar to those made by Whalley and Trela. As in the analysis of Table 1, the migration effects reported here are smaller than those reported by Whalley and Trela. The results are, however, qualitatively the same.

Resource Rents

In this section, the first and second issues discussed above will be addressed. What are the effects of Canada's large and regionally concentrated energy rents on labour allocation efficiency in Canada? And does equalization reduce migration incentives arising from these rents? Results reported in Table 3 present some evidence which can be used to address these questions.

Case 1 reproduces case 3 of Table 2 and is included for comparison. The migration elasticity for this case is 0.1 and is used for all the cases reported in this table. The choice of this particular value is based on the results of Table 1. For case 3, where $\eta = 0.1$, the overall effect on Canada of the equalization system is reported to be approximately neutral. This neutrality should allow the effects of the resource rents to be better highlighted.

Case 2 of Table 3 reports the results from an experiment designed to simulate the labour flows induced by the migration incentives of the energy rents in Canada.

2 of/de 2

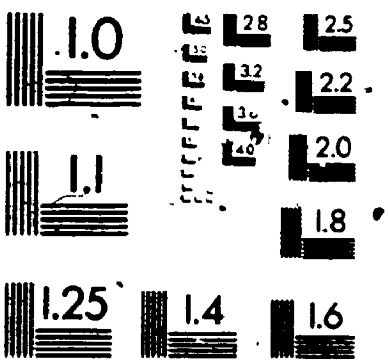

TABLE 3. Simulation of the Direct Incentive Effects of Regionally Concentrated Resource Rents on Labour Mobility in Canada; Actual Policy Unchanged

	Case 1	Case 2	Case 3
Hicksian EV's ($ millions 1981)			
Atlantic Canada	40	13	-0.5
Quebec	72	55	0.4
Ontario	-76	321	1.9
Manitoba/Saskatchewan	12	-10	-0.4
Alberta	-21	-305	-1.5
British Columbia	-12	66	0.7
Total	11	147	0.5
Net Labour Migration (+ indicates inflow)			
Atlantic Canada	-60	-20	0.5
Quebec	-87	-57	-0.3
Ontario	99	-307	-1.4
Manitoba/Saskatchewan	-12	22	0.4
Alberta	33	377	1.3
British Columbia	28	-16	-0.5

Case 1: See case 3, Table 2.

Case 2: Benchmark calibration excludes regional resource rents from the migration decision process. Policy change involves the introduction of these effects.

Case 3: As in case 2, except migration incentives of resource rents are introduced on an equal per capita basis.

As discussed in the previous essay, the method of comparative statics analysis normally used with this model cannot be employed to accurately simulate migration flows which have already occurred. Under the assumption that regional energy rents have resulted in such flows, the alternative approach described in the previous essay has been used for the case 2 simulation. That is, in the benchmark the parameters for the migration decision functions are calibrated for the case where regional energy rents are not considered in an individual's migration decision process. An individual's income from a region's energy rents is the same as it would be in case 1 because the actual redistribution of the energy rents to individuals in a region is unaltered. The counterfactual analysis involves the situation where, given the benchmark migration functions, individuals now do consider regional energy rents in the migration decision process. Again, the "policy" change does not involve an actual change in an individual's share of energy rents. The resulting migration flows therefore simulate the direct incentive effects of the regional energy rents on labour mobility in Canada.

The migration results for case 2 suggest that Alberta experienced a large net inflow due to energy royalties, while each of the other regions had a net outflow. The largest outflow occurred from Ontario and, in the simulation here, this flow is over five times larger than the next biggest outflow, that from Quebec.

This suggests that the migration incentives due to energy royalties in Canada were largest between Ontario and Alberta. The welfare effects reported for this case reflect the pattern of wage adjustments caused by these migrations. Alberta shows a large loss, while Manitoba/Saskatchewan shows a small loss. All other regions, including Atlantic Canada and Quebec, gain. Note that Ontario's gain is larger than Alberta's loss and that Canada shows a relatively large welfare gain overall. This suggests that the migration incentive component of the regional energy royalties in Canada may have induced a reallocation of labour which, while causing a large loss for Alberta, was welfare improving for Canada.

This presents a scenario which is substantially different from that considered by Boadway and Flatters. What then do cases 1 and 2 imply about the relationship between the 1981 equalization system and the migration incentives of energy royalties? Recall that the two sets of results are based on different benchmark equilibria, so caution must be taken in making any comparison. However, assume that the equalization scheme does reduce migration to Alberta from the equalization-receiving regions. Since this policy is in place for the simulation in case 2, this implies that equalization may be retarding the migration to Alberta which is induced by energy royalties and, consequently, decreasing the possible gains to Canada.

As discussed in an earlier section, Boadway and Flatters showed in their analysis that the optimal scheme for removing the migration incentive effects of the regionally concentrated resource rents could be one involving a revenue-sharing pool. To simulate such an equalization scheme here, an experiment like that of case 2 is performed but the migration incentive effects of the resource rents are introduced on an equal per capita basis for all labour in Canada. The results from this experiment are shown in case 3 of Table 3.

The migration flows for this case are very small relative to those in cases 1 and 2. Consequently, the welfare effects arising from wage adjustments are very small. The total effect for Canada is a gain of $0.5 million. In light of the case 2 results, these results are not surprising. If, as case 2 shows, the migration incentive effects of the resource rents yield a large gain for Canada, then reducing these migration incentives should reduce the gain. If, in fact, the migration incentives of resource rents act as in case 2, then an equalization scheme designed to remove these migration incentives might not be desirable.

5. SUMMARY AND CONCLUSIONS

The results of the previous section can be summarised as follows:

1. The major impact of the equalization system in 1981 arises from the direct income effects of the transfer mechanism. The relatively lower income regions, in particular Atlantic Canada and Quebec, experience large gains, while the relatively high income regions lose.

   The migration disincentive effects of equalization appear to dampen any of the above gains or losses to the regions. The greater are the migration retarding effects of equalization, the smaller are the welfare costs to the non-recipient regions and the smaller are the gains to the equalization receiving regions.

2. The overall gain to Canada from the direct income effects of equalization appears to be small. Canada appears to lose from the migration disincentive effects of equalization, which suggests that these effects contributed to labour allocation inefficiency in Canada. The larger are these effects, the larger is the loss. This loss can outweigh any gains arising from income effects and suggests that the equalization system in 1981 may have been a welfare losing policy for Canada overall.

   Note, though, that these losses are not large even for the cases where migration possibilities are quite large. Note too, however, that administration costs of the program have not been taken into account.

3. Labour migration induced by regional resource rents may have resulted in a welfare gain for Canada. While Alberta loses due to labour in-migration, the gains to the rest of Canada from out-migration more than offset this loss. This presents a scenario substantially different from that considered by Boadway and Flatters

and, as a consequence, the interactions required by their analysis may not exist. In the results here, if equalisation does, in fact, retard out-migration from equalisation receiving regions, then it may be reducing the gains to Canada which could arise under the migration incentives of the regional resource rents. Furthermore, an equalization scheme involving a revenue-sharing pool aimed at removing the migration incentives of resource rents would remove these gains almost completely.

4. For most of the cases reported here, the migration and welfare results for Ontario were amongst the largest. In most cases, these played a prominent role in determining the overall consequences of a policy for Canada. This reinforces the argument by Dales that the multi-region consequences of equalization must always be considered and, of course, emphasizes the importance of the general equilibrium approach.

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ESSAY III

CUSTOMS UNION FORMATION AND INTRA-UNION TARIFFS

1. INTRODUCTION

The idea that a customs union is not necessarily Pareto-superior for all members goes back at least as far as Johnson (1958), when he showed that free trade need not make all nations better off relative to some tariff-restricted situation. Much of the recent customs union literature has dealt with determining the conditions (for example, relative differences in country sizes) under which a country might gain from joining a customs union. Wooton (1986) presents an analysis which embodies much of this work. But pre-dating much of this stream of analysis was the proposition of Kemp and Wan (1976). They showed that if transfers could be made between countries, then a customs union solution (defined by a set of common external tariffs and a system of lump-sum transfers) would exist which would make all members better off relative to a non-cooperative state. Furthermore, they showed that a solution would exist which would make enlarging the union better for all members, so a set of transfers must exist which makes all countries better off under complete free trade.

McMillan (1986) presents two arguments to explain why free trade might be reached in the Kemp and Wan model, but not in the real world. First, tariffs are not set in any aggressive or retaliatory way in the model. However, as the expanding union becomes bigger it should be gaining increased market power relative to the rest of the world. In his analysis of retaliatory optimal (Nash equilibrium) tariff rates, Johnson (1958) gives two-country examples in which a country with market power can impose tariffs which make it better off than under a free trade solution. Kennan and Riezman (1982) have extended Johnson's analysis to the three-country case and have shown that a union with such power can impose optimal external tariffs which would make member-countries better off and would stop further progression to a final free trade solution.

The second argument presented by McMillan deals with the fact that intra-union lump-sum transfers may be needed. These may not be politically feasible and even if they can be implemented, transfer agreements must be enforceable or the union may break down. However, Dixit and Norman (1986) have presented a model in which commodity taxes and subsidies are used to distribute a nation's gains from trade amongst its consumers so that freer trade could be a Pareto improvement. This idea can be extended to the distribution of gains from customs union formation. Of course, while individual nations would have to coordinate their taxation to achieve this result, this does present a redistribution scheme which might be more politically acceptable to the members of a customs union.

A customs union exists when two or more countries remove barriers to trade between themselves and impose a common set of restrictions on trade with the rest of the world. In this essay, the role of using non-zero intra-union tariffs as a means of redistributing union gains is analysed. But rather than following the Kemp and Wan (1976) model where the union external tariffs are set in a passive way, the union and the non-member nations will adopt Nash equilibrium tariffs. Thus, while world-wide free trade may not be achieved, the situations under which positive intra-union tariffs can make union membership become Pareto superior will be explored.

This essay employs numerical simulations to investigate the role of non-zero trade barriers in the formation of customs unions. A pure exchange model involving 3 countries and 3 goods is used for the analysis. Non-cooperative strategies are characterized by Nash retaliatory tariffs and, due to the the modelled capability for customs union formation, a mixture of cooperative and non-cooperative strategies can occur in an equilibrium.

The modelling of Nash retaliatory tariffs is based on Johnson's (1958) work on optimal tariffs and retaliation. Since the model is an extension of Johnson's 2x2 analysis to a higher dimensional case, his observations on the possible gains from cooperative and non-cooperative trading strategies can be considered for the case of customs union formation. For the simple examples examined here, these observations appear to hold.

Results presented here suggest that the presence of non-zero intra-union tariffs may reduce the gains which can arise from union formation. More importantly though, these tariffs can alter the strategic options available to the trading nations. Non-zero intra-union tariffs can allow a union to be the optimal strategy for all its members, whereas in the intra-union free trade case the union is an inferior strategy for some. Details of the possible consequences of alternative intra-union tariff specifications are explored.

2. COOPERATIVE/NON-COOPERATIVE TRADING STRATEGIES AND CUSTOMS UNION MODELLING

As stated in the introduction, Johnson's (1958) work on optimal tariffs and retaliation forms the groundwork for the modelling here. Johnson's analysis is an attempt to demonstrate that a country may gain from a retaliatory tariff war, and to determine the conditions under which this may happen. For a two country, two good pure exchange model, Johnson diagrammatically shows that in the Nash-equilibrium characterization of retaliatory optimal tariff warfare, one country may gain over free trade. He then attempts to describe the conditions underlying the occurrence of any such equilibrium; in particular, he attempts to determine the relationship between a country's preferences and the probability that the country will gain from tariff warfare.

Confronted with the difficulties of performing this task analytically, Johnson instead performs some simple numerical experiments involving constant elasticity offer curves. He derives some insight into the possibility of gains from retaliatory tariff warfare for cases involving different relative import demand elasticities between countries. For his simple two country model, Johnson observes that the probability of a country gaining from retaliatory tariff warfare is greater the higher is its import demand elasticity (IDE) relative to the foreign elasticity.

Johnson also shows how the size of a country's optimal tariff can be related to the various elasticities underlying the foreign offer curve. If the exports of the home country are denoted by X and the imports from the foreign country as Y, then the elasticity of the foreign offer curve, σ^f, is given by

$$\sigma^f = \frac{Y}{X}\frac{dX}{dY}.$$

Johnson shows that the home country's optimal tariff rate is given by

$$t^* = \sigma^f - 1 = \frac{1}{\eta_X^D - 1},$$

where η_X^D is the foreign country's import demand elasticity. One implication of this formula is that the higher is the import demand elasticity of the foreign country, the smaller is the home country's optimal tariff against imports from it. Note that this formula is derived for a very simple case and, as Johnson shows,[1] quickly becomes more complicated as this case is expanded upon. However, an attempt will be made to relate the results presented here to this formula.

Hamilton and Whalley (1983) extend Johnson's analysis by performing numerical simulations of optimal tariff retaliation for a 2x2 model involving a more extensive set of parameters. These include non-constant import demand elasticities, production possibilities, variable country size, and variable endowment mix for each country. For various configurations of these parameters, Hamilton and Whalley report the gains and losses relative to free trade which arise from a retaliatory tariff war between the two countries. For a set of import demand elasticity specifications they compare their results to Johnson's and, in general, agree with his observations.

Kennan and Riezman (1982) have developed a numerical modelling procedure which involves optimal tariff retaliation and is an extension of Johnson's analysis to the 3x3 case. The representative consumer has preferences which are described by a linear expenditure system and endowments are fixed in the exchange-only economy. The simplicity of the model allows country utilities and Nash equilibrium tariffs to be solved for explicitly. For alternative specifications of endowment shares and preference weights, model solutions are calculated for the cases of free trade, full retaliatory tariff warfare, and various cooperative strategies. In analyzing the results relative

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[1] Pages 59–61 in Johnson (1958).

to the parameter settings, Kennan and Riezman suggest some motivations for why countries would form customs unions. Most importantly, they show how a customs union can be formed as a defensive response to aggressive, non-cooperative trading behaviour on the part of other countries. Results from the model employed here present an extension to this argument. This is discussed later when the model results are described.

The simulations performed by Kennan and Riezman involve no explicit analysis of alternative trade elasticity regimes. As mentioned in the introduction, a goal of the analysis here is to consider customs union formation in light of Johnson's observations on the relationship between relative IDE's and the gains from cooperative/non-cooperative strategies. As a result, the modelling procedure developed here is based on the structure of the Hamilton and Whalley model, and carries most of the richer demand-side parameter set used by them to the 3x3 case.

In Johnson's 2x2 analysis of the probability of gains from a retaliatory tariff war, the concept of relative import demand elasticities which is employed can be interpreted as representing relative bargaining strengths in trade. A relatively higher IDE implies relatively higher total substitution possibilities in the country's demand and supply of traded goods. For the low IDE country, relatively lower substitution possibilities are implied and so trade is relatively more important to this country. In a retaliatory tariff war starting from the free trade position, a lower IDE country will not be able to improve its terms of trade and, in fact, these may be worsened by the optimal tariffs imposed by the other country. The higher IDE country has, in effect, greater trading (terms-of-trade) power due to the relatively greater importance of trade to the lower IDE country.

In the model used here, the higher dimensionality combined with the number of available parameters makes the specification of relative trading power rather arbitrary.

As will be seen later, the relative size of endowments or the relative size of share weights on imported goods in the CES utility functions could each be used to specify trading power. Following Johnson's analysis, the modelling procedure and data are structured so that the specification of import demand elasticities represents (and determines) the relative trading power of the countries. While allowing Johnson's insights on the gains from retaliatory tariff war to be extended to the three country case and to the formation of customs unions, parameter specifications which yield a strict and clear division of the gains and losses in a simulation will, more importantly, also allow the optimal strategy for any country to be easily identified. This aids in the study of the possible consequences of customs union formation.

The following sections, therefore, describe a model and data specification which, while restricting the generality of any extension of Johnson's analysis, yields a well-behaved case under which to study customs union formation with non-zero intra-union tariffs. While the results presented in this study are also not general, they do present some interesting insights into the possible effects and uses of intra-union barriers in a customs union.

A common criticism of the use of these simple models involving stylized data is just that: they are simple and involve stylized data. Many large-scale numerical general equilibrium models have been developed for the analysis of international trade issues,[2] so why can't they be extended to the analysis of customs union formation? Two recent papers have made advances in this area. The modelling approaches of these will be considered briefly and compared to the model used here.

Markusen and Wigle (1987) employ an extended version of Whalley's (1985) eight-bloc model of world trade in their analysis. With it, they consider the role

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[2] See the Shoven and Whalley (1984) survey of the use of these models to analyze trade and public finance issues.

of country size, scale economies, and capital mobility in determining the Nash-equilibrium tariff rates for Canada and the U.S. The model is repeatedly solved over a grid of Canada–U.S. tariff rates. The resulting sets of welfare effects for Canada and the U.S. are compared and the Nash equilibrium is determined. Protection levels in all other countries are maintained at their currently modelled levels, as are the Canadian and U.S. rates on imports from these countries. Furthermore, adjustment of the protection levels in Canada and the U.S. involves only a proportional scaling of levels on all traded goods. Thus, tariffs in a country are changed in a non-discriminatory fashion.

Markusen and Wigle argue that the solution of the model for a full retaliatory Nash tariff equilibrium involving all countries and using discriminatory optimal import tariffs would be beyond computational constraints. In their analysis then, this capability, and the ability to make a detailed analysis of alternative cooperative/non-cooperative strategies, have been traded for the ability to employ a detailed data set and a rich structure of functional forms and policies. The modelling here, meanwhile, makes the opposite trade-off: while data and functional form are simple, a more detailed analysis of strategic trading behaviour is possible. Import tariffs which are discriminatory across both sectors and countries can be used to determine a Nash optimal tariff equilibrium involving full retaliation among all countries. More importantly though, equilibria can be calculated for a mixture of cooperative and non-cooperative strategies.

Harrison and Rutström (1986) have implemented a modelling approach which should allow for the use of large-scale numerical models in the study of Nash retaliatory equilibria and other equilibria which are potentially very computationally intensive. For a given numerical general equilibrium model, say the Whalley eight-bloc model, repeated solutions would be calculated over a grid of values for all protection levels on all goods in all regions. Harrison and Rutström can then apply their computational procedure to the data from these solutions in order to determine the Nash equilibria present. This approach can be applied to models involving a wide range of policy instruments and allows multiple Nash-equilibrium solutions to be determined for non-cooperative games. Harrison and Rutström suggest that cooperative strategies such as customs unions might also be accommodated in the modelling. However, no work on this aspect has been reported yet.

As will be seen, the modelling of Nash-retaliatory optimal tariffs for the 3x3 case has been complicated. An extension of the Harrison/Rutström approach to include cooperative strategies would create a solution procedure which would allow the simulations done here to be much more easily performed. Furthermore, not only could the model structure and data be enhanced, but a higher dimensional model could be used and customs unions involving more than two members (and even multiple customs unions) could be analyzed. Such a model would allow an analysis of the generality of the basic findings made here concerning customs unions and intra-union tariffs.

3. THE MODEL

In moving from a 2x2 to a 3x3 analysis, the possibility of numerous different trading patterns becomes an issue which must be considered. Furthermore, the pre- and post-union pattern and direction of trade should ideally be determined as part of the equilibrium solution. Lloyd (1982) shows how different fixed-pattern assumptions lead to different analytical results for models of small tariff change. The problem is further aggravated here by the fact that customs union formation is being considered under large tariff changes. If two countries open free trade between themselves while erecting joint barriers against trade from the rest of the world, some change in production patterns accompanied by a new pattern of trade between the partners should occur. This brings out another aspect of the modelling: it should involve production responses.

As noted in the previous section, model tractability requires that some trade-off be made between the degree of model detail and the ability to analyze strategic trading behaviour. For this reason, the fixed pattern of trade described below and the pure exchange economy formulation, for which some further justification is given later, are assumed for the modelling done here. However, while this specification allows only specific cases to be considered, insights can still be gained into the circumstances under which gains from union formation occur. Johnson's analysis provides some direction for the 3x3 cases to be studied.

Johnson's model obviously involves a fixed symmetric pattern, but in the 3x3 case a symmetric pattern can, for example, have either each country importing two goods and exporting a third not exported by the others, or each country exporting two goods and importing a third not imported by others. However, Jones' (1976) has suggested that for most multi-good models, trading solutions involve, realistically, each country importing more goods than it exports. A fixed pattern of trade following that of Meade (1955) is therefore adopted for a three country pure exchange model with each country endowed with some quantity of the 3 goods. For simplicity of exposition, each case to be analyzed is set up so that country one exports good 1 and imports goods 2 and 3, country two exports good 2 and imports 1 and 3, etc.

The demand side of each country consists of a single consumer who owns all endowments in the country and to whom all revenues collected in the country are returned lump sum. As discussed in the previous section, the modelling techniques used here are based on those used by Hamilton and Whalley because their approach involved the explicit specification of trade elasticities. The specification of these parameters in the model used here is discussed in a later section. Following the Hamilton and Whalley model, CES preferences are assumed for the single consumer in each country. The demand function for good i in country k can be written as:

$$X_i^k = \frac{(\alpha_i^k)^{\sigma^k} I^k}{(P_i^k)^{\sigma^k} \cdot \sum_j (\alpha_j^k)^{\sigma^k} (P_j^k)^{1-\sigma^k}} \tag{1}$$

where the α_i^k are the share parameters and σ^k is the elasticity of substitution for the utility function. Ad valorem import tariffs are used in this model, so P_i^k is the domestic (gross of tariff) price of good i in country k, and the income term I^k contains the tariff revenue.

The presence of tariffs and the lump sum return of the tariff revenues to the consumer raises the usual problem for general equilibrium modelers of having to simultaneously determine consumer demands and tax revenues when each is dependent on the other. Shoven and Whalley (1974) have shown that to solve this problem, market demands for a country must be written as a function of both prices and the revenues generated in the country by the tariffs. That is, given $P = (P_1, P_2, \ldots, P_n)$ the vector of world prices for the n goods, t^k the vector of ad valorem import tariffs on imports into country k, and R^k the revenue from these tariffs which is distributed to the consumers, then the market demand for good i in country k is written as $\xi_i^k(P, R^k)$. The exact definitions for the various model equilibria will be described later.

The actual numerical methods used to solve this type of model usually involve the direct presence of these revenue elements (or some sort of revenue scaling terms) in the vector of "prices" to be solved for in the approximation process. The simple structure of the model used here, however, allows an alternative technique to be employed. This is largely possible due to the absence of a detailed structure of nested functions on the demand and production side.[3] The following is a brief description of this technique.

In equation (1), the presence of tariffs implies that $P_i^k = P_i(1 + t_i^k)$, where P_i is the world price[4] for good i. If w_i^k is the country k endowment of good i, then the income term for equation (1) can be written as

$$I^k = \sum_j P_j w_j^k + R^k, \tag{2}$$

where $R^k = \sum_j P_j t_j^k X_j^k$. Dropping the country superscript k for simplicity of notation, equation (1) can now be written as

$$X_i = \frac{\alpha_i^\sigma \sum_j (P_j w_j) + \alpha_i^\sigma \sum_j (P_j t_j X_j)}{(P_i(1+t_i))^\sigma \cdot \sum_j \alpha_j^\sigma \left(P_j(1+t_j)\right)^{1-\sigma}}. \tag{3}$$

For the three good model employed here, the demand equations for any country can then be written as

$$\begin{aligned}
X_1 &= \frac{\alpha_1 \sum_j (P_j w_j)}{D_1} + \frac{\alpha_1 P_1 t_1}{D_1} \cdot X_1 + \frac{\alpha_1 P_2 t_2}{D_1} \cdot X_2 + \frac{\alpha_1 P_3 t_3}{D_1} \cdot X_3, \\
X_2 &= \frac{\alpha_2 \sum_j (P_j w_j)}{D_2} + \frac{\alpha_2 P_1 t_1}{D_2} \cdot X_1 + \frac{\alpha_2 P_2 t_2}{D_2} \cdot X_2 + \frac{\alpha_2 P_3 t_3}{D_2} \cdot X_3; \\
X_3 &= \frac{\alpha_3 \sum_j (P_j w_j)}{D_3} + \frac{\alpha_3 P_1 t_1}{D_3} \cdot X_1 + \frac{\alpha_3 P_2 t_2}{D_3} \cdot X_2 + \frac{\alpha_3 P_3 t_3}{D_3} \cdot X_3.
\end{aligned} \tag{4}$$

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[3] For an example of the type of nesting commonly used, see Appendix I of the previous essay in this thesis.

[4] Note then that a superscripted price denotes domestic price, while no superscript denotes world price.

where $D_i = (P_i(1+t_i))^{\sigma} \cdot \sum_j \alpha_j^{\sigma} (P_j(1+t_j))^{1-\sigma}$. The above form is, of course, the system of equations $X = A + BX$, where X can be solved from $X = [I - B]^{-1}A$, given values of w, P, t, σ, and α.

Thus, the demands for any country can be solved for in this simple model by solving the system of equations in (4). Note that this does not include any explicit solution of a revenue term.

Model Equilibrium Solutions for Alternative Trading Strategies

The strategies analyzed here include free trade (FT), full retaliatory tariff warfare (FTW), and customs unions (CU). The solution concepts underlying these will first be described,[5] then the methods used to numerically solve them will be outlined. Note that the solution concepts employ the market demand functions described previously.

(1) *Free trade equilibrium.* In this case, $t^k = 0$ and $R^k = 0$ in every country k. Equilibrium is defined by a vector of world prices P^* which satisfies the condition

$$\sum_k \xi_i^k(P^*) \leq \sum_k w_i^k$$

for every good i, where the condition holds with strict equality when corresponding prices are positive. The assumption that Walras' Law is satisfied on an individual country basis yields the property for this equilibrium that external sector balance holds for every country, i.e., $\sum_i \left[P_i^* \cdot \left(\xi_i^k(P^*) - w_i^k\right)\right] = 0$.

(2) *Nash retaliatory optimal tariff solution for each country k.* Equilibrium is defined by a vector of world market prices P^* such that country k maximizes the social welfare function

$$U^k\left(\xi^k(P^{k*}, R^{k*})\right)$$

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[5] These draw heavily on the description in Hamilton and Whalley (1983).

subject to the equilibrium conditions:

$$\sum_k \xi_i^k(P^{k*}, R^{k*}) \le \sum_k w_i^k, \qquad \forall i \qquad (= \text{ if } P_i^* > 0).$$

P^{k*} denotes the vector of goods prices in country k, and $(P^{k*} - P^*)/P^*$ gives each country's vector of optimal tariffs which supports the equilibrium. In equilibrium, external sector balance holds for each country. Government budget balance also holds, where $R^{k*} = \sum_i \left[(P_i^{k*} - P_i^*) \cdot \xi_i^k(P^{k*}, R^{k*})\right]$.

(3) *Equilibrium involving a single customs union.* For a given customs union, C, with m member nations, equilibrium is defined by a vector of world market prices P^* such that the m members maximize the union social welfare function

$$U^C\left[U^1\left(\xi^1(P^{C*}, R^{1*})\right), \ldots, U^m\left(\xi^m(P^{C*}, R^{m*})\right)\right],$$

the exact specification of which is described later. The non-member countries, n, maximize

$$U^n\left(\xi^n(P^{n*}, R^{n*})\right), \qquad \forall n,$$

and all maximization is subject to the equilibrium conditions:

$$\sum_k \xi_i^k(P^{k*}, R^{k*}) \le \sum_k w_i^k, \qquad \forall i \qquad (= \text{ if } P_i^* > 0).$$

P^{n*} denotes the vector of goods prices in a non-member country n, and a non-member country's vector of optimal tariffs on all imports, $(P^{n*} - P^*)/P^*$, supports the equilibrium. For the customs union, each member adopts the union's optimal tariff rates on imports from non-members. In the zero intra-union tariff case, each member faces the vector of goods prices P^{C*}, and the equilibrium is supported by the vector of optimal tariffs $(P^{C*} - P^*)/P^*$ which is adopted by all members. In the non-zero intra-union tariff case, individual members will face different prices on goods traded within the union.[6] In all cases, government budget balance and external sector balance both hold for each country in equilibrium. Note that this implies that cash transfers from one member to another are ruled out.

Numerical Solution Methods

A free trade solution is determined by using the algorithm of Van der Laan and Talman (1979) to find the vector of world prices which clears world demands for the three goods. The full tariff warfare case involves calculating a post-retaliation (Nash) equilibrium involving optimal ad valorem import tariffs for all countries. The procedure used to perform this calculation is an extension of that used by Hamilton and Whalley to solve for the 2 country, 2 good case. As the groundwork for the 3x3 approach developed here, their procedure will be briefly described.

As mentioned above, CES preferences are adopted for each consumer and from these are determined a country's market demand functions. Combined with the country's endowments, these yield the country's excess demand functions. Hamilton and Whalley show that a property of the offer curves generated by these functions is non-constant elasticities. Using these functions, Hamilton and Whalley employ a solution procedure which is the algorithmic equivalent of the Nash tariff retaliation process described by Johnson (1953).

Figures 1 and 2 give the familiar 2x2 offer curve depiction of the solution for a country's non-retaliation optimal tariff. Hamilton and Whalley assume a fixed direction of trade with, as in Figure 1, country one exporting good 1 and country two exporting good 2. In determining country one's first-round optimal tariff, they first assume that the world price of good 2 is equal to one, then numerically calculate

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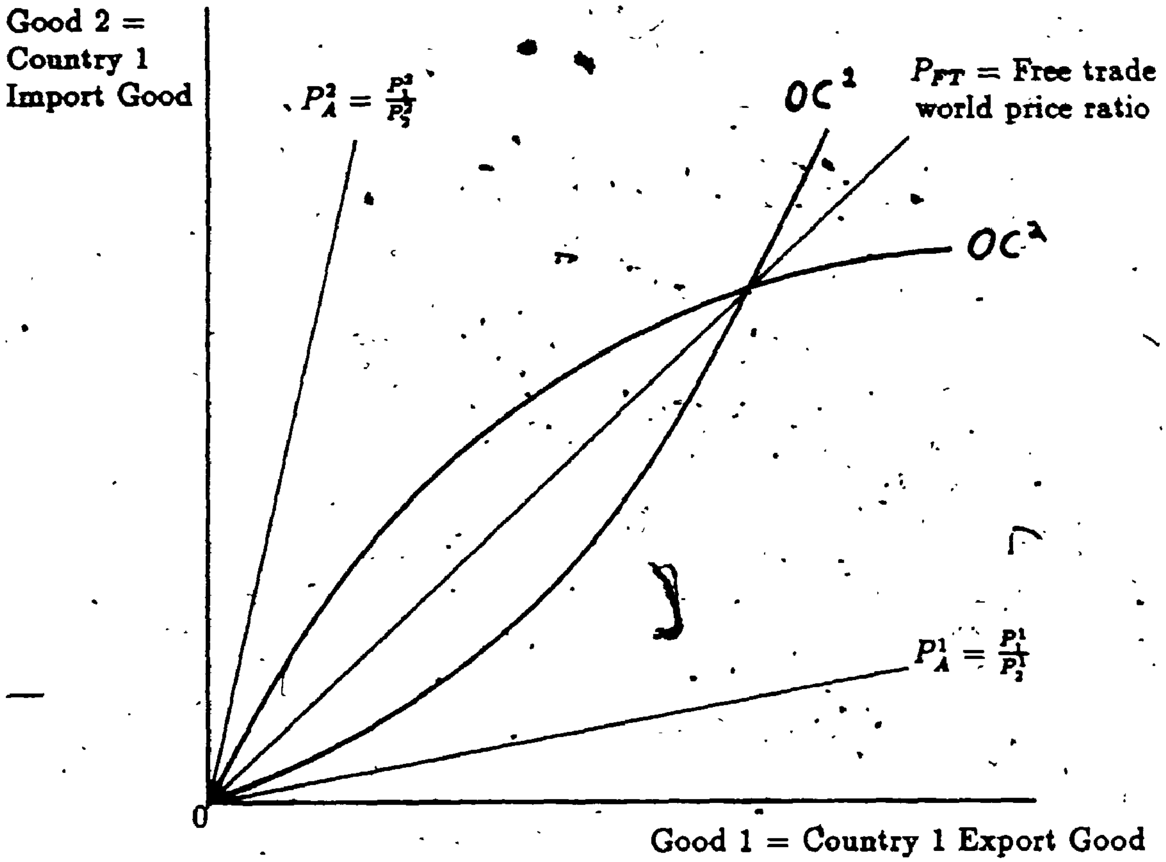
[6] Which implies that the notation for the vector of prices faced by each union member must change and, subsequently, the maximization condition must also change. For the sake of brevity, this is not done here.

Figure 1. Free Trade Solution



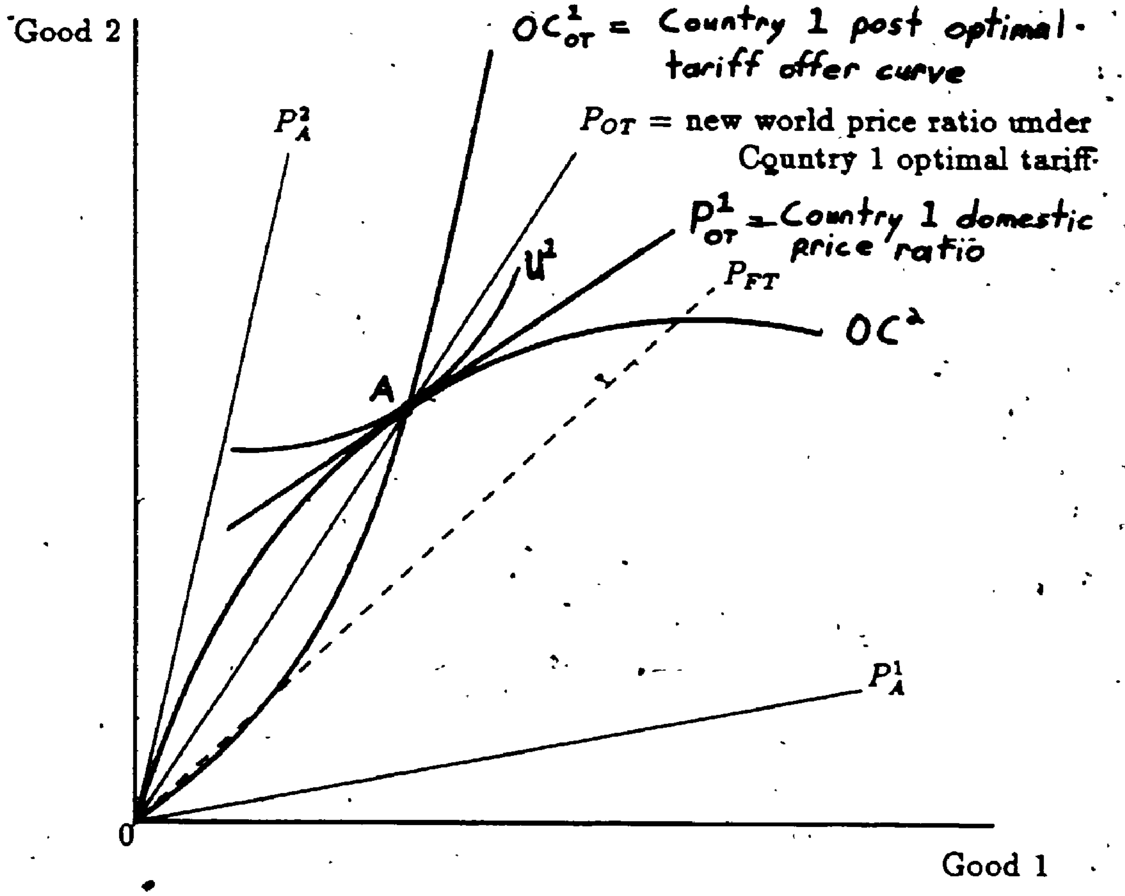
the country two demands as the world price of good 1 is varied over the range of the autarky price levels. That is, over the range

$$P_A^1 = P_1^1/P_2^1 \quad \text{to} \quad P_A^2 = P_1^2/P_2^2, \tag{5}$$

where superscripts denote country and subscripts denote goods.

If it is assumed that country one consumes the residual of the world endowments after country two's calculated demands have been removed, this implicitly moves country one's offer curve, OC^1, along the offer curve of country two. While moving over the range of autarky prices, country one's utility is calculated and the world price

Figure 2. First Round Optimal Tariff Solution for Country One



level at which this is a maximum is determined. Thus an approximation of point A in Figure 2 is made. Note that country one's offer curve now passes through point A and that, in all probability, its elasticity at this point is different than it was at the free trade equilibrium position.

At point A, country one's demands and the world price ratio are known. The parameters of the utility function are also known, so the consumer's marginal rate of substitution (MRS) can also be calculated. Since the equilibrium condition for a country k is

$$MRS^k_{1,2} = P^k_1/P^k_2 = \left(P_1 \cdot (1+t^k_1)\right) / \left(P_2 \cdot (1+t^k_2)\right), \tag{6}$$

then for country 1, where the tariff on good 1 is zero, the tariff necessary to reach point A can be calculated as:

$$t^1_2 = (P_1/MRS^1_{1,2}) - 1. \tag{7}$$

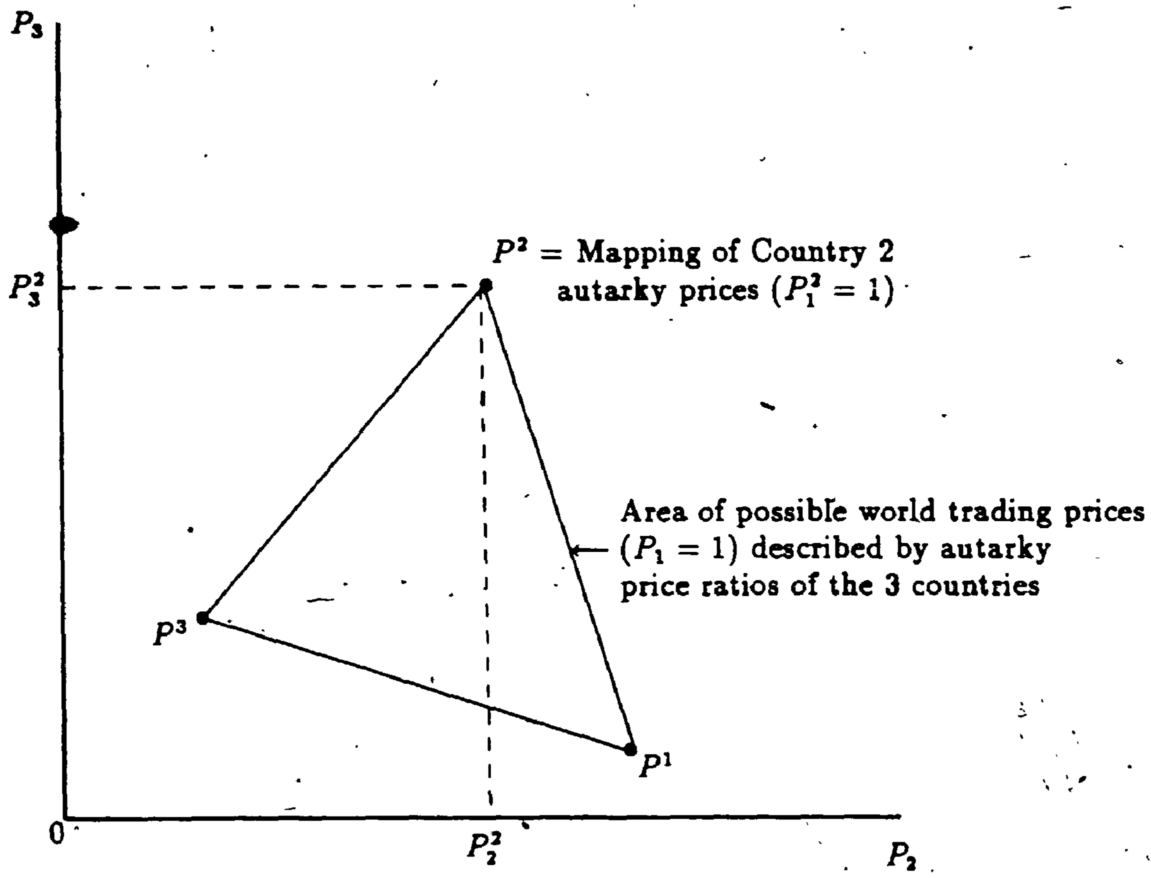
Once this tariff is calculated and adopted, then country two's optimal tariff rate is determined for the new situation. This process is repeated for each country until each calculated tariff does not differ from its previous value by more than a specified tolerance. In other words, until no country can gain by changing its tariffs, given the rates existing for other countries. Thus, this solution is an approximate Nash equilibrium for the modelling problem.

The approach used here is a 3x3 analogue of the above procedure. Good 1 is assumed to be the numeraire and based on this, the autarky price levels for the three countries are mapped in (P_2, P_3) space. An example is shown in Figure 3. In the 2x2 offer curve analysis of Figure 1, trade occurs at a world price ratio somewhere between the two autarky price ratios. For the 3x3 case, trade will occur at a set of world prices (price of good 1 equal to one) somewhere in the triangle defined by the three sets of autarky prices.

Consider the first round optimal tariff case for country one. A numerical grid search over the price triangle is performed in order to find the set of world prices which yields the highest utility for country one, given that it receives the residual from the world endowment after the utility maximizing demands of countries two and three have been removed. As in the 2x2 approach, the tariff rates yielding country 1 this result can be calculated as:

$$t^1_2 = (MRS^1_{2,1}/P_2) - 1 \quad \text{and} \quad t^1_3 = (MRS^1_{3,1}/P_3) - 1. \tag{8}$$

Figure 3. Autarky Prices in (P_2, P_3) Space



In successive rounds, countries two and three determine their optimal tariff rates in a similar way. This iterative procedure would continue until no country was willing to change its tariffs, given the tariffs set by the other countries. Again, this is an approximate Nash equilibrium.

The customs union solution involves calculating an optimal external import tariff for the union based on the maximization of a union social welfare function. Choice of this function's form will, of course, affect the outcome of the analysis.[7] The functional form used here employs the simple Benthamite objective of maximizing the sum of the utilities of the individual member countries. That is, for a union between countries 1

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[7] See Atkinson and Stiglitz (1980) for a discussion of social welfare functions.

and 2, the union welfare level is:

$$U^C_{(1,2)} = U^1 + U^2. \tag{9}$$

The optimal tariff rate determined for the union is adopted by each member on imports from the non-member. In the central case customs union, intra-union tariffs are zero. The use of non-zero rates is discussed in the results section. Note that since the objective is to find the optimal import tariff on a good that both members import, then except for the more perverse individual utility function specifications, a union optimum for this simple model should not involve one member's utility value dominating the social welfare level while the other member's approaches zero.

Ideally, the choice of social welfare function should be part of the bargaining process. Again, model tractability is the major reason for the fixed function used here. Note that some positive transformation of the above function could also be used, with the share weights determined through bargaining. However, a more "realistic" scenario is one in which the customs union maximizes according to some fixed function and the gains from the union are distributed amongst the members through some set of transfers or other internal policies which were adopted through bargaining. This is the approach followed here and the redistributive policies which are used are the non-zero tariffs on intra-union trade.

The "offer curve" search technique used for the full tariff warfare solution cannot be easily used to determine a customs union's optimal common external tariff. Instead, rates of the common tariff are searched over in order to find the one which maximizes the union's social welfare function. The non-member is assumed to adopt discriminatory retaliatory optimal tariffs against imports from each of the union members. For this case, the "offer curve" technique can be used. As in the full tariff warfare case, the union and the non-member determine their optimal tariff rates in successive rounds until neither is willing to change its rates, given those set by the other. Again, this is an approximate Nash equilibrium.

4. CALIBRATION AND DATA

As discussed previously, the major goal of the analysis here is to study how the use of non-sero intra-union tariffs within a customs union can alter the strategic options available to the member nations. Furthermore, Johnson's observations on relative import demand elasticities and the gains from cooperative/non-cooperative strategies are considered for the case of customs union formation. Given these goals, the example data and calibration procedure were chosen so that import demand elasticity specifications can be used which yield clearly identifiable welfare changes across the various strategies modelled. These choices will be described in this section, but first the absence of a production structure and its effects on the modelling will be discussed.

Production

The process of model calibration involves the solution of certain model parameters so that under the assumption that consumers are maximizing utility subject to their budget constraints, the values are consistent with an equilibrium solution for the functional forms and data chosen. In the procedure used here, excess demand functions are calibrated to specified import demand elasticity (IDE) values. Obviously, this process is simplified by the lack of production in the model. This strong assumption thus yields reduced complexity in both model calibration and solution. As will be shown next, however, this assumption may not be as strong as it appears, given that the proper calibration procedure is used.

One model variant of the analysis performed by Hamilton and Whalley involves production possibilities which are modelled through constant elasticity transformation curves. They note that some of their results for this variant suggest:

> "... a plausible approximation that the sum (in absolute value) of the final

import demand and transformation elasticities gives a total import demand elasticity which in turn can be approximated by a pure exchange variant. Given that estimated import demand elasticities are total elasticities incorporating both demand side and production side responses, a given 'estimated' import demand elasticity can be calibrated to in these models either through an implied demand side elasticity alone or through demand and production side elasticities whose sum meets the specified condition."

Note that in the model here, each country imports two goods and, as will be discussed below, the parameters to which the model is calibrated are different from those used by Hamilton and Whalley. However, if the above approximation does hold for the approach used here, then the results which are presented may be roughly representative of those for cases in which both demand and production side functions are modelled and their elasticities meet the above condition. With the model data and calibration process chosen so that a specified set of relative import demand elasticities between the countries represents the relative trading strengths, then some of the possible demand/supply relations which underlie such a specification may be speculated upon.

For example, suppose a country's parameters have been calibrated so that its import demand elasticities are high and, therefore, its trading strength is high relative to lower IDE countries. Under the approximation rule proposed by Hamilton and Whalley, results from this case may represent a situation involving a low elasticity of substitution in demand and a relatively high elasticity of transformation. The more linear the production surface, the smaller are the terms-of-trade effects that are possible against the country through import tariffs by the other countries. While substitution possibilities in demand are low, the transformation possibilities outweigh these so that, in total, substitution possibilities for this country are greater than those in the other countries.

If the elasticity of transformation is small, the pure exchange case is approached. Substitution in demand would have to be relatively high to yield the trading power represented by the high IDE which was specified. Again, the overall substitutability would give the trading strength. This would also hold for cases where the elasticities of demand and supply are comparable in size.

For the relatively low IDE countries, these three cases could also occur, but whichever is considered, the overall substitutability underlying import demands must be relatively lower than that for the high IDE country.

Specification of Model Elasticities

In the two country, two good exchange model, a simple import demand elasticity formula can be derived for which approximate values may be calculated. Using this, Hamilton and Whalley calibrate their model by determining a substitution elasticity for each country which is consistent with an assumed point estimate of the country's import demand elasticity. In other words, they are pre-specifying the import demand elasticity for some point on each country's offer surface. The point chosen by Hamilton and Whalley is usually the free trade equilibrium.

For the 3x3 case where each country exports one good and imports two, the concept of import demand elasticities is not easily implemented into a numerical model even when it is simplified by the assumption of no production. As a result, for each import good a partial import demand elasticity is used which is equivalent to the simple 2x2 case formula used by Hamilton and Whalley. Model calibration involves determining each country's utility function share parameters and is done for the same arbitrary position on each country's offer surface. The free trade equilibrium could not be used because the share parameters values are needed in order to determine the free trade prices and thus the free trade equilibrium. Following standard general equilibrium modelling practice, the point chosen for calibration is that which is determined by a unitary price vector.

The calibration of a country's utility function share parameters to assumed import demand elasticity values is, of course, dependent on the country's endowments and elasticity of substitution in consumption. These latter values must, therefore, be consistent with the range of IDE's to be analyzed, otherwise the calibration procedure may not solve. Furthermore, as will be seen later, there exists more than one set of these values which is consistent with a particular IDE specification. As a result, certain assumptions have been made to allow the data requirements discussed above to be met and also to make the model more tractable.

First, a country is assumed to have equal preference for its two import goods. That is, the share weights in the country's utility function will be the same for these two goods. Second, at the unitary price calibration point a country's two IDE's are assumed to be identical. These assumptions make import patterns in a country a function of relative prices only and not a function of an explicit preference for one import over another. This allows a clearer picture of the gains and losses which arise from strategy changes. In this exchange model, these assumptions also imply that a country's initial endowments of its two import goods must be equal.

In a CES utility function, the elasticity of substitution is equal to the Allen cross-elasticities between goods. Since the simple IDE specification used here sets the relationship between an import good and the export good, setting an elasticity of substitution value which is equal to the IDE value (which is the same for both imports) yields a convention consistent with the set of parameters to be analyzed. This leaves the IDE's and endowment shares to be specified; subject to the constraints discussed in the previous paragraph.

TABLE 1. Initial Endowment in 3x3 Exchange Model

Strategy	Good 1	Good 2	Good 3
Country 1	8000	1000	1000
Country 2	1000	8000	1000
Country 3	1000	1000	8000

TABLE 2. Example of Alternate Endowment Distribution

Strategy	Good 1	Good 2	Good 3
Country 1	7000	1500	1500
Country 2	1500	7000	1500
Country 3	1500	1500	7000

Endowments for each country are set such that each country's income at the unitary price calibration point is the same. Under the above constraint that the endowments of import goods are equal, then if each country's income is 10000, for example, the pattern of endowments used might be like the one shown in Table 1. This pattern is, in fact, the "base case" setting of the endowments chosen for the experiments performed here. However, while it does satisfy all the restrictions on parameter values which have been made so far, obviously alternative patterns such as that shown in Table 2 could also be used and so some justification for this choice is needed.

From Johnson's simple optimal tariff formula, the study of optimal tariffs requires the use of IDE's which are in the elastic range. The range which is chosen for this analysis is -1.5 to -6.0. Consider a country with an IDE of -6.0. Substitution possibilities should be high and, given that the other countries have lower IDE values, the country will have a relatively high trading strength and can alter the terms of trade in its favor through optimal tariffs. The low IDE countries, meanwhile, will have a relatively low trading strength and will be less able to favorably alter their terms of trade with this country. Optimal tariffs against imports from the high IDE country

TABLE 3. Calibrated Share Parameter Values for Various IDE Specifications using the Table 1 Endowment Pattern

IDE	Good 1	Good 2	Good 3
-1.5	.16	.42	.42
-3.0	.32	.34	.34
-6.0	.34	.33	.33

TABLE 4. Calibrated Share Parameter Values for Various IDE Specifications using the Table 2 Endowment Pattern

IDE	Good 1	Good 2	Good 3
-3.0	.25	.37	.36
-6.0	.31	.35	.35

should be relatively low.

Under the endowment specification of Table 1, share parameters for country one were calculated for various IDE values and are reported in Table 3. Note that for the highest elasticity value allowed, -6.0, the share parameters reflect an approximate pattern of indifference between the three goods, whereas those for the less elastic import demands reflect stronger preferences for the import goods (in this case, goods 2 and 3.)

Now consider the endowment pattern of Table 2 where the income level is the same as in Table 1, but the distribution of the endowments is different. The country one share parameters for this distribution are shown in Table 4. A solution could not be found for the case of an IDE equal to -1.5. More importantly though, a comparison of the Table 4 values to those of Table 3 reveals that the share parameter values for the IDE of -6.0 indicate a relatively stronger preference for the import goods over the export good. A similar result holds for the -3.0 IDE case.

An important implication of the differences arising from the two endowment specifications is that a country with an IDE of, for example, -6.0 has a reduced "trading power" under the second specification due to the stronger preference for imports. Since the goal is to maintain an analysis similar to Johnson's where the IDE's represent bargaining or trading strength, the endowment pattern used as the central case configuration should be the one which yields the higher degree of trading power for the highest elasticity value (-6.0) used in the experiments. The Table 1 endowment pattern results in a set of preferences which represents consumer indifference between import and export consumption. This yields an intuitively appealing case of maximum trading strengths to which lower levels, represented by lower IDE's, may be compared.

A similar argument can be made to justify the use of the strongly symmetric export (and import) levels across the countries. That is, this argument can be used to justify the use of the common value of 8000 for the export good in each country in Table 1. While the symmetric specification makes the model represent only a very special case, the use of non-symmetric patterns would reduce the ability of the model to use different IDE specification's to represent easily identifiable differences in relative trading power across the countries.

5. MODEL RESULTS

In this section results are reported for the various experiments performed with the model. All experiments employ the model data specification of Table 1 and follow all of the strong uniformity restrictions discussed in the previous section. However while the model results are derived from a very special model example, some interesting results are presented.

The first set of results considers a case where two similar lower IDE countries face a third higher IDE country. Johnson's observation on relative IDE values and the probability of gains from retaliatory tariff warfare over free trade is compared to the results reported here. In particular, it is considered relative to the results on the formation of coalitions between the regions. For the specific case considered here, the results observed by Johnson appear to hold for union formation too. The next set of experiments reconsiders the analysis of the previous case under a regime of non-zero intra-union tariffs. A range of values for the intra-union rates is analyzed and the results indicate that the relative intra-union rates can be very important in determining the distribution of the gains from union formation amongst the member countries. In particular, it is shown that non-zero intra-union tariffs can allow a union to be a preferred strategy for all its members, whereas in the zero intra-union tariff case the union is an inferior strategy for some.

Union formation and Johnson's Observations

The model results considered here are listed in Tables 5 and 6. Each reports the equilibrium values for the model variables under various cooperative and non-cooperative strategies. For both tables, the endowment specification is that shown in Table 1. The only differences between the two specifications are the IDE values.

In Table 5, the IDE for country three is set equal to -6.0, while countries one

TABLE 5. Cooperative and Non-Cooperative Strategies involving Intra-Union Free Trade for the (-1.5, -1.5, -6.0) Elasticity Specification

Strategy		Country 1	Country 2	Country 3
Free Trade				
Utility		3546	3546	3542
	good 1)	0	0	0
Tariffs	good 2)	0	0	0
	good 3)	0	0	0
Full Tariff Warfare				
Utility		3089	3089	3981
	good 1)	0	0.48	0.94
Tariffs	good 2)	0.48	0	0.94
	good 3)	0.34	0.34	0
Customs Union (1,2)				
Utility		3192	3193	3767
	good 1)	0	0	0.78
Tariffs	good 2)	0	0	0.78
	good 3)	0.20	0.20	0
Customs Union (1,3)				
Utility		4269	2113	3672
	good 1)	0	0.44	0
Tariffs	good 2)	1.93	0	1.93
	good 3)	0	0.44	0

and two are both assumed to have the less elastic values of -1.5. This configuration yields a case with two countries which are similar and a third which is very different. In Table 6, country three retains the same IDE value, but the common value for countries one and two is now equal to -3.0. Thus, while countries one and two are still similar, the difference between them and country three is reduced.

Comparing the free trade results for the two tables, the larger utilities in Table 5 reflect the increased gains from trade arising from the higher level of trade. The less elastic demands for countries one and two in Table 5 motivate these higher levels to which country three, with its highly elastic import demands, responds.

Extrapolating Johnson's observations to the cases studied here suggests that the greater is a country's IDE relative to the other regions' values, the greater is the probability that the country will gain from full tariff warfare (FTW) over free trade (FT). The full tariff warfare results reported for both cases support this. In both tables, country three gains in the retaliatory tariff war, while the less elastic countries lose. Furthermore, country three's gain over FT is larger in the Table 5 results.

Note also that the resulting tariff rates appear to follow Johnson's formulation that a country's optimal import tariff is equal to the reciprocal of the other country's IDE minus one. The rates adopted by country three relative to those adopted by one and two against three reflect the fact that the reciprocal of one and two's IDE's minus one is greater than the reciprocal of three's IDE minus one. Furthermore, both one and two adopt higher rates against each other than against country three. Finally, a comparison of the Table 6 rates to those of Table 5 shows that those in Table 6 reflect the smaller relative difference in IDE's across countries.

Now consider the Table 5 customs union result for the two similar countries, one and two. Johnson's intuition for the 2x2 case suggests that the probability of gains to a country is lower the more similar are the countries. Or, stated another way,

TABLE 6. Cooperative and Non-Cooperative Strategies involving Intra-Union Free Trade for the (-3.0, -3.0, -6.0) Elasticity Specification

Strategy		Country 1	Country 2	Country 3
Free Trade				
Utility		3322	3322	3365
	good 1)	0	0	0
Tariffs	good 2)	0	0	0
	good 3)	0	0	0
Full Tariff Warfare				
Utility		3195	3196	3401
	good 1)	0	0.25	0.30
Tariffs	good 2)	0.25	0	0.30
	good 3)	0.21	0.21	0
Customs Union (1,2)				
Utility		3250	3250	3338
	good 1)	0	0	0.27
Tariffs	good 2)	0	0	0.27
	good 3)	0.17	0.17	0
Customs Union (1,3)				
Utility		3404	3004	3384
	good 1)	0	0.19	0
Tariffs	good 2)	0.41	0	0.41
	good 3)	0	0.19	0

free trade is probably the strategy which is preferred by two similar countries over retaliatory tariff war. For the numerical examples here, this can be extended to the customs union result, denoted by (1,2), for countries one and two. Both gain over their full tariff war solution by removing barriers to trade between themselves. The same union for Table 6 yields similar results with the smaller gains reflecting the closer IDE's between all three countries.

The final strategy listed in Table 5 involves a customs union between countries one and three. (The results are identical for a union between two and three.) Johnson's 2x2 analysis suggests that for two different countries, the greater is a country's IDE relative to the other country's, the greater is the probability of it gaining from a retaliatory tariff war. Similarly, a move from a retaliatory tariff war position to free trade may result in a loss for the higher IDE country. For the examples shown here, this would occur if customs union (1,3) were formed from the full warfare position. In both tables, country three loses from the customs union relative to full warfare, while country one gains.

A major contribution of Johnson's simple 2x2 analysis was the demonstration that a move to free trade from a retaliatory tariff position will not necessarily make all countries better off. The cases presented here extends this demonstration to the formation of a customs union: membership in a customs union is not necessarily welfare improving relative to the alternative strategies available. In both Tables 5 and 6, the country with the higher trading power, country three, prefers the FTW solution over both free trade (as in the Johnson example) and membership in a customs union.

In this higher dimensional model, determining the optimal strategy for a country requires the full consideration of the possible strategies, including those available to the other countries. Table 7 lists the strategies which are possible and the utilities which would arise under each, given the Table 5 model specification. For example, row one of the table shows the utilities for the case where all three countries opt for free trade (FT). In row two, country one has adopted a retaliatory optimal tariff warfare (RTW) strategy.

Starting from the free trade position, country three would gain the most from unilaterally imposing optimal tariffs on imports from countries one and two. Due to country three's high relative trading power, retaliatory optimal-tariffs by both countries one and two would result in reduced utilities for both and a slight increase for country three. This full tariff warfare outcome represents a Nash equilibrium, with no country able to unilaterally change to another set of tariffs which makes it better off. However, suppose countries can cooperate. Country three would not form a customs union with either of the other countries since the non-member's optimal response would be optimal retaliatory tariffs, and this would result in a utility level for country three which was lower than any of its RTW levels. The optimal strategy for country three is RTW, while countries one and two would form a customs union.

Table 8 reports the utility levels possible under the Table 6 model specification. Relative to the free trade results, country three would gain by adopting retaliatory optimal tariffs. RTW strategies by countries one and two would still result in country three being better off than under any regime of FT on its part. The full tariff warfare solution would again represent a Nash equilibrium as defined above. A customs union involving countries one and two, however, would result in a utility level for country three which was lower than the free trade case. Thus, in a world where cooperative strategies are possible, this union blocks country three's non-cooperative strategy so that the optimal strategy for country three is a union with one of the other countries. Bargaining should determine with which of the other countries the union is formed and is considered in detail in the following section.

TABLE 7. Possible Strategies and Resulting Utility Levels under the Table 5 Model Specification

Strategy[1]			Utility		
Country 1	**Country 2**	**Country 3**	**Country 1**	**Country 2**	**Country 3**
FT	FT	FT	3546	3546	3542
RTW	FT	FT	3577	3519	3505
FT	RTW	FT	3519	3577	3505
RTW	RTW	FT	3548	3549	3464
(1,2)	(1,2)	FT	3614	3614	3337
FT	FT	RTW	3130	3130	3980
RTW	FT	RTW	3203	3061	3919
FT	RTW	RTW	3061	3203	3919
RTW	RTW	RTW	3089	3089	3981
(1,2)	(1,2)	RTW	3192	3193	3767
(1,3)	FT	(1,3)	4450	1962	3800
(1,3)	RTW	(1,3)	4269	2113	3672
FT	(2,3)	(2,3)	1962	4450	3800
RTW	(2,3)	(2,3)	2113	4269	3672

[1] Strategies are:

FT = free trade.

RTW = retaliatory tariff warfare.

(i, j) = customs union involving countries i and j.

TABLE 8. Possible Strategies and Resulting Utility Levels under the Table 6 Model Specification

Strategy[1]			Utility		
Country 1	Country 2	Country 3	Country 1	Country 2	Country 3
FT	FT	FT	3322	3322	3365
RTW	FT	FT	3367	3273	3326
FT	RTW	FT	3273	3367	3326
RTW	RTW	FT	3318	3318	3282
(1,2)	(1,2)	FT	3367	3367	3219
FT	FT	RTW	3217	3217	3484
RTW	FT	RTW	3287	3126	3451
FT	RTW	RTW	3126	3287	3451
RTW	RTW	RTW	3195	3196	3401
(1,2)	(1,2)	RTW	3250	3250	3338
(1,3)	FT	(1,3)	3489	2926	3456
(1,3)	RTW	(1,3)	3404	3004	3384
FT	(2,3)	(2,3)	2926	3489	3456
RTW	(2,3)	(2,3)	3004	3404	3384

[1] Strategies are:

FT = free trade.

RTW = retaliatory tariff warfare.

(i,j) = customs union involving countries i and j.

Kennan and Riesman (1982) present an example like that of Table 7 and propose that it suggests one explanation for the existence of customs unions: they may be created as a defensive response to aggressive, non-cooperative behaviour on the part of other countries. The results in Table 8 present a further explanation. While country three might receive its maximum welfare level by pursuing a non-cooperative strategy, it joins a customs union as a defensive response to the possible cooperative counter-strategies of the other countries.

Non-zero Intra-Union Tariffs

As was just shown, the optimal strategy for country three in Table 8 is the formation of a union with one of the other countries. Membership in such a union represents the preferred strategy for either of these other countries, so bargaining should play an important role in determining which enters into the union. Bargaining should involve the distribution of the gains from the union. While explicit inter-country transfers are usually not a politically feasible tool for this process, a more acceptable alternative might be the use of some structure of positive intra-union tariffs.[8]

The results presented in Table 9 consider the (1,3) union of Table 6 under alternative specifications of intra-union tariffs. No systematic attempt is made to determine an optimal set of tariffs on the trade between the two members. Recall that country three has an IDE of -6.0, while countries one and two both have an IDE of -3.0.

The utility values for the FT, FTW, and (1,2) union cases of Table 6 are repeated

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[8] Negative import tariffs imply subsidization of imports of foreign goods and, therefore, also represent a less acceptable bargaining tool. Clark Leith (1987) notes that the South African Customs Union (SACU) does allow cash payments in order to offset disadvantages for net importers from partners. NTB's are used and may have trade-restricting effects similar to those of intra-union tariffs, although different revenue effects. Finally, provisions exist for intra-union tariffs for infant industry protection. Analyzing all these devices concurrently appears to be a task which would require the procedure of Harrison and Rutström (1986).

TABLE 9. Welfare Effects for the (1,3) Customs Union of Table 6 with Non-Zero Intra-Union Tariffs

Strategy	Country 1 Utility	Country 2 Utility	Country 3 Utility		
Free Trade	3311	3322	3365		
Full Tariff Warfare	3196	3195	3401		
Union (1,2)	3250	3250	3338		
Intra-Union Tariffs For Union (1,3)				Union[1] Utility	World[2] Utility
(0%,0%)	3404	3004	3384	6788	9792
(0%,10%)	3316	3004	3467	6783	9787
(0%,20%)	3240	3006	3520	6760	9766
(0%,30%)	3175	3011	3551	6726	9737
(10%,0%)	3445	3007	3330	6775	9782
(20%,0%)	3465	3009	3285	6750	9759
(30%,0%)	3471	3012	3248	6719	9731
(5%,5%)	3381	3005	3400	6781	9786
(10%,10%)	3356	3006	3409	6765	9771
(15%,15%)	3328	3009	3410	6738	9747
(20%,20%)	3298	3011	3406	6704	9715
(30%,30%)	3238	3020	3386	6624	9644
(5%,10%)	3339	3005	3436	6775	9780
(5%,20%)	3262	3007	3488	6750	9757
(5%,30%)	3197	3012	3517	6714	9726

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[1] Sum of the utilities for countries 1 and 3.

[2] Sum of the utilities for all three countries.

here for comparison. The first utility values reported for the (1,3) union restate the Table 6 results for the case of zero intra-union tariffs. This case shall be referred to as the base or intra-union free trade (IUFT) case. In the analysis that follows, these four cases will be the only strategic alternatives to the strategy under consideration.

The next three cases in Table 9 involve a positive rate for country three only. This is analyzed for a range of values from 10 percent to 30 percent. Listed next are three similar cases but with country one having the positive rate only. The remaining sets of results involve positive rates for both countries.

For all of the Table 9 results involving nonzero intra-union tariffs, the non-member gains over the base case, although only slightly, and the higher are these tariffs, the higher is this gain. Similarly, the sum of the member's utilities (which is the object of the union maximization problem for determining the external tariff) is lower than in the base case. The higher are the rates used, the greater is this difference. An important implication of these results is that intra-union tariffs can dissipate the gains which would accrue under intra-union free trade. For each set of cases analyzed in the simple model here, the higher are the rates involved, the greater is the dissipation. Furthermore, a common rate adopted for both countries results in a greater loss than when only a single country adopts the same rate.

Consider the results involving a positive rate for only one member. For both sets of these results, the member country with the positive rate gains over its base case utility level and, for the range analyzed, the higher is the rate then the higher is the gain. The other (zero-rate) member loses relative to the base case and this loss increases with the size of the intra-union tariff. By altering the internal terms of trade for the union, a one-sided intra-union tariff redistributes the gains from the union in favor of the imposer.

Note that for the three cases in which country three has a positive tariff on imports from country one, country three is not only better off than at IUFT, but also FTW and FT. Thus, this union changes from being the strategy which is optimal but not preferred for country three in the IUFT case, to being both preferred and optimal. For the results presented in Table 5, country three's optimal trading strategy is to be totally non-cooperative. If these four strategies are the only ones possible, then the (1,2) union case will occur. However, an intra-union tariff rate should also exist for country three in the (1,3) union in Table 5 which causes this union to be its optimal strategy. Thus, intra-union tariffs could be used to "unblock" cooperative strategies. The tariff imposed by country three must not, of course, cause the union to be a sub-optimal strategy for the other member. In Table 9, the 10 percent tariff for country three "unblocks" the (1,3) union so that it is an optimal strategy for both countries.

A customs union strategy involving zero intra-union tariffs for one country and a positive rate for the other would probably not be politically acceptable. The strategy which might be most acceptable is one involving a common rate for both members. For the common rate results listed in Table 9, country one's highest utility is achieved at a rate of zero. However, country three would not accept this strategy. For a rate in the range 10 to 20 percent both countries are better off than under FTW, and country 1 is still better off than under the (1,2) union.

In the case where only country one has a 10 percent tariff, a comparison of the (10%,0%) results to those of the (10%,10%) case reveals that in the former case, country one is better off and country three worse off. Introducing the 10 percent tariff for country three causes union gains to be transferred to that country from country one. In the case where only country three has a 10% tariff, country one is worse off and country three better off than in the (10%,10%) case. An interesting interpretation of this last comparison is that a unilateral initiative to intra-union free trade by the lower IDE country may be detrimental to it even when the member countries are pursuing a joint strategy against the non-member.

Note that for the (0%,10%) case, country one is still better off than at FTW. Comparing the (30%,30%) results to those for the (0%,30%) case reveals that a unilateral move to IUFT here could cause country one to be worse off than at FTW. Recall from Table 6 that in the FTW results country three's optimal import tariff against one is 30 percent. Country one's utility is very low in the (0%,30%) results because country three effectively has an optimal tariff on its trade with country one, while country one has no retaliatory tariff in place against three. Country three achieves its highest utility level for any of the results presented here due to the benefits of the joint strategy of the customs union plus the favorable intra-union terms of trade.

Now consider the common rate results alone. For the lower IDE country, the preferred common rate would be one as close to zero as possible. For the high IDE country, the preferred rate appears to lie between zero and the optimal tariff rate which country three would impose against country one under FTW (30% from Table 6). As the common rate increases, the gains from the union are dissipated. Furthermore, union gains are transferred to country three from country one. Together, these factors result in losses for country one relative to the IUFT case. Initially, the gains transferred to country three outweigh any losses to the union, so that country three gains over the IUFT case. At some rate in the 10 to 20 percent range, country three's utility reaches a maximum and is greater than its FTW level (the preferred strategy for country 3 in Table 6.) At rates higher than this, the loss of union gains starts to outweigh the gains transferred, and country three's utility starts to decline. Somewhere between 20 and 30 percent, country three's utility drops below that in the FTW case.

Experiments similar to these could be performed with the model specification of Table 5. Since country three's FTW tariff rate is much higher in this case, then, intuitively, the common rate which is optimal for country three should be higher. This suggests that the greater is the difference in IDE's between the member countries, the higher is the common rate that is optimal for the higher IDE country.

Obviously, positive but unequal rates could be set by the member countries. The final set of results in Table 9 considers cases where country one's rate is fixed at 5 percent and country three's rate is increased. These results show that some set of unequal intra-union tariffs could also be used to "unblock" country 3's cooperative strategies and make some of these strategies optimal for both members of a union. However, like the cases where one member country had a zero intra-union tariff rate, the unequal tariff rate scenario might not be politically acceptable.

6. SUMMARY AND CONCLUSIONS

While the results presented in this essay have been derived from a set of very special model examples, they still present some valuable insights into the possible gains and losses from customs union formation. Consider the following:

(1) Johnson's observations on the relationship between relative import demand elasticities (interpreted here to mean relative trading strengths) and the probability of gaining over free trade by following non-cooperative strategies appear to carry over to the case of customs union formation. The results presented here suggest that the greater is the difference in the import demand elasticities of two countries, the greater is the probability that a customs union involving intra-union free trade between the two countries will result in one country losing relative to the full retaliatory tariff warfare results while the other country gains.

(2) The results also suggest that an important effect of the use of positive tariffs on trade between union members is the dissipation of the gains which the union realizes over the full tariff warfare case. Even more important, though, is the implication that intra-union tariffs might be used to redistribute gains within a union. If direct cash transfers between member countries are not politically feasible, intra-union tariff or non-tariff barrier equivalents might be used to redistribute the union gains in a manner which induces countries into a customs union they would not have joined under intra-union free trade.[9]

(3) Results are presented for various specifications of intra-union tariffs. For cases where one member has a higher rate than the other, that country receives a larger share of the union gains than if the rates were equal. Political considerations and the added difficulty of choosing the optimal set of unequal rates suggest that a common

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[9] Glenn Harrison has labelled this an "infant customs union" argument for intra-union tariffs.

rate might be the policy which is most acceptable to the member countries. In the examples here, a range of common rates is shown to exist which yields utility values for both members which are superior to those available in the alternative strategies. The rate which is chosen will depend on the relative bargaining strengths of the member countries. A further implication of the experiments performed here is that the unilateral initiative of one member to intra-union free trade may be very costly to that country.

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