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THE DEMAND FOR UNIVERSITY GRADUATES BY FIELD OF STUDY TO 1985

PART III

METHOD

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THE DEMAND FOR UNIVERSITY GRADUATES BY FIELD OF STUDY TO 1985

PART III

M E T H O D

Forecasting Division
University Branch
MOSST

OUTLINE - PART III

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SECTION 1

INTRODUCTION

Part III of the study provides a description of the methodology of the model and its various components. The main purpose is to present a concise summary of the model blocks and the calculation algorithms, and of the various classification schemes.

Because there exist a number of extensive studies dealing with theoretical questions of manpower projections, discussions of the theoretical aspects are not repeated here, except in cases where this model differs from earlier approaches. This is done in Section 2 of this part, where there is a brief examination of the questions of technological stability, the production function implications, and the linkages between manpower studies and the educational system.

Section 3 provides an overview of the model, in flow-chart as well as in algebraic form.

Earlier attempts to project manpower requirements did not have the benefit of large econometric models such as the CANDIDE model. Often such studies had to rely on rather crude projections of the industrial structure of the economy. This study uses the CANDIDE framework for the purpose of deriving the future industrial employment structure which constitutes an important input for many of the occupational demand estimates. The use of the CANDIDE model is described in Section 4. A brief description of CANDIDE itself is given in the Appendix to Part III.

This study is one of the first major applications of the occupational data collected in the 1971 Census under the Canadian Classification and Dictionary of Occupations. Section 5 provides the definition for HQM based on this dictionary and discusses the occupational classifications used.

The need to replace personnel due to death, emigration and retirement constitutes a significant, and in many cases, the major, source of demand for university graduates. The model that is used for estimating attrition is described in Section 6.

Since the major objective of this study is the demand for university graduates, particular attention is given to the educational background of new labour market entrants. Educational upgrading is discussed in "University Degree Requirements for New Entrants" (Section 7). The transition coefficients for calculating the educational field of study of new entrants are based on the 1973 HQM Post-Censal Survey. The use of this data system, and the classification scheme adopted, are described in Section 8.

SECTION 2

SOME CONCEPTUAL QUESTIONS

Earlier projections of manpower requirements, especially of HQM requirements, have tended to suffer from a lack of essential information in a number of areas. As a consequence, assumptions about many conceptual relationships in those models could not be made explicit. For example, assumptions had to be made about the uniqueness of the occupational structure in relation to a given level of economic output. Other problems arose in connection with the projection of the industrial output, employment and occupational structure and manifested themselves in peculiar production functions implications. Also, a major drawback of previous models was that manpower requirement projections could not be linked to educational policies in a satisfactory manner.

The MOSST model is able to deal more explicitly with these problems, made possible mainly by recent data developments. Of particular benefit are the development of the Canadian Classification and Dictionary of Occupations, 1971, and its influence on the 1971 Census and other data sets, such as the Occupation Employment Survey; the development of powerful administrative data banks for several key HQM occupations on an annual basis (it is expected that this kind of development will continue to expand to even more professions, such as physicians and lawyers); the development of the CANDIDE econometric model of the Canadian economy which provides estimates of the industrial structure of output and employment; and the HQM post-censal survey of 1973 which provides the field of study information for university graduates in HQM occupations.

The MOSST model does not provide regional information. Requirements studies on a national level have been criticized for the fact that they ignore the wide regional disparities that exist in Canada[1]. However, since the model restricts itself to HQM, and since HQM is highly mobile[2], not only nationally but in many disciplines internationally, it was found difficult to justify a regionalized approach.

Constancy of the Technological Structure

The traditional Leontief approach has been criticized because of its assumptions regarding the constancy of the technological relationships[3]. In the case of manpower

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[1] Ahamad, B. and Blaug, M. (1973), The Practice of Manpower Forecasting

[2] Mobility can be restricted, however, in some professions when there are institutional or language barriers

[3] Ahamad, B. and Blaug, M. (1973), op. cit.

requirements projections, this means the assumption of a rigidly determined occupational structure, within each industry, independent of supply. This approach also does not deal with the transition from the technological aspects, which deal with functions that are performed by production factors, to manpower aspects that deal with human beings who change occupations and who, in the same occupation, often have different educational backgrounds.

The MOSST study attempts to deal with these particular shortcomings, first, by examining the behaviour of the technological coefficients, and by adapting them in those cases where there is evidence of change[1]. Second, the MOSST model makes a clear distinction between the concept of a job function that is performed by persons in a particular occupation, and the qualifications of those persons who carry out such job functions. For example, a particular managerial function might be carried out by a graduate in electrical engineering who, prior to assuming the managerial job, carried out the function "technical sales". When he left the sales function, his place was taken by a person with

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[1]As noted below, health and education occupations and several other occupations, the demand for which is not determined by economic and technological factors, were not calculated by the input-output methodology

a degree in physics who, before, had worked in the occupation "mechanical engineering", etc. The assumption is made that, in the aggregate, interoccupational shifts net out to zero. The MOSST model can take explicit account of such shifts because of two major recent developments in data -- the CCDO and its application in the 1971 Census; and the HQM Post-Censal Survey. The Census occupations are now defined in terms of work functions rather than qualifications. The HQM survey, on the other hand, provides the particular educational background of all university graduates in the Census.

The production function implications

In the ideal case, the demand for labour should be estimated in a production function that specifies the labour inputs by type of labour (say, by occupation), and all the other types of inputs, in order to take account of substitution, for example, between engineers and non-labour inputs, but also other labour inputs such as technologists, blue collar labour, etc. Some inputs would be highly substitutable, while others would not be substitutes at all. In practice, however, the available data do not permit this kind of disaggregated estimation of production functions.

Most earlier models used simpler devices and assumptions to estimate future industrial output, employment and productivity. Which of these elements was projected usually depended on the method used for estimating occupational requirements. One of the two main approaches is the occupation coefficient method, in which the growth in the number of persons in a particular occupation is related to the growth in output. The other main approach is the projection of the occupational distribution or the occupation/industrial employment coefficient method.

The former method is usually advocated because it is claimed to be "less sensitive to cyclical fluctuations in the state of the economy", and because "relating occupational projections by industry directly to industrial output is more in keeping with the concept of manpower requirements than is the occupational distribution approach"[1]. However, business cycle experience shows that output is significantly more volatile than employment, even when the latter is expressed in man-hours rather than man-years. The reason

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[1] Holland, J., Quazi, S., Siddiqui, F., and Skolnik, M., (1971), Manpower Forecasting and Educational Policy

for this is that there is a substantial cost involved in the hiring and training of labour, and that the cost grows with the degree of training and education of a particular occupation. To minimize the costs involved in cyclical labour turnover, employers attempt to reduce the movement of labour in and out of their firms as much as possible. The cyclical changes in employment probably do vary for different types of labour, and are highest for the least skilled. Nevertheless, the total work force of an industry varies less than the output during the course of a business cycle, and from this point of view alone the occupational distribution (occupation/industrial employment coefficient) approach would be preferable. Both methods, however, have implications for the underlying production function that are usually not made explicit.

The MOSST model employs a two-step procedure in estimating occupational requirements. The first is to produce a CANDIDE solution[1] that yields the desired projections of industrial output and employment. The second step is to estimate the relative importance of the various HQM occupations in the employment total of each of the industries.

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[1] A full description of the CANDIDE model and its use is given in Section 4 and Appendix below

(This is done only for those HQM occupations for which the requirements are determined by economic and technological factors). The relative importance of some occupations in certain industries was found to be rising. But the production function employed in the CANDIDE model[1], which is of the Cobb-Douglas type, does not distinguish between different types of labour, and does not take explicit account of the effect that an improvement in the quality of an industry's work force exerts on total productivity. The rising relative importance of some HQM categories is therefore an important contributor to the technological advance measured implicitly in the CANDIDE specification, and the method used here merely takes explicit account of this trend.

Manpower Demand Projections and Educational Policies

In previous manpower demand models, the occupation-education relationship has been the weakest element in the process of deriving educational implications from labour market forecasts. The MOSST model contains innovations in three different areas of this process. As a consequence, the potential for obtaining useful inputs into educational

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[1]See Illing, W., CANDIDE Project Paper No.10, CANDIDE Model 1.0: Labour Demand, Economic Council of Canada

policy has been significantly enhanced.

The first type of improvement that has been available to the MOSST model is the distinction in the occupational classifications of the educational and vocational training required in each occupational function[1]. This permits the identification of job groups consistent with certain categories of educational and vocational qualifications. In the past, the only information on the occupation-education link was the year of schooling of persons in the various occupations. There was obviously no assurance that the educational attainment of the incumbents in an occupation was reflective of the underlying requirements for that job function.

The second area where the MOSST model benefits from new information is the knowledge of the particular field of study in which university graduates have obtained their degree, cross-classified by occupation and industry[2]. This

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[1] As developed in the CCDO -- see Section 5 below for a more detailed discussion

[2] This information was not available in Canada in 1968 when Meltz and Penz undertook their study on the manpower implications of potential output projections for 1970 of the Economic Council of Canada. It was necessary for them to estimate the educational distribution within occupations with the assistance of the Department of Manpower and Immigration. See Meltz, N. and Penz, G.P. (1968), Canada's Manpower Requirements in 1970

information is derived from the 1973 post-censal HQM survey[1]. Having the speciality by field of study of persons employed in a particular HQM occupation, it is possible to estimate probabilities of new entrants into HQM occupations by various fields of university specialization. These transition coefficients are estimated on the basis of age structure differences in qualifications, and prior knowledge of legal and institutional requirements regarding field of study and degree requirements. Since the model explicitly allows for the fact that there is not generally a one-to-one correspondence between occupation and discipline, the implications for the educational system are more firmly based. This approach, however, still assumes that the educational distribution within occupations is rigidly determined and that a change in relative cost or supply of university graduates will not affect the distribution. Any study of the effects of supply on the educational distribution of an occupation would require a forecast of the supply of university graduates by field of study. At this point, such a study is for theoretical reasons, much more difficult.

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[1]See Section 8 below for a more detailed discussion

The supply of educated manpower can have an impact on the educational qualifications of new entrants into certain HQM occupations (i.e. university degree versus no university degree). Under more plentiful supply conditions, educational upgrading is more common, as is evidenced by the difference in the qualifications of the younger as compared with the older members of many of the HQM occupations. The HQM model provides for such upgrading in certain occupations, based on a quasi-longitudinal approach[1]. This also tends to render the educational policy implications more explicit.

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[1]See Section 7 below for a detailed discussion

SECTION 3

THE HQM PROJECTION MODEL

The outputs of this model are estimates of the demand for university graduates in occupations requiring a university degree. Such estimates are calculated by field of study. Various intermediate outputs are also generated in the process of solving the model, such as changes in HQM occupational stock required in the economy in future years, estimates of changes in the age structure of the future HQM occupational stock, and the replacement demands due to future attrition.

Most of the information on the basic HQM characteristics is cross-sectional rather than time series data. The most suitable method for the purpose of the project was found to be an input-output approach, but with some important additional features. The most interesting of these is the provision for changes, over time, in the coefficients of the various matrices and vectors relating to technological, behavioural and socio-demographic relationships. Changes in the coefficients can be introduced when new information becomes available, for purposes of policy simulation, or for sensitivity analysis.

A graphic outline of the model's elements and their major causal relationships is presented in Chart III-1. At the basis of this solution process are the following:

- Population estimates by sex and single year of age, 1971 - 1985;

CHART III-1

HQM DEMAND PROJECTION MODEL

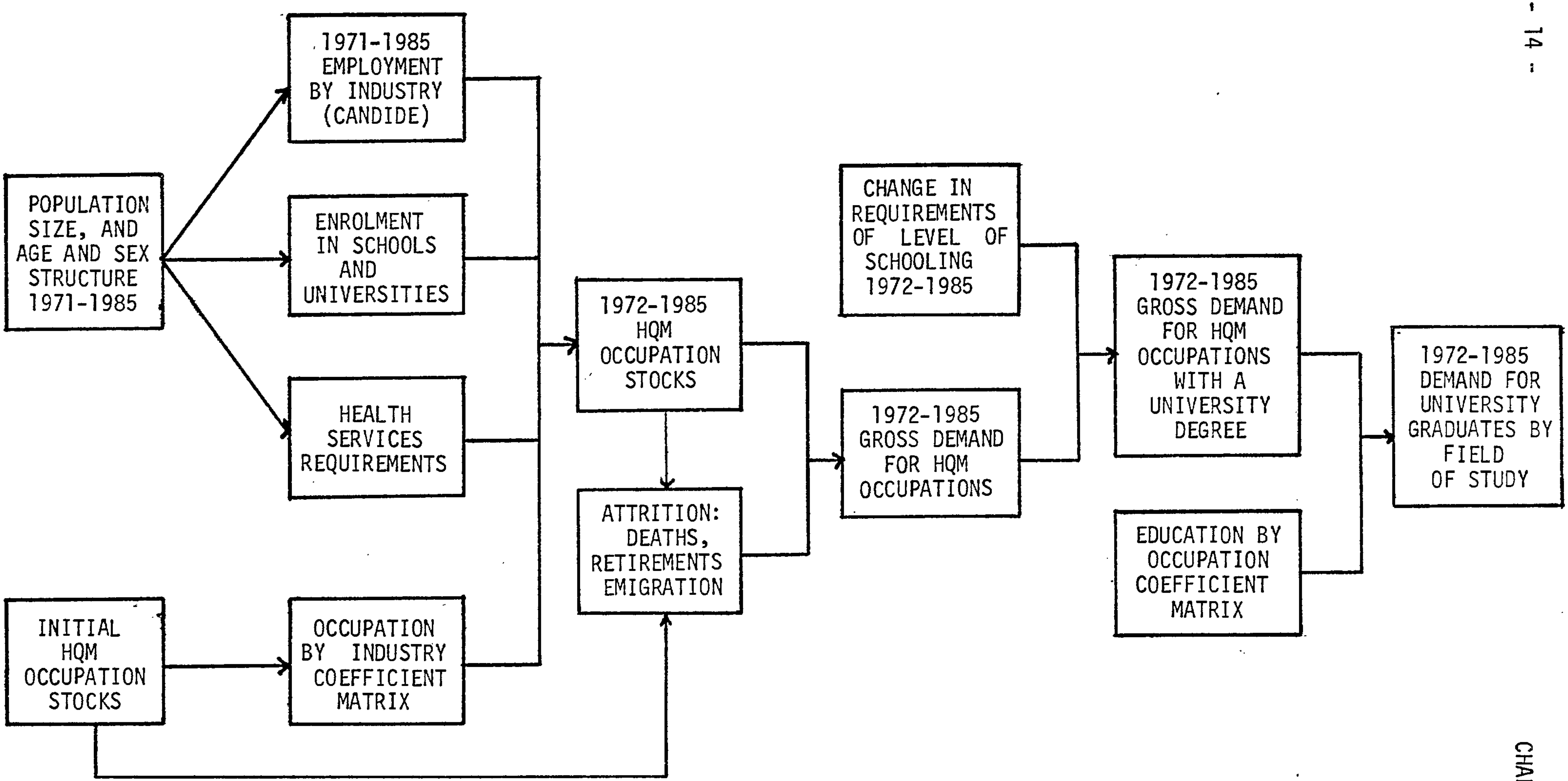

CHART III-1

- Estimates of employment by industry, as defined by the SIC, for the years 1971-85. The employment projections are carried out with the CANDIDE econometric model (for a detailed description of the employment projections and the CANDIDE Model, see Section 4 and Appendix I).
- The most up-to-date estimates available of the number of persons in the various HQM occupations by sex and single year of age, and by industry. The definition of HQM occupations is taken from the OCM, requiring a GED/SVP of 12. (Section 5 below describes the classification of the occupation data in greater detail).
- Technological relationships, describing the proportion of HQM functions in total employment, by industry (these are contained in the occupation by industry coefficient matrix). The coefficients can be varied, when there is evidence of technological change that is quantifiable.
- Behavioural relationships in the fields of education and health services, and several other professions. These are mainly based on such factors as enrolments at various levels of schooling, student-teacher ratios, changes in the age structure of the population, and ratios of various types of health services personnel to age-sex groups of the population. (The projection method is provided in greater detail below, in this Section).

The first phase of the solution is the calculation of the stocks of occupations for 1972-85 that are required in the economy, based on the industrial employment projection on the one hand and the occupation/industry coefficients on the other. Estimates of the required stocks of health and education are computed directly, using the above-noted population figures, together with the behavioural relationships.

The estimates of the occupational stocks are then passed through an attrition calculation (see Section 6 for a detailed description of the attrition model). Briefly, mortality, withdrawal, and immigration factors are applied to the initial occupational stocks and to the stocks of each year from 1972-85, taking into account the fact that there are new entrants each year who are also subject to the same attrition risks as persons in the base-year stock.

The attrition estimates provide requirements of replacements, to maintain the occupational stocks at the same level. This replacement demand is added to the net change in the stock requirements calculated in the first phase of the model, yielding the total number of new entrants required for each HQM occupation. This produces an annual vector of gross demands for HQM occupations for 1972-85.

The next phase estimates the number of new entrants who require a university degree. In most HQM occupations, only a proportion of the incumbents have, or even require, a degree, and this requirement varies considerably among the various occupations. (The method for this phase of the model is provided - Section 7 below). This calculation yields a vector, for each year from 1972-85, of the gross demand for new entrants into HQM occupations requiring a university degree.

The demand for university graduates by field of study is then calculated on the basis of the estimate for new entrants requiring degrees on the one hand, and a matrix of coefficients containing the distribution of persons with university degrees by level and field of study in the various HQM occupations. This takes account of interdisciplinary mobility. Details regarding the classification of the fields of study, and the sources of the data, are provided in Section 8 below.

The following is a brief algebraic summary of the model.

Algebraic Formulation of the Model

An overview of the HQM projection model is presented here in algebraic notation. The model equation comprises the following components:

- a column vector e_t of employment by industry (IND) in year t

$$e_t = \{e_{1t}, e_{2t}, \ldots\ldots e_{IND,t}\} \qquad t = 1971 \text{ to } 1985$$

- a matrix [(1)] of coefficients P representing the distribution of occupations within each industry in a given year t

$$P_t = [p_{ij}] \qquad i = 1,2,\ldots,K; \quad j = 1,2,\ldots, IND$$

where K is the number of occupations,

$$\sum_{i=1}^{K} p_{ij} = 1 \qquad \text{for all } j \quad ,$$

and

$$0 \leq p_{ij} \leq 1 \qquad \text{for all } i,j$$

(1) For the health and education occupations, the coefficients are estimated on the basis of socio-demographic factors (see method below).

- a column vector a_t of attrition by occupation in year t

$$a_t = \{a_{1t}, a_{2t}, \ldots, a_{Kt}\} \qquad t = 1971 \text{ to } 1984$$

- a vector g_t of the proportion of jobs in each occupation to be filled by university graduates in year t

$$g_t = (g_{1t}, g_{2t}, \ldots, g_{Kt}) \qquad t = 1972 \text{ to } 1985$$

- an array N representing the distribution of educational backgrounds, classified into the major fields of study and degree level within each occupation in a given year t

$$N_t = [n_{ijl}] \qquad i = 1,2,\ldots, K;\ j = 1,2,\ldots,FOS \quad l = \text{BA, MA, PHD.}$$

where FOS is the number of fields of study.

The demand for university graduates by field of study in year t is thus written as

$$D_t = [P_t e_t - P_{t-1} e_{t-1} + a_{t-1}]' \ Z_t N_t$$

where Z_t is a diagonal matrix of the vector g_t.

Method for Projecting Stocks of Health HQM

The demand for health manpower is expressed as a function of a given (current) level of health services, and the foreseeable changes in the composition of the population requiring such services. (Replacement requirements due to attrition are also estimated, as described in the attrition model in Section 6 below).

The demand for manpower within a given health occupation is assumed to be the sum of the manpower required in that occupation by the various age and sex groups that comprise the total population.

$$D_1^k + D_2^k \; .... + D_n^k = D_{TOTAL}^k$$

where D_i^k = the manpower required in the k^{th} health occupation by the i^{th} age and sex group

$i = 1,2, \; ...., \; n.$

In the base year 0, the demand for manpower in a given health occupation k, within the i^{th} age and sex group, is defined as a function of some base year indicator of utilization (i.e. expenditures, average chairtime per person, etc...).

$$D_{i0}^k = b^k E_{i0}$$

where E_{i0} = the expenditure or degree of utilization of the i^{th} age and sex group in the base year 0.

b^k = constant for all $i = 1,2, \; .... \; , n.$

The above n equations along with the constraint in the base year,

$$D_{10}^k + D_{20}^k + \; .... + D_{n0}^k = D_{n0}^k = D_{TOTAL,\,0}^k$$

(where $D_{TOTAL,\,0}^k$ is known) form a system of $n+1$ equations and n unknowns. This system is solved simultaneously to obtain D_{i0}^k for all i.

In order to derive estimates of the health manpower required to 1985, the ratio of manpower required in the k^{th} health occupation by the i^{th} age and sex group to the population of that group is assumed to remain constant to 1985:

$$\frac{D^k_{i0}}{P_{i0}} = R^k_i = \frac{D^k_{it}}{P_{it}} \qquad \text{for all } t \text{ to } 1985$$

where P_{it} is the population of the i^{th} age and sex group in year t.

Thus the total manpower demanded in a given health occupation k, in a given year t is calculated in the following way:

$$D^k_{TOTAL,t} = \sum_{i=1}^{n} D^k_{it}$$

where $$\sum_{i=1}^{n} D^k_{it} = \sum_{i=1}^{n} R^k_i \cdot P_{it} \qquad i = 1, 2, \ldots\ldots, n$$

Projection of Teachers

The stocks of the various teaching occupations are a function of a given (current) level of service, as expressed in various student-teacher ratios, and of changes in enrolments. The latter are determined by changes in the composition of the population, and by the propensities of the various age cohorts to attend school.

The required stocks of university teachers to 1985 are based on estimates of the size and changing composition of the university-age population (i.e. the population 15 and over) to 1985, base year age-specific propensities to attend university and base year assumptions regarding the student-teacher ratio. The propensities to attend university by single years of age are derived from base year enrolments and an age distribution of enrolments obtained from the Post-Secondary Student Survey of 1975 for the following types of enrolments: undergraduate full-time, undergraduate part-time, graduate full-time and graduate part-time. Thus for each type of enrolment;

$$r_i = \frac{E_o d_i}{P_{oi}} \qquad i = 15, 16, 17 \ldots\ldots 50+$$

where r_i is the propensity of persons of age "i" to attend university

E_o is total enrolment in the base year 0,

d_i is the proportion of enrolments of persons of age "i",

and P_{oi} is the population of age "i" in the base period 0.

The propensities of the various age cohorts to attend university are assumed to be invariant over time.

Thus, university enrolment by type of program to 1985 is

$$E_t = \sum_i r_i P_{it} \qquad \text{for all } t \text{ to } 1985 \text{ and } i = 15, 16, \ldots\ldots 50+$$

Total enrolments are expressed in full-time equivalents on the basis of 3.75 part-time undergraduates for one full-time undergraduate and 2.5 part-time graduates for one full-time graduate.

The stock of university professors required to 1985 is related to these projected enrolments by means of the base year student-teacher ratio:

$$UT_t = S^{-1} E_t$$

where UT_t is the stock of university professors required in year t

and S is the base year student-teacher ratio.

The total stock requirements of university professors are broken down into the requirements by teaching specialty. (Distributions of professors by teaching specialty are available from the University Full-Time Teaching Staff System, which allows classification of professors into 71 teaching specialties[1], for the academic years since 1971-72).

The projections of post-secondary non-university enrolments are derived using base year enrolments and an age distribution of community college enrolments obtained from the Post-Secondary Student Survey of 1975. The required stocks of teachers are based on these enrolment projections and base year assumptions regarding the student-teacher ratio.

Stock requirements of preschool, Grades 1 - 8 and Grade 9 and over teachers are determined by the size of their respective age cohorts, the base year student-teacher ratio being held constant:

$$T_t = K^{-1} P_t$$

where T_t is the stock of teachers required in period t

K is the base year student-teacher ratio

and P_t is the population of the appropriate age cohort in the year t.

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[1] See Table III-7 under the occupation "University Teaching" for the list of the teaching specialties.

Other Professions

In a few professions, the underlying demand determinants cannot be quite as clearly identified as in the categories of occupations described above. Lawyers, architects and veterinarians are the major examples of such professions, where the approach in estimating demand is more arbitrary and pragmatic. The demand for architects is related to the growth of employment in the construction industry, while the demand for lawyers is linked to the growth of the adult population. Similarly, the demand for the services for veterinarians is tied to demographic factors.

The replacement demand for such independently derived forecasts is also calculated by the general attrition model described in Section 6.

SECTION 4

EMPLOYMENT - - PROJECTION METHOD

Industry Classification

A framework of disaggregated industrial employment estimates was chosen because it permits a more concise assessment of the occupational developments. One important element in the demand for HQM is the change in the industrial structure of the economy. It is therefore an advantage, when projecting HQM demands, to use the finest level of detail possible in estimating future industrial employment trends.

The HQM projection model uses the industrial disaggregation provided in CANDIDE, the econometric model that is used for the employment projections (see below), with some further breakdown of manufacturing and public administration. The CANDIDE employment estimates for manufacturing are split into durable and nondurable manufacturing; those for the service industry are divided into education, health and welfare, services to management, and other services; and those for public administration are split into federal government, and all other public administration. In particular, manufacturing employment, as provided by the Labour Force Survey up to 1975, and as estimated to 1985 by CANDIDE, was split by using the actual Labour Force data on durable/nondurable employment to 1975, and holding the 1975 ratio constant to 1985. Employment in the service industry was divided according to actual Labour Force data to 1975.

From 1975 on the employment shares of the education and health sectors are based on socio-demographic factors, while the shares for the other two sectors are derived residually. The public administration employment was split by using actual Statistics Canada employment data to 1975, and assuming a growth rate for federal public administration employment of one per cent per year for the projection period. The growth of employment in non-federal public administration is derived residually.

Table III-1 provides the SIC categories used in the HQM projection model.

Econometric Employment Projections by Industry

Projections of employment by industry are obtained for the CANDIDE model. CANDIDE is a large econometric model designed to project annual values over the medium term horizon. It is a general purpose model that represents most of the major aggregates shown by Statistics Canada in their publications and used by government departments for policy analysis. Due to its general purpose orientation and the inclusion of some industrial detail, CANDIDE is much larger than most econometric models. Currently, it contains some 2,050 equations, of which 616 are stochastic. The remaining equations are identities, of which some 427 are used to incorporate the input-output sub-models. There are 450 exogenous variables.

TABLE III-1

HQM PROJECTION MODEL -- INDUSTRIAL DISAGGREGATION OF EMPLOYMENT

SIC DIVISION	SIC MAJOR GROUPS	INDUSTRY
1	All	Agriculture
2	All	Forestry
3	All	Fishing and Trapping
4	All	Mines (including Milling) Quarries and Oil Wells
5	8,9,12,13,14,15,16,17	Durable Manufacturing
5	1,2,3,4,5,6,7,10,11, 18,19,20	Non-durable Manufacturing
6	All	Construction
7	4	Utilities (Electric, Gas, Water)
7	1,2,3	Transportation and Communication
8	All	Trade
9	All	Finance, Insurance and Real Estate
10	1	Education
10	2	Health and Welfare
10	5	Services to Business Management
10	4,5,6,7,8	Other Services
11	1	Federal Administration and Defence
11	2,3,4	Other Public Administration

The data and relationships in the CANDIDE model are arranged in sectors that are interdependent (see Chart III-2). Moreover, the variables in all sectors are determined simultaneously; i.e. changes in one sector are simultaneously reflected in others. The model makes use of lagged effects, some of which enter the model directly through lagged variables, while others enter through stocks. The effect whereby the solution values of endogenous variables in a given year are partially determined by the solution values of previous years renders the model dynamic. In addition, a number of the equations are nonlinear, in that the magnitude of a change in any one year depends on the solution values for that particular year.

A particular model solution is predicated on a set of basic assumptions regarding the exogenous variables. The values of these variables are known for historical periods. When making projections, values are assigned to the exogenous variables. While some future values are readily available (mainly in the demographic area), most others, including those related to export markets, have to be assumed. This is done either by taking such values from the output of other models (for example, from models for the U.S. economy), or from detailed studies of a particular government program or commodity market.

A summary of the major CANDIDE sectors and their causal relationships is provided in Appendix I to this volume.

CHART III-2

C A N D I D E   M O D E L

MAJOR DETERMINANTS OF THE INDUSTRIAL STRUCTURE

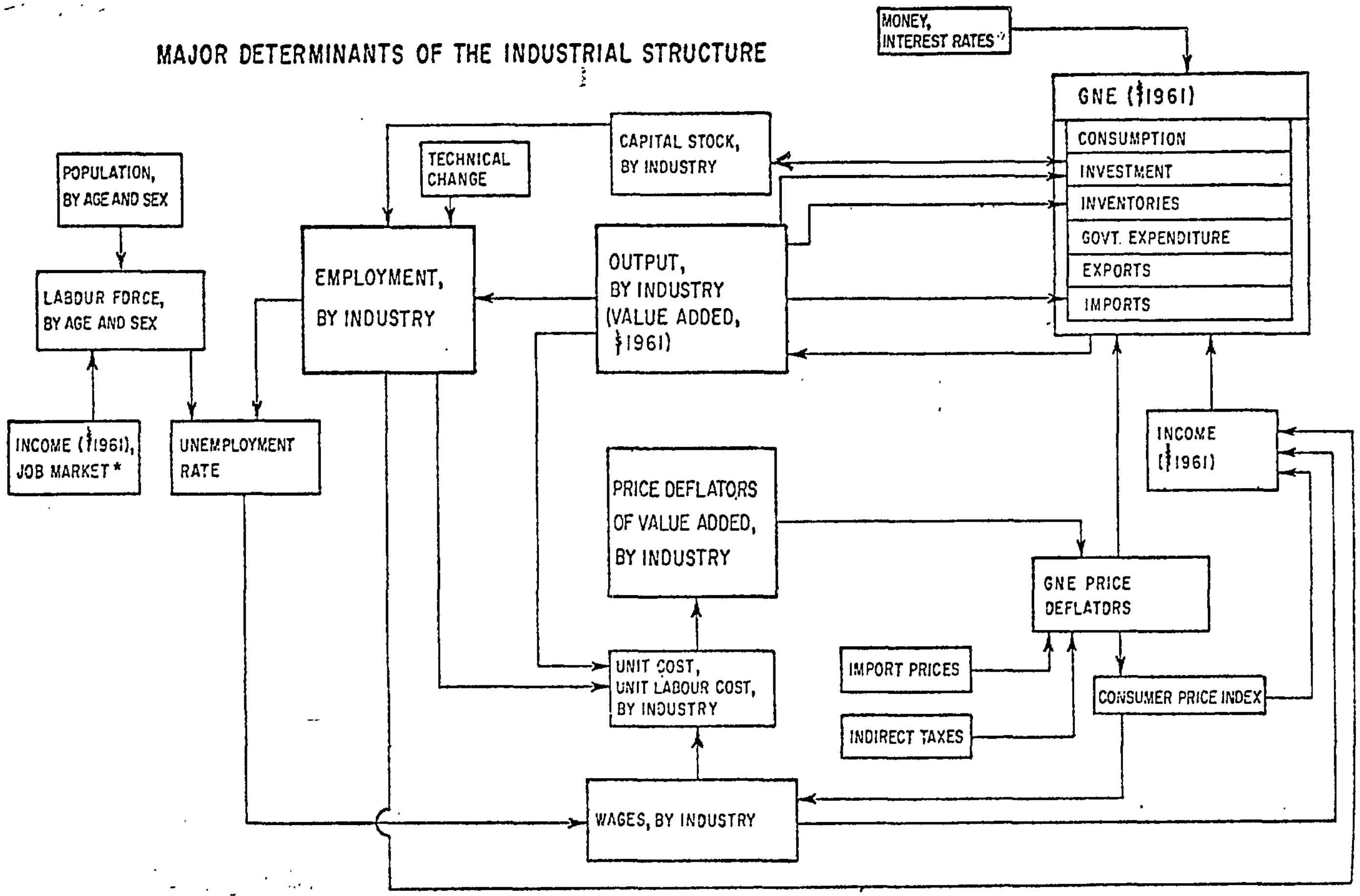

CHART III-2

SECTION 5

OCCUPATIONS -- DEFINITION AND CLASSIFICATION

The occupational definitions used in this projection model are based on the Canadian Classification and Dictionary of Occupations (CCDO) and the 1971 Occupational Classification Manual (OCM)(1) that was used for the 1971 Census and the HQMPS.

The CCDO structure encompasses 23 major groups (specified by a 2-digit code) which are the highest level of aggregation of occupations and represent broad fields of work rather than specific types of work performed. These major groups are sub-divided into 81 minor groups (designated by a 3-digit code) which are in turn disaggregated into 498 unit groups (represented by a 4-digit code). The narrowest category specified in the CCDO classification system is the individual occupation (specified by a 7-digit code) and composed of over 25,000 occupational titles.

A unique feature of this classification system which distinguishes it from previous census classifications is the delineation of the educational and vocational training required within each 7-digit occupational group. In particular, associated with each 7-digit occupation are what are termed "General Educational Development" (GED) and "Specific Vocational Preparation" (SVP) indices. These indices help define those occupational groups which require a university degree.

(1) Although Statistics Canada has provided occupation data, via the census mechanism since 1931, the CCDO was the first attempt to define the qualification required for each occupational group. For an excellent summary of the intercensal occupational definitions, see "Establishing Comparable Census Occupations for Historical Comparisons of Earnings and Other Data" by H.H. Meltz and D.A.A. Stager, Centre for Industrial Relations, University of Toronto, August 12, 1976.

Each 7-digit occupation is assigned a General Educational Development index (GED) which ".... embraces those aspects of education (formal and informal) which contribute to the worker's (a) reasoning development and ability to follow instructions, and (b) acquisition of "tool" knowledges, such as mathematical and language skills. GED is education of a general nature which does not have a recognized, specific occupational objective. Ordinarily, such education is obtained in elementary school, high school, or college; however it is derived also from experience and self-study"(1).

A different interpretation of GED levels in terms of years of schooling is shown in Table III-4 .

TABLE III - 4

LEVELS OF GENERAL EDUCATIONAL DEVELOPMENT, CCDO

Levels	Approximate Duration of Schooling
6	17 years plus
5	13 to 16 years
4	11 to 12 years
3	9 to 10 years
2	7 to 8 years

SOURCE: Department of Manpower and Immigration, CCDO, Vol. 2, p. XV.

(1) Department of Manpower and Immigration, Canadian Classification and Dictionary of Occupations, (henceforth referred to as the CCDO), Vol. 1, Appendix A, p. 1161. For a discussion concerning reading, mathematical and language requirements see P. 1162.

As well as the GED, each occupation is assigned a specific vocational preparation (SVP) index which is: "... measured by the amount of time needed to acquire the information, techniques, and skills needed for average work performance in a specific occupation. This training may be acquired in a school, work, military, or institutional environment, or through vocationally-oriented hobbies. It does not include orientation training required of a worker to become accustomed to the special conditions of a new job for which he is already fully qualified".[1]

In addition, the SVP includes training given in any of the following forms: (a) university or college training where the average four-year university or college curriculum is considered as equivalent to about two years of specific vocational preparation; (b) vocational training; (c) apprenticeship; (d) in-plant training; (e) on-the-job training; and (f) experience in other jobs. The various levels of SVP are shown in Table III-5 below.

TABLE III-5

LEVELS OF SPECIAL VOCATIONAL PREPARATION -- CCDO

Level	Period of Preparation
1	Short demonstration only
2	Anything beyond short demonstration up to and including 30 days.
3	Over 30 days up to and including 3 months

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[1] Department of Manpower and Immigration, CCDO, Vol. 1. p. 1163.

TABLE III-5 (cont'd)

Level	Period of Preparation
4	Over 3 months up to and including 6 months
5	Over 6 months up to and including 1 year
6	Over 1 year up to and including 2 years
7	Over 2 years up to and including 4 years
8	Over 4 years up to and including 10 years
9	Over 10 years

SOURCE: Department of Manpower and Immigration, CCDO, Vol. 1, Appendix A, Sec. II, p. 1163

The GED and SVP indices provide the basis for defining a highly-qualified manpower occupation. The model calculations are carried out at the 4-digit occupational level, since the 1971 Census does not provide the necessary tabulations at higher-digit aggregations. For this reason, the GED/SVP levels for the 4-digit groups are averages of the levels pertaining to the 7-digit job titles, as provided in the CCDO.

Table III-6 shows the average levels of GED/SVP for 4-digit occupational groups, and the number of 7-digit occupational groups contained in each 4-digit group.

It should be noted that the CCDO occupational titles and code numbers were used only as a framework for the Occupational Classification

Manual (OCM), and, in fact, there are several differences between these two systems[1]. For this reason, the 4-digit occupations used here refer to the OCM and not the CCDO occupational classes. Thus, each CCDO occupation was examined to assure consistency, since the 1971 Census data are based on the OCM. In cases where the GED/SVP was not provided in the CCDO, estimates were made as to whether or not the occupation in question should be classified as HQM. Those occupations with an average GED/SVP of less than 12 were also examined to determine their possible HQM content. For example, elementary and pre-school teachers were classified as HQM, although the average GED/SVP was only 11. Because of educational upgrading, all future elementary and pre-school teachers require a degree.

The generally accepted definition for an HQM occupation is a GED/SVP index of 12 or higher. Table III-7 shows the grouping of all HQM occupations, classified in such a way that the data can be linked with employment by industry on the one hand and field of study on the other.

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(1) The document entitled "Classification Discrepancies Between the 1971 Occupational Classification Manual (OCM) and the 1971 Canadian Classification and Dictionary of Occupations (CCDO)" which was prepared for the seminar on Occupational Research, Statistics Canada, March, 1976, discusses the major differences between the two manuals.

TABLE III-6

LIST OF 4-DIGIT OCCUPATIONS,
WITH AVERAGE GED/SVP LEVELS AND NUMBER OF 7-DIGIT GROUPS

Aggregate Occupation	OCM No.	4-Digit Occupations	CCDO GED/SVP Average	Number of 7-Digit CCDO Groups
HEALTH	3113	Dentistry	14	7
	3111	Medicine	15	18
	3151	Pharmacist	13	3
	3130	Nursing, Supervisors	12	1
	3131	Nursing, Graduate	12	10
	3137	Rehabilitation Therapists	12	4
	1134	Health Administration	12	7
	3117	Osteopaths & Chiropractors	12	2
	3119	Health Diagnosing	12	2
	3153	Optometrists	12	1
	3133[1]	Nurses-in-Training	-	-
	3134	Nursing Assistants	8	1
	3135	Nursing Aides and Orderlies	7	2
	3139	Nursing, Therapy and Related Assisting Occupations, n.e.c.	8	7
	3154	Dispensing Opticians	10	1
	3155	Radiological Technologists and Technicians	11	3
	3156	Medical Laboratory Technologists and Technicians	11	7
	3157	Dental Hygienists, Assistant and Technicians	9	19
	3159	Other Occupations in Medicine and Health, n.e.c.	8	16
ENGINEERING	2141	Architecture	14	2
	2142	Chemical Engineering	14	2
	2143	Civil Engineering	14	13
	2144	Electrical Engineering	13	12
	2147	Mechanical Engineering	13	9
	2151	Metallurgical Engineering	13	1
	2155	Aeronautical Engineering	13	7
	2153	Mining Engineering	13	1
	2154	Petroleum Engineering	13	3
	2145	Industrial Engineering	13	8
	2157	Nuclear Engineering	14	1
	2159	Architects & Engineers, n.e.c.	13	13

TABLE III-6 (cont'd)

Aggregate Occupation	OCM No.	4-Digit Occupations	CCDO GED/SVP Average	Number of 7-Digit CCDO Groups
ENGINEERING (cont'd)	2160 [1]	Supvrs. Other Eng. & Arch.	--	3
	2161	Surveyors	11	4
	2163	Draughtsmen	10	20
	2165	Architectural and Engineering Technologists and Technicians	11	14
	2169	Other Occupations in Architecture and Engineering, n.e.c.	11	6
LIFE SCIENCES	3115	Veterinary Medicine	14	1
	3152	Dietetics and Nutrition	12	5
	2131	Agriculture and Related	14	7
	2133	Biology and Related	14	26
	2135	Life Science Technologists and Technicians	10	14
	2139 [2]	Occupations in Life Sciences n.e.c.	14	2
PHYSICAL SCIENCE & MATH	2112	Geology	14	8
	2114	Meteorology	14	1
	2111	Chemistry	14	7
	2113	Physics	14	15
	2181	Mathematicians, Statisticians, Act.	13	12
	2189	Occs. in Math, Stats., System Anal.	12	2
	2183	Computer Programming and Related	12	6
	2117	Physical Sciences Technologists and Technicians	10	18
	2119	Occupations in Physical Sciences n.e.c.	11	5
HUMANITIES & FINE ARTS	2511	Ministers of Religion	14	2
	2513 [3]	Nuns and Brothers	--	--
	2519	Occs. in Religion, n.e.c.	13	3
	2350	Supvrs. Library, Museum & Arch. Sc.	13	4
	2351	Librarians & Archivists	12	6

TABLE III-6 (cont'd)

Aggregate Occupation	OCM No.	4-Digit Occupations	CCDO GED/SVP Average	Number of 7-Digit CCDO Groups
HUMANITIES & FINE ARTS (cont'd)	3355	Translation	12	4
	3311	Painters, Sculptors, Artists	12	4
	3313	Product & Interior Design	12	21
	3314	Advertising & Illustration Artists	12	10
	3330	Producers and Directors, Arts	13	14
	3332	Musicians	12	11
	3333	Choreographers and Dancers	12	2
	3352[4]	Writers and Editors	12	7
	3315	Photographers and Cameramen	10	15
	3319	Occupations in Fine and Commercial Art, Photography and Related Fields, n.e.c.	8	23
	3335	Actors	11	5
	3337	Radio and Television Announcers	11	6
	3339	Occupations in Performing and Audiovisual Arts, n.e.c.	9	21
	3359	Occupations in Writing, n.e.c.	9	5
	3370	Coaches, Trainers, Instructors, and Managers, Sport & Recreation	10	16
	3371[4]	Referees and Related Officials	8	15
	3373[4]	Athletes	9	4
	3375[4]	Attendants, Sport and Recreation	6	17
	3379[4]	Others in Sport and Recreation, n.e.c.	8	6
	2353	Technicians in Library, Museum and Archival Sciences	11	7
	2359[2]	Occupations in Library, Museum and Archival Sciences, n.e.c.	12	3
EDUCATION	2711	University Teachers	14	12
	2731[5]	Elementary and Preschool	11	3
	2733	Secondary School Teachers	12	2
	2739[4,5]	Other Elementary and Secondary	--	1

TABLE III-6 (cont'd)

Aggregate Occupation	OCM No.	4-Digit Occupations	CCDO GED/SVP Average	Number of 7-Digit CCDO Groups
EDUCATION (con'd)	2391	Counselling and Guidance	13	4
	2795	Spec. Educ. Excep. Children	12	5
	1133	Education Administrators	13	9
	2791	Community Coll. & Voc. Teachers	12	6
	2792	Fine Arts Teachers	12	5
	2793	Post-Secondary Teachers, n.e.c.	13	3
	2719	University Teachers and Related n.e.c.	12	2
	2797	Instructors and Training Officers, n.e.c.	11	11
	2799	Other Teaching and Related Occupations, n.e.c.	10	7
LAW	2341	Judges and Magistrates	15	1
	2343	Lawyers and Notaries	13	3
COMMERCE, ADMINISTRATION, GOVERNMENT	1111	Members Legislative Bodies	--	3
	1113	Government Administration	13	6
	1115	Postmasters	12	2
	1116	Inspectors & Reg. Off. Gov't	11	16
	1119	Officials & Admin. Unique to Gov't	11	24
	1130	Gen. Mgrs. & Other Sr. Officials	14	10
	1131	Mgt. Occs. Nat. Sc. & Eng.	13	6
	1132	Mgt. Occs. Soc. Sc. & Rel.	13	4
	1135	Financial Mgt. Occs.	13	6
	1136	Personnel and Ind. Rel. Mgt. Occs.	13	2
	1137	Sales & Advertising Mgt. Occs.	13	4
	1141	Purchasing Mgt. Occs.	12	2
	1142	Service Mgt. Occs.	12	6
	1143	Production Mgt. Occs.	13	3
	1145	Mgt. Occs. Const. Oper.	13	2
	1147	Mgt. Occ. Trans. & Comm.	13	13
	1149	Other Mgrs. & Admin., n.e.c.	13	11
	1174	Personnel and Rel. Off.	12	7
	1175	Purchasing Off. & Buyers & Trade	12	4
	1176	Inspectors & Rel. Off. Non Gov't	10	15
	1179	Occs. Rel. to Mgt. & Admin.	11	18

TABLE III-6 (cont'd)

Aggregate Occupation	OCM No.	4-Digit Occupations	CCDO GED/SVP Average	Number of 7-Digit CCDO Groups
COMMERCE, ADMINISTRATION, GOVERNMENT	1171	Accounting	12	21
	5131	Technical Sales	12	12
	5170	Super. Sales & Serv.	11	5
	6116 [1]	Commissioned Officers	--	--
	7131	Farm Management	11	3
SOCIAL SCIENCES	2331	Social Work	13	6
	2399	Other Occs. Soc. Sc. & Rel. n.e.c.	12	4
	2351	Psychologists	14	11
	2311	Economists	14	13
	2313	Sociologists, Anthropologists and Related	14	2
	2319	Occs. Soc. Sc. n.e.c.	13	7
	2333	Occs. in Welfare and Community Services	10	5
	2339	Occs. in Social Work and Related Fields, n.e.c.	8	3
	2349	Occs. in Law and Jurisprudence, n.e.c.	11	8

NOTES:

1. No GED/SVP were provided for these groups.
2. The 7-digit occupations classified in the CCDO were not equivalent to the 7-digit occupations in the OCM. For these groups, the occupations defined in the OCM were designated as non-HQM.
3. These groups were not classified in the CCDO but were contained in OCM.
4. These occupations were classified as 3353, 3710, 3711, 3713, 3715, 3719 in the CCDO, but 3352, 3370, 3371, 3373, 3375, 3379 in OCM respectively.
5. These groups were defined as HQM because of institutional requirements.
6. All management groups were designated as HQM.

SOURCE:

Department of Manpower and Immigration, CCDO, Vol. 1, and DBS, Occupational Classification Manual, (prepared for the 1971 Census).

TABLE III-7

HQM PROJECTION MODEL - - CLASSIFICATION OF HQM OCCUPATIONS

MAJOR GROUP	OCM NUMBER	OCCUPATION
Health	3113	Dentistry
	3111	Medicine
	3151	Pharmacy
	3130-31	Nursing
	3137	Rehabilitation Therapy
	1134	Health Administration
	3117-19-53	Other HQM Health
Engineering	2141	Architecture
	2142	Chemical Engineering
	2143	Civil Engineering
	2144	Electrical Engineering
	2147	Mechanical Engineering
	2151	Metallurgical Engineering
	2155	Aeronautical Engineering
	2153	Mining Engineering
	2154	Petroleum Engineering
	2145	Industrial Engineering
	2157-59	Engineering n.e.c.
Life Sciences	3115	Veterinary Medicine
	3152	Dietetics and Nutrition
	2131	Agriculture and Related
	2133	Biology and Related
Physical Sciences and Mathematics	2112	Geology
	2114	Meteorology
	2111	Chemistry
	2113	Physics
	2181-89	Mathematics
	2183	Computer Sciences
Humanities and Fine Arts	2511-13-19	Religion
	2350-51	Library and Archival
	3355	Translation
	3311-13-14-30-32-33-52	Other HQM Humanities and Fine Arts

MAJOR GROUP	OCM NUMBER	OCCUPATION
Education	2711	University Teaching
		Dentistry
		Medicine
		Pharmacy
		Nursing
		Rehab Therapy
		Health Adm. & Other
		Medical Research
		Architecture
		Chemical Engineering
		Civil Engineering
		Electrical Engineering
		Mech., Aero. Engineering
		Metall. Engineering
		Mine., Geol. Engineering
		Indust. & Other Engineering
		Agric. Engineering
		Veterinary Medicine
		Dietetics
		Agriculture
		Forestry
		Biochemistry
		Biology
		Botany
		Zoology
		Household Sci.
		Agric., Bio. Sci.
		Geol., Metro., Ocean.
		Chemistry
		Physics
		Mathematics
		Computer Sciences
		Metallurgy
		Other Math., Phys.
		Theology
		Library, Archiv.
		Translation
		Fine, Applied Arts
		History
		English
		French
		Mod. Languages
		Classics, Philos.
		Other Humanities
		Secondary School Teaching
		Elementary School Teaching
		Education Admin.
		Counselling
		Special Education
		Other Teaching
		Educ. Psychology
		Other non-teaching Ed.
		Education, Other
		Law

MAJOR GROUP	OCM NUMBER	OCCUPATION
		Accounting
		Commerce, Admin.
		Social Work
		Clinical Psych.
		Psychology (other)
		Economics
		Anthrop., Archaeol.
		Geography, Env. Stud.
		Pol. Sci.
		Sociol., Demog. Crimin.
		Linguistics
		Other Soc. Sciences
	2731	Elementary and Pre-School
	2733	Secondary School
	2791	Community College Teaching
	2719-39-92 93-95 and 2391 and 1133	Other HQM Education
Law	2341-43	Law
Commerce, Administration and Government	1111-13-15-16-19	Government Officials and Administrators
	6116	Commissioned Officers
	1130-31-32-35-36-37-41-42-43-45-47-49	General Administration
	1174-75-76-79	Related Management Occupations
	1171	Accounting
	5131	Technical Sales
	5170	Supervising - Sales and Services
	5173	Sales, Securities
	7131	Farm Management
Social Sciences	2331-99	Social Work
	2315	Psychology
	2311	Economics
	2313	Sociology, Anthropology and Related
	2319	Other Social Sciences and Related n.e.c.

SECTION 6

ATTRITION ESTIMATES

The Attrition Model

The attrition model generates estimates of the replacement demand for highly qualified manpower by taking perpetual inventory of the stocks by age, sex and occupation and subjecting them to the risks of attrition - mortality, retirement and emigration. The inventory is based on the age and sex distribution of employment within each HQM occupation in the base year and assumptions pertaining to mortality rates, emigration, retirement rates and the age-sex distribution of new entrants. This section describes both the underlying assumptions and the method involved in the calculation of the demand due to attrition.

The analysis is carried out at an extremely fine level of detail, with regard to the number of occupations, and the age-sex composition by single years of age. For this reason, all input data files are obtained in machine-readable form, directly from the various survey sources. Base-year information on the number of persons in most occupations other than those in the health and education fields are from the 1971 Census. The health and education numbers are obtained from Statistics Canada administrative records, not only for the base-year (usually 1971) but also for more recent years. The number, and distribution by specialization, of university professors is from the Statistics Canada

"University Full-Time Teaching Staff System".

The information on the base year age-sex distribution for most occupations is obtained from the 1971 Census, while the distribution for university teachers, relating to the year 1975, is from the above Statistics Canada university files.

Basic Assumptions

Mortality assumptions are based on the most recent information available, and relate to single-year age-sex groups. One set of mortality rates serves for all occupations, and the rates are the same for all years to 1985. This is a common type of assumption in recent demographic studies, since there appears to have been relatively little change in recent mortality behaviour to warrant different assumptions. Not enough information is available to ascertain whether death rates for the various HQM occupations differ significantly from each other.

The overall level of emigration to all countries is assumed to be 80,000 a year, for each year to 1985. Of the total, emigration from HQM occupations is estimated, by reference to U.S. immigration records, to be at approximately 10,000 a year. The occupational and sex distribution of emigrants from HQM occupations is assumed to be the same as that of the Canadian labour force in 1971. The age distribution of emigrants is based on a recent Statistics Canada study[1].

[1]Statistics Canada, Technical Report on Population Projections for Canada and the Provinces, 1972-2001, Cat. No. 91-516, p.218; and Statistics Canada, 1971 Census, Occupations by Sex and Age, Cat. No. 94-723.

A lower age bound of 25 years is assumed for emigrants leaving HQM occupations. These assumptions are held constant over the projection period.

Age, sex and occupation-specific net withdrawal rates for 10 male and 4 female occupational groups are derived for those aged 55 and over, using a method similar to that by which working life tables are calculated. The 1971 Census provides stock estimates by single years of age, sex and occupation. For each occupation group "participation rates" by single years of age and sex are calculated by standardizing the 1971 stock numbers to the 1971 population by single years of age and sex. These rates are applied to the respective age and sex groups of a stationary population[1] to obtain the number of persons from a specific cohort who are in a given occupational group at each successive age. The difference in the stock of age i and the stock of age $i + 1$ in a given occupation is assumed to be due to the effects of mortality, retirement and emigration:

$$S^{k}_{i+1,\, j,\, t+1} = S_{ijt}\,(1 - d_{ij})(1 - r^{k}_{ij}) - E^{k}_{ij}$$

Given the stock estimates derived from the "participation rates" and the stationary population, the above equation can be solved for r^{k}_{ij}, withdrawal rate. The withdrawal rates are held constant to 1985[2].

[1] The stationary population comprises the number of persons who will be alive and in Canada at different ages out of an original group of 100,000 born alive. In practice, two stationary populations are calculated - one for males and one for females. They are computed using mortality rates and emigration estimates consistent with the assumptions of the attrition model.

[2] See next page for an explanation of the symbols

The total number of new entrants into an occupation each year is the sum of (a) the growth in the required stock of persons; and (b) the demand for replacements due to the various types of attrition noted above. The age-sex distribution of such new entrants into each HQM occupation is based on the HQM post-censal survey.

Method

The existing stocks in the base period 0 are subjected to the risks of mortality, withdrawal and emigration appropriate to their age, sex and occupation. The decrease this causes in the overall stock level by occupation is the demand due to attrition at the beginning of period 1. Algebraically this can be expressed in the following way:

$$D^k_{R_1} = \sum_i \sum_j S^k_{ijo} \, (d_{ij})(r_{ij}{}^k) + E^k_{ij}$$

where $D^k_{R_1}$ is the replacement demand in the k^{th} occupation in period 1

S^k_{ijo} is the stock in the k^{th} occupation of age i and sex j in the base period 0

d_{ij} represents the mortality rate of persons of age i and sex j

r^k_{ij} is the withdrawal rate of persons in the kth occupation of age i and sex j

E^k_{ij} is the number of emigrants from the k^{th} occupation of age i and sex j.

The new entrants by single years of age, sex and occupation in period 1 are added to the age, sex and occupation-specific stocks remaining from period 0. These new stocks are, in turn, subjected to the various risks of attrition, producing estimates of replacement demanded by each occupation in period 2. The process is reiterated to the end of the projection period.

SECTION 7

UNIVERSITY DEGREE REQUIREMENTS FOR NEW ENTRANTS

An analysis of Census data shows that, first, not all HQM jobs are filled with university graduates, and, second, the proportion of HQM jobs in a given occupational classification filled by university graduates is changing. Naturally, the demand for university graduates is sensitive to the magnitude and direction of these changes. For simulation purposes three variants are posited: (1) the percentage of persons with a university degree in a given HQM occupation is held constant at the 1971 level; (2) all HQM jobs becoming available over the projection period are assumed to be filled by university graduates and (3) the proportion of jobs filled by university graduates is raised, either by assuming it to be fixed at a higher than the 1971 level, or by allowing it to rise gradually over the projection period.

Rising trends in such proportions are calculated on the basis of 1971 Census data using a quasi-longitudinal approach. In particular, in a given occupation, the percentage of university graduates in the age group 25-34 is assumed to be representative of the degree-non-degree composition of new entrants in 1971, and the percentage of university graduates in the 35-44 age group is assumed to be indicative of the composition of new entrants in 1961.

For the purpose of determining the degree-nondegree composition of new entrants, the HQM occupations are divided into four categories. The first consists of those HQM occupations in which it is assumed that, because of regulated entry into the profession and the strict educational requirements, all or a constant proportion of available jobs are filled by university graduates. These occupations are assigned constant coefficients to 1985. The second category consists of all HQM occupations in which the percentage of jobs filled by university graduates declined from the 35-44 age group to the 25-34 age group. In the absence of any data to substantiate a continued decline or foretell an eventual increase, the coefficients for these occupations are assumed to remain constant at the 1961 level up to 1985. The third category consists of those HQM occupations in which the percentage of university graduates increased from the 35-44 age group to the 25-34 age group. In these occupations it is assumed that the proportion of university graduates will increase as a function of time. Logit equations, which approximate an "S" shaped curve, are used to derive the coefficients.

Letting y_{it} be the percentage of jobs filled by people with university degrees in the i^{th} HQM occupation in the t^{th} time period (t=1 for 1961 t=11 for 1971) the logit equation can be written:

$$(1) \qquad \frac{Y_{it}}{1-Y_{it}} = e^{a_i+b_i t} \qquad \text{for } t=1,\ 11 \text{ and } i=1,\ 2,\ldots\ldots,\text{QCC}$$

In order to obtain values for 'a' and 'b' it is necessary to transform the above equation into linear form. Taking the natural logarithm of both sides gives:

$$\ln\left(\frac{y_{it}}{1 - y_{it}}\right) = a_i + b_i t,$$

Letting $t=1$ and $t=11$, two equations of the above form are obtained for each 'i' (i.e, for each HQM occupation). These equations are solved simultaneously to derive values for a and b using the following formula (in matrix notation):

$$(2) \quad \hat{B}_i = (T'T)^{-1}T'Y_i$$

where $\hat{B}_i = \begin{bmatrix} \hat{a}_i \\ \hat{b}_i \end{bmatrix}$, $T = \begin{bmatrix} 1 & 1 \\ 1 & 11 \end{bmatrix}$,

and $Y_i = \begin{bmatrix} \ln\left(\frac{y_{it}}{1 - y_{it}}\right) \\ \ln\left(\frac{y_{it}}{1 - y_{it}}\right) \end{bmatrix}$.

Equation (2) is the least squares estimator of B_i (i.e. a_i and b_i). Since this estimation equation involves only two points, t_1 and t_{11}, the measures of standard error are all equal to zero and the coefficient of determination equals one. Using the values for $\hat{a}_i$ and $\hat{b}_i$ derived from the above equation, y_{it} is calculated from equation (1) for each occupational classification for the years 1971 to 1985.

The fourth category comprises all non-HQM jobs as well as the residual group "All other OCM codes". The percentage of university graduated employed in these occupations is not an indication of a demand for university graduates, since these occupations have a GED/SVP of less than that required for HQM occupations. They were assigned coefficients of zero.

SECTION 8

FIELD OF STUDY - DATA SOURCE AND CLASSIFICATION

Data Source

Unlike the numerous potential occupational data sources, there is only one source which provides estimates of the stock of university graduates classified on the basis of educational attainment. This is the Highly Qualified Manpower Post-Censal Survey (HQMPS) which was carried out in September of 1973 by Statistics Canada, in co-operation with the Ministry of State for Science and Technology.(1) From this Survey, the Ministry was able to obtain 1973 estimates of the educational qualifications of those graduates who reported a university degree in the 1971 Census. This survey does not provide a complete 1973 stock picture, since it excludes those persons who received undergraduate degrees between June 1, 1971 and September of 1973, and those persons who died, emigrated or immigrated during this time period. As well, it only includes those persons who were classified as permanent residents on June 1st, 1971.

Classification

Table III- 8 provides a detailed specification of the 92 Field of Study Classifications which are available from the HQMPS. These 92 fields are rearranged into the disciplinary groups shown in Table III- 9, to generate a list of disciplines which display the best possible match with the HQM occupational groups defined in Section 5 . These sub-groups

(1) Copies of the Survey Methodology and data tapes can be obtained from the Educational Science and Culture Division of Statistics Canada.

are further aggregated into the fields of specialization shown in Column 1, Table III- 9.

The Occupation by Education Arrays

The basis for these tables is the tabulation of the number of persons in a given occupation by level and type of university degree. Depending on the direction of the normalization, tables of coefficients can be generated showing the distribution of degree holders in a given field of study and degree level by the various occupations, or the distribution of the incumbents in a given occupation by level and type of degree. The latter kind of array is used in the projection model to estimate the demand for university graduates by level and field of study, based on occupational projections (See Section 3). Two arrays are constructed - one for all HQM occupations except university teaching and a second for university professors where occupation is defined as teaching specialty. The definition of these arrays is derived from the occupation classifications in Table III-7, and the field of study classification in Table III- 9.

For the majority of the occupations in the first array, the field of study and degree level distributions are derived from the 1973 HQMPS. However, for occupations where there are institutional barriers to entry the field of study distribution is restricted to the relevant field(s) of study with the degree level distribution held constant as reported in the 1973 HQMPS. In both cases, the reference population is the labour force under the age of 35 in 1971. The under 35 group is selected because it was felt to be more representative of new entrants than the total population. However, in certain occupations (notably those dealing with administration) where experience is an important factor in the obtainment of the position, the total HQM population is used as the reference group. The field of study is defined as that of the last highest degree obtained by 1971.

The occupation by education array for university professors is deduced from two distributions; the 1975 field of teaching distribution for university professors obtained from the Statistics Canada University Full-Time Teaching Staff System, and the 1973 field of study for all university professors from the HQMPS data base. The distribution of new entrants into the university teaching profession by degree level is determined by estimating the total attrition by field of specialty and degree level over the period 1971/72 to 1974/75, and comparing this with the total change in stocks over the same period. The distribution of new entrants by degree level over the years 1971-72 to 1974-75 is assumed to be invariant over the projection period.

TABLE III- 8

HQMPS FIELD OF STUDY CLASSIFICATION

CODE[1]	FIELD OF STUDY	CODE[2]
0	General Arts - No Major Field	00
1	Elementary and Pre-School Education	01
2	Special Education For Exceptional Children	02
3	Physical Education, Recreation and Related	03
4	Teaching Art, Commerce, Vocational Subjects	04
5	Secondary Education	05
6	Teaching Fields, n.e.s.	06
7	Counselling and Guidance in Schools	07
8	Education Administration and Organization	08
9	Educational Psychology	09
10	Education in General	10
11	Other Non-Teaching Fields Related to Education	11
12	Fine and Applied Arts	12,14
13	Music	13
15	Classics and Classical Languages	15
16	History	16
17	Library and Archival Sciences	17
18	English	18
19	French	19
20	Other Modern Languages and Literature	20
21	Philosophy	21
22	Theology and Religion	22

TABLE III- 8 (cont'd)

CODE[1]	FIELD OF STUDY	CODE[2]
23	Translation and Interpretation	23
24	Journalism, Creative Writing, Humanities, n.e.s.	24
25	Institutional Admin. (Except School and Health)	25
26	Agricultural Economics	26
27	Anthropology	27
28	Archaeology	28
29	Area Studies (Canadian, Mediaeval, Asian, etc.)	29
30	Commerce, Management and Administration	30,32,33
31	Accounting	31
33	Hospital and Health Administration	25
34	Criminology	34
35	Economics	35
36	Geography	36
37	Law	37
38	Linguistics	38
39	Environmental Studies (Urban Planning, etc.)	39
40	Political Science	40
41	Clinical Psychology	41
43	Psychology (Except Clinical and Educational)	42,43
44	Public Administration	44
45	Secretarial Science	45
46	Social Work	46
47	Sociology (Including Demography)	47
48	Social Science, n.e.s.	48

TABLE III- 8 (cont'd)

CODE[1]	FIELD OF STUDY	CODE[2]
49.	Agriculture	49
50	Biochemistry	50
51	Biology	51
52	Botany	52
53	Dietetics and Nutrition	53
54	Forestry	54
55	Household Science and Related, n.e.s.	55
56	Veterinary Medicine and Veterinary Sciences	56
57	Zoology	57
58	Aeronautical Engineering	58
59	Agricultural Engineering	59
60	Architecture	60
61	Landscape Architecture	61
62	Biomedical Engineering	62
63	Chemical Engineering	63
64	Civil Engineering	64
65	Electrical Engineering	65
66	Engineering Physics and Science	66
67	Geological Engineering	67
68	Industrial Engineering	68
69	Mechanical Engineering	69
70	Metallurgical Engineering	70
71	Mining Engineering	71
72	Petroleum Engineering	72
73	Engineering, n.e.s.	73

TABLE III- 8 (concluded)

CODE[1]	FIELD OF STUDY	CODE[2]
74	Dentistry	74
75	Basic Medical Sciences (Biochemistry, Pharmacology, etc.)	75
76	Medicine	76
77	Medical Specialties (e.g., Internal, Psychiatry)	77
78	Paraclinical Medical Science (e.g. Immunology, Virology)	78
79	Surgery, Surgical Specialties	79
80	Nursing	80
81	Pharmacy	81
82	Public Health and Hygiene	82
83	Rehabilitation, Occupational and Physical Therapy, Audiology	83
84	Optometry, Medical Technology, Other Health	84
85	Astronomy and Astrophysics	85
86	Chemistry	86,87,88,89
90	Computer Science	90
91	Geology and Related, n.e.s.	91
92	Mathematical Statistics	92
93	Mathematics (Including Operational, Research, Actuarial)	93
94	Metallurgy and Materials Science	94
95	Meteorology	95
96	Oceanography	96
97	Physics	97
98	General Science - No Major	98

Source: Statistics Canada, Highly Qualified Manpower Post-Censal Survey.

Notes:

[1] These Codes and Field of Study correspond to the list as provided in the Post-Censal Survey Data Dictionary

[2] Codes in this column refer to the Post-Censal Survey Questionnaire

TABLE III - 9

FIELD OF STUDY CLASSIFICATION

Aggregate Group	Description	HQM Category Numbers*
Health	Dentistry	74
	Medicine	76,77,79
	Pharmacy	81
	Nursing	80
	Rehabilitation Medicine	83
	Health Administration	33
	Med. & Paraclinical Sciences	75,78
	Other Health	82,84
Engineering	Architecture	60
	Chemical	63
	Civil	64
	Electrical	65
	Mechanical	69
	Metallurgical	70
	Aeronautical	58
	Mining & Geological	71,67
	Petroleum	72
	Industrial	68
	Agricultural	59
	Other Engineering	61,62,66,73
Life Sciences	Veterinary Medicine	56
	Dietetics and Nutrit.	53
	Agriculture	49
	Forestry	54
	Biochemistry	50
	Biology	51
	Botany	52
	Zoology	57
	Household Science	55
Physical Sciences and Mathematics	Geology	91
	Meteorology	95
	Chemistry	86
	Physics	97,85
	Mathematics	92,93
	Computer Science	90
	Metallurgy and Materials Science	94
	Oceanography	96
	General Sciences - No Major	98

TABLE III - 9 (continued)

Aggregate Group	Description	HQM Category Numbers*
Humanities and Fine Arts	Theology	22
	Library and Archival Science	
	Translation	23
	Fine and Applied Arts	12,13
	History	16
	English	18
	French	19
	Modern Languages	20
	Classics and Philosophy	15,21
	Journalism, Creative Writing and Humanities NES	24
Education	Secondary	5
	Elementary	1
	Educational Admin.	8
	Counselling	7
	Special Education	2
	Other Teaching Fields	3,4,6
	Educ. Psychology	9
	Other Non-Teaching Fields	10,11
Law	Law	37
Commerce, Administration, & Accounting	Accounting	31
	Commerce & Admin.	25,30,44,45
Social Sciences	Social Work	46
	Clinical Psychology	41
	Psychology (Other)	43
	Economics	26,35
	Anthropology, Archaeology, Area Studies	27,28,29
	Geography and Environ. Studies	36,39

TABLE III - 9 (concluded)

Aggregate Group	Description	HQM Category Numbers*
Social Sciences (cont'd)	Political Science	40
	Sociology, Demography Criminology	34,47
	Linguistics	38
	Other Social Sciences	48
General Arts	General Arts	0

*These categories are defined in the Highly Qualified Manpower Survey Data Dictionary.

APPENDIX I

Summary of CANDIDE

This summary is included here to help the user of the HQM model in understanding the way in which the employment projections were derived. It is basically written for those who may have no more than a passing knowledge of econometric models. Detailed documentation on the model used (CANDIDE) is contained in two series of Economic Council of Canada's publications[1]. The discussion presented here deals with the major CANDIDE sectors and their causal relationships, and is based on the two Economic Council publications.

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(1) See M.C. McCracken, An Overview of CANDIDE Model 1.0, CANDIDE Project Paper No. 1, published by Economic Council of Canada for the Interdepartmental Committee of CANDIDE, Information Canada, Ottawa, 1973. (There are 15 detailed studies dealing with various aspects of the CANDIDE Model). See also: CANDIDE Model 1.1, Project Paper No. 18, edited by R. Bodkin and S. Tanny, Economic Council of Canada, 1975.

Exogenous Variables

Table III-2 provides a classification of the exogenous variables in CANDIDE Model 1.1. Table III-2 shows that there are a number of dummy variables and several types of time trends that attempt to capture the influence of unusual historical circumstances, such as unusual crop years, and the presence of a centennial year, 1967.

TABLE III-2

Classes of Formal Exogenous Variables in CANDIDE Model 1.1

Class	Description	Number of Variables
I	Dummies (including time trends)	51
II	Foreign trade variables	
	1 Exports -- flows and adjustment items	27
	2 Foreign trade prices	58
	3 Imports -- fuel flows and adjustment items	11
III	International financial transactions (including the exchange rate)	8
IV	Capital stock characteristics (scrappage levels)	84
V	Policy variables (instruments)	
	1 Government expenditures on transfers and goods and services	32
	2 Monetary variables	2
	3 Tax rates and government revenues	62
VI	Demographic variables (underlying magnitudes)	46
VII	Real income variables and overseas economies	3
VIII	U.S. economy	
	1 Wharton Model variables	21
	2 Others	2
IX	Miscellaneous exogenous variables	
	1 Adjusting items	28
	2 Others (excluding REZ)	18
	Total	453

Canada has an open economy that is influenced by events occurring in foreign economies; these influences are represented by exogenous variables. The great majority of the variables pertaining to the U.S. economy are generated by the Wharton Annual and Industry Forecasting Model. Other exogenous variables are foreign trade prices, foreign income, and certain foreign trade flows, particularly on the exports side. The exogenous foreign trade prices include a number of export prices and Canadian wholesale prices.

There are also a number of international financial variables, including the exchange rate,at least during fixed periods, that are not explained in the financial flows sector but are taken as exogenous to the model. (The exchange rate could be regarded as an important policy variable).

Two classes of exogenous variables account for two sets of stock variables -- population, and capital stocks. Such underlying magnitudes as the general fertility rate of women of child-bearing age, marriage, divorce, and death rates appear as fundamental inputs into the demographic sector. A number of other demographic variables relating to school and university enrolments, and to household formation, also appear in this group, as well as the primary participation rate of males aged 25 through 54. The scrappage levels of specific stock series are the only exogenous inputs required to account for the levels of the relevant capital stock series. The levels of gross investment, which are analogous to births for human populations, are generated within the business fixed investment sector as a set of endogenous variables.

The exogenous policy variables or instruments are the most interesting set of variables because, in principle, they are under the control of the policy-makers. In the CANDIDE model, it is the fiscal instruments, as judged by the large number of exogenous variables on both the expenditures and taxation sides of fiscal policy, that are the most fully articulated. On the expenditures side, exogenous constant terms can be added to those categories of government expenditure that are endogenous to the model. On the taxation side, the principal exogenous variables are particular rates of taxation and specific parameters of the income tax submodel. The only two exogenous monetary policy variables are federal government deposits in chartered banks and the official NHA mortgage rate.

Savings and Consumption[1]

Aggregate consumption is determined, at least in the first instance, by subtracting personal savings and two other exogenous elements (consumer interest payments and household transfers to foreigners). The differing underlying motives for two types of savings behaviour are distinguished -- namely, contractual and discretionary savings. Two behavioural equations explain the levels of each of these two principal types of saving on the part of Canadian households.

Approximately fifty categories of consumption expenditure are generated, using a variant of the theoretical framework developed by Houthakker and Taylor. This is a dynamic theory of demand, in which the notion of a stock of durable goods is generalized into

[1] The exact number of stochastic equations and identities for this sector, as well as for all other sectors discussed below, is given in Table III-3.

TABLE III-3

Sectors and Equations in CANDIDE 1.1

Shortened Name of Sector	Number of Equations in Sector
Personal savings and aggregate consumption	9 (2,B; 7,I)
Consumption categories	116 (40,B; 76,I)
Residential construction	24 (11,B; 13,I)
Business fixed capital formation	268 (74,B; 194,I)
Inventory investment	38 (8,B; 30,I)
Government expenditures on goods and services	77 (22,B; 55,I)
Export flows	164 (34,B; 130,I)
Import flows	92 (20,B; 72,I)
Trade flows in automobiles (detail)	52 (12,B; 40,I)
Derivation of Real Domestic Products, by industry	267 (63,B; 188,I/O; 16, other I)
Labour supply	15 (4,B; 11,I)
Labour requirements	39 (24,B; 15,I)
Wage rates and labour income	39 (21,B; 18,I)
Industry prices (GDP of value-added deflators)	79 (35,B; 44,I)
Export prices	20 (all I)
Deflators of import trade flows	40 (all I)
Prices of competing import commodities	80 (46,B; 34,I)
Derivation of final demand deflators	413 (147,B; 239,I/O; 27 other I)
Private nonlabour and total income	46 (21,B; 25,I)

...cont'd

TABLE III-3 (cont'd)

Sectors and Equations in CANDIDE 1.1

Shortened Name of Sector	Number of Equations in Sector
Government revenues	40 (11,B; 29,I)
Money and interest rates	10 (9,B; 1,I)
Financial flows, balance of payments	14 (6B; 8,I)
Demography	58 (1B; 57,I)
National income accounting relationships, including savings and government budget balance measures	37 (1,B; 36,I)
Linkages with U.S. and other foreign economies	12 (4,B; 8,I)
Total number of equations	2,049 (comprised of: 616,B; 427,I/O; 1,006,other I)

B -- behavioural equations
I -- identities
I/O -- input-output relationships

the concept of a "state" of past experiences, which is then applied to non-durable goods and services as well. Accordingly, long-run and short-run coefficients (or elasticities) can differ. Although the structure is flexible enough to permit the introduction of specific determinants of the various individual categories, recurring explanatory variables are total consumption expenditures and various relative prices. The estimation is typically done in per capita form, and the derivation from the theoretical model leads to a form of estimation in which the lagged dependent variable appears as an explanatory variable. To guarantee consistency between the estimate of total consumption as a residual between savings and disposable income on the one hand, and the sum of the components of the estimated detailed consumption expenditures on the other hand, this sector also contains an adjustment mechanism that distributes the discrepancy between these two estimates, partly or completely, among the various categories of consumption expenditure. The model's final estimate of total consumption expenditures will also be adjusted, thus assuring consistency between the parts and the whole. After adjustment, there are some 42 expenditure categories that are utilized as inputs in the model of output determination by industry.

Residential Construction

The explanation of residential construction expenditures is based on a distinction between single-family and multiple-family units, as the demand patterns are sufficiently different to make this distinction fruitful. Each of these two types of housing starts is explained by a mechanism of incomplete adjustment of the actual number of units to the desired number, account being taken of replacement needs. As not all starts are finished in the year in which they are begun, there are completion equations for these two types of units. Thus, housing starts give rise, with lags, to both expenditures and completions, which are then added to the initial stock. This approach has been widely followed by other model-builders as well. The explanatory variables in the two critical-starts equations include the initial stocks, disposable income, and relative price effects (for single-family dwellings). Demographic factors play an important role, both as a result of expressing the variables in the starts equations in per-household terms and by including the proportion of non-family households as an explanatory variable for multiple starts. Availability of finance, both on the open capital market and from funds offered by the Central Mortgage and Housing Corporation, is also taken into account.

Investment

Business fixed capital formation, separately for structures (plant) and for machinery and equipment, is explained separately for 38 industries. These investment outlays are explained by two models. First, a simple adaptation of Professor Jorgenson's "neoclassical" theory of investment has been utilized at times. Attempting to maximize profits over the long-term in a competitive world, the firm gears its net investment to the desired stock of capital, in conformity with the theory of optimal accumulation of capital. Second, this approach was modified to produce an eclectic model of stock adjustment. Here the desired stock of capital is assumed to be a linear function of expected output and expected relative prices. These expectational variables are approximated by weighted averages of the present and immediate past values of the variables.

Inventories

A stock adjustment theory underlies the explanation of inventory investment. It is assumed that the present and immediately past evolution of industry output (or sales) generates a good index of the desired stock. The selected breakdown of inventory investment primarily reflects the needs of the model of industry output determination to which this sector contributes seven categories of expenditure on inventory change.

Government Expenditures

Current government expenditure on goods and services, and government gross fixed capital formation, are disaggregated into several categories that are related to either specific demographic factors or to the general development of the economy, as reflected by GNP. Government inventory change is exogenous.

Foreign Trade

Exports are substantially disaggregated. Each export category is explained by a U.S. or other foreign activity variable and by the export price relative to the foreign price. Because of the substantial institutional changes that occured in some sectors of the Canadian economy during the 1960's, some export variables are treated exogenously.

Imports are determined either by industry outputs or by a final demand category such as investment in machinery and equipment. Foreign prices relative to domestic prices also enter a number of the functions.

Industry Output

The various final demand estimates described above result in a breakdown of Gross National Expenditure into 169 categories. The model of industry output determination begins by converting this vector of final demand by ultimate use into a vector of final demand according to the commodity input classification of the Input-Output system. A rectangular Input-Output model (one that distinguishes between the intermediate commodities and the producing industries) is then solved to generate preliminary estimates of the Real Domestic Product of 75 industries, at the most detailed level of disaggregation. In the preliminary estimates so obtained, no explicit corrections are made for technological change, changing relative prices, and compositional changes within groupings; such rigidities are entailed in the use of I/O tables pertaining to a single calendar year (1961). These are mitigated somewhat by the application of autoregressive corrections to the preliminary estimates. The next step is to adjust these preliminary estimates by autoregressive correction equations, in which the discrepancy between the measured Real Domestic Product of a particular industry and its Input-Output estimate is expressed as a function of a constant term, a time trend, and the lagged value (or lagged values) of this discrepancy. This procedure, which also entails a slight amount of aggregation, yields the model's final estimates of Real Domestic Product originating in some 63 Canadian industries, including several that are partially outside the Input-Output system.

Industry Employment

Once industry output has been determined, a requirements approach is utilized to determine the demand for labour, on the basis of both the number of employees and the total man-hours. After aggregating the levels of net output (Real Domestic Product) of the 63 detailed industries into twelve major industries, it is assumed that entrepreneurs hire workers (with their associated man-hours) in order to realize their levels of planned output, as a general rule. In ten of the twelve major industries, required labour input (employees and man-hours) is generated by inverting a Cobb-Douglas production function. The use of a Cobb-Douglas production function to obtain estimates of required labour inputs is not inconsistent with the use of a Leontief-type production function (the Input-Output system) to determine gross outputs, by industry. The capital stock variables that are utilized as inputs in this inverted production function are also generated internally in the model. Lags due to institutional rigidities in the labour market are approximated by representing (in the majority of the industries) the logarithm of planned net output as a linear combination of the logarithms of current and immediately past levels of net output. Summing across the twelve major industries, total employment (and total man-hours demanded) are obtained on an economy-wide basis. This sector also contains the simple identities for average hours worked per week (the quotient of total man-hours worked divided by total number of employees), for both the twelve major industries and for the economy as a whole.

Labour Force

The total supply of labour (persons in the labour force) is explained on the basis of both the demographic variables and participation rates. In particular, the demographic sub-model produces values of the source population for five cohorts or age-sex groups: the so-called "primary" source population, males aged 25-54; and four so-called "secondary" groups -- females under 35 years, females 35 years and older, males 14-24, and males 55 years and older. The rates of labour force participation are multiplied by the size of the appropriate cohort to yield the supply of labour (individuals in the labour force) from each cohort; a summation across the five age-sex groups yields the total labour force. The participation rates of the four "secondary" cohorts are explained by behavioural relationships. These fitted relationships also capture the phenomenon that the female labour force has increased in importance relative to the male groups, and this trend is still continuing. The "primary" labour force (drawn from the cohort of males aged 25-54) is a group whose attachment to the labour market has remained exceptionally stable historically. Accordingly, the participation rate of this group is taken as exogenous. Having obtained the total labour force and the economy-wide level of employment, the latter is subtracted from the former to obtain residually the numbers unemployed. The absolute level of unemployment is then expressed as a percentage of the labour force, to calculate the rate of unemployment.

Wages and Prices

There are equations for total wages and salaries paid for the twelve major industries of the economy. In three cases, the approach follows a modified Phillips-curve or wage-adjustment function; here the determinants of the rate of wage changes are the unemployment rate, the rate of change of the corresponding U.S. wage rate, and (in one instance), the rate of change of consumer prices. In the other nine cases, the total wage payments are explained in terms of variations in productivity, output, and/or employment in the respective major industry and also by the recent level of the Consumer Price Index. This second approach is also utilized to explain net unincorporated business income in four major industries where it is important -- namely, agriculture; forestry; fishing and trapping; and finance, insurance, and real estate. The deflators of Gross Domestic Product in current dollars for the twelve major industries are estimated on the basis of unit labour and unit total costs. However, the price formation relationships also contain, on occasion, explanatory variables reflecting the supplementary influence of demand forces and/or an export price (or, in one instance, the corresponding U.S. industry price). On the basis of the industry prices explained by behavioural relationships, the model expands the explanation of industry price determination in order to generate estimates of the deflators of Gross Domestic Product for the remaining industries of the CANDIDE Input-Output system. This is done in some cases by an ad hoc behavioural relationship that relates the deflator of the detailed industry to the corresponding deflator for the major industry; in other cases, the deflator for the detailed industry is simply assumed to be equal to its corresponding major industry price. The deflators of Gross Domestic

Product for the industries of the CANDIDE I/O system in turn are an important input into the CANDIDE I/O prices submodel.

Foreign Trade Prices

Although the basic foreign trade prices are exogenous in the CANDIDE model, three sectors are devoted to keeping track of relationships among the price indexes and current-dollar and constant-dollar foreign trade flows. The implicit deflator of an export expenditure category is defined as current-dollar export flows divided by the corresponding constant-dollar magnitude. The exchange rate enters the formulation of price relatives, in which a U.S.-dollar price index (usually for U.S. prices) is compared with a corresponding Canadian price, in Canadian dollars. The 40 identities which treat import price indexes are similar; 25 of these simply take an import price level in U.S. dollars and by multiplying it by the exchange rate, convert it into Canadian dollars. Thirteen of the remaining import price identities are implicit deflators, defined as a current-dollar flow of imports divided by the corresponding constant-dollar figure. The major foreign prices that drive the mechanism for explaining the detailed import prices are also generated. These detailed import prices, the price indexes of competing import commodities, are generated by relating the detailed import prices to the major foreign trade prices. In turn, the price indexes of competing import commodities are an important input into the prices submodel of the CANDIDE I/O system.

Final Demand Prices

The CANDIDE Input-Output prices submodel is a pure cost-push model of industrial price formation. The critical inputs into the CANDIDE I/O prices submodel are the industry prices (the implicit deflators of Gross Domestic Product for the detailed I/O industries) and the price indexes of competing import commodities. Other independent variables in the prices submodel are the price level of noncompeting imports and some tax and subsidy variables, for the various sorts of taxes levied (subsidies applied) at different stages of production. Given the values of these independent variables and also the parameters of the relevant I/O tables, price levels of domestically produced commodities are calculated first. The second step is to calculate the implicit deflators of the categories of domestic final demand expenditures; briefly, these are consumption deflators, deflators of the various types of private investment, and deflators of government current and capital expenditures. In effect, the steps of the submodel of industry output determination is largely retraced, moving in the opposite direction for the prices submodel; important duality relationships exist at a number of points. The prices submodel makes a number of assumptions, such as constant I/O coefficients and constant import shares; moreover, no explicit allowance is made for varying demand pressures or variations in sellers' market power. Accordingly, it is desirable to refine these first approximations of the deflators of domestic final demand expenditures and thus generate, within the model, final estimates of these price levels. Usually this is done by fitting an autoregressive correction equation, in which the discrepancy between the measured value of the deflator and its I/O estimate is regressed against a constant term, a time trend, and lagged values of the discrepancy; however, more complicated correction mechanisms exist. Again, there is an analogy to the mechanism generating Real Domestic Product by industry. Finally, aggregative price levels (such as the deflator of total consumption expenditures or the implicit deflator of Gross National Expenditure) are obtained by dividing the appropriate current-dollar aggregate by the corresponding constant-dollar magnitude; this is equivalent to taking a weighted average (with current weights) of the relevant deflators of the detailed components.

Private Sector Incomes

Private incomes are broken down into four functional income shares: wages and salaries (labour income), income of unincorporated businesses, corporate profits, and other property incomes. The first two functional income shares are determined in aggregate and also by major industries. The critical concept of net property income is then constructed by taking the model's estimate of Gross National Product and subtracting labour income, unincorporated business income, capital consumption allowances, and some adjusting entries. Net property income is the key explanatory variable in the regression equation for corporate profits, whose cyclical fluctuations are captured by a significant, negative dependence on the rate of unemployment as well. Dividends paid by corporations are estimated on the basis of corporate profits (after deducting corporation income taxes), and the division of these dividends between Canadians and nonresidents is exogenous.

There are also relationships for capital consumption allowances and inventory valuation adjustment, both in the aggregate and for a modest industrial disaggregation. (Corporate profits are also broken out for three major nongovernment industries.) Transfer payments from governments to persons (required to be moved from national income, which is on a production concept, to personal income) arelargely exogenous, however, demographic variables, among others, are used to explain two sorts of transfer payments -- family allowances and old-age pension payments. Finally, there are conventional accounting identities for personal income and for disposable income, both in current dollars. Constant-dollar disposable income, which plays a major role in the two final demand sectors, is obtained by dividing current-dollar disposable income by the implicit deflator of total consumption expenditures.

Government Revenues

The bulk of government revenues are tax receipts, although transfer payments from individuals to governments and various types of government investment income are also taken into account. There is complete disaggregation of government revenues by level of government, as federal receipts are distinguished from the revenues of all other levels of government combined. For indirect taxes, the typical treatment is to express tax collections as the product of an exogenous rate and an endogenous base; alternatively, the total receipts or collections may be regressed on one of several appropriate explanatory variables, such as a tax base or the product of a nominal rate times such a base. The collections of some indirect taxes, such as provincial and local real property taxes, are taken as exogenous. The collections of nonresident withholding taxes are linked to current-dollar levels of interest and dividend income payments to nonresidents. Government investment income (at the two levels broken out) is expressed as the sum of exogenous components, such as interest income received, royalties, and remittances from government business enterprises (which are analogous to a private coroporation's dividends to its shareholders). There is a small submodel to generate estimates of corporate income taxes, separately at the federal and provincial levels, on the basis of the intermediate variable, taxable corporate profits, and the rates of corporate income taxation at the two separate levels. There is an elaborate submodel of the mechanism of personal income taxation, taking account of the various changes in the Income Tax Act in the recent past and, in particular, of the 1974 introduction of cost-of-living indexation into the tax liabilities of individuals. Other direct taxes on persons, such as the succession duties and estate taxes of the federal government and the succession duties of the provinces, are exogenous, at least for the sample period. Net deficits of provincial and municipal governments are also calculated; such deficits are used to explain net new issues of provincial and municipal bonds sold abroad.

Financial Structure

The approach to money and the structure of interest rates is strongly in the Keynesian tradition. The key rate of interest -- namely, the average yield of three-month Treasury Bills -- is determined in semireduced form, where it is regressed against five explanatory variables including: the supply of high-powered money (expressed in constant dollars by dividing it by the implicit deflator of Gross National Expenditure), real Gross National Product (less the imputed items of national income), and a distributed lag in the interest yield on prime commercial paper in the United States (a Wharton Model variable). Other interest rates in the model (specifically, the government bond rate, the industrial bond rate, and the conventional mortgage rate) are determined, at least in part, by this key interest rate. There are three behavioural equations to determine components of the money supply, in constant dollars; these components are currency in the hands of the public, publicly held demand deposits, and publicly held term and notice deposits, all in constant dollars. Finally, there is a reaction function, applicable during the post-sample period, for the Bank of Canada's supply of high-powered money; this variable is exogenous during the sample period.

Financial Flows and the Balance of Payments

There are two types of direct investment flows and three types of long-term portfolio investment flows. After taking account of three exogenous types of long-term portfolio investment flows, the net balance on long-term capital flows are determined by identity. The balance on current account is then calculated by subtracting the relevant current-dollar import flow from the appropriate current-dollar export flow. It is at this point that the treatment varies, depending upon whether the economy is on a fixed- or floating-exchange-rate regime. Under fixed rates (the basic assumption of the model), there is a structural relationship for short-term capital flows, and the balance-of-payments accounting identities determine changes in international reserves. These changes in international reserves are presumably one of the objectives of monetary policy, under a regime of fixed exchange rates. CANDIDE Model 1.1 also makes provision, in principle, for a regime of floating or flexible exchange rates. According to the model, the change in international reserves then becomes an exogenous variable, which may be assumed to be one of the instruments under the control of the Bank of Canada. In this case, the accounting identities linking the balance-of-payments variables then determine short-term capital flows, and a relationship analogous to the relationship for short-term capital flows under fixed rates is then utilized to solve for a market-determined exchange rate. Accordingly, the rate of foreign exchange, in a regime of floating exchange rates, is regarded as the price of short-term capital flows. In practice, the accuracy of this submodel of a floating exchange rate is very imprecise and, in our judgment, this submodel should be regarded as experimental. It would be desirable to have a tolerable submodel of a floating exchange rate, as the Canadian economy has operated under such a regime since mid-1970 (as well as during the years 1950 through 1962).

Demographic Sector

The demographic submodel is comprised entirely of identities, with the exception of a behavioural equation to determine net immigration. This behavioural equation makes net immigration depend upon economic conditions (as measured by the unemployment rate) in the immediately preceding two years The age-sex groups of the population (by five-year cohorts up to age 65) are esssentially exogenous during the sample period, but there are algorithms to project the size of these cohorts beyond the sample period. The basic determinants are the overall fertility rate, the age-sex specific death rates (which are implicit in the algorithms), and the level of net immigration, as determined by the one behavioural equation of this sector. The demographic submodel then processes the basic information in order to get population variables that are utilized elsewhere in the model. Among these outputs are total population (a widely used variable), total number of households (used in Residential Construction), civilian-source population groups, (by applying participation rates), and various measures of school and post-secondary enrolments (utilized mainly in our submodel of government expenditures).

U.S. and Other Foreign Economics

The model contains certain linkages with the U.S. economy and other foreign economies (principally that of the United Kingdom). Exogenous variables and variables determined within the sector itself are transformed so that they are immediately usable in the solution of CANDIDE Model 1.1. Four equations constitute a mechanism for breaking down the Wharton variable, U.S. constant-dollar expenditures on food and alcoholic beverages, into its two obvious components; the results of this breakdown are utilized in explaining the relevant export flows. There are equations for two indexes of industrial production; constant-dollar U.S. manufacturing output; three interest rate variables (one U.S. and two U.K.); U.S. constant-dollar consumption of automobiles and parts; and finally U.S. consumption of newsprint in thousands of tons. All but one of the exogenous variables utilized as right-hand side variables come from the Wharton Annual and Industry Forecasting Model; accordingly, they are exogenous from the point of view of the CANDIDE model but endogenous from the point of view of the model of which they are outputs.