AN INTEGRATED FORECASTING SYSTEM FOR THE ST. JOHN'S CENSUS METROPOLITAN AREA, NEWFOUNDLAND

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BY

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Abstract

The objective of this thesis is to construct and evaluate a regional Integrated Forecasting System (IFS) using the St John's, Newfoundland, Census Metropolitan Area (CMA) as a case study area. The purpose of an IFS is to model the relationships among a number of key variables (e.g. population, employment and housing) which are central to the planning process for any area. Demographic characteristics, for example, are important factors in the need or ability to attract employment and the demand and supply of housing. At the same time, new employment opportunities may result in in-migration or reduce out-migration. Furthermore, lack of available housing may act as a constraint on in-migration, or new house building may encourage it. These inter-linkages require the development of a forecasting approach which is characterized by common and compatible supply-demand assumptions for the key variables and an explicit consideration of the relationships among them. The product from this thesis is such a forecasting model. To demonstrate the capabilities of the IFS, the potential impacts of the Hibernia offshore oil project on selected socio-economic activities in the St. John's Census Metropolitan Area (CMA) are examined as a case study.

Chapters I and II of the thesis provide a background to the work, describing the St. John's CMA study area, the recent economic development history of the St. John's region and Newfoundland, and reviewing the literature on integrated forecasting systems.

The structure and evaluation of the model and data are described in Chapter III. The overall design of the IFS follows the basic format of models developed for the Gloucestershire and Grampian regions in the United Kingdom. The IFS is basically a recursive rather than a simultaneous model. This model consists of five interacting blocks: labour demand, labour supply, migration and household formation, housing demand and housing supply. A series of tests are applied to each regression equation (R^2, standard error of estimate statistics, F-test, t- statistics and Durbin-Watson statistics) developed to describe each block and, where necessary, modifications are made to the equations in order to improve the model's performance. The sources and methods used in the preparation of the data input are discussed in the last section of this chapter.

In Chapter IV, the characteristics of the equations and the within-sample performance of the model are evaluated. Mean Absolute Percentage Error (MAPE) statistics are calculated to examine the model's performance. This evaluation IFS suggests that the model is appropriate for projecting the impacts of the Hibernia Project on the socio-economic characteristics in the St. John's CMA and has the potential to

project impacts for other major projects or sectoral changes.

Chapter V describes the model's forecasting performance and the assumptions on which the IFS is based. According to the IFS, the Hibernia Project will not change the basic economic situation of the St. John's CMA -- St. John's will not become another Calgary in eastern Canada -- though it will help the economy of the region to some extent. Overall, this thesis concludes that the IFS provides valuable which can be of value to both regional planners and local businesses.

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Chapter I - Introduction

1.1 Introduction

Central to the planning of any area are the forecasts of population, employment and housing. While these key topics provide the background to a host of planning concerns, including the need to provide serviced land, physical infrastructure (roads, water services, sewers, etc.), recreation facilities, and social infrastructure (schools, hospitals, etc.), they are closely interlinked in a circular scheme of causal relationships. The level and structure of population affect the need or ability to attract employment and the requirements for housing, changes in employment affect migration and housing, while lack of available housing may act as a constraint to in-migration to fill vacant jobs. These inter-linkages have pointed to the need to develop *integrated forecasting systems*, where integration means the use of a set of empirically derived, common and mutually compatible, supply-and-demand assumptions for population, employment, migration, households and housing, with explicit consideration of their relationships (Field and MacGregor, 1987:184).

In light of this need, the objective of this thesis is to construct and evaluate a regional Integrated Forecasting System (IFS)using the St. John's Census Metropolitan Area (CMA) as a case study area. To illustrate its application the forecasting model is used to analyze the potential impacts of the Hibernia Project on selected socio-economic variables in the St. John's CMA. The potential value of such a model goes beyond this individual case study insofar as it can contribute to the planning process in the region by helping to understand the consequences of any major changes to the structure of the local economy.

With reference to the potential impacts of offshore oil development in the region, these have been the subject of debate since the field was discovered in 1979. However, while there have been a number of descriptive assertions about those potential effects, there have been no attempts to model them in any structured fashion. Since the commencement of the development phase of the project in 1990, there have been a range of effects on the St. John's CMA but these have been much smaller that those predicted by the media and politicians in particular. As the Hibernia mega-project moves to the production stage in 1997 it promises to bring about further changes in the economic, social, cultural and environmental characteristics of the St. John's CMA which are expected to last for at least two decades. With the possibility that the Terra Nova and other offshore fields will be developed the planning implications of the long-term socio-economic outcomes of offshore oil development on the St. John's CMA become of even more interest. Planning for oil-related growth could therefore benefit from a forecasting model that will allow individual and, more importantly, cumulative field development impacts to be assessed.

The IFS developed here could also be modified to incorporate additional types of impacts, for example, service and infrastructure impacts. It can be used to demonstrate the impacts of wind-down or the phase-out of activities as well as their growth. The model developed is described as being appropriate for "meso-scale" analysis, which essentially means that it is designed to better understand issues at the regional scale rather than at the individual community (micro-scale) or provincial (macro-scale) levels. While some information might be lost and some inter-relationships incapable of being examined at this scale, the output of the model is helpful in understanding and forecasting a range of potential short- to medium-term socio-economic changes.

1.2 Traditional Forecasting Systems

Traditional methods of forecasting are essentially linear and deductive; the output of one forecast is usually used as an input to other forecasts, and, more importantly, no constraints or positive or negative feedback are considered. The linear-deductive approach can be simple, inexpensive and quick to develop and apply, and can be easily understood by planners and explained to politicians and the public. However, it is inadequate to deal with the complex forecasting requirements for urban and regional systems development because almost all economic, demographic, social and political activities are closely inter-related (Bracken and Hume, 1981; Breheny and Roberts, 1978). A review of traditional forecasting methods illustrates several important limitations:

First, linear deductive models ignore the mutually constraining interrelationships among key activities. The emphasis is on parameters directly related to each activity rather than on the interrelating parameter. Bracken (1982) points out that there is a strong tendency to compartmentalize the forecasts for the key activities -- population, employment and housing -- or at best to derive estimates for one activity as a simple function of another.

In traditional forecasting approaches, for example, an employment demand forecast would generate a population forecast which would in turn produce a housing demand forecast. In this approach, from the employment demand to the housing demand, the interrelationship and constraints of one forecast on another are simply ignored. The housing supply, estimated as a function of population change, may itself influence migration. This, in turn, will require adjustment to the population estimate which informed the process in the first place (Breheny and Roberts, 1978).

Second, traditional forecasting models are usually principally concerned with the demand parameters of population, employment, housing and households, rather than the supply side. It means that there is no consideration of the constraining effects of the supply side of housing or population. In fact, the supply side of these key activities is rarely considered in the same way as the demand side in most traditional forecasting exercises.

The interrelationships of supply and demand sides should be explored in forecasting if the both sides are closely interrelated in reality. The supply side of population and household estimates, for example, not only influence the forecast of housing demand, but are also constrained by the forecast of housing supply. Moreover, failure to treat the forecasting of both demand and supply side activities probably indicates that planners have no ready means of assessing the degree of 'dis-equilibrium' in the system.

Third, this approach rarely includes the anticipated effects of policy. In this way, forecasts are often made with little regard to planning powers. As such there is no clear guidance for public or private investment. There is a tendency to take forecasts as targets and to assume that activity levels are not the subjects of policy. In some situations urban planners may merely be able to monitor change and make forecasts about those continuing situations; however, in others, planners will be able to exercise sufficient control (for example, through refusal to allow development to take place), so that future trends may bear little relationship to past trends (Bracken, 1982:54). Thus, the anticipated effects of related policy should be included in most forecasting and planning. For instance, an important input to a forecast could be an assessment of the probable effect of policies and the chance of their being successful, because we know that public policy could be a partial (strong or weak) influence in most social and economic activities to which it is applied.

1.3 Integrated Forecasting Systems

Although the nature of the inter-relatedness, such as positive or negative feedbacks or constraints between different subsystems, has been explicitly recognized through the use of systems theory since the 1960s (Chadwick 1971; McLoughlin, 1969), rarely is it actually incorporated into planning models.

Only limited effort has been made to integrate different forecasting models in the past. There exist only a few truly integrated models in urban and regional planning, though many efforts have been made to link individual sub-models of urban and regional systems. For example, Wilson (1967) developed the original spatial interaction model in the framework of entropy maximization, and Boyce (1977) and Los (1978) integrated location and transportation in their models to obtain optimum transportation solutions. Later, Putman (1980; 1983) and Lakshmanan (1982) created more complex integrated multi-regional transportation economic models, while more recently, Wegener (1986) has developed more comprehensive, multi-activity urban and regional models.

Several regions have attempted to develop integrated forecasting models for their own needs and purposes over the past two decades. However, although many individual component forecasts use the standard methods such as cohort survival, headship rates and shift-share analysis, when one examines those models that seek to integrate demographic, employment, housing and other socio-economic variables it becomes apparent that there is no standard approach to their formulation.

Particular attention here is given to three models developed for purposes similar to that outlined here. These are the models developed by the Gloucestershire County Council, the Grampian Regional Council and the Greater Manchester Council, respectively, in the United Kingdom. In each case these models adopt a well-established logic, one which is consistent with similar models used elsewhere. Another reason for the selection of these three IFS models is that very few such models have been written up in detail and appear in the literature -- these examples are among the few which are relatively well documented. Finally, and of particular relevance to the case study of offshore oil development, is the fact that the Grampian model was developed specifically to address the planning needs brought about by rapid offshore development

1.3.1 The Gloucestershire County Council Model

The Gloucestershire County Council model is mainly concerned with establishing the interactive supply and demand relationships among and between employment, population and housing. Of particular importance, is the fact that the model assumes that the activity level of each of the components is developed so as to be mutually adjustable. In other words, once one activity level is determined, the others are adjusted accordingly. By so doing the integrated forecasting model generates an assumed equilibrium. According to Breheny and Roberts (1978:310), the model has following basic features:

> (i) the relationships between supply and demand factors determine their activity levels;
>
> (ii) the characteristics of other activities will influence the supply and demand factors which in turn will influence these activities;
>
> (iii) the prime mover in the model sets the main constraints on the factors; once the 'constrained activity' has been determined and its parameters set, other activities have to be made consistent with it;
>
> (iv) the basic activities considered in the model are employment, population, households and housing;
>
> (v) the model is static, rather than dynamic; and

(vi) the model is only an accounting device to ensure compatibility among activities and does not attempt to model theoretical cause and effect.

The assumed 'prime movers' for the model are employment, which determines general demand-side levels of all other activities, and housing, which determines supply-side activity levels. On the one hand, employment (labour) demand is assumed to determine population and migration, and thereby constrain housing demand. On the other hand, projected housing supply must match housing demand, i.e., housing supply must be greater than or equal to housing demand, otherwise, households, population and employment must be adjusted downwards until housing supply and demand are equal.

1.3.2 The Grampian Regional Council Model

The first Grampian Regional Council model was constructed in the late 1970s to forecast population and housing demand for this Aberdeen-centered region as part of the planning response to rapid offshore oil-related growth. In this context housing demand was considered the key factor constraining overall growth and activity in the region (Grampian Regional Council, 1978). In this initial model, if house building rates failed to keep up with forecasted net in-migration, then a constraint was identified and a feedback mechanism introduced to the model that effectively limited in-migration and hence the available labour force and employment.

The first model was simple and designed to serve only limited purposes hence the Grampian Regional Council developed a second model which incorporates three dimensions of integration: horizontal, vertical and organizational (Cockhead and Masters, 1984:473-474). They are defined as follows:

> *Horizontal Integration* - the traditional type of integration that represents the integration between different activity systems, e.g. population, housing and employment, to ensure their mutual compatibility;
>
> *Vertical Integration* - the integration of large area, long term, strategic activity forecasts with small area, short term, operationally oriented forecasts; and
>
> *Organizational Integration* - the integration of the forecasts into the policy-making and forward planning of the Council.

As Field and MacGregor (1987:192) point out, a key element in the rationale for developing this model was "the need to ensure organizational integration, i.e., that all organizations with responsibility for the planning of the region used the same forecasts." This form of integration is not dependent on technical developments, but on the establishment of the role and credibility of forecasts within the organization.

The model is more comprehensive than its predecessor, and consequently has much greater temporal and spatial data requirements. It is also more complex, particularly in terms of the linkages among the different model components that ensure that individual (component) forecasts are mutually compatible.

The general forecasting framework for the region consists of three main dimensions (Cockhead and Masters, 1984:475):

> (i) *Strategic*: integrated forecasts of population, employment and housing for large areas such as district council and structure plan areas;
>
> (ii) *Land development*: forecasts of residential and industrial development rates by individual site over the next 5-15 years. These were based on plans presented by the private and public sectors; and
>
> (iii) *Secondary*: forecasts to meet particular requirements of different service departments, such as school enrolment and electorate.

The framework is operated on an annual basis, and a special attention is given to the strategic forecasts. The annual cycle of forecasting is seen as the key to ensuring organizational integration. The underlying structure of integration is similar to that of the Gloucestershire model, with labour demand assumed to be the key determinant and iteration is used to ensure compatibility. Once again the model is essentially a static accounting framework, notwithstanding the fact that it is updated annually and involves a more elaborate monitoring of developments. The main linkages remain essentially the same: activity rates, vacancy and sharing rates, and migration. The integration is not rigid and technical, but involves judgement and policy input. The approach is described by Cockhead and Masters (1984:481) as one in which "various independent activity forecasts are grouped together as a loose 'federation' around a central set of accounts which link the individual 'linkage parameters' with the various activity forecasts." Despite this emphasis there does not appear to be any substantive difference in technique from the Gloucestershire model. What makes the Grampian model distinct is the emphasis on the level of organizational integration.

1.3.3 The Greater Manchester Council Model

A third variant of the general model was developed by the Greater Manchester Council. In the early 1980s, in response to the policy issues relating to service provision facing strategic planners within the region, the Council developed two multi-regional integrated forecasting systems to provide forecasts for different users (see Dewhurst, 1984). The Greater Manchester models adopt a complex multi-regional approach in order to take into account the effects of population movement within the County. The approach adopted by the County Council incorporates demographic, economic and housing factors in an integrated forecasting framework. This approach was based on the assumption that "Greater Manchester is a reasonably closed labour market area" and that migration within this area is closely related to private housing factors, while migration to and from Greater Manchester is mainly influenced by employment opportunities (Field and MacGregor, 1987:195).

The basic principles of the models are quite similar to those of Gloucestershire and Grampian. What is interesting to note is that the scale at which the Manchester model operates, that of a major connurbation, presents difficulties. As Field and

MacGregor (1987:195) point out, "It is relevant to note that one of the problems which arose was that local authority boundaries did not make the best spatial units for the forecasts, which necessarily involved consideration of housing market areas." This is less of a problem in Gloucestershire or Grampian where settlements are smaller and the district council areas larger.

The general approach adopted and the underlying structure of these IFS models is quite similar. While the structures of the Grampian and Greater Manchester models are more complex than that of the Gloucestershire model, each is integrated only insomuch as the component forecasts are based on a common set of assumptions and are consistent within an accounting framework. Furthermore, as Field and MacGregor (1987:195) point out, they are equilibrium approaches rather than dynamic models insofar as they do not model the dynamic and possibly continual imbalance of reality. The models do, however, represent an advance on linear-deductive methods of forecasting and in general have proven to be of greater value to strategic planners in the respective regions. Nevertheless they remain short-term models, requiring frequent revision, as it is inappropriate to forecast activities in equilibrium for other than a few years.

1.4 Objectives of the Thesis

The primary objectives of this thesis are to construct and evaluate an IFS model and then demonstrate the model's capability. In this case the IFS is constructed and used to illustrate the potential impacts of the Hibernia Project on selected socio-economic variables in the selected study area -- the St. John's Census Metropolitan Area (CMA). The case study illustrates how the IFS model can be used to generate data that are potentially useful as inputs into planning decisions. The Hibernia case study is important primarily as an example of how the model runs and can be applied in situations where significant economic changes in labour force activity (increases or decreases) are anticipated.

In general terms, data generated from models of this type are useful for structure planning:

(i) as a background to the activities of the agency making the forecasts;

(ii) to identify problems or constraints that may result in:
- accepting problems or constraints and acting accordingly;
- actions by the agency to solve the problems or remove the constraints;

(iii) to plan positively to meet the demands created by the future state of the system;

(iv) some combination of (i)-(iii) as is likely in structure planning (Breheny and Roberts, 1978:308).

The basic tasks of this study are to design, determine and calibrate the appropriate equations and parameters and to evaluate the IFS model. The IFS model is also tested against known data to demonstrate the model's capability before being used it for forecasting purposes.

The outputs from these tasks are also subject to review and evaluation as appropriate and feasible. As previously noted, equilibrium conditions are not likely to prevail for very long periods -- life styles and socio-economic activities are subject to fairly rapid changes. Consequently this system is not considered suitable for long-term forecasting, e.g. beyond 15 years. Secondly, the output of the IFS should not be assumed to be precise. Given the number of interdependent assumptions and their associated uncertainties, the approach adopted is to develop a range of parameters and input data. These scenarios, designated as Low, Most Likely and High, are used to indicate a range of possible outcomes.

Before using the model in a forecasting role the IFS model is evaluated for stability. More specifically, the sensitivity of the IFS to a number of parameter changes is used as a test of the robustness of the model. Though the IFS is conceptually simple, its subsequent application to a real situation confirms that it can provide robust, realistic, and useful results for planners and local business in their decision-making.

In reality all activities and their relationships are dynamic and an equilibrium may never be reached, though theoretically an equilibrium might be reached temporarily. However, some assumptions have to be made in order to generate static equilibrium in the IFS model. In this case the IFS assumes that if supply and demand for labour and housing match, or if supply is greater than demand, equilibrium is achieved and no parameter adjustments are necessary. Adjustments normally take place in the model only if demand exceeds supply. Any imbalances can be assessed initially to see if marginal adjustments to certain parameters will bring the estimates nearer to equilibrium. It is this characteristic of the model which may be of particular use and assistance to policy-makers and planners.

1.5 Outline

The overall structure of the thesis is as follows. In Chapter II the criteria for the selection of a study area for the IFS are discussed. Based on these criteria the St. John's CMA is determined to be the most appropriate and practical area for the development and application of the model. The main socio-economic characteristics of the CMA are then described. Given the application of the model to forecasting Hibernia-related impacts, a description of the economic development of the region, with particular emphasis on the history of and potential for offshore oil development, is provided. Offshore oil-induced changes in the study area were initially primarily related to administrative activities.

support and supply facilities for exploration and transportation. Current activities relate to the administration and design of the offshore production platform, and future activities are expected to include operations administration, support and supply of operations activities, and servicing. Though Hibernia-related activity in the CMA involves little construction employment (most of which is concentrated at the Bull Arm site on the Isthmus of Avalon), because of the role that St. John's will play as the administrative and supply/service centre during production, the impact on the CMA will be of a longer-term nature i.e. 20-25 years compared with 5-7 for the Bull Arm Site.

Chapter III outlines the IFS, its submodels and the various equations that define them. Broadly speaking, the overall design follows the format of the Grampian Regional Council model. The main differences are that the IFS is simpler, more flexible and suitable for a number of different purposes. The oil sector, or any other major change in the structure of the CMA's economy, is accommodated through the use of an exogenous variable. Employment values for the new activity are entered for the dummy variable and the impacts on the system examined. In this case Hibernia oil-related employment is incorporated into the IFS to forecast possible impacts on selected socio-economic characteristics in the study area.

The IFS consists of five interacting blocks -- labour demand, labour supply, migration and household formation, housing demand, and housing supply. Each equation is modelled (in most cases using time series data for the period 1971-1986), using regression analysis, and following a general-to-specific methodology. A series of tests are applied to each regression (R^2, standard error of estimate statistics, F-test, t-statistics and Durbin-Watson statistics) and, where necessary, modifications are made to the equations in order to improve performance. Ordinary Least Squares (OLS) is used as an estimating technique for many of the equations in the IFS. For each of the equations the results indicate that OLS is an appropriate estimation technique.

The last section of Chapter III is devoted to a discussion of the sources and methods used in the preparation of the data inputs. Almost all the data inputs are obtained or constructed from published sources. Most of these data are from the Census of Canada. Where necessary, data for Census Division 1 (Avalon Peninsula) are used as the basis for estimates for the St. John's CMA. As discussed in this section, some of these data are less reliable than others, e.g. employment (reflecting labour demand), which contributes to some of the model's performance limitations.

In Chapter IV, the characteristics of the equations and the within-sample performance of the model are considered together as a system. A number of alternative evaluation methods and techniques are discussed, and those which seem most relevant applied. Mean Absolute Percentage Error (MAPE) statistics are calculated to examine the performance of the IFS. It is found that the estimation procedure from regression analysis allows construction of a model with the most acceptable performance characteristics.

In order to test the robustness of the IFS its sensitivity to a number of different parameter values is examined. Responses to parameter changes in both endogenous (within of the model) and exogenous (external to the model) variables are evaluated.

Whilst a number of fairly minor problems emerge, the dynamics embedded in the IFS appear reasonable, logical and the outcomes intuitively acceptable. The model proves to be comparatively stable and most of the fluctuations are associated with changes in the variables that are consistent with prior thinking. The forecasting results themselves provide further affirmation of the model's robustness and usefulness.

Chapter V appraises the model's forecasting performance. First, the assumptions on which the IFS is based are discussed. Then the various forecasting results of the IFS over the period 1986-2001 are assessed. Finally, the forecasting ability of the IFS is evaluated. Generally speaking, its overall performance appears adequate. However, there is some variation in the performance of individual blocks. While the population, family size, total employment (labour demand), households and housing supply components tend to project reasonably well, by contrast projections for unemployment, housing completions and net migration in particular, seem less reliable. In some cases this is a function of input data quality, in others, such as migration, it is a function of the complexity of the factors which contribute to the phenomenon.

Chapter VI provides a brief summary of the thesis and presents a set of conclusions. Overall, it is concluded that the IFS approach can provide some useful results for planning purposes. It represents a regional scale integrated forecasting system which performs as well as might reasonably be expected. In the medium term, this should prove of assistance particularly to regional planners but also to local business. The model can be used for a variety of forecasting purposes in the St. John's CMA, but in the broader context it illustrates the feasibility of constructing such models for other areas at a similar scale.

Chapter II - The Study Area

2.1 Introduction

The chapter begins with a discussion of the rationale for the selection of the St John's CMA as the study area. The second part of the Chapter then outlines the main economic characteristics of the region to provide an overview and a baseline prior to developing and using the IFS. To further set the stage for the application of the model, the third part describes the main characteristics of offshore oil activity and the specific role that the St. John's region has played and is expected to play in this process.

2.2 Study Area Selection

The Hibernia oil field is located offshore Newfoundland on the Grand Banks some 315 kilometers east southeast of the City of St. John's (see Figure 2.1). By world standards it is a small- to medium-size field with reserves estimated to be in the 700 million barrel range (C-NOPB, 1993:11). This offshore oil project will be the second in Canada[1] and is expected to come into production in 1997.

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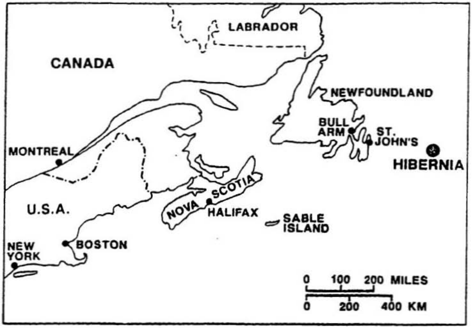
1 The LASMO/NSRL Cohasset/Panuke Field off Nova Scotia was the first to be developed. Recoverable reserves are estimated at 35 million barrels (Hibernia 666 m.bbls.). Production began in 1992 and is expected to continue until 1996 (Nova Scotia. n.d.).

2.1 Hibernia Location Map



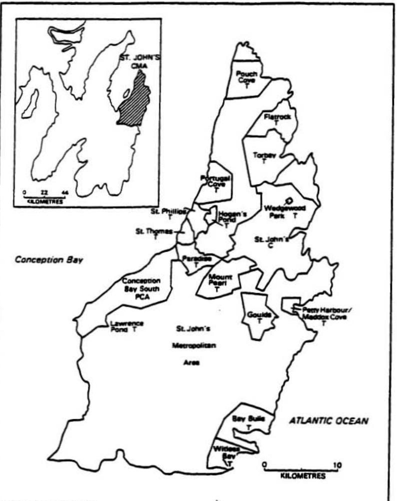
The development of the Hibernia oil field has already had a significant impact on the economies of both the Province and the St. John's CMA and will continue to do through out the remainder of the construction and development phase and during the estimated 18 years for which the field is expected to remain in production (see Figure 2.2 and 2.3).

The main reasons for choosing the CMA as the study area are as follows. As a simplified simulation model of the real world, the IFS is designed for 'meso-scale' rather than the 'micro-' or 'macro-scale' analysis. In this case 'meso-scale' refers to a contiguous major urban region, the boundaries of which are approximately co-incidental with the regional labour shed, i.e. the daily journey-to-work region. By contrast the 'micro-scale' is equated with smaller regional units, such as the City of St. John's, and the 'macro-scale' with the Province as a whole.

While a model that would operate at the micro-scale would arguably be more useful from a planning perspective (particularly in terms of housing and service provision), it is extremely difficult, if not impossible, to separate the city from its region given the close socio-economic relationships between them. At this scale some of the model's assumptions would no longer hold. Secondly data availability and reliability also become problematic as the available data base for the City is less comprehensive than that for the CMA.

Figure 2.2 Census Divisions of Newfoundland

Figure 2.3 The St. John's Metropolitan Area



SOURCE: Census of Canada, 1986.

Similarly the model is not appropriate for use at the macro-scale. While the economic components of the provincial economy can be relatively easily separated from that of mainland Canada, any forecasting results would have little practical meaning because of the problem of determining the geographical distribution of inputs to and outputs from the model. For instance, in a situation in which the demand for skilled labour increases resulting in in-migration and an associated population increase and increased housing demand, those changes must be allocated to a specific region in order to match housing demand and housing supply. It obviously makes little sense, for example, to assume that excess housing supply capacity on the west coast of the Island will meet demand needs on the east coast. The model is thus most appropriate for forecasting changes in a relatively autonomous labour market area.

Given the thesis objectives and these model characteristics the selection of the study region is essentially reduced to two choices. The two regions most affected by the Hibernia Project are the Isthmus of Avalon, where the Bull Arm construction site for the Project is located, and St. John's, where the within-province administration, design and management activities for the Project are currently taking place, and where subsequent administration, supply and service functions will occur during the production phase. The St. John's CMA was chosen over the Isthmus of Avalon because:

(i) While employment impacts on the Isthmus from the construction activity will be significantly greater than those from administration and operations in St. John's, (peak construction employment is expected to be in the order of 3,600 while production is estimated to require only 2-300 persons not all of whom will need to be based in St. John's), the construction phase is a comparatively short-term event (1990-1997), while the production phase is expected to last at least 18 years, from 1997-2015;

(ii) The Isthmus region is largely insulated from the major demographic, housing and infrastructure impacts of the Project by the isolation of the project and, more specifically, the housing of the temporary workforce at the Bull Arm site. The single most important impact management tool has been the use of the work camp which is capable of accommodating some 3,000 workers (no families) and which has had the desired effect of dramatically reducing the potential demands on local housing, infrastructure and services that would otherwise have occurred. While there has been some in-migration of staff and their families to the region this has been relatively small. As of April 1993 there were 1160 persons working on site, of whom 144 were from the Impact Area (HCSEMC 1993:3). In-migration to the local communities of project employees and their families totalled only 148 (HCSEMC, 1993a:1). This compares with total direct project employment in St. John's of just over 300 at the same time. While data on local/non-local employees are not available, in-migrants (workers and families) occupying company housing totalled 101 persons (HCSEMC 1993:1).

In contrast to the Isthmus area, the St. John's region is not subject to any impact management approaches. Responses to changes in demands for labour and the subsequent impacts on migration, housing, etc., are to be resolved entirely through the `free-market' system and are in no way constrained by any direct planning mechanisms. At present no agency within the province has developed any formal process for forecasting economic change either for the City or the CMA. Given the current and potential impacts of Hibernia and possible subsequent offshore developments there is therefore a need to develop forecasting capabilities for planning purposes in this region;

(iii) Finally, the model has significant data demands, both to calibrate parameter values and in order to run the model. Data of the type required are more readily available for the Census Metropolitan Area (CMA) and hence, from a practical perspective, there are good reasons for choosing this region over that of the Isthmus.

Geographically, the St. John's CMA, the most easterly region of the province, is the nearest metropolitan area to the Hibernia offshore oil field. Being the largest urban area in the province and the second largest in eastern Canada, the area has the physical and economic capacity and capability to support and serve the Project. The key features are that:

(i) In the Port of St. John's, the CMA has an excellent sheltered deep water, ice-free harbour, that includes a container terminal and ship repair facilities. This harbour is already firmly established as the major service and supply base for oil-related and other marine-based industries. Since the early 1960s, most rigs and drillships that have operated offshore of Newfoundland and Labrador have been supplied and serviced from the Port of St. John's. It has been estimated that the harbour can serve 14 to 19 rigs at any one time (House, 1985:166).

(ii) The St. John's airport, located only minutes to the north of the City, is one of the main airports in eastern Canada and has the capacity - if not, the potential for expansion - to provide the necessary air support for offshore development, including air ambulance services, assistance to air and marine search and rescue, and multi-engine helicopters to service the offshore industry.

(iii) The physical infrastructure (roads, water, power, etc.) in the CMA is adequate to meet the foreseeable needs of the industry and there is suitable and sufficient industrial and residential land to meet anticipated needs. Likewise social infrastructure such as hospitals and schools are concentrated in the CMA and are, in general, also capable of meeting anticipated demands.

(iv) Educational and medical facilities and services, research and development industries and institutes have an important role to play in the development of the offshore oil industry. Many of the existing facilities and services in Newfoundland are concentrated in St. John's including; Memorial University of Newfoundland, the only university in the province, and which includes the Fisheries and Marine Institute, the Centre for Cold Ocean Resources Engineering (C-CORE), the Ocean Sciences Centre (OSC), the Ocean Engineering Research Centre (OERC), the Ocean Drilling Program, and the Centre for Offshore and

Remote Medicine; the Cabot Institute of Applied Arts and Technology, and; the National Research Council's Institute for Marine Dynamics.

(v) St. John's is also the main decision-making centre within the province. It is the seat of the provincial government and home of the Canada-Newfoundland Offshore Petroleum Board - the agency with primary responsibility for managing offshore developments. Likewise, the head offices of commercial banks, other financial institutions and most of the major corporations operating within the province are found here. The CMA is also the main retail and wholesale centre in the province.

(vi) It is not surprising to find that in response to this combination of factors that virtually all of the oil operators and drilling companies, and local oil-related service and supply companies have located in the CMA.

While many elements of the infrastructure of the CMA (e.g. the University, the airport) serve the wider region, the CMA does have a relatively closed labour, production and consumption market, i.e. the socio-economic activities in this region are closely inter-related within a fairly well defined and spatially restricted area[2], a characteristic which facilitates this research.

2.3 The Economic Development of the St. John's CMA

The fishery has been Newfoundland's most important means of economic support for several hundred years. St. John's possesses an excellent ice-free harbour, is not only close to the major fishing grounds on the Grand Banks, and but also close to England. Its geographical location, with respect to the fishing grounds and with respect to England,

2 Commuting, primarily to and from the St. John's CMA can be explicitly considered in the IFS. The CMA can be considered as a local market, the rest of the Avalon Peninsula can be regarded as another area from which people can commute to work or shop in the St. John's region, and all the other areas can be regarded as an external market which may influence St. John's. In the model which follows, however, labour commuting to the CMA is not included because the data are not available.

with which the former colony's governments have been intimately linked since the 16th century, resulted in St. John's becoming the dominant urban centre in the province.

Most of the major fish merchants and suppliers have been located in the City of St. John's since the 17th century, and as the seat of government the City evolved as the colony's economic and political centre. Furthermore, fishery, food processing, manufacturing and other services industries evolved to serve growing local and province-wide markets, contributing to the development of the City as the primary trading and economic centre. As a matter of fact, the City of St. John's was the only important urbanized area on in Newfoundland until the end of the 19th century, much of the rest of the island being undeveloped or underdeveloped.

The completion of the trans-island railway in 1897 made a very important contribution to the development of the central and western regions of Newfoundland. Not only did the trans-island railway connect the eastern region with the central and western regions to make transportation much easier and cheaper for people and commodities, but also accelerated the economic development of the central and western regions. Since the early 1900s, two major pulp and paper mills were established in Corner Brook and Grand Falls and mining operations in Buchans. After confederation in 1949, with the help of the federal government of Canada, other new regional centres such as Gander, Marystown and Clarenville have emerged. At the same time, the economy of the St. John's region has continued to grow and it has remained by far the largest and most important economic, political, educational and medical centre in the province.

More importantly, the economy of the St. John's region has developed and diversified much faster than that of the rest of the province. In comparison with the other regions in the province, this region has the highest concentration and most diversified industrial base, including manufacturing, trade, construction, finance, insurance, real estate, community business, personal service and public and defence industries, albeit there is lack of resource-based industries, for instance, the pulp and paper, and mineral industries.

Since the 1970s, St. John's has taken on an additional role, the primary supply and service base and administrative centre for offshore oil development. The Hibernia mega-project has influenced, and will continue to influence, the economic development and industrial structure of St. John's region. The impact of offshore oil development from this project alone is expected to last for at least another two decades and with other offshore projects in the planning stages, St. John's appears likely to develop as an important regional oil centre in the future.

2.4 Demographics of the St. John's CMA

The St. John's CMA accounted for almost 30% of the population of the province (the Island of Newfoundland and Labrador) in 1991. Over the past 40 years the average growth of population in the region has been much faster than that for the province as a whole (see Table 2-1). The population growth in this region has come from natural population growth and in-migration because the fertility rate for the region has been lower than the province's average[3].

In comparison with other census metropolitan areas in eastern Canada over the past 40 years the St. John's CMA has had the fastest population growth rate (see Table 2-2). Its population in 1991 represents an overall 150.45 % increase over 1951 (compared with 139.30% for Halifax, 59.54% for Saint John, 112.47% for Montreal and 133.69% for

Quebec City). As Table 2-2 illustrates, growth rates were high in the 1950s, '60s and '70s, slowing in the 1980s and '90s. Though the Hibernia Project will probably attract some in-migration and reduce out-migration, the absolute numbers are expected to be fairly small, and in the absence of any other major stimulus to the economy the growth of the CMA in comparison to others in eastern Canada is expected to continue to remain relatively slow.

3 In-migration data are not available for the region. Estimates are based on differences between projected and actual population cohorts.

Table 2-1 Population of the St. John's CMA and Newfoundland and Labrador and Intercensal Growth Rates, 1951-1991

Year	St. John's CMA Population(%)		Newfoundland Population (%)	
1951	68620		361416	
1956	79153	15.35	415074	14.85
1961	90838	14.76	457853	10.31
1966	117533	29.39	493396	7.76
1971	131814	12.15	522105	5.82
1976	145400	10.31	557725	6.82
1981	154820	6.48	567680	1.78
1986	161901	4.57	568349	0.12
1991	171859	6.15	568575	0.04
Total	150.45		57.32	

Sources: Statistics Canada, 1951-1991 Census of Canada, 92-515, 92-713, 92-901, 95-150 and 93-301

Table 2-2 Population and Intercensal Growth Rates of CMA's in Eastern Canada 1951-1991

Year	Halifax (%)		Saint John (%)		Montreal (%)		Quebec (%)	
1951	133931		78337		1471851		276242	
1956	164200	22.60	86015	9.80	1745001	18.56	311604	12.80
1961	183946	12.03	95563	11.10	2109509	20.89	357568	14.75
1966	209901	14.11	106744	11.70	2570982	21.88	436918	22.19
1971	222637	6.07	106195	0.00	2743208	6.70	480502	9.98
1976	267991	20.37	112974	6.38	2802547	2.16	542158	12.83
1981	277727	3.63	114048	0.95	2828349	0.92	576075	6.26
1986	295922	6.55	121265	6.33	2921357	3.29	603267	4.72
1991	320501	8.30	124981	3.06	3127242	7.05	645550	7.01
Total	139.30		59.54		112.47		133.69	

Sources: Statistics Canada, 1951-1991 Census of Canada, 92-535, 92-708, 95-943 and 93-303

While the total population of the metropolitan region is increasing, like many other cities in North America, movement to the suburbs has resulted in the population of the City of St. John's decreasing. Most of the suburban growth has occurred to the southwest (Conception Bay South) and south (Mount Pearl) of the City of St. John's. In the case of Mount Pearl the population now exceeds 20,000 and the community has received designation as a City.

The population age structure of the region has also changed (see Table 2-3). The baby-boomers, like those in most other regions of the country, began to enter the middle-age, 30-45, group in the early 1990s, illustrating the aging trend for the population as a whole. However, structural changes have been comparatively slow, probably because most in-migrants are young people which slows down the population aging process. Traditionally, most in-migrants to the region have come from and continue to come from other regions of the province.

Given the recent closures in the fishery and the associated prospect of rural out-migration, plus the potential impacts of the production phase of the Hibernia Project, the relative and absolute importance of the region in the provincial economy is expected to increase, and recent population growth trends are expected to continue for the foreseeable future.

Table 2-3 Population by Five and Ten-Year Age Groups and Sex, St. John's CMA

1976-1991

Age group	1976				1981			
	Male	Female	Total	(%)	Male	Female	Total	(%)
0 - 4	6700	6440	13140	9.16	6510	6325	12835	8.29
5 - 9	6940	6725	13665	9.53	6925	6550	13500	8.72
10 - 14	7895	7610	15505	10.81	7115	6835	13950	9.01
15 - 19	7605	7785	15390	10.73	8110	8180	16290	10.52
20 - 24	7225	7750	14975	10.44	7360	8375	15735	10.16
25 - 34	11380	11600	22980	16.03	13670	14100	27770	17.94
35 - 44	7325	7090	14415	10.06	9055	8975	18030	11.65
45 - 54	6215	6250	12465	8.69	6455	6570	13025	8.41
55 - 64	5250	5575	10825	7.55	5455	5670	11125	7.18
65 - 69	1710	2085	3795	2.65	2085	2635	4720	3.05
70 - +	2325	3910	6235	4.35	2940	4920	7860	5.08
Total	70575	72815	143390	100.00	75675	79145	154820	100.00

Table 2-3 (cont.)

Age group	1986				1991			
	Male	Female	Total	(%)	Male	Female	Total	(%)
0 - 4	6165	5865	12030	7.43	6500	5885	12385	7.21
5 - 9	6510	6205	12715	7.85	6110	5995	12105	7.04
10 - 14	6935	6530	13465	8.32	6560	6315	12875	7.49
15 - 19	7150	7070	14220	8.78	7010	6620	13630	7.93
20 - 24	8155	8610	16765	10.35	7225	7155	14380	8.37
25 - 34	14460	15300	29760	18.38	15700	16750	32450	18.88
35 - 44	11430	11705	23135	14.29	13515	14055	27570	16.04
45 - 54	6980	7015	13995	8.64	8835	8985	17820	10.37
55 - 64	5005	5870	11375	7.03	5885	6350	12235	7.12
65 - 69	2230	2700	4930	3.04	2360	2635	4995	2.91
70 - +	3540	5990	9530	5.89	4415	7000	11415	6.64
Total	79060	82860	161920	100.00	84115	87745	171860	100.00

Sources: Statistics Canada, 1976-1991 Census of Canada, 95-150, 95-903 and 93-301

2.5 The Labour Force of the St. John's CMA

In 1991 the St. John's CMA had a little more than its share of the total provincial labour force when compared with total population (31% compared with 30.2%). While lacking employment opportunities in pulp and paper and mining it nonetheless has the most diversified industrial base, the highest participation rates and the lowest unemployment rates of any region in the Province.

During the period 1961-1986, while the total CMA population increased by about 78%, the CMA labour force increased by about 160% (see Table 2-4). The numbers working in Trade; Finance, Insurance and Real Estate; Community, Business, and Personal Services, and; Public Administration and Defence sectors increased dramatically. While not unique to this region, these labour force increases have significantly changed the structure and pattern of industrial employment in the St. John's CMA over the past 25 years.

As the local market has grown, national chains and mainland firms have been induced to establish their branches and divisions in the region. From the 1960s on, following mainland patterns, a number of shopping malls have been developed, usually financed by mainland property developers. The labour force in the Community, Business, Personal Services & Other Industries increased by 274% between 1961 and

Table 2-4 Labour Force 15 Years and Over, the St. John's CMA, 1961-1986

Industry Divisions	1961	1971	1981	1986
All Industries (%) (1961 = 100)	29456 100.00	48370 164.21	69760 236.83	76365 259.25
Primary	570	885	1690	1800
Manufacturing	2693	3345	5460	5380
Construction	2001	3420	4515	4290
Transportation & Other Utilities	4196	5515	6435	6595
Trade	7035	9535	13635	14365
Finance, Insurance & Real Estate	882	1570	3640	3915
Public Administration & Defence	4342	5280	9060	11090
Community, Business, Personal Services & Other Industries	7737	18850	25325	28930

Sources Based on: Statistics Canada, 1961, 1971, 1981 and 1986 Census of Canada, 94-518, 94-742, 93-961 and 95-150

1986 and at almost 29,000 represents the largest segment of the labour force. Trade and Public Administration represent the next largest segments of the labour force and showed increases of 104% and 155% respectively over the same time period. Other major increases in the time period were in the Finance, Insurance and Real Estate sector (344%), however, the total labour force for this sector in 1986 was less than 4,000 and the sector ranked seventh of eight in terms of total labour force.

The Construction sector grew considerably from 1961 to 1981, with the modernization of education and health facilities and the development of the road network and public utilities, such as water and sewer systems. In the 1980s federal cutbacks in particular cooled activities, resulting in considerable unemployment and overcapacity in this sector and a downsizing in the labour force. Transportation and Utilities has shown only modest growth overall (51%) and among the other smaller sectors Manufacturing (100%) and Primary Industry (215%) growth experience has been mixed. In the case of the Manufacturing sector there was in fact a decline in the labour force from 1981 to 1986. While some improvement might be expected as a result of the Hibernia Project. the manufacturing sector in this region is still comparatively weak and accounts for only a small share (7.05%) of the labour force.

The development of the economy in the St. John's CMA can also be viewed from the perspective of the education level of the labour force. Table 2-5 shows that the education levels of the St. John's CMA labour force are much higher in comparison to the rest of the province. Over 50% of people with university education (48.10 without degree, 53.70 with degree) in the province live in the St. John's CMA which accounts for only about 29% of the population of the province. The comparatively well-educated labour force again makes the St. John's CMA better situated for taking advantage of new employment opportunities, including those in the offshore oil industry.

Finally, Table 2-6 illustrates participation and employment rates for the CMA and the province. Both male and female participation rates are higher in the CMA and unemployment rates significantly lower. This illustrates the relative economic strength of the CMA, compared to the rest of the province. Nevertheless participation rates are still

Table 2-5 Education by Highest Schooling

the St. John's CMA and Newfoundland and Labrador, 1986

By Highest Schooling	St. John's CMA (% of the Province)	Newfoundland and Labrador
15 years and over	121455 (29.11)	417205
Less than grade 9	18220 (16.42)	110940
Grade 9-13		
without secondary certificate	34725 (26.56)	130730
with secondary certificate	10690 (29.95)	35695
Trade certificate or diploma	2205 (30.46)	7240
Other non-university education		
without certificate	5475 (37.40)	14640
with certificate	20935 (34.91)	59970
University		
without degree	16560 (48.10)	34430
with degree	12655 (53.70)	23565

Sources: Statistics Canada, 1986 Census of Canada, 95-150, 94-102

Table 2-6 Labour Force, Labour Participation and Employment

the St. John's CMA and Newfoundland and Labrador, 1986

	St. John's CMA	Newfoundland and Labrador
Labour Force	78905	247095
Participation (%)	65.00	59.20
Male	75.10	70.20
Female	55.60	48.40
Employed	66835	183840
Male	37275	109750
Female	29560	74050
Unemployed	12065	63305
Male	6575	35830
Female	5490	27475
Unemployed (%)	15.29	25.60
Male	15.00	24.60
Female	15.70	27.10

Sources: Statistics Canada, 1986 Census of Canada, 95-150, 94-102

low (especially for females) and at 15 or more percent unemployment rates are still high. The potential impact on these rates of offshore development is thus a key question and one which the model developed in this thesis should be capable of addressing.

2.6 The Offshore Oil Industry and the St. John's CMA

2.6.1 Exploration for Offshore Oil and Gas

Exploration for oil and gas offshore Newfoundland and Labrador first began in 1964 with the issue of the first exploratory permits and the commencement of geophysical surveys. Drilling began on the Grand Banks in 1966 and off Labrador in 1971. The first oil was found on the Grand Banks in 1973 and the first gas offshore Labrador in the same year. Many of the early discoveries were of gas and condensate off the coast of Labrador (Table 2-7) but since the discovery of the Hibernia oilfield in 1979 most drilling activity has concentrated in the northeast sector of the Grand Banks (Figure 2.4)(C-NOPB, 1986:10).

Offshore activity has not proceeded at a constant pace (see Figure 2.5). To the end of 1992 a total of 117 exploratory wells and 23 delineation wells had been drilled (C-NOPB, 1993:10), and there was no exploration activity in 1993. After the first drilling activity in 1966 there was a hiatus until 1971 after which annual activity rose to a peak in 1973 before declining to zero in 1977.

All exploratory activities ceased in 1977 because of the implementation of the Newfoundland government's petroleum industry regulations (Newfoundland, 1977). These regulations attempted to give the Province much greater control over offshore drilling activities including public ownership provisions, local business and employment preferences, and compulsory education, research and development expenditures within the province. The oil companies strongly disagreed with these regulations and in protest ceased activity in the Newfoundland offshore. However, "the area had too much potential to be abandoned, and the rapidly worsening crisis of OPEC oil pricing counselled a less arrogant stance. One by one they found it expedient to meet provincial requirements" (Scarlett, 1990:7-17).

Exploration activities resumed in 1978 when the oil companies began to comply with the Newfoundland regulations. In that year, Chevron found another significant natural gas accumulation with high flow rate at its Hopedale E-33 in the Labrador Sea, which again stimulated drilling activities off Newfoundland and Labrador.

From 1978 to March 1980, favourable federal tax incentives in the form of frontier tax allowances further encouraged exploration activities. In response to the Chevron discovery, about $180 million was spent on drilling ten exploratory wells offshore of Newfoundland and Labrador in 1979 in comparison with the three wells drilled the year before (Newfoundland and Labrador Petroleum Directorate, 1983).

In the summer of 1979, the first Hibernia well, P-15, was drilled off the Newfoundland coast some 315 kilometers east southeast of St. John's. Successive delineation wells opened up the prospect of the first commercial oil field, the largest yet known in Canada. On January 3, 1980, Chevron Standard, on the behalf of its partners Gulf Canada, Mobil, Columbia Gas Development and Petro-Canada, announced that the Hibernia field was capable of producing up to 250,000 barrels per day of high-quality, low-sulphur oil.

Since oil fields are rarely found in isolation, there were good reasons to speculate that several other oil fields would be found in the Jeanne d'Arc Basin (also called the Avalon Basin). Since the discovery of the Hibernia field (estimated to contain 666 million barrels of oil and 1,017 billion cu.ft of gas), subsequent drilling activities on the Grand Banks have led to significant oil discoveries at the Terra Nova (406 m.bbls.), Hebron (195 m.bbls.), Whiterose (178 m.bbls.), West Ben Nevis (25 m.bbls.), Mara (23 m. bbls.) and other fields, and significant gas finds at Whiterose (1,509 b.cu.ft.), North Dana (470 b.cu.ft.) Springdale (236 b.cu.ft.) and Ben Nevis (229 b.cu.ft. (C-NOPB, 1993:11) (see Table 2-7 and Figure 2.4).

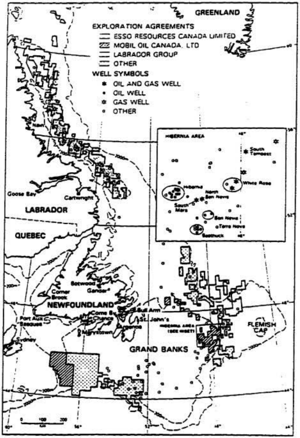
While exploration activity continued to increase until 1985, dispute between the federal and Newfoundland governments over offshore jurisdiction contributed to a delay of several years of the development of the Hibernia field. In 1984 the Supreme Court of Canada ruled that the federal government had jurisdictional responsibility for offshore resources off Newfoundland, and in February 1985 the Canada-Newfoundland Offshore Petroleum Board (C-NOPB) was established as part of a joint agreement known as the Atlantic Accord to manage offshore exploration, development and production activities. Under the Board's mandate, approval to proceed with the development of the Hibernia field was given in June 1986 (C-NOPB, 1986). Subsequently financial arrangements were agreed to by the two levels of government and the Hibernia partners at the time (Mobil Oil Canada Ltd., Gulf Canada Corporation, Petro-Canada Inc. and Chevron Canada Resources Ltd.) and construction of the Gravity Base System (GBS) that will be used to produce oil from the field began in 1990.

Table 2-7 Oil and Gas Discoveries off Newfoundland and Labrador
Wells Spudded, 1973-1989

Year	Discovery Oil & Gas Wells off Newfoundland and Labrador	Recoverable Resources
1973	Bjarni H-81.	420 BCF Gas and 20 MBI NGL.
1974	Gudrid H-55.	810 BFC Gas and 37 MBI NGL.
1975	Snorri J-90.	60 BCF Gas and 5 MBI NGL.
1976	-	
1977	No drilling activity.	
1978	Hopedale E-33.	240 BCF Gas, 12 MBI NGL.
1979	Hibernia P-15.	666 MBI Oil, 1.017 TCF Gas and 111 MBI NGL.
1980	Ben Nevis I-45; South Tempest G-88; North Bjarni F-06.	19 MBI Oil,229 BCF Gas and 30 MBI NGL. 8 MBI Oil. 1.95 TCF Gas and 88 MBI NGL.
1981	Hebron I-13; Nautilus C-92.	195 MBI Oil. 13 MBI Oil.
1982	North Dana I-43.	470 BCF Gas and 11 MBI NGL.
1983	Terra Nova K-08; Trave E-87.	406 MBI Oil. 30 BCF Gas and 1 MBI Oil.
1984	White Rose N-22; West Ben Nevis B-75; Mara M-54; North Ben Nevis P-93; South Mara C-13.	178 MBI Oil. 25 MBI Oil. 23 MBI Oil. 18 MBI Oil, 115 BCF Gas and 4 MBI NGL. 4 MBI Oil, 144 BCF Gas and 8 MBI NGL.
1985	-	
1986	Fortune G-27.	6 MBI Oil.
1987	-	
1988	-	
1989	Springdale M-29.	14 MBI Oil and 236 BCF Gas.

Sources based on: Newfoundland Ocean Industries Association, 1991:15-24.
Key: BCF - Billions of Cubic Feet ;TCF - Trillions of Cubic Feet; MBI - Millions of Barrels; NGL - Natural Gas Liquids

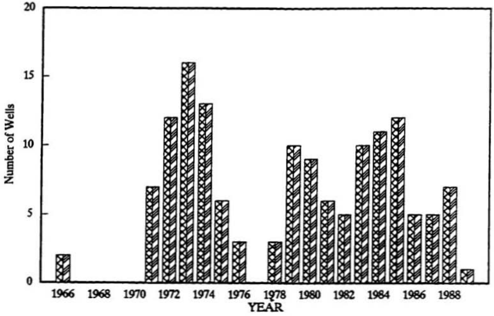
Figure 2.4 Exploration and Discovery of Hydrocarbons Offshore



Source: M.J. Scarlett, 1990, The Newfoundland Economy: A Spatial Analysis, 3rd Edition, Department of Geography, Memorial University of Newfoundland, pp7-21.

Figure 2.5 Newfoundland Offshore Drilling Activity,

Wells Spudded, 1966-1990



Sources: CNOPB, 1986 and 1990

low (especially for females) and at 15 or more percent unemployment rates are still high. The potential impact on these rates of offshore development is thus a key question and one which the model developed in this thesis attempts to address.

While there have been subsequent delays to the project,[4] production from the field is anticipated to commence in 1997, some 18 years after its initial discovery.

In total, since the first well was drilled 26 years ago, more than $400 million has been spent on exploration. An estimated $12 million was spent on environmental studies as part of the approval process for the Hibernia Project and the total estimated cost of developing the Hibernia field is $6.2 billion, 55-60% of which is to be spent in Canada. Expenditures during the production phase are estimated to be a further $10 billion over the life of the Project. While there were no estimates of total expenditures in the St. John's CMA (this will ultimately depend on the award of contracts for various components of the Project), the potential economic impact on the St. John's area, especially during the production phase, is likely to be quite important over the life of the Project.

4 Gulf Canada withdrew from the Hibernia consortium in 1992. A new partner, Murphy Oil Corporation based in Arkansas, USA, joined the consortium in early 1993.

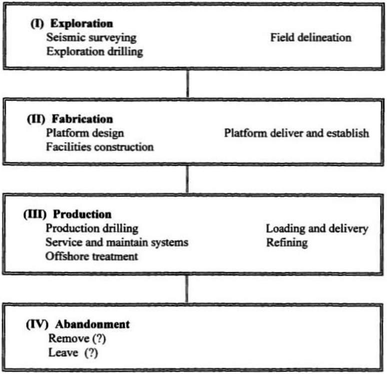
2.6.2 The Offshore Oil Development Process

A four-phase activity typology can be used to describe the offshore oil industry: exploration, development (fabrication or construction), production and abandonment (Lewis and McNicoll, 1978). While for any one field there may be some overlap of activity (e.g. ongoing exploration and development during production) the main overlap occurs when oil and gas fields are discovered and developed at different times. The main components of the general development process are illustrated in Figure 2.6.

Exploration consists primarily of seismic survey analysis, exploration drilling assessment and oil and gas field delineation. Seismic studies make up most of the survey analysis, which indicate geologic structures and the potential for oil. Exploration drilling distinguishes the actual oilfield sites and the significance of any hydrocarbons shows. Following initial discovery, the boundaries of potentially significant fields are determined through delineation drilling. To date drilling offshore Newfoundland has been done from both drillships and semi-submersible drill rigs.

Exploration drilling activities generated significant employment in Newfoundland in the mid-1980s. At peak, in 1985, over 3000 persons were employed in offshore activities, including marine and technical crews on seismic vessels, drillships and semi-submersible drill rigs; marine crews on the supply ships; helicopter pilots and people in the onshore services and administration. Most of these activities have typically been serviced from St. John's, the primary offshore administration, service and supply base. While most of the drilling and seismic activities were undertaken by foreign companies and vessels, economic benefits increased significantly after 1977 with the establishment of the Provincial regulations designed to maximize local expenditures and hiring.

Figure 2.6 The Retrieval Process Associated with Offshore Activity



Development, or the fabrication/construction of offshore production systems, is the most capital intensive phase of activity. Typically, activities are also short-term and intensive with respect to employment, technology and entrepreneurship requirements. Construction experienced with the Hibernia Project is expected to run from 1990 to 1997, including slowdowns while the search for a partner to replace Gulf Canada was ongoing. The main direct social and economic impacts occur during this phase and for this Project will be experienced mainly in the communities near the Bull Arm construction site. It is here that the construction of the GBS and the design and fabrication of one of seven of the topside modules and other topside components are taking place, and it is where the mating and outfitting of the complete platform will occur.

Once complete the platform will be towed out and installed at the Hibernia field. After the initial production wells are drilled, two or three shuttle tankers will be used to transport the oil to market. While the destination of the oil is as yet unspecified, it will probably go to markets on the eastern seaboard of the U.S. Movement of the oil may involve transhipment to other tankers owned by other carriers. This might occur in Newfoundland at, for example, Come By Chance, however, no final decisions had been reached on this as of mid-1996.

In the 1985 Hibernia Environmental Impact Statement it was estimated that at peak (1994-1995) about 3,600 people would be employed in design and construction at the Bull Arm site (NODECO, 1991:2-6). In fact this number has approached almost 6000. Some fabrication and engineering work was projected to occur and has taken place at the Marystown shipyard. In the meantime activities in St. John's include design engineering for the GBS, project management and administration.

This stage was expected to generate in the order of 10,000 person years of employment in Newfoundland, much of which was to occur at the construction site. However, the workforce is being drawn from across the province and beyond, with the workforce being housed in a workcamp at the site. Consequently the employment benefits are likely to be felt over a much wider geographic area, including the St. John's CMA where a significant portion of the provincial labour force resides (see Table 2-5).

Production, the third stage, includes production drilling, service and maintenance of offshore systems, delivery and refining. Hibernia crude will receive primary processing offshore to separate oil, gas, water, etc., before being transferred by tanker for further refining. Supply, service and maintenance, plus administration are expected to provide the main employment opportunities at this time, with approximately 2-300 workers being directly involved. With St. John's being the main supply, service and administrative Centre, many of these jobs can be expected to be found here. However. the commuter labour force that works offshore need not reside in the St. John's CMA and many will not. While no onshore processing of Hibernia crude is expected, transshipment is a possibility, though St. John's is likely to benefit indirectly from such activity as the most likely locations for a transshipment terminal are some distance away in, for example, Placentia Bay.

As offshore projects enter the development and production phases, onshore activities tend to increase in number and variety. As the largest urban area in the province, as the one most proximate to the offshore oil fields and the one with the most developed decision-making systems and service and support infrastructure, it seems inevitable that the lion's share of any long-term growth will accrue to the St. John's region. Once St. John's had become the major centre for the industry, agglomeration effects have come into play in which growth tends to procreate growth from new activities clustering near existing ones. Thus, agglomeration economies, (those benefits accruing to all firms, not necessarily in the same industry, from the geographical association of a number of economic activities [Armstrong and Taylor, 1985:77]), make the region increasingly more attractive to both the oil and gas industry and other sectors.

This is not to overstate the prospect for oil-related development in the St. John's CMA. Both federal and provincial governments have made a strong commitment to help Canadian and Newfoundland enterprises through such mechanisms as the Canada Benefits requirements and local preference guidelines. However, to date there has only been limited development of activities directly and indirectly supporting this sector and the firms involved have come and gone as industry fortunes have risen and fallen.

As previously noted, the attempts to foster local development were initially not well received by the oil industry. The companies involved in offshore exploration were primarily non-Canadian and, given the specific and usually short-term nature of their activities, were generally used to being able to hire who they pleased - a system which rarely involved many local workers. Under the 1977 Provincial **Act Respecting Petroleum and Natural Gas**, and its associated regulations, any business contracts awarded were to show preference in descending order as follows:

> Newfoundland-owned companies with at least 51% of company shares (Type A Companies);
>
> Companies with local offices and a majority of local employees (Type B Companies); and
>
> All other companies (Type C Companies)(House, 1985:139).

Although these regulations were to some degree successful in helping local business and employment opportunities to develop in the exploration stage, the success was limited because non-Newfoundland corporations (Type C Companies) monopolized drilling and related activities. According to Grinling (1984:33), despite closer supervision of company purchasing procedures than in practically any other offshore regime, only 6.9% of oil-related expenditures had gone to Newfoundland firms by 1983.

This limited involvement will likely be repeated in the construction and production phases. Data on Project expenditures are not readily accessible, except in aggregate form. For example, cumulative Project expenditures, from July 1988 to March 31, 1992 amounted to $5.8 billion of which 41%, or $1.6 billion, was reportedly made in Newfoundland. However, data on the within-Province breakdown is patchy. For example, as of June 1995 $34.2 million had been spent in the Bull Arm/Isthmus of Avalon area, but no similar data for the CMA are available (HMDC, unpublished data, 1996). Thus while the impact on business in the CMA is likely to have been and be both significant and beneficial, it is difficult to determine exactly how much so.

Estimates of oil-related employment in the St. John's CMA are likewise difficult to obtain because of the aggregate form which data are reported. Peak employment during the construction phase in the St. John's CMA of 766 was reached in October 1994.

Since then numbers have declined as project engineering activities have been completed (HMDC, unpublished data, 1996). Even if indirect employment is considered, the numbers employed in the St. John's CMA during the development phase are relatively small. Nevertheless, oil-related employment in St. John's has become and is expected to remain an important component of the regional economy, particularly given the decline in fishery related activities, downsizing of government, and losses in other sectors associated with the current poor economic environment.

Experience elsewhere suggests that international oil industry companies and their branches will dominate the manufacturing and production activities. As House (1985:141) points out:

> Even the most prominent satellite oil centres, such as Calgary, Aberdeen, and Stavanger, have poorly developed manufacturing sectors. They are essentially service-and-supply centres for exploration and production operations.

In the foreseeable future St. John's cannot expect to do even as well as these centres. In the case of Calgary, for example, the boom in activity there followed the 1973 oil crisis when OPEC increased crude oil prices. Numerous oil and gas companies, consultants, and service companies were already established and ready to take advantage of the new opportunities. More important, exploration in Alberta was onshore and local expertise was available allowing a range of different scale local exploration and production companies to become involved. In St. John's the industry is still new, and there are few local companies to take advantage of the opportunities that arise, except insofar as they are able to joint-venture with outside companies.

St. John's will also not become a major offshore oil centre like Aberdeen in Scotland. Offshore oil activity developed rapidly in Aberdeen during the 1970s, and while there have been significant fluctuations in activity it remains an extremely important component in that area's economic structure. In 1990 the oil sector employed 52,500 people, representing about 20% of total employment in the Aberdeen-centered Grampian Region. A key difference from St. John's is that at that time there were 51 oil fields in production and a further 11 under development in the northern North Sea (Grampian Regional Council, 1990:2). The major periods of platform construction and field development followed the 1973 and 1979 oil price rises in particular. By contrast, Newfoundland has not had similar incentives for rapid development and, seventeen years after the initial major discovery, there is only one field under development, and even the best case scenario would see perhaps another two or three fields with potential for development in the near future.

In short, the prospects for the oil industry changing the economic structure of the St. John's region in the same way that it changed that of Calgary and Aberdeen are remote. Nonetheless, for both geographical and economic reasons, St. John's is the logical offshore oil centre for the province and the industry will have an important impact on its economic structure and future growth during the development and production phases.

Abandonment is the final phase in the overall process. All oil fields eventually stop producing and must be abandoned. For Hibernia there are several choices. The offshore platform could be completely or partially removed from the field and then dumped somewhere in the ocean, it could be used to process oil from other fields in the vicinity, or, at least for a short time, it could be used for meteorological or navigational purposes. At this stage no decision has been made with respect to the fate of the platform, however, Condition 10 of the C-NOPB's **Decision 86.01** requires "that the Proponent...design the GBS so that it could be removed if the Authorities at that time so require" (C-NOPB, 1986:74). At such time as the field is abandoned, St. John's will likely the be the base from which the operation is directed and serviced. While this will be a significant undertaking, any economic benefits are likely to be short-term and in any event will be offset by the loss of employment associated with production activities.

From a more positive perspective, it is unlikely that Hibernia will be the only offshore field to be developed. In fact, once one field is in operation the technical, economic and administrative obstacles to the development of other fields are likely to be significantly reduced. Whether any subsequent field developments will involve the construction of another GBS or the use of the Bull Arm site for a different type of production platform is debatable. What is probable is that St. John's would continue to be the main supply, service, transportation and administration centre for the industry. If exploration activity on the Grand Banks or even Labrador resumes, this too will likely benefit St. John's more than any other centre in the province.

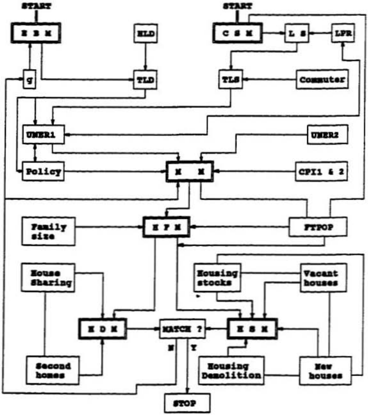
Chapter III - Outline of the Integrated Forecasting System

3.1 Introduction

This chapter describes the structure of the Integrated Forecasting System (IFS) model. The overall design of the model follows the basic format of the Gloucestershire and Grampian models discussed in Section 1.2. The IFS consists of five interacting blocks: labour demand, labour supply, migration and household formation, housing demand, and housing supply. The blocks and the relationships among them is illustrated in Figure 3.1. In the last section, the data used to determine parameter values in the regression analyses and the input data required to run the model are discussed in terms of their availability and quality.

Each block, or sub-model, is represented by a series of equations representing the relationships within the block which are based on general theory or other accepted models. For example, the labour demand block adopts an economic base approach to model these relationships, while labour supply is in part based on the use of a cohort survival model. Once the relationships were modelled for each block, a range of statistical tests were applied to determine the most appropriate parameter values for each variable. The output from each block then becomes input to the next. For example, the output from the migration and household formation block is the input to the housing demand block.

Figure 3.1 The Basic Structure of the Integrated Forecasting System Model



CPI =consumer price index
FTPOP =final total population
HFM =household formation model
LPR =labour participation rate
TLD =total labour demand
UNER2 =Nfld. unemployment rate

CSM =cohort survival model
g =economic growth rate
HLD =Hibernia labour demand
LS =labour supply
TLS =total labour supply

EBM =economic base model
HDM =house demand model
HSM =house supply model
MM =migration model
UNER1 =local unemployment rate

Feedback in the system occurs when there are mismatches between housing demand and supply. As a test of the model the IFS was run using data for 1971-1986 and is shown to provide a reasonable description of the data for that period.

3.2 Forecasting Methodology

The IFS model has several important characteristics:

(i) The IFS is a single region model and, as discussed earlier, it is designed for 'meso-scale', i.e. regional (the St. John's CMA), analysis;

(ii) The model is designed for a maximum 'medium-term' (10-15 years) forecasting timeframe - many of the parameter values in the model change within the long-term, but are relatively stable within the short- and medium-terms, e.g. birth rates and family formation patterns, which limit the time period for which the model is likely to be relevant;

(iii) The set of variables comprising the model are limited and not comprehensive. It would be unreasonable to propose that the IFS model could contain all the demographic and economic factors, causal links and government policies that are present in the real world. Therefore, only those variables which are considered to represent the most important and relevant activities and factors are included in the IFS. The model focuses on the employment, population, household formation and housing characteristics of the St. John's CMA, with each sub-model or activity interacting to varying degrees with other parts of the system.

(iv) The IFS is basically recursive rather than simultaneous, in that the endogenous variables can be determined sequentially. Ordinary Least Squares (OLS) was selected as an appropriate estimation technique for many of the equations, because the assumption that errors were not correlated across equations was valid. It was felt that the extra effort to evaluate the model was worthwhile because OLS sometimes results in biased and inconsistent parameter estimates. Therefore, the mean absolute percentage error (MAPE) was used to evaluate the model's performance. Most tests considered in the evaluation of the model have been developed for non-linear or linear regression models (for details of these tests see Draper and Smith, 1966). The selected diagnostics[5] are described below:

Goodness-of-fit can be measured in a variety of different ways. In this research R^2 and percentage standard error of the estimate statistics (SE%) were calculated for each equation. The OLS regressions were also tested for the structural change of the IFS. The overall significance of F-test was calculated at the 5% level.

Parameter significance for all the regression equations, as measured by t-statistics, are shown in parentheses below each equation. In nearly every instance the values of the estimated coefficients differed from zero at the five percent level. Some variables were retained whose coefficients were not statistically significant where they were regarded as important to the overall structure of the model. In addition, each regression was tested for autocorrelation using Durbin-Watson statistics (DW).

(v) The forecasting methodology used in the IFS was tested and proved to be appropriate for structure planning. However, some assumptions have to be made. These assumptions are based mainly on the principles of the Gloucestershire and Grampian models discussed earlier. The basic activities considered in the IFS included employment, population, migration, household formation and housing. The assumptions made in the model are as follows:

> (a) Supply and demand associated with any one component are the major factors which determine the activity levels of other components which in turn influence the supply and demand levels of the original component;
>
> (b) Population change consists of natural increase, decrease and migration;
>
> (c) Migration is mainly employment-oriented, i.e. it is a function of job opportunities and unemployment rates; migration is also closely related to living expenses as reflected in the consumer price index;
>
> (d) Most activities in the IFS are mutually adjustable; for example, if housing demand does not match the forecasted population, i.e. the demand is larger than supply, then migration is assumed to be

5 Derived using SPSS software

constrained in the short-term by a lack of affordable housing, which will in turn influence labour supply and population growth[6];

(e) Government labour training programs and policies which influence the above activities, particularly employment and migration, are considered and treated as a dummy variable to adjust the relevant parameters and exogenous variables. For instance, if government can maintain or deliver better labour training programs, a more qualified labour force will be available locally, that may help to reduce in-migration.

(vi) Although the development of the oil industry in the St. John's CMA can be traced back to the late 1960s, its impacts were minimal until recently. Until now there has been little incentive to collect employment data for the oil industry in disaggregated form and none are available. The IFS was calibrated using historical data to reflect the socio-economic activities in and characteristics of the St. John's CMA. In the absence of actual time series data, the employment forecast for the Hibernia Project by Mobil Oil Canada, Ltd. in its Environmental Impact Statement for the Project is integrated into the IFS to forecast possible impacts on the study area.

3.3 The Structure of the Integrated Forecasting System

In order to facilitate development and analysis of the model, the IFS is divided into the five blocks previously identified and illustrated in Figure 3.1. Some factors are considered as exogenous variables to the model, including industrial growth rates, fertility rates, the consumer price index, house-demolition rates, and government policies because they are not determined by the IFS internally.

6 Differences in the British and Canadian house construction markets suggest that housing supply is likely to be a lesser constraint in St. John's than the regions for which other IFS models have been developed. This issue is discussed further in section 3.4.

The labour demand and labour supply blocks are viewed as the prime movers determining labour demand and supply and unemployment in the IFS. Subsequently, with other factors, such as employment policy and the consumer price index, and on the assumption that migration is assumed to be job-oriented, they are used to determine migration patterns in the study area. The cohort survival model (CSM) is at the heart of the labour supply block and is used to determine population, labour supply, number of households from which demands for housing and social and other services can be estimated. An economic base model (EBM) is used to determine industry growth and labour demand. Together with the cohort survival model, it determines the level of unemployment, and further migration, which in turn influences the size of the population and number of households. Furthermore, the population and the number of households determine housing demand and influences housing supply in the region.

At the same time, the supply of housing, social services and other community facilities and services may in turn impose constraints on migration which can influence labour supply. For example, migration to the CMA may be constrained if the supply of housing, schools and other facilities in the region cannot keep the pace with the growth in demand for dwelling units and services. An insufficient labour supply may slow local economic development which in turn further influences labour demand, migration and population.

The operational process of the IFS will not stop until it has reached an equilibrium or conditional disequilibrium[7], i.e. the values for the levels are consistent. In this case the model considers only housing supply as a constraining factor. The North American house building industry, by virtue of differences in construction materials and methods, building codes and other regulations, and private/public sector involvement, appear to be able respond more quickly to demand than Brtish markets. As such housing may not constrain in-migration to the same degree here as in Britain. Nonetheless, the IFS developed here assumes that levels of activities in urban systems are determined by the interplay of demand and supply factors. However, the activity demand and supply levels are themselves dependent upon the state of other activities. For instance, housing demand is influenced by the size of the population and the number of families and households. Housing demand cannot exceed housing supply, and, where housing is in short supply, in-migration and new household formation may be constrained. It is these types of linkages and feedbacks which, though important, are rarely considered. Their incorporation into the IFS represents a major difference from traditional forecasting methods.

The IFS developed here is a static model, and therefore needs a measurement point to reach a static equilibrium situation. The actual activity levels cannot be

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7 All supply should be equal to or larger than demand in this system.

determined until demand and supply are mutually adjusted because all elements are dependent upon the values of other elements. However, within the IFS, values for the other levels cannot be determined until at least one level has been held constant. Once one level has been held constant the values for the other levels can be determined.

To illustrate how the IFS works the operation of the model can be described as follows: First, total labour demand (TLD) is calculated using an economic base model (EBM) which comprises nine individual industrial divisions (EMP), including one which represents direct Hibernia employment. Total labour supply (TLS) is determined using a cohort survival model (CSM) and the labour participation rates (LPR). Commuters passing across the St. John's CMA boundary are set to zero. The difference between labour demand and supply generates the local unemployment rate (UNER1).

Second, the ratio of the local unemployment rate (UNER1) to the provincial unemployment rate (UNER2), the ratio of the local consumer price index (CPI1) to the Ontario consumer price index (CPI2) and government training programs and employment policy (as a dummy variable, DUMMY) are entered into the migration model (MM) as variables determining net migration to the St. John's CMA. The local unemployment rate (UNER1) can also influence the local labour force participation rate (LPR) where individuals are discouraged from seeking work given high unemployment levels.

Third, the output of the cohort survival model (CSM) is modified by the output of the migration model (MM) to generate final total population (FTPOP). Then the final total population and family size rates (FAMIS - persons per family) are treated as inputs to the household formation model (HFM) to estimate the number of households.

Fourth, the number of households (HH), the number of houses shared by families (SHH) and second homes (SH - set to zero here) are used in the housing demand model (HDM) to calculate housing demand (HD). In the meantime, existing housing stocks, vacant houses (VH), newly built houses (NBH) and demolished houses (DEH) are entered into the housing supply model (HSM) to calculate housing supply (HS).

Fifth, if the housing supply (HS) and housing demand (HD) match, i.e. the demand is equal to or less than supply, the operation stops. Otherwise, some marginal adjustment (through the relevant parameters) becomes necessary. On the demand side, the family house-sharing rate can be increased to reduce housing demand. On the supply side, the number of vacant houses and house demolition rates are decreased, and the house-building rate (lagged in one year) increased to expand housing supply. Both HS and HD are then compared again. If they match this time, the IFS stops operating.[8]

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8 Housing demand in particular will also be significantly affected by interest rates and mortgage availability. Further refinements to the model should attempt to incorporate these variables.

Finally, if the housing supply is still less than the demand, then primary adjustment steps must be taken. That is, the limited housing supply constrains in-migration and other than natural increases in the total population. This is again based on the assumption that people will not come to this region and stay, if they cannot find housing to meet their needs at an affordable price. Housing demand is thus constrained and local industrial growth rates are reduced. Then the whole operation procedure begins again until the system finally reaches equilibrium or conditional equilibrium.

3.4 The Integrated Forecasting System Sub-Models

Having reviewed the approach to and the general structure of the IFS, the following sections discuss and examine the individual sub-models in terms of the equations used to define them. All the variables defined and described (t = a year) here are summarized in Appendix I.

3.4.1 Labour Demand Block

The demand for labour in the study area was calculated using an economic base theory approach. This labour demand block determines the labour demand in the study area (for details see Field and MacGregor, 1987). Generally speaking, the theory assumes that industries can be allocated to the 'basic' or 'export' sector if their sales respond to forces determined by other regions -- these are usually the primary and manufacturing sectors; or the 'non-basic' or 'induced' sector if activities are oriented towards local markets -- these are usually service activities. It is normally assumed that expansion of the non-basic sectors is dependent on the growth of the basic sectors. As Isard (1960:190) suggests:

> The reason for the existence and growth of a region ... lies in the goods and services it produces locally but sells beyond its borders.

However, in reality, the stimulus for regional growth may also come from traditional non-basic sectors or factors. For instance, as the capital city of the Province, the expansion of employment in public administration in the St. John's CMA has been definitely related to the level of provincial government expenditure; the increases of technology and service export from traditional non-basic or service sectors also certainly help the growth of the region. As a matter of fact, the flow of income inside the community also generates income and hence community development. To accommodate this type of impact some employment in service industries, traditionally treated as non-basic, was allocated to the basic sector.

The economic base model, first developed by Tiebout (1956 and 1962), has come in for considerable criticism both from theoretical and practical perspectives and because of difficulties of implementation and limitations of the concept. Most criticisms of the model focus on the fact that it is a simplification of reality to postulate that the export sector, even when defined to include net income payments to residents from abroad, is the sole mover of local growth, although there may be a general correlation between growth in the export sector and growth in the local economy as a whole.

Even if the weaknesses of the initial assumptions are overcome, there are a number of limitations involved in the use of this concept as a forecasting device. The concept of the multiplier, which is integral to the model, is usually used in economics with reference to short-term fluctuations and as such may fail to consider other factors and issues more relevant to long-term development. There are also considerable difficulties with the use of this concept at different regional scales. These affect both the numerical value of the multiplier and its usefulness. From a practical perspective, a significant problem is in allocating activities to basic and non-basic categories. (For further discussion of the model see, for example, Hewings, 1969; Steele, 1972; McCalden, 1973; Rosen and Mathur, 1973; Sparkes, 1973; Mathur and Rosen, 1974; and Field and MacGregor, 1987).

Notwithstanding the theoretical limitations of the economic base model and the practical difficulties of its implementation, the economic base model is still widely used in urban and regional planning mainly because of its relative simplicity and availability of data. In the absence of feasible alternatives the economic base model is adopted here.

Statistics Canada categorize census data for industries in the St. John's CMA into eight industrial divisions: (I) Primary; (II) Manufacturing; (III) Construction; (IV) Transportation and Related Utilities; (V) Trade; (VI) Finance, Insurance and Real Estate; (VII) Public Administration and Defence; (VIII) Community, Business, Personal Services and Other Industries. In the model developed here labour demand directly associated with the Hibernia Project is categorized separately and labelled as division IX. The unit of measurement used in this IFS is the number of employees in all industries. The total labour demand is simply the summation of labour demand in each individual industry.

There is no standard definition how industries should be divided into basic and non-basic sectors. In this case a location quotient approach (see Isard 1960:195), "modified" to reflect local conditions, was adopted as a guide to assign workers by industry division to basic/non-basic categories. Location quotients, or concentration ratios, for each industry division were calculated as the ratio of per capita employment in the CMA to that of the province as a whole based on 1986 census data. Ratios greater than unity are taken to indicate an export or basic industry and the amount by which the ratio exceeds unity taken to indicate the extent to which total employment is basic. The results from the calculations were then in some cases "modified" based on knowledge of local conditions. For example, the location quotient for the Primary sector in the CMA is .3, suggesting that primary activities are non-basic and serve the local market. In fact much of the primary activity in the CMA is related to fishing and as such associated with export activities. The low ratio is a function of the high employment in this sector plus the lack of diversity in other sectors in the rest of the province. In this case Primary sector 'basic' employment in the CMA was adjusted to attempt to reflect this (see section 3.5.1).

After growth rates in the basic sector in each industry, $\mathbf{g_{i,r}}$, were determined, several total to basic employment ratios were tested to find the economic base multiplier. Employment in the basic and non-basic sectors of each industry, total employment and base multipliers can be described by equations 3.1 - 3.5:

$$\mathbf{EMP_{i,t} = BEMP_{i,t} + NBE_{i,t}} \qquad \mathbf{(3.1)}$$

where: $EMP_{i,t}$ = employment in industry i at time t (i = 1,2,...9);
$BEMP_{i,t}$ = basic employment in industry i at time t (i = 1,2,...9);
$NBE_{i,t}$ = non-basic employment in industry i at time t (i = 1,2,...9).

$$\mathbf{TEMP_t = TBE_t + TNBE_t} \qquad \mathbf{(3.2)}$$

where: $TEMP_t$ = total employment in all industries at time t;
TBE_t = total basic employment at time t;
$TNBE_t$ = total non-basic employment at time t.

$$\mathbf{m = TEMP_t / TBE_t} \quad (3.3)$$

where: m = economic base multiplier;
$TEMP_t$ and TBE_t as before.

$$\mathbf{TBE_t = \sum_{i=1}^{9} BEMP_{i,t}} \quad (3.4)$$

where: $BEMP_{i,t}$ and TBE_t as before.

$$\mathbf{TNBE_t = \sum_{i=1}^{9} NBE_{i,t}} \quad (3.5)$$

where: $NBE_{i,t}$ and $TNBE_t$ as before.

From equation 3.3, we get equations 3.6 and 3.7:

$$\mathbf{TEMP_t = m * TBE_t} \quad (3.6)$$

then

$$\mathbf{TEMP_{t+1} = m * TBE_{t+1}} \quad (3.7)$$

In order to calculate the total employment in the forecast year, the only requirement is knowledge of the basic employment in the forecast year and the growth rates of the individual industries, $\mathbf{g_{i,t}}$, which can be projected using regression models. Given equations 3.1 to 3.7, equations 3.8 to 3.11 allow estimates of basic employment in each industry, total employment, total non-basic employment and non-basic employment in each industry in the forecast year:

$$\mathbf{BEMP_{i,t+1} = g * BEMP_{i,t}} \tag{3.8}$$

$$\mathbf{TEMP_{t+1} = (TEMP_t/TBE_t) * \sum_{i=1}^{9} g_{i,t} * BEMP_{i,t}} \tag{3.9}$$

$$\mathbf{TNBE_{t+1} = TEMP_{t+1} - TBE_{t+1}} \tag{3.10}$$

$$\mathbf{NBE_{i,t+1} = TNBE_{t+1} * (NBE_{i,t}/TNBE_t)} \tag{3.11}$$

where: $BEMP_{i,t+1}$ = basic employment in industry i at time t+1 (predicted);
$g_{i,t}$ = a growth factor for industry i at time t;
$NBE_{i,t}$, $BEMP_{i,t}$, $TEMP_t$, TBE_t, $TNBE_t$, as before.

One of the most important elements of this model, $\mathbf{g_{i,t}}$, which determines the growth rates of employment in each individual industry, is derived from a time series model. The time series model is selected because actual employment data by each industrial division at this scale are not available from the Census of Canada. On the assumption that labour force data (including the unemployed in the industry), adjusted by unemployment rates, can be used as a surrogate for actual employment, census data on the adjusted labour force 15 years and over were used to estimate growth of employment in each individual industry.

A number of factors, such as wage and non-wage costs, and the level of regional output, all of which may influence industry growth rates, were considered at the outset. However, these variables either did not prove significant and were consequently omitted (see equation 3.19), or data relating to them were not available. Therefore, a time-series approach was adopted. Several different equations (linear or non-linear) were tested for each industrial division which best describe these variables. Sometime it is more difficult to analyze and explain the data transformed from non-linear forms because of the loss of the explicit variable movements. Therefore, these non-linear forms were kept in the IFS. These equations are given below with t statistics shown in parentheses below each equation[9].

$$g_{i,t} = EMP_{i,t}/EMP_{i,t-1} \quad (i=1,2,3....8) \tag{3.12}$$

Equation	R^2	F	DW	SE%
$EMP_{I,t} = -11098.41 + 6559.61 * \log(t)$ (-10.123) (11.046)	0.968	122.016	1.401	11.217
$EMP_{II,t} = 6400/(1 + e^{3.892545-0.057431*t})$ (8.950)(-9.506)	0.957	90.364	1.935	17.614
$EMP_{III,t} = 8596.75 - 390200.18 * (1/t)$ (20.944) (-14.059)	0.972	137.259	1.881	7.386
$EMP_{IV,t} = 10725.62 - 416126.51 * (1/t)$ (36.108) (-20.718)	0.991	429.255	3.094	4.582
$EMP_{V,t} = -64175.64 + 39873.02 * \log(t)$ (-11.285) (12.946)	0.984	167.587	2.243	6.216
$EMP_{VI,t} = 3800/(1 + e^{9.840644-0.139887*t})$ (9.469)(-9.690)	0.959	93.905	1.305	4.209

9 EMP for division (IX) is based on data from non-census sources (see Table 5-1).

$EMP_{VII,t} = -7199.44 + 186.61 * t$ (-5.490) (10.244)	0.963	104.934	1.995	8.778
$EMP_{VIII,t} = -158589.30 + 94455.81 * \log(t)$ (-10.530) (11.581)	0.971	134.128	2.846	9.862

3.4.2 Labour Supply Block

The labour supply block, which determines the labour force in the area, includes labour participation rates (LPR), the cohort survival (CSM) and commuting models, but excludes migration.

The main element of the block is a cohort survival model (see Coffey, Smith and Harvey, 1979; Field and MacGregor, 1987), which determines the population and its sex and age distribution (single-year groups) and thus the potential labour supply. Unlike other cohort survival models, which usually include migration, this model only takes into account two components of population change: survival (death) and female fertility (birth) rates. Changes in these rates are assessed and projected using a trend-based approach.

In order to try to separate out the influence of oil development, net migration is calculated separately as the output of a migration model. Net migration flows from the migration model are then incorporated into the cohort survival model and the estimated population and its sex and age structure adjusted to derive an estimate of final total population (FTPOP) as follows:

$$\mathbf{POP_{i,s,t+1} = (SUR_{i,s,t} + FFR_{i,t})POP_{i,s,t} + MIGe_{i,s,t}} \qquad \mathbf{(3.13)}$$

where: $POP_{i,s,t}$ = estimated single-year population matrix at time t;
$SUR_{i,s,t}$ = survival rates matrix at time t;
$FFR_{i,t}$ = female fertility rates vector at time t;
$MIGe_{i,s,t}$ = estimated net migration matrix at time t (from migration model);
i = cohort i (i=1,2,...,90);
s = sex (male and female).

$$\mathbf{TPOP_t = \sum_{i=1}^{90} POP_{i,s,t}} \qquad \mathbf{(3.14)}$$

where: $TPOP_t$ = estimated total population at time t;
$POP_{i,s,t}$ as before.

In the cohort survival model, death is indirectly determined by the use of life table survival rates (SUR) instead of death rates, i.e. the total number of deaths is computed by subtracting the population that survived from the total population of the previous year plus total births and migration (see equation 3.15). The population that survived for single years of age and sex is calculated by multiplying the population of the previous year by the appropriate survival rates (see equation 3.16).

$$\mathbf{TDTH_t = TPOP_{t-1} + TBTH_t + TMIG_t - TPOP_t} \qquad \mathbf{(3.15)}$$

$$\mathbf{TBTH_t = \sum_{i=1}^{90} (FFR_{i,t} * POP_{i,s,t})} \tag{3.16}$$

where: $TDTH_t$ = total number of deaths at time t;
$TBTH_t$ = total number of births at time t;
$TMIG_t$ = total migration at time t (from migration model);
$TPOP_{t-1}$ = total population at time t-1;
$FFR_{i,t}$, $POP_{i,s,t}$ as before.

Labour supply, by single-year and sex group (equation 3.17), is computed by multiplying the population (including net migration) of each age-sex group by the appropriate labour participation rate respectively. The total labour supply (equation 3.18) is simply the summation of labour supply in each group. Commuters are not estimated because of lack of data. However, a variable to account for commuters is included in the IFS (set here = 0) which can be utilized if and when data are available.

$$\mathbf{LP_{i,s,t} = POP_{i,s,t} * LPR_{i,s,t} + COMN_t} \tag{3.17}$$

$$\mathbf{TLS_t = \sum_{i=1}^{90} Lp_{i,s,t}} \tag{3.18}$$

where: $LP_{i,s,t}$ = labour participation (supply) matrix at time t;
$LPR_{i,s,t}$ = labour participation rates matrix at time t;
TLS_t = total labour supply at time t;
$COMN_t$ = net commuters at time t (here COMN = 0);
$POP_{i,s,t}$ as before.

Average labour participation rates can be determined from the labour participation model given by equation 3.19:

$$\ln ALPR_t = a + a_1 \ln WAG_t + a_2 \ln NWAG_t + a_3 X_t + \epsilon \quad (3.19)$$

where: $ALPR_t$ = average local labour participation rate;
WAG_t = wage rate;
$NWAG_t$ = percentage of the non-labour income which includes transfer payments, other income and leisure time;
X_t = other factors which influence the labour participation rate;
ϵ = random error term;
t = a time subscript.

However, lack of suitable data, including wage rates and non-labour income, did not allow calibration of this equation and it could not be used. Time-series techniques were once again adopted by using five-year labour participation rates from census data to determine average male and female labour participation rates each year. A number of linear and non-linear regression equations were tested to model labour participation rates. The preferred equations are as follows:

	R^2	F	DW	SE%
$MLPR_t = 0.895947 - 0.100719*(100/t)$ (46.259) (-8.706)	0.948	73.401	2.981	5.623
$FLPR_t = 1.118821 - 0.455983*(100/t)$ (31.044) (-19.044)	0.98 9	262.691	2.120	2.366

Since the early 1970s, death rates (survival rates) in the St. John's CMA, as in most other regions of North America, have been comparatively stable -- death rates declining very slowly over time. Consequently the mean (6.15%) of the death rates during the period 1971-1990 was taken as the estimated death rate for the forecast period 1987-1996, and thereafter assumed to be 6.10%..

3.4.3 Migration and Household Formation Block

This block includes a migration model and a household formation model. These two models generate final total population and the number of households, and are the basis for determining total housing demand in the St. John's CMA.

Migration Model

In this model local unemployment rates (UNER1) and labour training programs and government employment policy (a dummy variable) are treated as the endogenous variables. Local unemployment rates are calculated from the total labour supply and labour demand blocks described above:

$$\mathbf{UNER1_t} = \frac{(\mathbf{TLS_t} - \mathbf{TLD_t})}{\mathbf{TLS_t}} * 100\% \qquad (3.20)$$

where: $UNER1_t$ = local unemployment rate at time t;
TLS_t = total labour supply at time t;
TLD_t = total labour demand at time t;

Since actual migration data are not available for the regression analysis, estimated net migration is derived as follows:

$$\mathbf{MIGe_{(t)} = TPOPe_{(t)} - TPOPa_{(t)}} \qquad (3.21)$$

where: $MIGe_t$ = estimated net migration at time t;
$TPOPe_t$ = estimated total population at time t;
$TPOPa_t$ = actual total population at time t.

Ideally, the effects of regional policy on migration should be incorporated in to the model. Local labour training programs and regional employment policies are among some of the ways that policy might affect migration, but data to reflect these effects were not readily available. To recognize that it would be desirable to include a policy effect variable, a dummy variable (set here = 1) was introduced as an "explanatory" variable in the migration regression model. This assumes that the programs and policies will remain unchanged in the forecasting period. Any further development of the IFS model might consider surrogate measures of these components. In the meantime, the local consumer price index (CPI1) and wage rates were treated as exogenous variables in this model.

Earlier studies by Swan and Kovacs (1981) and Broadway and Green (1981) had indicated that the consumer price index (CPI2), wages, and unemployment rates in Ontario strongly influence in- and out-migration from Newfoundland, hence these factors were considered as possible exogenous variables in the migration model regression.

However, in testing the relationship between these factors and migration between the St. John's CMA and Ontario neither wage differentials nor unemployment rates proved to be significant explanatory variables.

While this relationship was not apparent, the regression analysis did show that migration was closely related to the ratio of unemployment rates in the St. John's CMA (UNER1) and to those of the province (UNER2). When the ratio of UNER1/UNER2 decreases, in-migration increases and *vice-versa*. This probably reflects that fact that most in-migrants to the CMA come from within the province rather than outside and that people move to the St. John's CMA as well as Ontario when the unemployment rate in the province increases. Consequently, the unemployment rate for Newfoundland (UNER2) was used in the regression model instead of that for Ontario (see equation following).

	R^2	F	DW	SE%
$TMIG_t$ = 4849.02 - 3873.57 * (UNER1/UNER2) (7.306) (-4.498)	0.871	27.009	1.21	45.1

- 1188.81 * (CPI1/CPI2) - 224.24 * (DUMMY = 1 for the years after 1981)
(-1.761) (-1.813)

Household Formation Model

The results from the migration model are then used in conjunction with the estimates of total population and its age and sex distribution (derived from the cohort survival model), and estimates of family size, to determine first the final total population (equation 3.22) and then, based on a number of simplifying assumptions, the number of households (equation 3.23).

$$\mathbf{FTPOP_t = TPOP_t + TMIG_t} \qquad \mathbf{(3.22)}$$

where: $FTPOP_t$ = final total population at time t;
$TPOP_t$, $TMIG_t$ as before.

In this model, a household is defined as a family living together and occupying one dwelling unit. Any other persons living with the family are considered to be sharing the house. Family size (average number of persons per family) is treated here as an exogenous variable and once again is projected using a regression model (See equation $FAMIS_t$). The number of households is estimated from the final total population and family size (equation 3.23).

$$\mathbf{HH_t = \frac{FTPOP_t}{FAMIS_t}} \qquad \mathbf{(3.23)}$$

where: HH_t = number of households at time t;
$FAMIS_t$ = family size (persons per family) at time t;
$FTPOP_t$ as before.

	R^2	F	DW	SE%
$FAMIS_t = e^{2.627197 - 0.016819 * t}$ (29.831) (-28.704)	0.9952	823.9055	1.777	0.938

3.4.4 Housing Demand Block

In this block, it is assumed that there are two major types of housing demand: demand for houses and demand for apartments[10]. While recognizing that the demand for houses and apartments is different, for simplicity these are aggregated and treated as 'housing units'. Housing demand is then projected based on household supply from the household formation model, the estimates of average house-sharing[11] rates and number of second homes (equation 3.24). Second homes are set to zero in this model because it is assumed that the number in this area is negligible.

$$\mathbf{HD_t = HH_t - HH_t * HSHR_t - SH_t} \qquad (3.24)$$

where: HD_t = housing demand at time t;
HH_t = number of household at time t;
$HSHR_t$ = house-sharing rate at time t;
SH_t = second house at time t (set to 0).

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10 Apartments are calculated in terms of number of living units.

11 House-sharing: sharing one house with another family, for example, use of rooms by people who might otherwise have their own houses or apartments.

$$\mathbf{HSHR_t = SHH_t / HD_t} \qquad \mathbf{(3.25)}$$

where: SHH_t = shared houses at time t;
$HSHR_t$ and HD_t as before.

The house-sharing rate is one parameter which can influence and allow adjustments in housing demand without involving a time lag, i.e. when housing demand is greater than housing supply, the house-sharing rate can increase immediately. A range of low and high house-sharing rates were set up to control the operation of the model. This means that when the house-sharing rate reaches the upper limit and housing vacancy rate reaches the low limit, the IFS model requires basic adjustment, e.g. industrial growth rates and in-migration are constrained to the point where housing supply can meet housing demand.

Furthermore, house prices are also taken into account as an exogenous variable. Here price is assumed to be influenced by housing demand subject to a time lag. If housing demand is larger than the supply, the house-sharing rate reaches its upper limit and the housing vacancy rate reaches its lower limit in the previous time period, then house prices (HPI) in this time period will increase.

	R^2	F	DW	SE%
$HPI_t = -9.186269 + 0.143292 * (t-1)$ (-31.810) (40.303)	0.9884	842.7309	1.233	4.0769

3.4.5 Housing Supply Block

Similar simplifying assumptions are adopted in the housing supply model. In this block, it is assumed that there are two major types of housing but as in the housing demand block, the supply of houses and apartments are treated as a single item. The housing supply model begins with a base-year housing stock (existing houses). Based on this housing stock, the number of new houses completed, demolitions and vacant houses are used to predict the future housing supply (equations 3.26, 3.27 and 3.28).

$$\mathbf{VH_t = HVR_t * HS_t} \qquad (3.26)$$

where: VH_t = vacant houses at time t;
HVR_t = housing vacancy rates at time t;
Hs_t = housing supply at time t;

$$\mathbf{HS_t = EXH_{t-1} + NBH_{t-1} - VH_t - DEH_{t-1}} \qquad (3.27)$$

where: HS_t = housing supply at time t;
EXH_{t-1} = existing houses at time t-1;
NBH_{t-1} = newly built houses at time t-1;
DEH_{t-1} = demolished houses at time t-1.
Vh_t as before.

$$\mathbf{DEH_{t-1} = EXH_t - NBH_{t-1} - EXH_{t-1}} \qquad (3.28)$$

where: EXH_t = existing houses at time t;
DEH_{t-1}, NBH_{t-1} and EXH_{t-1} as before.

The housing vacancy rate and demolition rate, like the house-sharing rate in the housing demand model, are assumed to be adjustable within a short time period, i.e., with in a year. The new-house-building rate is a time-lagged (a year) variable. It should also be noted that the price of housing influences both housing demand and supply in the same time period.

The results from this model are compared with those from the housing demand model. If housing demand is equal to or less than supply, the operation of the IFS stops here. If housing demand is greater than supply, housing vacancy rates, which might also influence housing prices, are adjusted to increase housing supply. After a number of iterative adjustments (usually one to three), if demand still exceeds supply, then it is assumed that industrial growth rates have to be reduced, and in-migration adjusted, in order that the population can be housed in the study area.

The focus of this chapter has been on describing an IFS developed for the St. John's CMA. The overall design of the model follows basic format of the Gloucestershire and Grampian models discussed in Chapter I. The IFS consists of five interacting blocks: labour demand, labour supply, migration and household formation, housing demand and housing supply. A broad range of statistics tests were applied in order to determine the most appropriate specification for each equation. Finally, the data used in the IFS are examined and discussed. As will be seen in the following chapters, the version of the model selected provides a reasonable description of the data over the period 1971-1986.

3.5 Data

This section examines the data used in the IFS. Almost all data were drawn or constructed from published sources, mainly from Census of Canada, which means that the IFS can run on 'standard' data which reduces the need for expensive data collection procedures. Census data for the 1971-1991 period for the St. John's CMA were used as the main sources for regression analysis to establish appropriate parameter values and for data to run the IFS. Wherever available, data for the 1951-1991 period were used In order to establish and project longer time trends. Most of these data are based on 20% sample census data and are considered sufficiently reliable and accurate. Other figures and estimated data such as vital statistics, fertility statistics, consumer price indices and unemployment rates were taken from other Statistics Canada sources.

Wherever the required data were not available, related or surrogate census data were used whenever possible to estimate or adjust the required input data for the IFS. For instance, employment data by individual industry are not available for the St. John's CMA. Data for total employment in all industries cannot be directly used in the IFS though the census data were readily available. To overcome this, the experienced labour force by industry was adjusted using corresponding industry unemployment to generate employment estimates at the disaggregated industry level. This means that data used in this IFS may in some cases be of inferior quality than would be the case if used in the same model for projections for a larger region, such as the Province, for which the appropriate data are available.

Turning to the sources of data required for the IFS, the following discussion is organized in the same manner as the discussion of the IFS model presented early in this chapter. The Labour Demand block is discussed first, followed by Labour Supply, Migration and Household Formation. Finally, Housing Demand and Supply blocks are considered together.

3.5.1 Labour Demand Block

Data for total employment (TEMP) in all industries in the St. John's CMA were drawn directly from 20% sample census data for the 1951-1986 period (Statistics Canada, 1951-1986). Regression analysis required time-series employment data for each of the individual industrial divisions (EMP_i). As noted above, these employment data (see Table 3-1) were based on the experienced labour force in each division and then adjusted using local unemployment rates (UNER1) from 20% sample census data for the same period. Equation 3.29 describes the assumed employment in each industry division, i:

Table 3-1 Estimated Employment in Industrial Divisions

the St. John's CMA, 1961-1986

Industrial Divisions	1951	1961	1971	1976	1981	1986
All Industries	17415	28801	45259	51449	62796	66902
I Primary	196	546	885	1209	1530	1685
II Manufacturing	2099	2533	3175	3768	4705	4832
III Construction	1052	1991	3139	3415	4023	3988
IV Transportation and Other	2557	3944	4862	5085	5786	5876
Utilities	4637	6913	9205	10788	12806	12660
V Trade						
VI Finance, Insurance and Real Estate	329	809	1491	2400	3203	3578
VII Public Administration & Defence	2619	4272	5198	7104	8106	9326
VIII Community, Business, Personal Service & Other Industries	3926	7793	17304	18080	22637	24957

Sources: Based on Statistics Canada, 1951-1986 Census of Canada, 94-519, 94-742, 93-961 and 95-150.

$$EMP_{i,t} = ELF_{i,t} * (1.00 - UNER1_t) \quad (3.29)$$

where: $EMP_{i,t}$ = employment in industry i at time t;
$ELF_{i,t}$ = experienced labour force in industry i at time t;
$UNER1_t$ = local unemployment rate at time t.

The determination of basic employment data in each industry (BEMP) was based on location quotient values modified to attempt to reflect local circumstances. The location quotient is, at best, a rough, descriptive indicator. The results may be seriously influenced by the level of disaggregation of the specialization variables in question (in this case employment in the sector and province as a whole), the choice of reference areas, and the year(s) for which it is computed. The caveats implicit in any inter-areal comparison apply to the location quotient - differences in tastes, needs, levels of income, exploitable resources, etc., and therefore economic structure - which means that, at best, the quotients should be used as a guide rather than definitive values for basic/non-basic allocations. In this case the following values were assigned to the model:

(i) 65% employment in industries I, II, III was allocated to the basic sector. This reflects the approximate location quotients values in sectors II-IV. The location quotient (.3) for the Primary sector (I) appears to seriously underepresent its export function. In this case basic employment was assumed to be at least as important as sectors II-IV and hence the same basic percentage value was assigned.

(ii) 50% of the employment in industry V, VI and VII was allocated to the basic sector. Based on location quotients alone this may somewhat underestimate basic employment in the Public Administration sector (VII) in particular as both the federal and provincial governments are the two main employers and the sector serves the province as a whole as well as the nation. The calculated location quotient (.5) again appears to be anomalous and the assumption was made that the proportion of basic workers was at least as great as that for the Trade and Finance sectors.

(iii) 80% of the employment in Community, Business, and Personal Services and Other Industries is allocated to the non-basic sector. Service industries are traditionally viewed as serving local markets. St. John's as the provincial capital. the largest urban centre and the focus of business activity in the province, is assumed to be the main consumer of such services. Based on the location quotient for this sector this assigned value may, however, underestimate the export role of service industries.

(iv) 100% of employment in industry IX (direct Hibernia employment) is treated as basic employment.

Lack of disaggregated employment data at the CMA level for each industry as input to the regression analysis further limited the accuracy of this component of the IFS. Fortunately, census data for total employment are available and were used to make sure that total employment data at the aggregate level was accurate, i.e., time-series data of total employment (1951-1986) was used to adjust basic employment to keep similar proportional growth in each industry. Furthermore, both national and provincial data from Statistics Canada show that the growth rate of the experienced labour force in each individual industry usually has a similar growth rate in employment for the corresponding industry.

Some of the data used to evaluate the simulation performances of the IFS were considered highly reliable. For example, time-series data were taken from 1951-1986 census data; initial input data used to run the IFS in the within-sample period were drawn from 1971 census data; and initial input data used to forecast the future activities of the IFS were from 1986 census data; 1991 census data were then used to compare actual with projected values from the IFS.

However, some data are considered much less reliable. For example, actual Hibernia employment data (Table 3-2) are spotty, and appear to underestimate actual numbers. Furthermore, projections over the life of the project are either outdated (see the 1986 Hibernia EIS, Vol. IV, p. 381), or more current but partial (see Table 3-3). In order to estimate the potential impacts of oil-related employment on the study area, best estimates, based on a mix of actual, and revised-projected data were used as the basis for the Most Likely scenario. To generate a range of impacts a set of High and Low estimates above and below this estimate are also considered. These data are discussed in Chapter V and Table 5-1.

3.5.2 Labour Supply Block

Data used in this block are considered to be reliable because most of them come from 20% or 100% sample census data. Population data (POP) for the age (single-year) and sex categories to run the model were drawn from 100% sample census data from Statistics Canada (1971-1986). The 1986 census population data (single-year and sex groups) are used as initial input data in the actual forecasting exercise.

Table 3-2 Direct Employment in the Hibernia Project Management and Design

St. John's, Newfoundland, 1992 and 1993

	HMDC	NODECO	PASSB	NOC	PSC	BEOTHUCK	Total
January 1992	106	123	64	54	46	-	393
January 1993	107	98	4	41	41	15	306

Source: HMDC, March, 1993.

Note: These data do not include sub-contractor and consultant employment. According to the article **Hibernia developments stabilize economy**, *Evening Telegram*, April 1, 1993, total Hibernia-related employment in St. John's was 416 at the end of December, 1992.

Data on female fertility rates (FFR) for the St. John's CMA are not available. Instead estimated figures for Census Division I (Avalon Peninsula) were used in the IFS (Vital Statistics, Statistics Canada, 1990). These data are still considered generally reliable because the population of the St. John's CMA accounts for more than 70% of the population of the Peninsula. However, some overestimate of births may result as fertility rates tend to be somewhat higher in the rural, compared with the urban, parts of the census division. Figures for survival rates (SUR), by age (five-year) and sex, were also drawn from vital statistics for the census division (Statistics Canada 1971 and 1986). Labour participation rates (MLPR, FLPR) for different age and sex groups were from

Table 3-3 Estimated NODECO Hibernia Employment Requirements for the St. John's CMA, 1990-1996

	1990	1991	1992	1993	1994	1995	1996
Management/Administration	50	50	50	50	50	40	30
GBS Engineering				20	20	20	20
Technical Staff	10	10	10	60	20	16	12
Site Development	10	4	4	4	4	4	4
Site Operations	1	19	19	19	27	20	14
Concrete GBS				0	0	0	
Marine Operations	15	15	15	15	18	15	50
Mechanical Outfitting Eng.	10	10	10				
Mechanical Outfitting				6	6	36	20
Total	96	108	108	174	145	151	150

Source: Unpublished data, NODECO, 1991

20% census sample data for the St. John's CMA (Statistics Canada, 1966-1986).

In order to predict trends in changing patterns of population and labour supply, time-series data were required for the regression analysis. Data on live births, deaths per

1000 (BIRTH and DEATH) and the ratio of male to female births were drawn from the Health Report, Statistics Canada (1966-1986). Figures on male and female labour participation rates (MLPR, FLPR) were obtained from Statistics Canada census data (1966-1986).

3.5.3 Migration and Household Formation Block

Data used for the multiple regression analysis of the migration model were drawn from the following sources: estimates of unemployment rates (UNER1 and UNER2) were from the Canadian Economic Observer, Statistics Canada (1991); annual average consumer price indexes (CPI1 and CPI2) from the Consumer Price Index, Statistics Canada (1971-1991); and net migration data (MIG) were estimated from equation 3.2.

Data to construct the household formation model and the average number of persons per family (FAMIS), were taken from 20% sample census data from Statistics Canada (1966-1991).

3.5.4 Housing Demand and Supply Blocks

In the housing demand block, house-sharing rates were based on data for non-family persons in private households in the St. John's CMA. These data are also 20% sample census data from Statistics Canada (1971-1986). Housing price indices (HPI, 1971=100) for the St. John's CMA were obtained from the Consumer Price Index, Statistics Canada (1971-1991). Total occupied private dwellings in the St. John's CMA (Statistics Canada, 1966-1991) in the IFS were assumed to represent the existing housing stock (EXH). Information on newly built houses (NBH) was drawn from data on average housing completions in the St. John's CMA (Housing Starts and Completions, Statistics Canada, 1971-1991). The number of houses demolished houses (DEH) were calculated from equation 3.28, while housing vacancy rates (HVR) were directly drawn from average housing and apartment vacancy rates for the City of St. John's (Canada Mortgage and Housing Corporation, 1992) because the data for the St. John's CMA are not available. This may, on the one hand, overestimate the vacancy rates because most rental houses and apartments are located in the urban parts of the study area and particularly within the City of St. John's, and on the other underestimate vacancy rates as only apartments in buildings with four or more units are included in the survey and in the past there has tended to be an under-reporting of apartment units.

Chapter IV - An Evaluation of the IFS Model

4.1 Introduction

In the previous chapter, the approach underlying the IFS, the model components and data used were examined and discussed. In this chapter, 'the within-sample performance' of the IFS is evaluated prior to using the model in a forecasting context. Within-sample performance means that the model was run for the period 1971-1986 and the results evaluated statistically and by comparison with the actual data. To illustrate this, first a number of potential evaluation techniques are outlined, the evaluation technique chosen examined, and the results discussed. Second, a number of sensitivity analyses were undertaken and assessed to indicate the responses of the IFS to 'shocks' to a number of key endogenous and exogenous variables, the objective here being to test the robustness of the model under extreme or unexpected conditions.

In examining the within-sample performance of the IFS, and in common with many other modelling evaluations, two general questions are posed. First, can the model be shown to reasonably represent past patterns? Second, does the model respond to a variety of shocks in a plausible and logical manner? Unfortunately, it was not possible to simulate and assess the response of the IFS to changes in Hibernia-related employment, or to calculate oil employment multipliers before using the IFS for forecasting purposes because the Project is new and there are no prior data.

4.2 Evaluating the IFS

A well-established set of tests was used to evaluate the individual regression equations developed in Chapter III, including, R^2, t-statistics and Durbin-Watson tests. However, the performance of a simulation model cannot generally be ascertained purely by reference to the statistical diagnostics of the regression equations. An equation with a good R^2 and low percentage standard error does not mean necessarily good simulation or forecasting qualities, because sometimes an equation with a good R^2 could still generate an unrealistic result. Therefore, modellers usually tend to examine summary statistics in order to obtain a broad indication of model performance.

A variety of summary statistic measures can be used as indicators, including percentage error, mean percent error, root mean square percent error, mean absolute percentage error (MAPE) and Theil's U statistic (see Makridakis, Wheelwright and McGee, 1983). Among them, MAPE is the most widely used measure used by modelling researchers probably because it well represents estimate and forecast errors and is easy to use. For a variable Y, MAPE can be defined as:

$$\text{MAPE} = 1/n \sum_{i=1}^{n} (Ya_i - Yp_i)/Ya_i \qquad (4.1)$$

where: Y_a = actual number of Y
Y_p = predicted value of Y
n = number of time periods in the simulation

Generally, MAPE values of less than five percent can be regarded as acceptable (Makridakis *et al.*, 1983, Draper and Smith, 1966), i.e. within this range, the estimate and forecast error will be mostly be found to be at a tolerable level. A model with lower MAPE values than others in a similar class would tend to be favourably regarded.

The version of the IFS described in Chapter III was used to 'hindcast' the period 1971-1986 to allow comparison of forecasts with actual data. The ability of a model to simulate events effectively can depend on the method and data used to estimate equation coefficients, i.e. the method and data quality used in a model directly determine the quality of the model's output. Following the example of other regional modellers (see, for example, Field and MacGregor, 1987; Nijkamp, 1986), the estimation procedure OLS was tested by examining the main components, and the results from the model simulation examined.

It is difficult and dangerous to make direct comparisons with the performance results of other models because of lack of similar models or regions. In general, however, it was found that the IFS performs well, especially at the overall aggregate level. Some aggregate variables were obtained through the summation of subtotals, such as total labour demand (TLD), total labour supply (TLS) and total population (TPOP). The main MAPE statistics for the IFS are given in Table 4-1 indicating the performance results of the model.

Table 4-1 MAPE Statistics for Principal Variables in the Historical Simulation of the IFS

Variable	MAPE	Variable	MAPE
TLD	4.7904	TLS	2.15
EMP1	13.9717	BIRTH	2.50
EMP2	5.3280	TMIG	40.82
EMP3	4.3456	CPI1	4.34
EMP4	1.5173	CPI2	4.28
EMP5	3.9460	HH	2.25
EMP6	10.4368	FTPOP	0.85
EMP7	5.1545	FAMIS	0 .88
EMP8	11.6370	HPI	5.23

Several points can be made about these results: in the first place, most of the MAPE statistics would seem to be acceptable (less than 5%). In particular, the MAPE statistics for most aggregate level variables (except for TMIG) for the model's performance are judged satisfactory by this criterion. While the MAPE of TMIG is extremely high (40.82%), this problem is not unique to the IFS. Migration is one of most difficult elements to predict in almost all regional models, and this problem is compounded when dealing with small regions like the St. John's CMA since specific events affecting particular firms or industrial sectors may have far more dramatic impacts than would be the case in a larger metropolitan area where they may be relatively minor in the larger scheme of things.

From Table 4-1, it is clear that the overall performance of the disaggregated sub-models is inferior to that of the aggregated models. In the latter case this is mainly because errors generated in the individual equations may offset each other in the aggregate. Some of the simulation errors in individual employment equations (EMP1, EMP6 and EMP8) are substantially higher than those of others. This can probably be explained by the fact that the IFS is developed for a comparatively small region. As Latham (1979:2) points out:

> In small regions, single firms can have inordinately large impacts on the region's economy. As a result, the fortunes of the region are more closely tied to those of individual firms than is the case in larger economies, and the consequent increase in variation should magnify the expected errors of prediction.

In the St. John's case, for example, the closure of the National Sea fish plant in 1990 resulted in the loss of almost 400 jobs, which was very significant for the region. Likewise the establishment of a regional federal taxation office in the early 1980s and employment fluctuations at the Marine Atlantic-owned shipyard in St. John's, individually have had significant impacts on this relatively small economy.

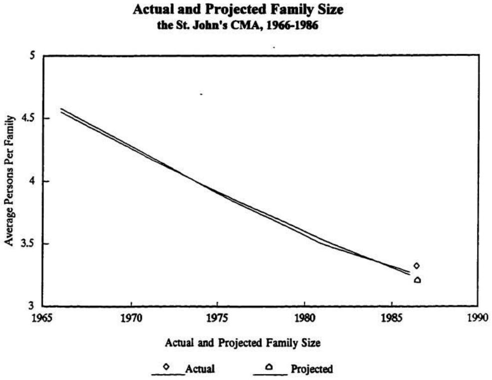
As well, the quality of input data for the IFS is relatively poor compared with that for other, larger regional models. For instance, some census or statistical data for the St. John's CMA are not available, such as female fertility rates. Instead, data for the Avalon Peninsula had to be used and converted for the use in the IFS. These regression estimates tend to contribute to poorer simulation performance results.

Furthermore, the time series for most IFS variables are relatively volatile and influenced by outside regions and events, and are not expected to remain constant for long period of time. It is therefore not surprising to find significant simulation errors for some variables. Nevertheless, even taking these limiting factors into consideration, the simulation performance of the IFS would seem to be satisfactory, especially at the aggregate level.

Simulations from the within-sample period for selected variables are illustrated graphically in Figures 4.1 to 4.6. These figures illustrate the point that the ability of the IFS to track general trends of basic economic characteristics varies. Family size (FAMIS, Figure 4.1) and housing supply (HS, Figure 4.2) simulated most satisfactorily, and final total population (FTPOP, Figure 4.3), total labour supply (TLS, Figure 4.4) and total labour demand (TLD, Figure 4.5) less so. However, the general movement of these activities was captured reasonably well. On the other hand, net migration (TMIG, Figure 4.6) does not illustrate any obvious trend at all.

Overall, the results are quite encouraging. Although the MAPE statistics calculated and the present formulation in the IFS are not totally satisfactory, as a medium-term model, the IFS can be shown to capture general trends quite well. Forecasting models can never be really completed. They evolve through a series of development stages. In this case, as with any other, further development and improvements remain possible. The present version of the IFS has undergone a limited amount of development and could undoubtedly be further refined to incorporate a wider range of variables, in some cases, less simplistic assumptions, and for some variables, alternative data.

Figure 4.1



Actual and Projected Family Size
the St. John's CMA, 1966-1986
Average Persons Per Family
5
4.5
4
3.5
3
1965
1970
1975
1980
1985
1990
Actual and Projected Family Size
Actual
Projected

Figure 4.2

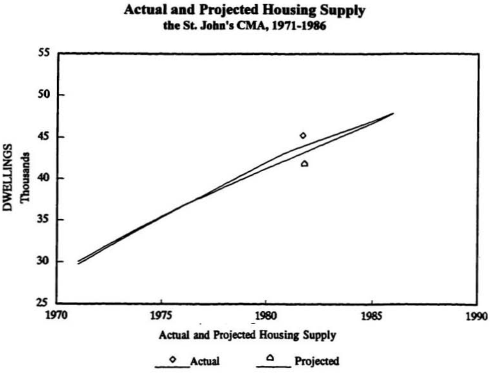
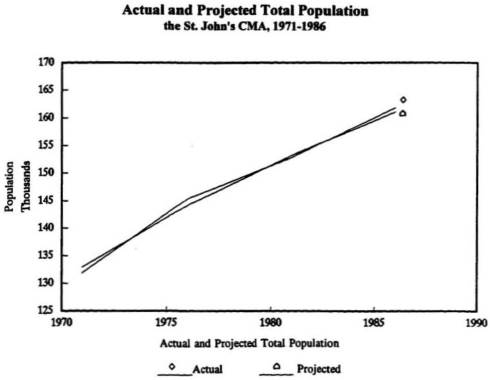

Actual and Projected Housing Supply
the St. John's CMA, 1971-1986
55
50
45
40
35
30
25
DWELLINGS
Thousands
1970
1975
1980
1985
1990
Actual and Projected Housing Supply
Actual
Projected

Figure 4.3



Actual and Projected Total Population
the St. John's CMA, 1971-1986
170
165
160
155
150
145
140
135
130
125
Population
Thousands
1970
1975
1980
1985
1990
Actual and Projected Total Population
Actual
Projected

Figure 4.4

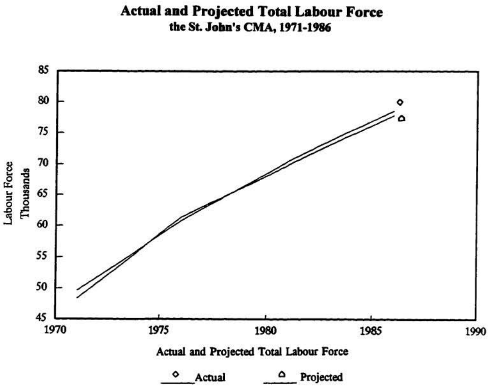

Actual and Projected Total Labour Force
the St. John's CMA, 1971-1986
85
80
75
70
65
60
55
50
45
Labour Force
Thousands
1970
1975
1980
1985
1990
Actual and Projected Total Labour Force
Actual
Projected

Figure 4.5

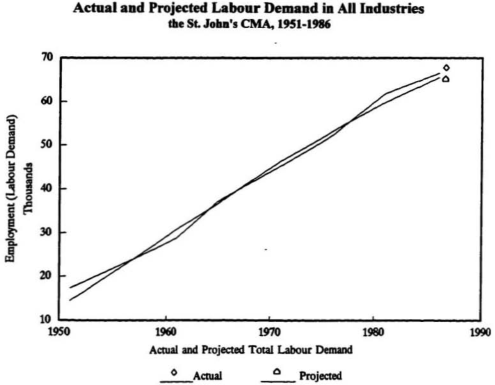
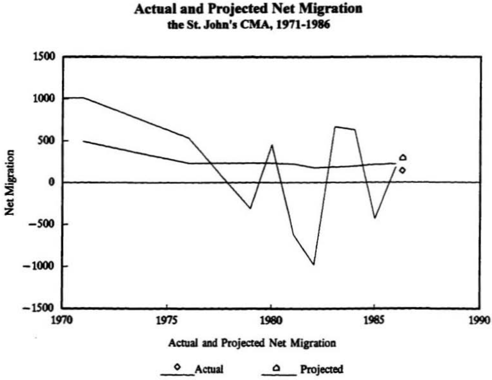

Actual and Projected Labour Demand in All Industries
the St. John's CMA, 1951-1986
Employment (Labour Demand)
Thousands
70
60
50
40
30
20
10
1950
1960
1970
1980
1990
Actual and Projected Total Labour Demand
Actual
Projected

Figure 4.6



Actual and Projected Net Migration
the St. John's CMA, 1971-1986
1500
1000
500
0
-500
-1000
-1500
Net Migration
1970
1975
1980
1985
1990
Actual and Projected Net Migration
Actual
Projected

4.3 Sensitivity Analysis

In this section the responses of the IFS to changes in selected variables are described. The effects of varying the initial input data of the IFS and the size of the shock are examined. Finally, some problems inherent in the current design of the IFS are considered. Generally, the dynamics of the IFS seems satisfactory. The system has proved to be stable and most of the shocks administrated produce changes in the variables which are consistent with or close to the socio-economic events in the real world.

A common approach to analyze the sensitivity of the IFS is to vary the independent variables over a range and then examine their shocks to the system (see for example, Makridakis *et al.*, 1983). Initially, a base run of the IFS is computed. A new solution run is then computed by perturbing an appropriate exogenous or endogenous variable by a given amount. The effects of this shock can be examined by comparing the results of this simulation with the calculation of elasticities. The dynamic elasticity for the year t+n can be obtained from:

$$E_{t+n} = \frac{(Yb_{t+n} - Yp_{t+n})/Yp_{t+n}}{\Delta X_t/X_t} \qquad (4.2)$$

where: E_{t+n} = the dynamic elasticity at time t+n;
Yb_{t+n} = the value of a dependent variable in the base run at time t+n;
Yp_{t+n} = the value of a dependent variable in the perturbed solution at time t+n;
ΔX_t = the amount by which the independent variable is shocked at time t.

If the IFS is stable, the rate of increase in the size of the dynamic elasticities should be greatest in the time periods immediately following the shock and then the shocks should be absorbed in a short period. Otherwise, the IFS will not be stable. It could be either oscillatory unstable or explosive unstable, i.e., it could keep moving up and down and/or moving away from the line of the original equation. The elasticities can therefore be a useful indicator of the performance properties of the IFS.

In order to illustrate this approach and simplify the interpretation, the impacts on several main variables are examined. These are: total population (FTPOP), migration (TMIG), total labour demand (TLD), total labour supply (TLS), housing demand (HD) and local unemployment rate (UNER1). It was found that the IFS is most sensitive to shocks to the basic employment (TBE) and the provincial unemployment rate (UNER2). The responses of the IFS to a variety of 5% shocks over a 15-year period are illustrated in Tables 4-2 and 4-3.

For the purposes of illustration, first consider a 5% rise in employment in the basic sector, TBE in 1971 (dummy variable DUMMY is set at one). In the second year, population increases by about 0.069%, migration by 1.273%, labour demand by 0.203%, labour supply by 0.053%, housing demand by 0.053% in the St. John's CMA. The local unemployment rate decreases by 1.019%. After five years the corresponding figures are

0.108%, 1.349%, 0.158%, 0.118%, 0.105% and 0.150%. It should be noted that the rise in basic employment has almost no impact on housing supply because of the very small increase in population.

A 5% decline in the unemployment rate of the province, UNER2 in 1971, generates a different shock to the IFS. In the second year, population decreases by about 0.015%, migration by 0.507%, labour supply by 0.008%, housing demand by 0.008% and the local unemployment rate (UNER1) by 0.048% in the St. John's CMA. In 1976, the corresponding shocks are 0.038%, 2%, 0.038%, 0.033% and 0.135%. It was also noticed that the decrease in the provincial unemployment rate has almost no direct impact on labour demand and housing supply because of very small decrease in in-migration.

Inspection of Tables 4-2 and 4-3 indicates that the impacts of the basic employment (TBE) and the provincial unemployment rate (UNER2) shocks are, for the most part, absorbed within five years. This is so for most of the IFS variables, which provides evidence to support the argument regarding the system's stability. In general the dynamics of the IFS seem stable and accord reasonably well with the expectations concerning the socio-economic characteristics of the St. John's CMA.

Although the performance of the IFS proves to be stable and reasonable, some inadequacies of the system still persist. The migration equation in particular is comparatively sensitive. This can be explained by the fact that the increase of employment is directly related to the unemployment rate (UNER1 and UNER2) which have strong impacts on migration because in the IFS migration is assumed to be job-oriented.

It should also be mentioned that these shocks also depend on other exogenous variables which could offset or enlarge the shocks. For instance, on the one hand, most variables in the migration model are exogenous (such as UNER2, DUMMY, CPI1 and CPI2), which could affect migration significantly. On the other hand, the flow-through from one part of the IFS to the other sometimes can be very weak or have no influence at all. For example, the effect from employment to housing supply could be very small, i.e., shocks affecting housing demand would not be necessarily transmitted to the housing supply block unless housing demand becomes larger than housing supply.

Elasticity values vary depending not only upon the shock of the base year considered, but also on the length of the time period. It was noticed that shocks to population, labour demand, labour supply and housing demand variables produce different effects at different points in time. This is probably caused by the use of a variety of non-linear time equations in which shocks could be absorbed by non-proportional increasing and decreasing rates. For example, the shocks could be absorbed fast at one stage of time and slow at another. Thus, the same degree of shock beginning at different base years would have different impacts on the whole system.

Table 4-2 Elasticities for the Endogenous Variable TBE (5%)

Year	FTPOP	TMIG	TLD	TLS	HD	UNER1
1971	-0.00871	-0.27613	-0.04336	0.00000	0.00000	0.47045
1972	-0.01396	-0.25587	-0.04071	-0.01065	-0.01067	0.20378
1973	-0.01747	-0.25793	-0.03826	-0.01673	-0.01510	0.11418
1974	-0.01973	-0.22167	-0.03594	-0.02055	-0.01820	0.06937
1975	-0.02082	-0.21345	-0.03383	-0.02278	-0.02019	0.04484
1976	-0.02165	-0.26923	-0.03179	-0.02365	-0.02103	0.03000
1977	-0.02204	0.01851	-0.02989	-0.02415	-0.02174	0.01935
1978	-0.02185	0.05851	-0.02812	-0.02421	-0.02212	0.01251
1979	-0.02149	0.12658	-0.02642	-0.02361	-0.02175	0.00914
1980	-0.02103	0.23008	-0.02485	-0.02292	-0.02123	0.00539
1981	-0.02045	0.32264	-0.02335	-0.02215	-0.02090	0.00324
1982	-0.01983	0.35643	-0.02194	-0.02134	-0.02028	0.00126
1983	-0.01916	0.43934	-0.02059	-0.02039	-0.01964	0.00062
1984	-0.01845	0.43820	-0.01932	-0.01939	-0.01897	-0.00060
1985	-0.01775	0.21839	-0.01810	-0.01833	-0.01824	-0.00060
1986	-0.01706	0.21387	-0.01693	-0.01726	-0.01757	-0.00058

In addition to varying the timing of the base run, the magnitude of the perturbation applied to the system was also modified. In fact, the dynamic elasticities resulting from a 5%shock were found to be very close to those generated by a 10% shock. This is probably because many of the sub-models used in the IFS are again based on time-series and non-linear equations.

Table 4-3 Elasticities for the Exogenous Variable UNER2 (-5%)

Year	FTPOP	TMIG	TLS	HD	UNER1
1971	0.001454	0.06708	0.000000	-0.004242	0.00000
1972	0.003016	0.10143	0.001748	0.001651	0.00977
1973	0.004232	0.14570	0.003424	0.002523	0.01684
1974	0.005491	0.23622	0.004976	0.004497	0.02178
1975	0.006638	0.36956	0.006363	0.005792	0.02462
1976	0.007676	0.40837	0.007603	0.006688	0.02743
1977	0.008672	0.41256	0.009615	0.007848	0.02810
1978	0.009525	0.40467	0.010451	0.008886	0.03073
1979	0.010315	0.31658	0.011189	0.009678	0.03161
1980	0.011044	0.43820	0.012207	0.009943	0.03254
1981	0.011234	0.20863	0.012305	0.011821	0.04251
1982	0.011652	0.38372	0.012522	0.011358	0.04128
1983	0.011972	0.32672	0.012692	0.011744	0.04132
1984	0.012118	0.59016	0.012893	0.011994	0.04060
1985	0.012345	0.40909	0.013051	0.012234	0.04127
1986	0.012574	0.20809	0.013163	0.012344	0.03988

4.4 Concluding Remarks

In this chapter, 'the within-sample performance' of the IFS model was discussed and the results of the performance evaluated statistically. This included an examination of the evaluation technique chosen and an assessment of the sensitivity analyses undertaken. Since some data used in the IFS were not available for the St. John's CMA, census or estimated figures for Census Division I (Avalon Peninsula) were used to construct the input data. Consequently, the input data used in the IFS in some cases is of poorer quality than is desirable. As will be illustrated in Chapter V, while this helps account for some of the limitations of the model's simulation performance it does not negate the overall model nor the general findings from the forecasting application.

Chapter V - The Forecasting Performance of the IFS Model

5.1 Introduction

In this chapter, the IFS is used to forecast selected socio-economic impacts of the Hibernia Project to the year 2001. First, the particular assumptions underlying the forecast are discussed. Second, the set of projections under a series of different assumptions for the period 1986 and 2001 are presented and interpreted. Third, the projections from the IFS for the period 1988 to 1991 are compared with census and other current data to evaluate the forecasting ability of the IFS for this portion of the overall projection period. Variations in the ways that different equations performed are reported and some possible areas for further model improvement are identified. The overall conclusion, however, is that performance of the model, in terms of the results generated, is sufficiently promising to suggest that it has significant potential for use as a planning tool.

5.2 Assumptions and Projections

In this section, the particular assumptions on which the IFS forecasts are based are discussed. While the model explores a number of alternative scenarios with respect to the outcomes of the Hibernia Project, the model assumes that, in the absence of any other specific information, socio-economic activities and patterns in the St. John's CMA will basically continue to follow past trends over the next 15 years. This assumption was made to retain the focus on the impacts of the Hibernia Project. Other parameter values could of course be changed were there reason to examine the impact of such changes on the socio-economic character of the CMA. However, here only three major combinations of assumptions are discussed in detail. Other possible outcomes are addressed only in general terms and for illustrative purposes.

5.2.1 Labour Demand Assumptions

In the labour demand block, the ratios of basic and non-basic employment in individual industries are assumed to remain constant during the forecasting period. Labour demand (employment) growth patterns in each industry division in the region are assumed to follow past trends. However, a range of assumptions were made to show the possible changes in total labour demand. Given past trends in socio-economic activities and patterns in the St. John's CMA, values of 5% higher and lower than the Most Likely level are assumed to reflect a reasonable range. These were categorized as:

$TEMP_{ML}$ - under which total labour demand maintains its past growth pattern, this is assumed to be the Most Likely assumption;

High assumption - under which total labour demand is assumed to be 5% greater than the Most Likely case;

Low assumption - under which total labour demand is assumed to be 5% less than the Most Likely case.

5.2.2 Hibernia Employment Assumptions

In order to examine the possible impacts of the direct employment associated with the Hibernia Project (HIBEMP), three different project employment assumptions (see Table 5-1) were made. These were:

Most Likely assumption - this assumption uses estimates of direct Project employment in the St. John's CMA developed by HMDC and its main contractors;

High assumption - direct Project employment is assumed to increase by 50% (there is no basis for determining this value, the assigned value is arbitrary but by no means unrealistic);

Low assumption - under this assumption employment in industry Division IX is set to zero at the start of the projection period.

5.2.3 Labour Supply Assumptions

It is assumed that in the labour supply block, the female fertility rate in the St. John's CMA has a range as follows:

Most Likely assumption - the fertility rate follows the regression model (see Section 3.4.2) until 1996, then remains constant to the end of the forecasting period;

High assumption - the fertility rate remains constant from 1986 to 2006, i.e., the 1986 fertility rate remains unchanged throughout the projection period;

Low assumption - under this assumption the fertility rate follows past patterns, i.e., the regression equation is used for forecasting.

Table 5-1 High, Most Likely and Low Assumptions for Direct Employment in the Hibernia Project, St. John's CMA, 1986-2001

Year	$HIBEMP_H$	$HIBEMP_{ML}$	$HIBEMP_L$
1986	75	50	0
1987	75	50	0
1988	75	50	0
1989	75	50	0
1990	150	100	0
1991	350	200	0
1992	600	400	0
1993	720	480	0
1994	720	480	0
1995	504	336	0
1996	352	235	0
1997	318	212	0
1998	318	212	0
1999	318	212	0
2000	318	212	0
2001	318	212	0

N.B. Most Likely values are based on unpublished estimates of actual and projected staff, NODECO Environmental Protection Plan 1991; HMDC 1993).

Male and female death rates in the study area are assumed to remain constant from 1986 to 1995, both then drop by 0.1% in 1996 and continue at this level thereafter. This is because there has been little variation in mortality during the past two decades. Other factors subject to change, such as male and female labour participation rates and the ratio of live births of males to females, are assumed to follow past trends. As in the within-sample performance discussed in Chapter IV, commuters in and out of the St. John's CMA are set to zero.

5.2.4 Migration and Household Formation Assumptions

In the migration and household formation block, all exogenous variables which influence net migration are assumed to follow past trends. In addition, the dummy variable, DUMMY, is set at one which means that government employment policy and training programs will remain constant in the St. John's CMA. Therefore, it is assumed that net migration patterns will also follow the same past trends throughout the forecasting period. Family size (average persons per family) is generated by the FAMIS regression equation (see Section 3.4.3) which is based on past trends.

5.2.5 Housing Demand Assumptions

In the housing demand block, the number of households is computed based on the estimated population and family size. The house-sharing rate is indirectly adjusted through housing supply, i.e., changes in the number of vacant houses and new housing completions. The variable relating to second homes is set to zero in this forecast.

5.2.6 Housing Supply Assumptions

Housing vacancy is directly calculated from the difference between housing demand and supply, then divided by existing dwelling units to obtain the vacancy rate. New house completions, like the house-sharing rate, are indirectly determined by housing demand, but with an assumed one year delay effect to allow for construction. Other variables, such as the housing demolition rate and other losses were, as before, set to zero and these patterns are assumed to remain constant.

Based on the above set of assumptions a number of projections were generated and examined. To examine the outcomes of all possible combinations of High, Most Likely and Low assumptions is not practical given the number (36) of possible combinations. Hence only three main projection combinations are discussed in detail. These are represent the "extremes" and most likely situations and are labelled as High ($_H$), Most Likely ($_{ML}$) and Low ($_L$). Table 5-2 specifies the assumption set for each projection based on the assumption characteristics outlined in sections 5.2.1 - 5.2.6 above.

Table 5-2 Assumptions for High, Most Likely and Low Projections

Projection	Labour demand	HIBEMP	Fertility rate
"High"	High	High	High
"Most Likely"	Most Likely	Most Likely	Most Likely
"Low"	Low	Low	Low

5.3 Forecasting Results and Interpretation

Tables 5-3 to 5-15 and Figures 5.1 to 5.6 show the results from the specified projections (High, Most Likely and Low assumptions) for each block of the IFS. Other selected projections are given in the tables in Appendix II. It should be reiterated that these highlighted projections may be better regarded as *examples* of how the IFS functions in a predictive context rather than as the only, or necessarily most important forecasts. In the cases chosen for illustration, for example, the High and Low assumptions are thought most unlikely to be realized. The purpose in including them is to test the response of the IFS under extreme circumstances and to bracket the range of potential outcomes.

5.3.1 Most Likely Assumption

The projections under this set of assumptions reveal several trends in a number of socio-economic variables in the St. John's CMA. Labour demand for the St. John's CMA basically follows past growth patterns with minor fluctuations associated mainly with the impacts of the Hibernia Project. Labour demand continues to grow but at a slowly declining rate from 8.54% in the period 1986-1991 to 5.95% in 1996-2001 (see Figure 5.1 and Table 5-3). In the meantime, labour supply also continues to grow, but at a declining rate from 11.37% in 1986-1991 to 7.20% in 1996-2001 (Figure 5.2 and Table 5-4).

The difference between labour demand and supply determines the local unemployment rate. According to the Most Likely projection, the unemployment rate in the region will probably continue to increase, but at a declining rate in the forecast period

(Figure 5.3 and Table 5-5). In the mid-1990s, the unemployment rate will be temporarily reduced because of the construction activities associated with the Hibernia Project.

The Most Likely population projection shows that population in the St. John's CMA will continue to grow but at a declining rate from 5.06% in 1986-1991, 4.04% in 1991-1996 to 2.54% in 1996-2001 which is consistent with historical trends (Figure 5.4 and Table 5-6). This is primarily because live births (fertility rate) are expected to decline from 2,519 in 1986 to 1796 in 2001, and the number of deaths increases from 999 in 1986 to 1,317 in 2001 (see Table 5-7). Fewer live births and a greater number of deaths reduce natural population growth.

Though the net migration between this area and other regions also has some influence on the population growth, in this case the influence is fairly weak. Net migration in the forecasting period seems to follow its historical average tendency without dramatic fluctuation (Table 5-8). Nevertheless, two peaks (317 in 1987 and 353 in 1994) in Figure 5.5 show that the net migration is sensitive to labour demand, especially to the direct labour demand from the Hibernia Project.

The sluggishly increasing natural population growth and relatively small absolute net migration lead to a decline in the household growth rate from 14.27% in 1986-1991 to

11.54% in 1996-2001 (Table 5-9), at the same time, average family size continues to get smaller (Table 5-10). Consequently, both the housing demand growth rate (Table 5-11) and the housing supply growth rate (Table 5-12) tend to decrease in the forecast period.

Table 5-11 and 5-12 indicate that the housing demand growth rate (15.39% in 1986-1991, 10.22% in 1996-2001) declines faster than that of housing supply (11.27% in 1986-1991, 8.94% in 1996-2001). This is mainly because both higher house vacancy rates (Table 5-13) and lower house sharing rates (Table 5-14) at the beginning of the forecasting period slow down new housing starts and completions (Table 5-15) which decelerate the housing supply growth rate. Obviously, under such a scenario no basic adjustment is needed in the running of the model, i.e., housing supply in the St. John's CMA will not be a constraint to either the development of the Hibernia Project or other industrial growth.

5.3.2 Evaluating the Impact of the Hibernia Oil Project

In order to evaluate the particular impacts of the Hibernia Project on the study area, total labour demand is set to the specifications of the Most Likely scenario and only the direct labour associated with the Hibernia Project is allowed to change. The IFS is then used to compare the projections under the $HIBEMP_{ML}$ assumption with two alternative scenarios which specify $HIBEMP_{H}$ and $HIBEMP_{L}$. All other economic activities are assumed to remain unchanged under the Most Likely assumption conditions. The assumptions of these additional projection combinations are:

(i) Labour $Demand_{ML}$; $HIBEMP_{H}$; $Fertility_{ML}$
(ii) Labour $Demand_{ML}$; $HIBEMP_{L}$; $Fertility_{ML}$

The differences in the High and Low HIBEMP assumptions are small and, not surprisingly, the differences in the overall impacts between projections are small. According to Table 5-16, for example, the population is forecast at 181,465 under the $HIBEMP_{ML}$ assumption, 182,138 under the $HIBEMP_{H}$ assumption and 180,635 under the $HIBEMP_{L}$ in 2001. The population projections indicate that even under the $HIBEMP_{H}$ assumption, population will be only 0.83% (1503) higher than that under the $HIBEMP_{L}$. If we compare the population under the $HIBEMP_{ML}$ assumption with the situation under the $HIBEMP_{L}$, the difference is only 830.

In the overall sense the Hibernia Project is expected to have only limited impact on employment, population, housing demand and supply in the St. John's CMA. The IFS suggests that population in the St. John's CMA will increase by only about 1000 in the next 15 years because of the impacts from the development of the Hibernia Project. This is because the influence on population growth comes mainly from job-oriented in-migration, the absolute number for which is relatively small.

Figure 5.1 - Labour Demand Projections
the St. John's CMA, 1951-2001

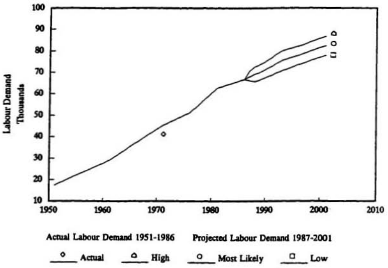


Table 5-3 High, Most Likely and Low Labour Demand Projections and % Change
the St. John's CMA, 1986-2001

Projection	1986	1991	1996	2001
TLD_H	66977	76556	81932	86759
Change (%)		14.34	7.02	5.89
TLD_{ML}	66952	72670	77748	82374
Change (%)		8.54	6.99	5.95
TLD_L	66902	68652	73400	77853
Change (%)		2.62	6.91	6.07

Note: TLD = Total labour demand

Figure 5.2 - Labour Supply Projections the St. John's CMA, 1951-2001

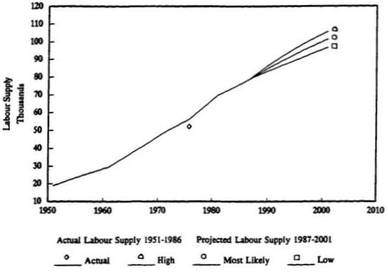


Table 5-4 High, Most Likely and Low Labour Supply Projections and % Change the St. John's CMA, 1986-2001

Projection	1986	1991	1996	2001
TLS_H	77868	88643	98160	105725
Change (%)		13.84	10.74	7.71
TLS_{ML}	77868	86718	94649	101459
Change (%)		11.37	9.15	7.20
TLS_L	77868	84760	90865	96905
Change (%)		8.85	7.20	6.65

Figure 5.3 - Unemployment Rate Projections the St. John's CMA, 1975-2001

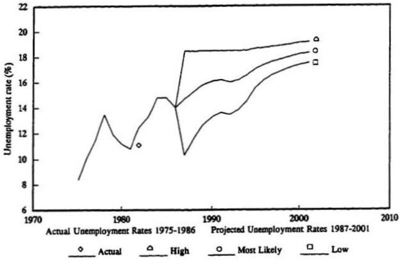


Table 5-5 High, Most Likely and Low Unemployment Rate Projections for the St. John's CMA, 1986-2001

Year	$UNER1_H$	$UNER1_{ML}$	$UNER1_L$
1986	14.08	14.02	14.02
1987	18.50	14.69	10.34
1988	18.47	15.27	11.60
1989	18.49	15.79	12.66
1990	18.48	16.07	13.29
1991	18.50	12.20	13.64
1992	18.49	16.00	13.47
1993	18.49	16.16	13.84
1994	18.53	16.55	14.50
1995	18.65	17.03	15.51
1996	18.72	17.36	16.14
1997	18.79	17.63	16.66
1998	18.88	17.83	16.86
1999	18.98	18.01	17.13
2000	19.11	18.21	17.38
2001	19.16	18.31	17.54

Figure 5.4 - Total Population Projections for the St. John's CMA, 1951-2001

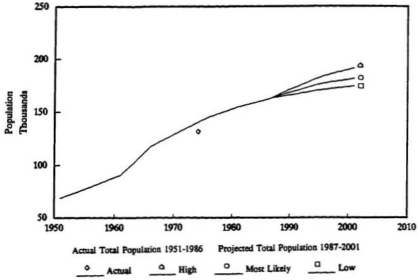


Table 5-6 High, Most Likely and Low Population Projections for the St. John's CMA, 1986-2001

Projection	1986	1991	1996	2001
TPOP $_H$	161900	173457	183872	191420
Growth (%)		7.14	6.00	4.11
TPOP $_{ML}$	161900	170093	176971	181465
Growth (%)	4.57	5.06	4.04	2.54
TPOP $_L$	161900	167022	171148	174364
Growth (%)		3.16	2.47	1.88

Note: TPOP = Total population

Table 5-7 High, Most Likely and Low Birth and Death Projections for the St. John's CMA, 1986-2001

Year	Births $_H$	Deaths $_H$	Births $_{ML}$	Deaths $_{ML}$	Births $_L$	Deaths $_L$
1986	2519	999	2519	999	2519	999
1987	2542	1026	2508	1026	2507	1026
1988	2562	1054	2477	1052	2461	1050
1989	2574	1082	2442	1078	2413	1074
1990	2582	1110	2407	1104	2369	1099
1991	2589	1139	2372	1132	2324	1125
1992	2583	1167	2326	1158	2270	1149
1993	2564	1195	2270	1184	2206	1174
1994	2535	1224	2207	1212	2135	1199
1995	2499	1254	2140	1239	2064	1224
1996	2466	1283	2078	1266	1998	1249
1997	2432	1294	2019	1276	1937	1258
1998	2402	1305	1964	1286	1881	1266
1999	2369	1316	1908	1296	1826	1275
2000	2336	1327	1854	1306	1772	1283
2001	2296	1340	1796	1317	1715	1293

Figure 5.5 - Net Migration Projections for the St. John's CMA, 1971-2001

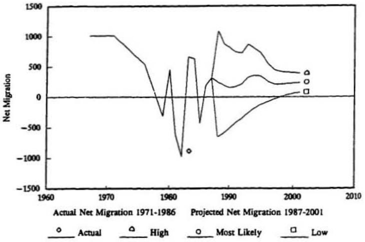


Table 5-8 High, Most Likely and Low Net Migration Projections for the St. John's CMA, 1986-2001

Year	$NMIG_H$	$NMIG_{ML}$	$NMIG_L$
1986	191	191	191
1987	317	317	303
1988	1090	244	- 654
1989	874	192	- 594
1990	809	155	- 508
1991	738	170	- 422
1992	726	214	- 345
1993	864	320	- 264
1994	798	353	- 189
1995	727	342	- 124
1996	557	257	- 78
1997	449	208	- 39
1998	415	206	- 2
1999	504	216	30
2000	400	229	60
2001	398	236	74

Table 5-9 High, Most Likely and Low Household Projections for the St. John's CMA, 1986-2001

Projection	1986	1991	1996	2001
HH_H	49716	57931	66797	75640
Growth (%)		16.52	15.30	13.24
HH_{ML}	49716	56808	64290	71706
Growth (%)		14.27	13.17	11.54
HH_L	49716	55782	62175	68900
Growth (%)		12.20	11.46	10.82

Note: HH = Households

Table 5-10 Family Size Projections for St. John's CMA, 1986-2001

Year	1986	1987	1988	1989	1990	1991	1992	1993
FAMIS	3.30	3.20	3.15	3.10	3.05	2.99	2.94	2.90

Year	1994	1995	1996	1997	1998	1999	2000	2001
FAMIS	2.85	2.80	2.75	2.71	2.66	2.62	2.57	2.53

Note: FAMIS = Family size

Table 5-11 High, Most Likely and Low Housing Demand Projections for the St. John's CMA, 1986-2001

Projection	1986	1991	1996	2001
HD_H	43711	51400	57922	64473
Growth (%)		17.59	12.69	11.31
HD_{ML}	43711	50440	57138	62975
Growth (%)		15.39	13.28	10.22
HD_L	43711	49506	55508	61575
Growth (%)		13.29	12.12	10.93

Note: HS = Housing demand

Table 5-12 High, Most Likely and Low Housing Supply Projections for the St. John's CMA, 1986-2001

Projection	1986	1991	1996	2001
HS_H	47755	53138	58547	64989
Growth (%)		11.27	10.18	11.00
HS_{ML}	47755	53138	58306	63518
Growth (%)		11.27	9.73	8.94
HS_L	47755	53138	58241	63140
Growth (%)		11.27	9.60	8.41

Note: HS = Housing supply

Table 5-13 High, Most Likely and Low House Vacancy Rate (%) Projections the St. John's CMA, 1986-2001

Year	HVR_H	HVR_{ML}	HVR_L
1986	6.31	6.31	6.31
1987	7.68	7.68	7.69
1988	6.42	7.06	7.68
1989	5.33	6.46	7.51
1990	4.28	5.83	7.27
1991	3.34	5.18	6.97
1992	2.38	4.49	6.62
1993	1.36	3.84	6.20
1994	0.86	3.19	5.75
1995	1.28	2.58	5.27
1996	1.09	2.04	4.77
1997	1.04	1.55	4.26
1998	1.07	1.06	3.84
1999	0.85	0.98	3.40
2000	0.96	0.89	2.96
2001	1.00	0.87	2.52

Note: HVR = House vacancy rate

Table 5-14 High, Most Likely and Low House-Sharing Rate (%) Projections the St. John's CMA, 1986-2001

Year	$HSHR_H$	$HSHR_{ML}$	$HSHR_L$
1986	12.08	12.08	12.08
1987	11.96	11.96	11.96
1988	11.84	11.84	11.84
1989	11.73	11.73	11.73
1990	11.61	11.61	11.61
1991	11.61	11.50	11.50
1992	11.61	11.39	11.39
1993	11.61	11.39	11.28
1994	11.73	11.39	11.17
1995	12.91	11.39	11.06
1996	13.29	11.39	10.95
1997	13.68	11.39	10.89
1998	14.07	11.39	10.85
1999	14.21	11.50	10.85
2000	14.62	11.83	10.85
2001	14.76	12.18	10.85

Note: HSHR = House-sharing rate

Table 5-15 High, Most Likely and Low House Completion Projections the St. John's CMA, 1986-2001

Year	HC_H	HC_{ML}	HC_L
1986	1170	1170	1170
1987	1160	1160	1160
1988	1188	1188	1188
1989	1176	1176	1176
1990	1165	1165	1160
1991	1153	1153	1148
1992	1153	1142	1136
1993	1153	1131	1126
1994	1154	1131	1120
1995	1164	1131	1109
1996	1282	1131	1098
1997	1320	1131	1088
1998	1358	1131	1079
1999	1398	1131	1077
2000	1411	1142	1077
2001	1422	1175	1077

Note: HC = House completion

Table 5-16 Population Projections with $HIBEMP_H$, $HIBEMP_{ML}$ and $HIBEMP_L$ Assumptions, the St. John's CMA, 1986-2001

Projection	1986	1991	1996	2001
$HIBEMP_H$	161900	170184	177602	182138
Growth (%)		5.12	4.36	2.55
$HIBEMP_{ML}$	161900	170093	176971	181465
Growth (%)		5.06	4.04	2.54
$HIBEMP_L$	161900	170016	176187	180635
Growth (%)		5.01	3.63	2.52

Labour demand projections under the three scenarios indicate that the Hibernia Project has only limited impact on total labour demand in the St. John's CMA. Even under the $HIBEMP_H$ assumption, total labour demand increases by only 646 in 1991, 768 in 1996 and 678 in 2001 respectively (Table 5-17). In comparison with total labour demand in the same period, these figures are fairly small. Similar conclusions can be drawn with respect to the labour supply projections (Table 5-18).

The overall impacts of the Hibernia Project on unemployment rates are also limited. In fact, the Hibernia Project only temporarily reduces unemployment rates in 1991-1996 (Figure 5.6 and Table 5-19), and the IFS suggests that the Project does not significantly help the serious unemployment problem in the study area. The local unemployment rate under these assumptions is projected to continue to increase albeit at a declining rate in the future.

The Hibernia Project does, however, appear to have significant impacts on net migration patterns because net migration is very sensitive to any changes in the unemployment rates in the study area. The percentage changes in net migration are large in the 1991-1996 period (Figure 5.7 and Table 5-20), which are consistent with the changes in unemployment rates in the same period. For example, for 1994, under the $HIBEMP_{ML}$ assumption, net migration is 21.90% (99) lower than that of the $HIBEMP_H$ scenario, and it is 279.01% (191) higher than that under the $HIBEMP_L$ respectively. However, the absolute value of net migration is still comparatively small, in 1994 it was only 452 under the $HIBEMP_H$ assumption and 353 under the $HIBEMP_{ML}$ assumptions respectively, which are the highest in the whole forecasting period. Furthermore, the differences in net migration before and after 1991-1996 are very small. Thus, the overall or cumulative effect of the Hibernia Project on economic activities in this area is not as significant as the high percentage change in net migration suggests.

Housing demand and supply projections under the three scenarios were also tested. Most of the differences in the results are negligible. Under the $HIBEMP_{ML}$ assumption, for example, housing demand in the CMA increases by 25 units in 1991, 154 in 1996 and 164 in 2001 respectively (Table 5-21). This means that the impact of the Hibernia Project on the housing market in this area is expected to be fairly small. The difference between the housing supply projections (Table 5-21) under these three scenarios are even smaller because of the adjustment of vacancy and house-sharing rates.

5.3.3 High Assumption

Under the specifications of what is regarded as an extreme assumption combination, total labour demand growth rate jumps to its highest level at 14.34% in 1986-1991 - mainly because of the assumed 5% increase which starts in 1986. It then quickly declines to 7.02% in 1991-1996 and 5.89% in 1996-2001, bringing it fairly close to the projections for the Most Likely and Low assumptions (Table 5-3). From Figures 5.1, 5.3 and 5.5, it can be seen that the change in total labour demand and Hibernia Project direct employment are the variables which have the most significant socio-economic impacts on the St. John's CMA (especially on migration patterns), and particularly in the early part of the forecasting period (1987-1994).

Table 5-17 Labour Demand Projections with $HIBEMP_H$, $HIBEMP_{ML}$ and $HIBEMP_L$ Assumptions, the St. John's CMA, 1986-2001

Projection	1986	1991	1996	2001
$HIBEMP_H$	66952	72911	78031	82628
Growth (%)		8.90	7.02	5.89
$HIBEMP_{ML}$	66952	72670	77748	82373
Growth (%)		8.54	6.99	5.95
$HIBEMP_L$	66952	72265	77263	81950
Growth (%)		8.02	6.92	6.07

Table 5-18 Labour Supply Projections with $HIBEMP_H$, $HIBEMP_{ML}$ and $HIBEMP_L$ Assumptions, the St. John's CMA, 1986-2001

Projection	1986	1991	1996	2001
$HIBEMP_H$	77868	86759	94936	101773
Growth (%)		11.42	9.74	7.20
$HIBEMP_{ML}$	77868	86718	94649	101459
Growth (%)		11.37	9.15	7.20
$HIBEMP_L$	77868	86668	94136	100913
Growth (%)		11.30	8.62	7.20

Higher labour demand and higher Hibernia Project direct employment mean more jobs and lower unemployment rates (Table 5-5). But more jobs or lower unemployment rates encourage more in-migration into the area (Table 5-7). Therefore there are two peaks in net migration movement, 1,090 in 1988 and 864 in 1993, when the unemployment rates are comparatively low. After 1993, net migration declines quickly, approaching around 400 (see Figure 5.5). These movements match the fluctuations in the Hibernia Project direct labour demand.

However, increased in-migration will in turn push the unemployment rate back to a higher level, i.e., the higher in-migration offsets some of the impact from the higher labour demand and thereby stabilizes the unemployment rate. This explains the reason that all unemployment rate projections under the three assumptions, High, Most Likely

Figure 5.6- Unemployment Rate Projections the St. John's CMA, 1975-2001

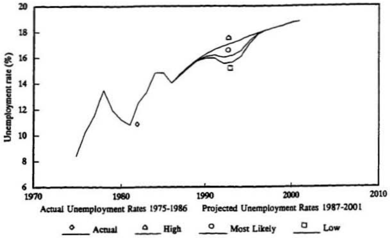


Table 5-19 Unemployment Rate Projections with $HIBEMP_H$, $HIBEMP_{ML}$ and $HIBEMP_L$ Assumptions, the St. John's CMA, 1986-2001

Year	$HIBEMP_H$	$HIBEMP_{ML}$	$HIBEMP_L$
1986	14.02	14.02	14.08
1987	14.61	14.69	14.74
1988	15.21	15.27	15.31
1989	15.74	15.79	15.83
1990	15.96	16.07	16.24
1991	15.96	16.20	16.62
1992	15.52	16.00	16.90
1993	15.64	16.16	17.16
1994	16.10	16.55	17.41
1995	17.13	17.33	17.71
1996	17.81	17.86	17.92
1997	18.12	18.13	18.12
1998	18.32	18.33	18.31
1999	18.51	18.51	18.49
2000	18.71	18.71	18.69
2001	18.81	18.81	18.79

Figure 5.7 - Net Migration Projections for the St. John's CMA, 1971-2001

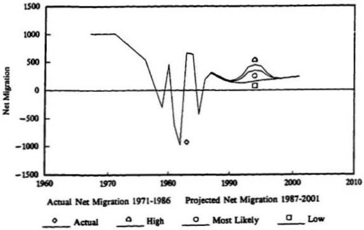


Table 5-20 Net Migration Projections with $HIBEMP_H$, $HIBEMP_{ML}$ and $HIBEMP_L$ Assumptions, the St. John's CMA, 1986-2001

Year	$HIBEMP_H$	$HIBEMP_{ML}$	$HIBEMP_L$
1986	191	191	191
1987	317	317	303
1988	261	244	233
1989	206	192	184
1990	167	155	148
1991	194	170	136
1992	261	214	130
1993	413	320	143
1994	452	353	162
1995	426	342	179
1996	295	257	188
1997	217	208	196
1998	208	206	207
1999	217	216	219
2000	229	229	232
2001	239	236	242

Table 5-21 Housing Demand and Supply Projections with $HIBEMP_H$, $HIBEMP_{ML}$ and $HIBEMP_L$, Assumptions, the St. John's CMA, 1986-2001

Year	$HIBEMP_H$		$HIBEMP_{ML}$		$HIBEMP_L$	
	Demand	Supply	Demand	Supply	Demand	Supply
1986	43711	47482	43711	47482	43711	47482
1991	50439	51535	50314	51535	50289	51535
1996	55191	56029	54971	55908	54817	55804
2001	60452	61456	60157	61213	59993	61067

the early period (10.34%, 14.69% and 18.50% respectively in 1987).

In the meantime, higher fertility rates (live births) generate higher population natural growth. Both greater net migration and faster natural population growth from the late 1980s to the early 1990s push the population growth rate of the St. John's CMA to a higher level during 1986-1991 (7.14%) and 1991-1996 (6.00%), the growth rate then declines to 4.11% in the 1996-2001, which is lower (4.57% in 1981-1986) than the lowest historical growth rate for the area (Table 5-6 and Figure 5.2).

Higher in-migration and natural population growth serve to increase total population (Table 5-4) and labour supply (Table 5-4). At the same time, decreasing average family size (Table 5-10) accelerates the growth of the absolute number of households (Table 5-9). Thus, both the increasing population and number of households demand an increase in housing supply (Table 5-12) which in turn boosts new house completions (Table 5-15) in the region.

However, there are still no basic adjustments necessary when running the model even under this High Assumption, because, for example, housing demand still does not reach the point which will constrain local industrial development or the Hibernia Project because of an insufficient supply of housing. Although the house vacancy rate declines dramatically from 6.31% in 1986 to around 1% in 2001, and the house-sharing rate goes up to 14.76% in 2001, compared with the housing situation in most other North American cities, these rates are still within common and normal levels (see Table 5-13 and 5-14). In the meantime, even though new house completions increase from 1170 in 1986 to 1422, it is still much lower than the figure 1,842 recorded in 1975 (Figure 5-6).

5.3.4 Low Assumption

Under this second extreme case, labour demand in the St. John's CMA increases by only 2.62% in the 1986-1991 period. Thereafter, the labour demand growth rates increase to 6.91% in 1991-1996 and 6.07% in 1996-2001, which are very close to the labour demand growth rates of 7.02% and 5.89% in the same periods under the High Assumption (Table 5-3).

Meanwhile, the population growth rate for the CMA declines from 3.16% in 1986-1991 to 1.88% in 1996-2001 (Table 5-6). These low growth rates result mainly from lower birth (fertility) rates and higher out-migration (Figure 5.5). Slow population growth and long-term negative net migration mean that labour supply remains at a comparatively low level, which moderates the local unemployment rate increase, though the unemployment rate is extremely high at the beginning (18.5% in 1987) of the forecasting period (Table 5-5).

Correspondingly, housing demand for the area is maintained at a comparatively low level and declines from 13.29% in 1986-1991 to 10.93% in 1996-2001 (Table 5-11). Low housing demand in turn keeps housing supply (Table 5-12) at a low level. Consequently, the house-sharing rate (Table 5-14) declines from 12.08% in 1986 and then remains at a lower level while house vacancy rates (Table 5-13) keep at a comparatively high level throughout the entire forecasting period. Meanwhile, new house completions also decrease from 1,170 in 1986 to 1,077 in 2001, because of sluggish housing demand. Under these circumstances, no basic adjustment to the model is needed.

5.3.5 Summary

Given the employment projections for the Hibernia Project, the IFS illustrates that there will not be significant population change in the St. John's CMA and the area will have enough dwellings to accommodate any increase in population and households in the forecast period, even based on the High Assumption. The results indicate that new housing completions, 1,422 in 2001 (Table 5-15), the house-sharing rate, 14.76% in 2001 (Table 5-14), and the housing vacancy rate, 1.0% in 2001 (Table 5-13) can meet or respond to, any demands placed upon them. In fact, the situation characterized by the High Assumption scenarios will be unlikely to happen in the near future, unless there is significant development of other local industries. Under the Low Assumption, on the other hand, because of slow population and household growth, housing demand will be at a reduced level as will housing supply. The most likely situation will probably fall somewhere between the two extremes. This implies that the housing supply in the region will not be problematic in the sense of constraining economic development in the area.

Other mixes of assumptions were also tested, such as the mix of assumptions of $HIBEMP_H$ with low fertility rate, and $HIBEMP_L$ with high fertility rate. In fact, most projections were relatively close to the projections under the Most Likely assumption set. This further suggests that future socio-economic, demographic and employment patterns in the St. John's CMA will most probably be close to the forecasts under the Most Likely case.

Under almost all sets of assumptions, in particular those incorporating Most Likely assumptions the overall performance of the IFS appears to offer a reasonable picture of future social and economic characteristics of the study area.

5.4 Forecasting Ability of the IFS

Determining forecasting ability is one of the most important aspects of any overall model evaluation process. It is impossible to conduct a complete examination of the forecasting abilities of the model because of the limited availability of data from 1986 to the present for the St. John's CMA. But some post-sample data for the 1986-1991 period are available and can be used for testing purposes. Although all forecast performances, including employment (labour demand), have to be assessed at the aggregate level because disaggregated data are not available, which limits the forecasting assessment, it is nevertheless worth undertaking as a means of assessing the general forecasting ability of the IFS.

In Table 5-22, all available current data for the St. John's CMA are compared with the projected values (Most Likely projections) for different variables from the IFS, together with the percentage difference between them. Most of these current data were drawn from 1991 census data, Statistics Canada.

The IFS projects population, family size, total employment (labour demand), labour force (labour supply), households and housing supply reasonably well. Among them, total population (-1.05% in 1991) and family size (-0.33% in 1991) are reasonably accurately projected largely because these variables tend to behave in a fairly stable manner over a comparatively long time period. Total employment was under-projected by 3.51% and 3.31% in 1990 and 1991, labour force was under-projected by 2.95% in 1991, all of these are better than the within-sample performance forecast discussed in Chapter IV. Households are over-projected by 2.84% in 1991 and housing supply is under-projected by 4.69% in 1991. Compared with other forecasting models, for instance the Structure Plans Model (Bracken and Hume 1981), these discrepancies seem to be within an acceptable level.

By contrast, net migration is extremely volatile and the high percentage errors in projection, especially for 1990, are not unexpected given its erratic changing pattern. However, the MAPEs for this equation described in Table 4-1 were quite high, and its overall performance here is not substantially worse than the case within-sample performance discussed in Chapter IV .

Although the percentage errors of net migration are extremely high, -23.2% in 1989 and 185.1% in 1990 (Table 5-22), in comparison with the absolute size of the population in the St. John's CMA in the same period, 167,101 and 168,621 (Table 1, Appendix II), the absolute value for net migration was very small, only -58 and 337 in 1989 and 1990 respectively. Hence, net migration appears to have only a minor impact on population growth in the St. John's CMA.

Local unemployment rates tend to be over-projected by 34.5%, 45.3%, 33.3% and 6.21 in 1988, 1989, 1990 and 1991 respectively, probably due to the under-projection of the labour supply, which might be the result of increasing labour participation rates, especially associated with rapidly increasing female labour participation (Table 5-23). However, it should be reiterated that the unemployment rates used in Table 5-19 are actually estimated data from the **Canadian Economic Observer**, Statistics Canada (1991), which are probably lower than the actual figures. This means that the percentage error in the projected unemployment rate could be significantly lower than appears to be the case.

The housing completions are under-projected by 13.8% in 1988, 29.1% in 1989 and 23.2% in 1991 respectively though it tends to be only over-projected by 1.9% in 1990. These percentage errors may be explained in part by the high number of new housing starts and completions in past few years based on an expected increase in in-migration, and therefore higher housing demand, associated with the Hibernia Project.

In summary, over the forecast period, it is clear that there is a variation in the performance of different parts of the IFS. The comparison of the actual and projected values from the IFS suggests the total population, family size, total employment, households and housing supply tend to be projected quite well. In contrast, the projections of net migration, unemployment rate and housing completions seem less reliable.

Overall, as a medium-term forecasting model, the performance of the IFS and its forecasting ability seem to be quite encouraging, though it is not totally satisfactory. While the present version of the IFS has already undergone several development stages, further refinements are possible. Forecasting models of this type can never be really completed. They always evolve through a series of development stages prompted by the fact that results from these types of models rapidly become outdated and there are many opportunities for refinement. The IFS developed here is no exception, further development and improvements of the model are always possible.

Table 5-22 Comparison of the Actual and Projected Values from the IFS

Variables	1988	1989	1990	1991
Total Population (000's)				
actual	N/A	N/A	N/A	171.9
projected				170.1
difference (%)				-1.05
Family size (units)				
actual	N/A	N/A	N/A	3.00
projected				2.99
difference (%)				-0.33
Total employment (000's)				
actual	N/A	N/A	74.0	75.2
projected			71.4	72.7
difference (%)			-3.51	-3.31
Labour force (000's)				
actual	N/A	N/A	N/A	89.36
projected				86.72
difference (%)				-2.95
Local unemployment rate (%)				
actual	11.3	10.8	12.0	16.1
projected	15.2	15.7	16.0	16.2
difference (%)	34.5	45.3	33.3	6.21
Net migration (units)				
actual	N/A	250	-182	N/A
projected		192	155	
difference (%)		-23.2	185.1	
Total households (000's)				
actual	N/A	N/A	N/A	552.3
projected				568.0
difference (%)				2.84
Housing supply (000's)				
actual	N/A	N/A	N/A	557.5
projected				531.3
difference (%)				-4.69
Housing completions (units)				
actual	1379	1658	1143	1501
projected	1188	1176	1165	1153
difference (%)	-13.8	-29.1	1.92	-23.2

Note: N/A data not available * estimated data from Statistics Canada or CMHC 1991

Table 5-23 Projected Male and Female Labour Participation Rate Projections the St. John's CMA, 1986-2001

Year	Male	Female
1986	73.78	52.92
1987	73.99	53.55
1988	74.36	54.25
1989	74.75	54.95
1990	74.98	55.64
1991	75.15	56.31
1992	75.39	56.86
1993	75.61	57.42
1994	75.82	57.97
1995	76.02	58.50
1996	76.19	59.00
1997	76.35	59.46
1998	76.50	59.96
1999	76.63	60.39
2000	76.79	60.83
2001	76.89	61.27

Chapter VI - Summary and Conclusions

6.1 Introduction

The objective of this research was to construct and evaluate an Integrated Forecasting System. The IFS was then applied to a particular case study in this case to demonstrate the possible socio-economic impacts of the Hibernia Oil Project on the St. John's CMA of Newfoundland. In this final chapter, the research process and the projection results are briefly summarized. This is followed by a discussion of some of the additional ways in which the IFS could be utilized. Finally, the constraints of the model are reviewed and possibilities for its further development outlined.

6.2 Summary

In Chapter I a review of integrated forecasting systems was provided. Integrated forecasting systems, such as those developed for Gloucestershire, the Grampian Region in eastern Scotland, and the Greater Manchester region, are an advance on traditional linear deductive forecasting models. Though the component forecasts of these models are based on a common set of assumptions and consistent within an accounting framework, and they are static equilibrium approaches rather than truly dynamic models, the techniques were used to develop an IFS and subsequently demonstrate its use by forecasting the possible impacts of a particular project in the St. John's CMA.

Chapter II discussed the selection criteria used to choose the study area and provided a brief description of the recent history of economic development, particularly that associated with offshore oil industry, in the St. John's CMA. In Chapter III the structure of the IFS was described and the model constructed. The fundamental design of the IFS was based on the Gloucestershire and Grampian models discussed in Chapter I, and consists of five interacting blocks: labour demand, labour supply, migration and household formation, housing demand, and housing supply. Of these the labour demand and supply blocks are the ones which drive the IFS. The labour demand and supply models determine the migration and household formation which, in turn, influence the housing demand model. Finally, housing supply puts constraints on housing demand. The whole operational procedure of the IFS focuses on supply-demand relationships and linkage parameters among the different components.

The data used in the IFS are also discussed in Chapter III. Most data in the model were drawn or constructed from published sources, which, from a planning application perspective, means less expensive and comparatively easy data collection and compilation procedures.

In Chapter IV the IFS was evaluated by examining its performance over the 1971-1986 period -- a hindcasting exercise which allows the outputs from the model to be compared with actual data. The testing of the model followed standard model-building methodological procedures. A broad range of statistical tests were applied to each regression analysis, including the R^2, standard error, t-statistic, the Durbin-Watson statistics. Estimation was generally carried out by ordinary least squares. For each equation, simulation results indicated the appropriate estimation technique. Moreover, the MAPEs of most variables of the IFS are within acceptable levels (most of them being less than 5%).

In addition, the responses of the forecasting system to changes in a number of the variables were examined. From both High and Low assumption projections, it was again demonstrated that the IFS is stable. "Shocks" from changes to most variables introduced into the IFS were absorbed in a relatively short period (within five years). These findings are consistent with real socio-economic events and also confirm the robustness of the model demonstrated as part of the system evaluation and sensitivity analysis described above.

In Chapter V, under a range of selected assumptions, the IFS was used to forecast socio-economic change associated with the Hibernia Project for the period 1986-2001. These projections were then tested against available data for the 1986-1991 period. The ability of the IFS to track historical data proved to be basically satisfactory, though some variation in the performance of the different parts of the IFS emerged. The labour demand, population, family size, households and housing supply variables tend to be projected reasonably accurately. In contrast, the local unemployment rate, net migration and new housing completions were projected less satisfactorily.

6.3 Utilizing the IFS as A Planning Tool

The forecasting performance of the IFS suggests that it can provide quantitative information regarding the effects on the socio-economic characteristics of a given study area associated with economic and social changes, such as increased labour demand, population growth and family formation. Such information is potentially useful for regional planners and local businesses in their decision-making. Though no claim is made regarding the precision of the forecasts made, they are sufficiently accurate to forecast the nature and order of magnitude of trends in selected socio-economic characteristics in the region over the medium-term arising from specific, induced changes.

The projections and other scenarios discussed in Chapter V illustrate the basic application of the IFS. However, further applications of the model are possible. The flexibility of the model allows planners to quickly and economically test various scenarios under different assumptions by using different baseline data, parameters or even equations, or by changing exogenous or endogenous variables or constants. In this way a better understanding of the possible impacts of changing social and economic conditions can be evaluated prior to any action being taken.

Further applications of the IFS could include an assessment of, for example:

(i) the development of additional oil fields in the vicinity Hibernia;

(ii) changes in social variables, e.g. family formation, divorce rates and the number of single parent families;

(iii) changes in demographic characteristics e.g. fertility and mortality;

(iv) changes in industrial structure or sectors in the study area; and

(v) future social and economic infrastructure requirements.

For example, the IFS could be applied to analyze the possible impacts of a second offshore oil field, such as Terra Nova, on the St. John's CMA. The impacts could be evaluated either if the development were to follow that of Hibernia oil field or if it were to occur concurrently. Alternatively, the model could be easily modified to estimate the possible socio-economic impacts of the Hibernia Project phase-out on the St. John's CMA.

As another example, planners could test the possible impacts of life-style changes on the study area. If there were reason to believe that divorce rates in the study area would increase dramatically in the near future, this would likely accelerate the decline in the local fertility rates and family size. Therefore, the increase in the divorce rate and the number of single parent families would increase the number of households and thus increase housing demand. In order to find the possible impacts of the divorce rate change on household formation and housing demand, expected fertility rates and family sizes could be used as base input data to the IFS to obtain an indication of the possible trends for household formation and housing demand in the future.

If needed, the IFS could be easily developed or modified to provide information for other applications. For instance, the IFS could be modified to provide the number of school enrollments by year in the study area, (obtained from the single year and sex population projections). Based on this, the IFS could be further modified to project the number of teachers and teaching facilities needed in the near future in the area. Similarly, the dependency ratio for the study area could also be calculated from the IFS in order to project the impact of changes in the area of other economic characteristics, such as labour participation and retirement age.

6.4 Conclusions

Though the IFS is not as comprehensive as the integrated models discussed in section 1.2, the results of the IFS generated suggest that the model is a useful tool to analyze a number of basic socio-economic activities and variables in regions such as the

St. John's CMA. The case study application of the IFS demonstrates how the Hibernia Project would probably influence the population, migration, labour demand and supply, housing demand and supply in the study area. It is adequate for predicting the overall impacts of the Project on the area, though it is difficult to trace and determine the precise impact of individual factors because of the complexity of the interactions among particular variables. For instance, it is extremely difficult, if not impossible, to determine the precise impact of unemployment rate on migration because migration is also influenced by many other factors, such as living expenses, moving costs, weather and environment, which cannot be separated from the model.

Compared to other integrated forecasting systems, this IFS requires only limited input data to obtain qualitatively accurate, if not quantitatively precise results, which can be very important to planners and local businesses in their decision-making. It means the data collection procedures of the IFS are, relatively speaking, neither expensive nor time consuming. The projections from the IFS might be more quantitatively precise and even more useful if used as planning inputs in the short- or medium-term, if more detailed and other better quality data became available.

In the early period after the discovery of the Hibernia oil field much of the media, many politicians, and government and non-government agencies expected that offshore oil development would have significant socio-economic impacts on the area -- even that St. John's would become another Calgary in eastern Canada. This view was challenged both at the time and since; the alternate view being that while the province in general and St. John's in particular would benefit from offshore development, the impacts would not begin to compare with those experienced in Calgary, Aberdeen or Stavanger (see, for example, Storey, 1984; House, 1985; Locke and Feehan, 1988). The forecasting results from the IFS developed here help confirm these latter views by simulating "normal", i.e. without-project, and with-project changes.

Unlike the situation in the Grampian Region of Scotland, the Hibernia Project will not change the basic economic situation of the St. John's CMA. For instance, all other things being equal, the unemployment rate of the study area would be expected to continue to stay at a relative high level though it might drop temporarily in the middle 1990s associated with the design and construction of the Hibernia Platform. In fact, the projections from the IFS indicate that the economic situation in the study area, as reflected, for example, in the unemployment rate and increased demand for labour, will not change dramatically in the long-term even with the Hibernia Project.

The present version of the IFS has undergone several development iterations to reach a stage where meaningful projections can be made and the effects of alternative scenarios can be analyzed and examined. Nevertheless, an integrated forecasting system is never complete -- further development and improvements always remain possible. Each of the building blocks of the model are based on a number of simplifying assumptions which could be refined. It should be also recognized that some problems may emerge because of the assumptions used in the IFS. For example, migration in this model is supposed to be job-related and directly connected with the unemployment rate. However, in reality migration is also influenced by many other factors, such as living costs and environment quality. These and other issues could be considered in any further developments of or refinements to the IFS.

Technically, this integrated forecasting system could incorporate more variables to model the real world. It could also be developed into a complex multi-regional model to include more detailed information, like the Greater Manchester model (see Dewhurst, 1984) or even developed as a dynamic multi-regional integrated model. Insofar as the model is always capable of improvements, it will never be finished.

In conclusion, this thesis has attempted to demonstrate that an integrated forecasting system can be developed that is appropriate for projecting the impacts of changing socio-economic characteristics in this case in the St. John's CMA. The impacts of increased demand for labour associated with the Hibernia project is but one example of how the model can be applied. In spite of the simplicity of many of the components of the IFS, the overall model proved to be adequate for projecting changes in the socio-economic characteristics of the study area and as such has potential to be used as an ongoing planning tool for analysis and forecasting in this and other similar regions.

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Appendix I Definition of Variables in the IFS

BEMP	= basic employment vector in each industry
BIRTH	= number of births
COMI	= in-commuters
COMN	= net commuters
COMO	= out-commuters
CPI1	= local consumer price index (1971=100)
CPI2	= consumer price index in Ontario (1971=100)
DEATH	= number of deaths
DEH	= demolished houses
DUMMY	= dummy variable
ELF	= experienced labour force
EMP	= total employment vector in each industry
EXH	= existing houses
FAMIS	= family size (persons per family)
FFR	= fertility rates matrix (per 1000)
FTPOP	= final total population
HD	= housing demand
HH	= households
HPI	= housing price index (1971=100)
HS	= housing supply
HSHR	= house-sharing rates (%)
HVR	= house vacancy rates (%)
LP	= local labour participation matrix
LPR	= local labour participation rate matrix (%)
MIGe	= estimated net migration matrix
$NBEMP_i$	= total non-basic employment vector (labour demand) in industry i (i = 1,2,...9)
NBH	= newly built houses
POP	= estimated population matrix
SH	= second houses
SHH	= shared houses
SUR	= survival rates matrix (%)
TBE	= total employment in basic sectors
TBTH	= total number of births
TDTH	= total number of deaths
TEMP	= total employment (total labour demand)
TLS	= total labour supply

TMIG	= total net migration
TNBE	= total employment in non-basic sectors
TPOP	= total population
UNER1	= local unemployment rate (%)
UNER2	= unemployment rates of the province (%)
VH	= vacant houses

Appendix II

Selected Forecasts from the IFS

Table 1 Most Likely, High and Low Population Projections the St. John's CMA, 1986-2001

Year	High	Most Likely	Low
1986	161900	161900	161900
1987	163757	163757	163742
1988	166463	165483	164530
1989	168945	167101	165346
1990	171247	168621	166176
1991	173457	170093	167022
1992	175633	171547	167875
1993	177863	173036	168732
1994	180031	174475	169575
1995	182068	175812	170386
1996	183872	176971	171148
1997	185504	177993	171858
1998	187058	178942	172535
1999	188560	179836	173180
2000	190014	180678	173792
2001	191420	181465	174364

Table 2 Most Likely, High and Low Labour Demand Projections the St. John's CMA, 1986-2001

Year	High	Most Likely	Low
1986	66952	66952	66902
1987	71521	68055	64606
1988	72662	69142	65640
1989	73787	70213	66658
1990	75085	71389	67622
1991	76056	72670	68652
1992	78391	74177	69629
1993	79757	75381	70590
1994	80805	76380	71539
1995	81293	77018	72476
1996	81932	77748	73400
1997	82851	78651	74313
1998	83846	79599	75214
1999	84829	80535	76104
2000	85800	81460	76984
2001	86759	82373	77853

Table 3 Most Likely, High and Low Labour Supply Projections the St. John's CMA, 1986-2001

Year	High	Most Likely	Low
1986	77868	77868	77868
1987	79772	79772	79763
1988	82195	81604	81009
1989	84479	83383	82279
1990	86592	85059	83511
1991	88643	86718	84760
1992	90598	88305	85949
1993	92564	89912	87136
1994	94508	91523	88351
1995	96400	93164	89644
1996	98160	94649	90865
1997	99771	96065	92075
1998	101338	97459	93293
1999	102857	98830	94515
2000	104360	100205	95762
2001	105723	101459	96905

Table 4 Most Likely, High and Low Household Projections, St. John's CMA, 1986-2001

Year	High	Most Likely	Low
1986	49716	49716	49716
1987	51133	51133	51129
1988	52860	52549	52246
1989	54558	53962	53395
1990	56239	55377	54574
1991	57931	56808	55782
1992	59653	58265	57018
1993	61435	59768	58281
1994	63238	61287	59565
1995	65039	62804	60866
1996	66797	64290	62175
1997	68533	65758	63492
1998	70279	67230	64823
1999	72045	68712	66169
2000	73832	70205	67529
2001	75640	71706	68900

Table 5 Most Likely, High and Low Housing Demand Projections the St. John's CMA, 1986-2001

Year	High	Most Likely	Low
1986	43711	43711	43711
1987	45187	45187	45183
1988	46804	46493	46191
1989	48359	47800	47268
1990	49903	49110	48373
1991	51400	50440	49506
1992	52925	51796	50665
1993	54508	53132	51851
1994	55824	54480	53056
1995	56642	55825	54278
1996	57922	57138	55508
1997	59161	58437	56747
1998	60388	59741	57935
1999	61808	60812	59137
2000	63035	61898	60351
2001	64473	62975	61575

Table 6 Most Likely, High and Low Housing Supply Projections the St. John's CMA, 1986-2001

Year	High	Most Likely	Low
1986	47755	47755	47755
1987	48855	48855	48855
1988	49943	49943	49943
1989	51019	51019	51019
1990	52084	52084	52084
1991	53138	53138	53138
1992	54192	54181	54181
1993	55246	55212	55212
1994	56299	56244	56233
1995	57364	57275	57242
1996	58547	58306	58241
1997	59767	59338	59229
1998	61026	60369	60207
1999	62324	61401	61185
2000	63636	62443	62163
2001	64989	63518	63140

Table 7 Most Likely Population Projections by Five-Year Age Groups and Sex the St. John's CMA, 1986, 1991, 1996 and 2001

Age group	1986			1991		
	Male	Female	Total	Male	Female	Total
0 - 4	6165	5865	12030	6471	5854	12325
5 - 9	6510	6205	12715	6168	5877	12045
10 - 14	6935	6530	13465	6539	6235	12774
15 - 19	7150	7070	14220	6958	6568	13526
20 - 24	8155	8610	16765	7165	7114	14279
25 - 29	7430	7950	15380	8162	8650	16812
30 - 34	7030	7350	14380	7442	7990	15432
35 - 39	6370	6555	12925	7042	7384	14426
40 - 44	5060	5150	10210	6366	6572	12938
45 - 49	3780	3740	7520	5025	5153	10178
50 - 54	3200	3275	6475	3713	3727	7440
55 - 59	2390	3115	6005	3089	3233	6322
60 - 64	2615	2755	5370	2694	3015	5709
65 - 69	2230	2700	4930	2306	2586	4892
70 - 74	1690	2380	4070	1844	2440	4284
75 - 79	1020	1680	2700	1276	2017	3293
80 - 84	480	985	1465	665	1269	1934
85 - 89	230	640	870	250	626	876
90 +	120	305	425	121	399	520
Total	79060	82860	161920	83341	86752	170093

Table 7 (continued)

Age group	1996			2001		
	Male	Female	Total	Male	Female	Total
0 - 4	5928	5362	11290	5149	4658	9807
5 - 9	6488	5880	12368	5943	5385	11328
10 - 14	6214	5925	12139	6527	5921	12448
15 - 19	6585	6299	12884	6251	5974	12225
20 - 24	6999	6636	13635	6614	6351	12965
25 - 29	7203	7180	14383	7023	6691	13714
30 - 34	8195	8715	16910	7227	7234	14461
35 - 39	7477	8048	15525	8211	8757	16968
40 - 44	7056	7420	14476	7473	8067	15540
45 - 49	6326	6583	12909	6997	7415	14412
50 - 54	4942	5140	10082	6200	6540	12740
55 - 59	3598	3690	7288	4763	5061	9824
60 - 64	2884	3132	6016	3353	3572	6925
65 - 69	2378	2834	5212	2547	2946	5493
70 - 74	1909	2337	4246	1972	2564	4536
75 - 79	1392	2071	3462	1443	1983	3426
80 - 84	827	1521	2348	903	1564	2467
85 - 89	350	810	1160	435	970	1405
90 +	130	421	551	173	516	690
Total	86926	90045	176971	89248	92217	181465

Appendix III

Fortran Programme of the IFS

```
*********************************************************************
*        Programme of the Integrated Forecasting System            *
*********************************************************************


      REAL*4  EMP(51,20),BE(51,96),NBE(51,20),G(51,20),G1(51,20),
     1   TE(51),TBE(51),TNBE(51),GROW(51),LD(51),LD1(51),
     1   G2(51,20),GT(51,20),TE1(51),TBE1(51),TNBE1(51),
     1   RADIO(51),GROW1(51,20),TG(51),AA1
      INTEGER       IYR,TYR,M,M1,M2,K,K1,T,NUMBER,NO,
     1        PROJ,HIGH,MOST,LOW
      CHARACTER*4     HIPHEN,PLUS
      PARAMETER      (HIPHEN='-',PLUS='+')


      REAL*4  MPOP(51,96),FPOP(51,96),BPOP(51,96),MSR(51,96),FSR(51,96)
     1   FFR(51,96),POT(51,96),MMIG(51,96),FMIG(51,96),BMIG(51,96)
     1   MMIGR(51,96),FMIGR(51,96),BMIGR(51,96),SEXR(51,96),
     1   MMIG1(51,96),FMIG1(51,96),MMIG2(51,96),FMIG2(52,96)
      REAL*4  MBR(96),FBR(96),CMBR(51),CFBR(51),NOB(51),TFFR(51),
     1   CMSR(51), CFSR(51),CBSR(51),CMMIGR(51),CFMIGR(51),
     1   CBMIGR(51),CFFR(51),CFFR1(51),TMPOP(51),TFPOP(51),
     1   TBPOP(51),TMSR(51),TFSR(51),TSEXR(51),TMPOP15(51),
     1   TFPOP15(51),TBPOP15(51)
      REAL*4  TMPOP14(51),TFPOP14(51),TBPOP14(51)
      REAL*4  POPG(51),POPGR(51),POPD(51),POPDR(51),TBR(51),
     1   TMMIG(51),TFMIG(51),TBMIG(51),TMMIGR(51),TFMIGR(51),
     1   TBMIG(51),COMUT(51),COMUTIN(51),COMUTINR(51),
     1   COMUTOUT((51),COMUTOUTR(51),MLPR(51,96),FLPR(51,96),
     1   CMLPR(51),CFLPR(51),CMLPR1(51),CFLPR1(51),MLS(51),FLS(51),
     1   LS(51),LS1(51),MLSR(51),FLSR(51),LSR(51),TBMIG1(51)


      REAL*4  MIGACT(51),UR(51),UR1(51),CPI(51),CPI1(51),UNEMP(51),
     1   POPACT(51),HOLD(51),FAMS(51),CONST1,A1,A2,MIGR(51)

      REAL*4  SHHD(51),SH(51),HP(51),HD(51),HSHR(51),SHR(51),
     1   CSHR(51),B(51),TEMP(51)


      REAL*4  HS(51),EHS(51),NBH(51),DEH(51),VH(51),OTL(51),
     1   NBHR(51),CHPR(51),CDEHR(51),VHR(51),COTLR(51),
     1   CNBHR(51),CSHHR(51),EHS1,NBH1,DEH1,VH1,OTL1,C1,C2
      REAL*4  TTBMIG(51),CG
```

```
*********************************************************************

      TG(1)=0.00
      GROW(1)=0.00
      WRITE(*,10)
10    FORMAT(' INPUT THE INITIAL YEAR')
      READ(*,'(I4)') IYR
      WRITE(*,20)
20    FORMAT(' INPUT THE TERMINAL YEAR')
      READ(*,'(I4)') TYR
      K=TYR-IYR
30    WRITE(*,40)
40    FORMAT(' INPUT NUMBER OF AGE GROUPS ')
       READ(*,'(I2)') M
      WRITE(*,50)
50    FORMAT(' INPUT NUMBER OF INDUSTRIES ')
      READ(*,'(I2)') K1
55    WRITE(*,60)
60    FORMAT(' FERTILITY, HIGH=1?, MOST LIKELY=2?, LOW=3?')
      READ(*,'(I1)') PROJ
      WRITE(*,70)
70    FORMAT(' CHANGE OF TOTAL EMPLOYMENT (%)?')
      READ(*,*) AA1
      OPEN (01,FILE='EMP10',STATUS='OLD')
       DO 80 I=1,K1
        READ(O1,*) EMP(1,I)
80     CONTINUE
      CLOSE(01)
      OPEN(02,FILE='BASICEMP10',STATUS='OLD')
       READ(02,*) (BE(1,I),I=1,K1)
      CLOSE(02)
      DO 90 T=1,K+2
       TT=T+IYR-1901
       GT(T,1)=-11098.4096+6559.6061*LOG10(TT)
       GT(T,2)=6400.0/(1+EXP(3.892545-0.057431*TT))
       GT(T,3)=8596.7465-390200.18*(1.0/TT)
       GT(T,4)=10725.62-416126.51*(1.0/TT)
       GT(T,5)=-64175.64+39873.02*LOG10(TT)
       GT(T,6)=3800.0/(1+EXP(9.840644-0.139887*TT))
       GT(T,7)=-7199.44+186.61*TT
       GT(T,8)=-158589.30+94455.81*LOG10(TT)
90    CONTINUE
      DO 100 T=1,K+1
       G(T,1)=GT(T+1,1)/GT(T,1)
       G(T,2)=GT(T+1,2)/GT(T,2)
```

```
      G(T,3)=GT(T+1,3)/GT(T,3)
      G(T,4)=GT(T+1,4)/GT(T,4)
      G(T,5)=GT(T+1,5)/GT(T,5)
      G(T,6)=GT(T+1,6)/GT(T,6)
      G(T,7)=GT(T+1,7)/GT(T,7)
      G(T,8)=GT(T+1,8)/GT(T,8)
100   CONTINUE
      IF(PROJ .EQ. 2) THEN
       OPEN(03,FILE='GROWR1',STATUS='OLD')
        READ(03,*) (G(T,9),T=1,K+1)
       CLOSE(03)
      ELSEIF(PROJ .EQ. 1) THEN
       OPEN(03,FILE='GROWR2',STATUS='OLD')
        READ(03,*) (G(T,9),T=1,K+1)
       CLOSE(03)
      ELSEIF(PROJ .NE. 1 .AND. PROJ .NE. 2 .AND.  PROJ .NE. 3) THEN
       GOTO 55
      ENDIF
      DO 110 I=1,K1+1
       G2(1,I)=0.00
       GROW1(1,I)=0.00
110   CONTINUE
      DO 10 I=1,K1
       NBE(1,I)=EMP(1,I)-BE(1,I)
       TE(1)=TE(1)+EMP(1,I)
       TBE(1)=TBE(1)+BE(1,I)
120   CONTINUE
      TNBE(1)=TE(1)-TBE(1)
      DO 130 T=1,K+1
       RATIO(T)=TE(1)/TBE(1)
130   CONTINUE
      LD(1)=TE(1)
      LD1(1)=TE(1)
***********************************************************************

      OPEN(08,FILE='BIRTHRATIO20',STATUS='OLD')
       READ(08,*) (MBR(T),T=1,K+1)
       DO 200 T=1,K+1
        FBR(T)=1.0-MBR(T)
200    CONTINUE
      CLOSE(08)
      OPEN(09,FILE='CBR20',STATUS='OLD')
       DO 210 T=1,K+1
        READ(09,*) CMBR(T)
        MBR(T+1)=MBR(T)*CMBR(T)
        FBR(T+1)=1.0-MBR(T+1)
```

```
210     CONTINUE
       CLOSE(09)
       OPEN(10,FILE='POP20',STATUS='OLD')
        DO 220 J=1,M+1
         READ(10,*) MPOP(1,J),FPOP(1,J)
220     CONTINUE
       CLOSE(10)
       OPEN(11,FILE='SURVIAL20',STATUS='OLD')
        DO 230 J=1,M+1
         READ(11,*) MSR(1,J),FSR((1,J)
230     CONTINUE
       CLOSE(11)
       OPEN(12,FILE='CSR20',STATUS='OLD')
        DO 240 T=1,K+1
         READ(12,*) CMSR(T),CFSR(T)
240     CONTINUE
       CLOSE(12)
       DO 260 T=1,K
        DO 250 J=1,M+1
         MSR(T+1,J)=MSR(T,J)*CMSR(T)
         FSR(T+1,J)=FSR(T,J)*CFSR(T)
250     CONTINUE
260    CONTINUE
       OPEN(13,FILE='FERTILITY20',STATUS='OLD')
        READ(13,*)  (FFR(1,J),J=1,M+1)
       CLOSE(13)
       IF(PROJ .EQ. 3) THEN
        DO 270 T=1,K+1
         I=T+IYR-1901
         CFFR1=EXP(5.556556-(0.013598*I))
270     CONTINUE
       ELSEIF(PROJ .EQ. 2) THEN
        DO 271 T=1,9
         I=T+IYR-1901
         CFFR1(T)=EXP(5.556556-(0.013598*I))
271     CONTINUE
        DO 272  T=10,K+1
         I=T+IYR-1901
         CFFR1(T)=EXP(5.556556-(0.013598*I))
272     CONTINUE
       ELSEIF(PROJ .EQ. 1) THEN
        DO 273 T=1,K+1
         I=1+IYR-1901
         CFFR1(T)=EXP(5.556556-(0.013598*I))
273     CONTINUE
       ENDIF
```

```
      DO 275 T=1,K
       CFFR(T)=CFFR1(T+1)/CFFR1(T)
275    CONTINUE
      DO 290 T=1,K
       DO 280 J=1,M+1
        FFR(T+1,J)=FFR(T,J)*CFFR(T)
280    CONTINUE
290   CONTINUE
      OPEN(15,FILE='MIGRATION20',STATUS='OLD')
       DO 300 J=1,M+1
        READ(15,*) MMIG(1,J),FMIG(1,J)
300    CONTINUE
      CLOSE(15)
      TMMIG(1)=0.0
      TFMIG(1)=0.0
      DO 310 J=1,M+1
       BMIG(1,J)=MMIG(1,J)+FMIG(1,J)
       TMMIG(1)=TMMIG(1)+MMIG(1,J)
       TFMIG(1)=TFMIG(1)+FMIG(1,J)
310   CONTINUE
      TBMIG(1=TMMIG(1)+TFMIG(1)
      TBMIG1(1)=TBMIG(1)
      DO 330 T=1,K+1
       DO 320 J=1,M+1
        MMIGR(T,J)=MMIG(1,J)/TMMIG(1)
        FMIGR(T,J)=FMIG(1,J)/TFMIG(1)
320    CONTINUE
       MIGR(T)=TMMIG(1)/TBMIG(1)
330   CONTINUE
      OPEN(17,FILE='PARTICIR20',STATUS='OLD')
       DO 340 J=1,M+1
        READ(17,*) MLPR(1,J),FLPR(1,J)
340    CONTINUE
      CLOSE(17)
      DO 350 T=1,K+2
       I=T+IYR-1901
       CMLPR1(T)=0.895947-0.100719*(100.0/I)
       CFLPR1(T)=1.106357-0.455983*(100.0/I)
350   CONTINUE
      DO 355 T=1,K+1
       CMLPR(T)=CMLPR1(T+1)/CMLPR1(T)
       CFLPR(T)=CFLPR1(T+1)/CFLPR1(T)
355   CONTINUE
      DO 370 T=2,K+1
       DO 360 J=1,M+1
        MLPR(T,J)=MLPR(T-1,J)*CMLPR(T-1)
```

```
        FLPR(T,J)=FLPR(T-1,J)*CFLPR(T-1)
360    CONTINUE
370   CONTINUE
      DO 380 J=1,M+1
       BPOP(1,J)=MPOP(1,J)+FPOP(1,J)
       TMPOP(1)=TMPOP(1)+MPOP(1,J)
       TFPOP(1)=TFPOP(1)+FPOP(1,J)
380   CONTINUE
      TBPOP(1)=TMPOP(1)+TFPOP(1)
      DO 385 J=16,M+1
       TMPOP15(1)=TMPOP15(1)+MPOP(1,J)
       TFPOP15(1)=TFPOP15(1)+FPOP(1,J)
385   CONTINUE
      TMPOP14(1)=TMPOP(1)-TMPOP15(1)
      TFPOP14(1)=TFPOP(1)-TFPOP15(1)
      TBPOP15(1)=TMPOP15(1)+TFPOP15(1)
      TBPOP14(1)=TBPOP(1)-TBPOP15(1)
*************************************************************************

      OPEN(19,FILE='COMUT20',STATUS='OLD')
       READ(19,*) COMUTIN(1),COMUTOUT(1)
      CLOSE(19)
      DO 390 T=1,K+1
       COMUTINR(T)=1.00
       COMUTOUTR(T)=1.00
390   CONTINUE
      COMUT(1)=COMUTIN(1)-COMUTOUT(1)
      DO 400 T=2,K+1
       COMUTIN(T)=COMUTIN(T-1)*COMUTINR(T-1)
       COMUTOUT(T)=COMUTOUT(T-1)*COMUTOUTR(T-1)
       COMUT(T)=COMUTIN(T)-COMUTOUT(T)
400   CONTINUE
*************************************************************************

      OPEN(21,FILE='MIGINPUT30',STATUS='OLD')
       DO 410 T=1,K+1
        READ(21,*) UR1(T)
410    CONTINUE
      CLOSE(21)
      DO 415 T=1,K+1
       I=T+IYR-1901
       CPI(T)=-10.107594+0.154591*I
       CPI1(T)=-10.737417+0.16199*I
415   CONTINUE
      OPEN(22,FILE='CONSTANT30',STATUS='OLD')
       READ(22,*) CONST1,A1,A2,A3,DUMMY1
```

```
      CLOSE(22)
      DO 420 J=1,M+1
        MLS(1)=MLS(1)+MPOP(1,J)*MLPR(1,J)
        FLS(1)=FLS(1)+FPOP(1,J)*FLPR(1,J)
420   CONTINUE
      LS(1)=MLS(1)+FLS(1)+COMUT(1)
      MLSR(1)=MLS(1)/TMPOP15(1)
      FLSR(1)=FLS(1)/TFPOP15(1)
      LSR(1)=LS(1)/TBPOP15(1)
      LS1(1)=LS(1)
      UNEMP(1)=LS(1)-LD(1)
      UR(1)=UNEMMP(1)/LS(1)
**********************************************************************

      DO 430 T=1,K+1
       I=T+IYR-1901
       FAMS(T)=EXP(2.627197-(0.016819*I))
430   CONTINUE
      HOLD(1)=TBPOP(1)/FAMS(1)
**********************************************************************

      OPEN(25,FILE='HDINPUT50',STATUS='OLD')
       READ(25,*) SHHD(1),SH(1)
      CLOSE(25)
      OPEN(26,FILE='HSTINPUT60',STATUS='OLD')
       READ(26,*) EHS(1),NBH(1),DEH(1),OTL(1)
      CLOSE(26)
      OPEN(28,FILE='CG50',STATUS='OLD')
       READ(28,*) CG
      CLOSE(28)
      OPEN(29,FILE='CONSTANT60',STATUS='OLD')
       READ(29,*) C1,C2
      CLOSE(29)
      HP(1)=1.00
      B(1)=HP(1)/CPI(1)
      TEMP(1)=B(1)
      HD(1)=HOLD(1)-SHHD(1)+SH(1)
      HSHR(1)=SHHD(1)/HOLD(1)
      SHR(1)=SH(1)/HOLD(1)
      HS(1)=EHS(1)+NBH(1)-DEH((1)-OTL(1)
      EHS(2)=HS(1)
      VH(1)=EHS(1)-HD(1)
      VHR(1)=VH(1)/EHS(1)
      NBHR(1)=NBH(1)/EHS(1)
      DO 440 T=1,K+1
       CNBHR(T)=1.00
```

```
      CSHR(T)=1.00
      CSHHR(T)=1.00
      CDEHR(T)=1.00
      COTLR(T)=1.00
      I=T+IYR-1901
      HP(T)=-9.186269+(0.143292*I)
440   CONTINUE
*********************************************************************

500   DO 699 T=1,K
501    DO 510 I=1,K1
        BE(T+1,I)=G(T,I)*BE(T,I)
        TBE(T+1)=TBE(T+1)+BE(T+1,I)
510    CONTINUE
       TE(T+1)=RATIO(T+1)*TBE(T+1)
       TE(T+1)=TE(T+1)*AA1
       TNBE(T+1)=TE(T+1)-TBE(T+1)
       DO 520 I=1,K1
        EMP(T+1,I)=TE(T+1)*(EMP(T,I)/TE(T))
        NBE(T+1,I)=EMP(T+1,I)-BE(T+1,,I)
        IF(NBE(T+1,I) .LT. 0.00) THEN
         EMP(T+1,I)=BE(T+1,I)
         NBE(T+1,I)=NBE(T,I)
        ENDIF
520    CONTINUE
       GROW(T+1)=(TE(T+1)-TE(T))/TE(T)
       DO 530 I=1,K1
        GROW1(T+1,I)=(EMP(T+1,I)-EMP(T,I))/EMP(T,I)
        G2(T+1,I)=G(T,I)-1.0
530    CONTINUE
       TG(T+1)=(TBE(T+1)-TBE(T))/TBE(T)
       LD(T+1)=TE(T+1)
       LD1(T+1)=TE(T+1)
*********************************************************************
       DO 570 J=1,M+1
        NOB(T)=NOB(T)+FPOP(T,J)*FFR(T,J)
570    CONTINUE
       MPOP(T+1,1)=MBR(T)*NOB(T)
       FPOP(T+1,1)=NOB(T)-MPOP(T+1,1)
       DO 580 J=2,M
        MPOP(T+1,J)=MSR(T,J-1)*MPOP(T,J-1)
        FPOP(T+1,J)=FSR(T,J-1)*FPOP(T,J-1)
580    CONTINUE
       MPOP(T+1,M+1)=MSR(T,M)*MPOP(T,M)+MSR(T,M+1)*
     1   MPOP(T,M+1)
       FPOP(T+1,M+1)=FSR(T,M)*FPOP(T,M)+FSR(T,M+1)*FPOP(T,M+1)
```

```
      TBMIG(T+1)=CONST1+A1*(UR(T)/UR1(T))+A2*(CPI(T)/CPI1(T))+
     1  A3*DUMMY1
      TBMIG1(T+1)=TBMIG(T+1)
      TMMIG(T+1)=TBMIG(T+1)*MIGR(T+1)
      TFMIG(T+1)=TBMIG(T+1)-TMMIG(T+1)
      DO 590  J=1,M+1
       MMIG(T+1,J)=MMIGR(T+1,J)*TMMIG(T+1)
       FMIG(T+1,J)=FMIGR(T+1,J)*TFMIG(T+1)
       MMIG1(T+1,J)=MMIGR(T+1,J)*TMMIG(T+1)
       FMIG1(T+1,J)=FMIGR(T+1,J)*TFMIG(T+1)
       BMIG(T+1,J)=MMIG(T+1,J)+FMIG(T+1,J)
590   CONTINUE
      DO 600 J=1,M+1
       MPOP(T=1,J)=MPOP(T+1,J)+MMIG(T+1,J)
       FPOP(T+1,J)=FPOP(T+1,J)+FMIG(T+1,J)
       BPOP(T+1,J)=MPOP(T+1,J)+FPOP(T+1,J)
       TMPOP(T+1)=TMPOP(T+1)+MPOP(T+1,J)
       TFPOP(T+1)=TFPOP(T+1)+FPOP(T+1,J)
600   CONTINUE
      TBPOP(T+1)=TMPOP(T+1)+TFPOP(T+1)
      DO 610 J=16,M+1
       TMPOP15(T+1)=TMPOP15(T+1)+MPOP(T+1,J)
       TFPOP15(T+1)=TFPOP15(T+1)+FPOP(T+1,J)
610   CONTINUE
      TBPOP15(T+1)=TMPOP15(T+1)+TFPOP15(T+1)
      TMPOP14(T+1)=TMPOP(T+1)-TMPOP15(T+1)
      TFPOP14(T+1)=TFPOP(T+1)-TFPOP15(T+1)
      TBPOP14(T+1)=TBPOP(T+1)-TBPOP15(T+1)
      DO 620 J=1,M+1
       MLS(T+1)=MLS(T+1)+MPOP(T+1,J)*MLPR(T+1,J)
       FLS(T+1)=FLS(T+1)+FPOP(T+1,J)*FLPR(T+1,J)
620   CONTINUE
      LS(T+1)=MLS(T+1)+FLS(T+1)+COMMUT(T+1)
      MLSR(T+1)=MLS(T+1)/TMPOP15(T+1)
      FLSR(T+1)=FLS(T+1)/TFPOP15(T+1)
      LSR(T+1)=LS(T+1)/TBPOP15(T+1)
      LS1(T+1)=LS(T+1)
      UNEMP(T+1)=LS(T+1)-LD(T+1)
      UR(T+1)=UNEMP(T+1)/LS(T+1)
      HOLD(T+1)=TBPOP(T+1)/FAMS(T+1)
      B(T+1)=HP(T+1)/CPI(T+1)
      TEMP(T+1)=B(T+1)
      HSHR(T+1)=HSHR(T)*CSHHR(T+1)
      SHHD(T+1)=HSHR(T+1)*HOLD(T)
      SHR(T+1)=SHR(T)*CSHR(T)
      SH(T+1)=SHR(T+1)*HOLD(T)
```

```
      HD(T+1)=HOLD(T+1)-SHHD(T+1)+SH(T+1)
      NBH(T+1)=NBH(T)*CNBHR(T)
      DEH(T+1)=DEH(T)*CDEHR(T)
      OTL(T+1)=OTL(T)*COTLR(T)
      HS(T+1)=EHS(T+1)+NBH(T+1)-DEH(T+1)-OTL(T+1)
      EHS(T+2)=HS(T+1)
      VH(T+1)=HS(T+1)-HD(T+1)
      VHR(T+1)=VH(T+1)/EHS(T+1)
630   IF(VH(T=1) .GE. EHS(T+1)*0.04) THEN
       HP(T+1)=HP(T+1)*C1
       B(T+1)=HP(T+1)/CPI(T+1)
       HSHR(T+1)=HSHR(T+1)*(1+B(T+1)-TEMP(T+1))
       SHHD(T+1)=HOLD(T)*HSHR(T+1)
       HD(T+1)=HOLD(T+1)-SHHD(T+1)+SH(T+1)
       VH(T+1)=HS(T+1)-HD(T+1)
       VHR(T+1)=VH(T+1)/EHS(T+1)
       CNBHR(T+1)=CNBHR(T+1)*(1+B(T+1)-TEMP(T+1))
       IF(HSHR(T+1) .LE. 0.12) GOTO 699
       GOTO 630
640   ELSEIF(VH(T+1) .LE. EHS(T+1)*0.015) THEN
       HP(T+1)=HP(T+1)*C2
       B(T+1)=HP(T+1)/CPI(T+1)
       HSHR(T+1)=HSHR(T+1)*(1+B(T+1)-TEMP(T+1))
       SHHD(T+1)=HOLD(T+1)*HSHR(T+1)
       HD(T+1)=HOLD(T+1)-SHHD(T+1)+SH(T+1)
       VH(T+1)=HS(T+1)-HD(T+1)
       VHR(T+1)=VH(T+1)/EHS(T+1)
       CNBHR(T+1)=CNBHR(T+1)*(1+B(T+1)-TEMP(T+1))
       IF(HSHR(T+1) .GT. 0.20) GOTO 650
       GOTO 630
      ENDIF
650   IF(VH(T+1) .LT. 0.00) GOTO 700
699   CONTINUE
      GOTO 999
***********************************************************

700   DO 710 I=1,K1
       G(T-1,I)=G(T-1,I)*CG
710   CONTINUE
      TBE(T)=0.00
      DO 730 I=1,K1
       BE(T,I)=G(T-1,I)*BE(T-1,I)
       TBE(T)=TBE(T)+BE(T,I)
730   CONTINUE
      TE(T)=RATIO(T)*TBE(T)
      TNBE(T)=TE(T)-TBE(T)
```

```
      DO 740 I=1,K1
       EMP(T,I)=TE(T)*(EMP(T-1,I)/TE(T-1))
       NBE(T,I)=EMP(T,I)-BE(T,I)
740   CONTINUE
      TE(T+1)=0.0
      TBE(T+1)=0.0
      TNBE(T+1)=0.0
      GROW(T)=(TE(T)-TE(T-1))/TE(T-1)
      DO 750 I=1,K1
       GROW1(T,I)=(EMP(T,I)-EMP(T-1,I))/EMP(T-1,I)
       G2(T,I)=G(T-1,I)-1.0
750   CONTINUE
      TG(T)=(TBE(T)-TBE(T-1))/TBE(T-1)
      LD(T)=TE(T)
*****************************************************************

      UNEMP(T-1)=LS(T)-LD1(T)*(LD(T)/LD1(T))
      UR(T-1)=UNEMP(T-1)/LS(T)
      TBMIG(T)=CONST1+A1*(UR(T-1)/UR1(T-1))+A2*(CPI(T-1)/CPI1(T-1))
      TMMIG(T)=TBMIG(T)*MIGR(T)
      TFMIG(T)=TBMIG(T)-TMMIG(T)
      DO 900 I=1,M+1
       MMIG(T,I)=MMIGR(T,I)*TMMIG(T)
       FMIG(T,I)=FMIGR(T,I)*TFMIG(T)
       BMIG(T,I)=MMIG(T,I)+FMIG(T,I)
900   CONTINUE
      TMPOP(T)=0.0
      TFPOP(T)=0.0
      TMPOP(T+1)=0.0
      TFPOP(T+1)=0.0
      NOB(T)=0.0
      MLS(T)=0.0
      FLS(T)=0.0
      LS(T)=0.0
      MLS(T+1)=0.0
      FLS(T+1)=0.0
      LS(T+1)=0.0
      DO 910 I=1,M+1
       MMIG2(T,I)=MMIG(T,I)-MMIG1(T,I)
       FMIG2(T,I)=FMIG(T,I)-FMIG1(T,I)
       MPOP(T,I)=MPOP(T,I)+MMIG2(T,I)
       FPOP(T,I)=FPOP(T,I)+FMIG2(T,I)
       BPOP(T,I)=MPOP(T,I)+FPOP(T,I)
       TMPOP(T)=TMPOP(T)+MPOP(T,I)
       TFPOP(T)=TFPOP(T)+FPOP(T,I)
       MLS(T)=MLS(T)+MPOP(T,I)*MLPR(T,I)
```

```
      FLS(T)=FLS(T)+FPOP(T,I)*FLPR(T,I)
910   CONTINUE
      TBPOP(T)=TMPOP(T)+TFPOP(T)
      LS(T)=MLS(T)+FLS(T)+COMUT(T)
      TMPOP15(T)=0.0
      TFPOP15(T)=0.0
      TBPOP15(T)=0.0
      TMPOP15(T+1)=0.0
      TFPOP15(T+1)=0.0
      TBPOP15(T+1)=0.0
      DO 920 I=15,M+1
       TMPOP15(T)=TMPOP15(T)+MPOP(T,I)
       TFPOP15(T)=TFPOP15(T)+FPOP(T,I)
920   CONTINUE
      TBPOP15(T)=TMPOP15(T)+TFPOP15(T)
      MLSR(T)=MLS(T)/TMPOP15(T)
      FLSR(T)=FLS(T)/TFPOP15(T)
      LSR(T)=LS(T)/TBPOP15(T)
      LS1(T)=LS(T)
      UNEMMP(T)=LS(T)-LD(T)
      UR(T)=UNEMP(T)/LS(T)
      HOLD(T)=TBPOP(T)/FAMS(T)
      GOTO 501
*********************************************************************

999   DO 1100 T=1,K+1
       POPD(T)=(TBPOP(T)+NOB(T)+TBMIG(T+1))-TBPOP(T+1)
       POPDR(T)=POPD(T)/TBPOP(T)
       POPG(T)=NOB(T)-POPD(T)
       POPGR(T)=POPG(T)/TBPOP(T)
       TBR(T)=NOB(T)/TBPOP(T)
       TBMIGR(T+1)=TBMIG(T+1)/TBPOP(T)
       DO 1020 J=1,M+1
        POT(T+1,J)=BPOP(T+1,J)/TBPOP(T+1)
        SEXR(T+1,J)=MPOP(T+1,J)/FPOP(T+1,J)
        TSEXR(T+1)=TSEXR(T+1)+SEXR(T+1,J)
1020   CONTINUE
       TSEXR(T+1)=TSEXR(T+1)/(M+1)
1100  CONTINUE

*********************************************************************
*                         OUTPUT                                    *
*********************************************************************

      OPEN(01,FILE='EMPLOY19',STATUS='NEW')
      DO 5100  T=1,K+1
```

```
      WRITE(01,5010) IYR+T-1
5010  FORMAT(/'=============================',4X,I4,4X,
  1   '========================================')
      WRITE(01,5020)
5020  FORMAT(/4X,'INDUSTRY',9X,'BASICEMP'.8X.'NONBEMP',11X,'EMP',
  1       5X,'BEGROW(%)'/)
      WRITE(01,5030)
5030  FORMAT(' ----------------------------------------',
  1   '----------------------------------------')
      DO 5050 I=1,K1
       WRITE(01,5040) I,BE(T,I),NBE(T,I),EMP(T,I),G2(T,I)
5040   FORMAT(8X,I2,4X,3(2X,F13.2),5X,F8.4)
5050  CONTINUE
      WRITE(01, 5030)
      WRITE(01,5060) TBE(T),TNBE(T,I),TE(T),TG(T)
5060  FORMAT(6X,'TOTAL',3X,3(2X,F13.2),5X,F8.4)
      WRITE(01,5070)
5070  FORMAT(' ========================================',
  1   '========================================')
5100  CONTINUE
      CLOSE(01)
***********************************************************************
      OPEN(02,FILE='POP29',STATUS='NEW')
      DO 5880 T=1,K+1
       WRITE(02,5800) IYR+T-1
5800   FORMAT(/'=============================',2X.I4,2X,
  1       '==================================')
       WRITE(02,5810)
5810   FORMAT(6X,'AGE',16X,'MALE',10X,'FEMALE',11X,'TOTAL')
       WRITE(02,5820)
5820   FORMAT('--------------------------------',
  1       '--------------------------------'/)
       DO 5840 J=1,M
        WRITE(02,5830) J-1,HIPHEN,J,MPOP(T,J),FPOP(T,J),
  1     BPOP(T,J)
5830    FORMAT(5X,I2,A,I2,3X,3(4X,F12.2))
5840   CONTINUE
       WRITE(02,5850)M+1,PLUS,MPOP(T,M+1),FPOP(T,M+1),
  1   BPOP(T,M+1)
5850   FORMAT(5X,I2,2X,A,3X,3(4X,F12.2))
       WRITE(02,5820)
       WRITE(02,5860) TMPOP(T),TFPOP(T),TBPOP(T)
5860   FORMAT(2X,'GRAND TOTAL',3(4X,F12.2))
       WRITE(02,5870)
5870   FORMAT('========================================',
  1       '========================================'/)
```

```
5880  CONTINUE
      CLOSE(02)
************************************************************************

      OPEN(03,FILE`=POP99',STATUS=`NEW')
      DO 5909 T=1,K+1
       WRITE(03,5900) IYR+T-1
5900   FORMAT(/`===============================',2X,I4,2X,
  1     `=================================')
       WRITE(03,5901)
5901   FORMAT(6X,`AGE',16X,`MALE',10X,`FEMALE',11X,`TOTAL')
       WRITE(03,5902)
5902   FORMAT(`-------------------------------',
  1     `-----------------------------'/)
       WRITE(03,5903) TMPOP14(T),TFPOP14(T),TBPOP14(T)
5903   FORMAT(4X,` 0 - 14',3X,3(4X,F12.1))
       WRITE(03,5904) TMPOP15(T),TFPOP15(T),TBPOP15(T)
5904    FORMAT(3X,`15 &  OVER',2X,3(4X,F12.1))
       WRITE(03,5902)
       WRITE(03,5905) TMPOP(T),TFPOP(T),TBPOP(T)
5905    FORMAT(2X,`GRAND TOTAL',3(4X,F12.1))
       WRITE(03,5906)
5906   FORMAT(`=====================================',
  1     `=================================='/)
5909  CONTINUE
      CLOSE(03)
************************************************************************

      OPEN(04,FILE=`TPOP29',STATUS=`NEW')
       WRITE(04,5910)
5910   FORMAT(`=======================================',
  1     `====================================')
       WRITE(04,5920)
5920   FORMAT(/2X,`YEAR',6X,`BASEPOP',6X,`BIRTH',6X,`DEATH',3X,
  1       `POPGROWTH',3X,`MIGRANT',5X,`FINALPOP'/)
       WRITE(04,5930)
5930   FORMAT(` -----------------------------------',
  1     `-----------------------------------')
      DO 5950 T=1,K
       WRITE(04,5940) IYR+T-1,TBPOP(T),NOB(T),POPD(T),
  1     POPG(T),TBMIG(T),TBPOP(T+1)
5940   FORMAT(2X,I4,2X,5(X,F10.1),3X,F10.1)
5950  CONTINUE
      WRITE(04,5910)
      CLOSE(04)
************************************************************************
```

```
      OPEN(05,FILE='LABORF39',STATUS='NEW')
       WRITE(05,5960)
5960   FORMAT(' ==============================',
  1    '==============================')
       WRITE(05,5970)
5970   FORMAT(2X,'YEAR',8X,'MLABOR',3X,'MPARTICIP',5X,'FLABOR',
  1     3X,'FPARTICIP',5X,'TLABOR',3X,'TPARTICIP')
       WRITE(05,5980)
5980   FORMAT(' ------------------------------',
  1    '------------------------------')
       DO 5990 T=1,K+1
        WRITE(05,5985) IYR+T-1,MLS(T),MLSR(T),FLS(T),FLSR(T),
  1         LS(T),LSR(T)
5985    FORMAT(2X,I4,2X,3(4X,F8.1,5X,F6.4))
5990   CONTINUE
       WRITE(05,5960)
      CLOSE(05)
*********************************************************************

      OPEN(06,FILE'HOUSEHOLD49',STATUS='NEW')
       WRITE(05,6000)
6000   FORMAT(' ==============================',
  1    '==============================')
       WRITE(06,6010)
6010   FORMAT(4X,'YEAR',8X,'TOTPOP',6X,'FAMILYSIZE',6X,
  1    'HOUSEHOLD'/)
       WRITE(06,6020)
6020   FORMAT(' ------------------------------',
  1    '------------------------------')
       DO 6040 T=1,K+1
        WRITE(06,6030) IYR+T-1,TBPOP(T),FAMS(T),HOLD(T)
6030    FORMAT(4X,I4,4X,F12.2,6X,F6.4,6X,F10.2)
6040   CONTINUE
       WRITE(06,6000)
      CLOSE(06)
*********************************************************************

      OPEN(07,FILE='EMPLOY39', STATUS='NEW')
       WRITE(07,6100)
6100   FORMAT('==============================',
  1    ==============================')
       WRITE(07,6110)
6110   FORMAT(4X,'YEAR',8X,'LABOR-D',7X,,
  1    'LABOR-S',6X,'UNEMPLOY',3X,'UNEMPLOY(%)')
       WRITE(07,6120)
       FORMAT(' ------------------------------',
```

```
1       '--------------------')
        DO 6130 T=1,K+1
         WIRTE(07,6140) IYR+T-1,LD(T),LS(T),UNEMP(T),UR(T)
6130    CONTINUE
6140    FORMAT(4X,I4,X,3(2X,F12.2),6X,F6.4)
       CLOSE(07)
*******************************************************************

       OPEN(08,FILE='HOUSING59',STATUS='NEW')
        WRITE(08,6100)
        WRITE(08,6150)
6150    FORMAT(4X,'YEAR',7X,'HOUSE-D',6X,'HOUSE-S',4X,'NEWHOUSE',
1           4X,'SHARE(%)',3X,'VACANCY(%)',)
        WRITE(08,6120)
        DO 6160 T=1,K+1
         WRITE(08,6170) IYR+T-1,HD(T),HS(T),NBH(T),HSHR(T),VHR(T)
6160    CONTINUE
6170    FORMAT(4X,I4,X,2(3X,F10.1),5X,F6.1,2(6X,F6.4)
        WRITE(08,6100)
       CLOSE(08)
       STOP
       END
```