ENGINEERING AND SCIENTIFIC MANPOWER IN CANADA

by

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CURRICULUM STUDIORUM

Archibald Donald Boyd was born March 12, 1929 in Antigonish, Nova Scotia. He received his Bachelor of Arts in Economics at St. Francis Xavier University, Antigonish, Nova Scotia in 1949, and a Diploma in Education from the same university in 1950. He received the degree of Master in Arts in Economics from the University of Toronto in 1952.

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CHAPTER I

INTRODUCTION

1. The Purpose of the Study

The purpose of the study is to examine the supply of and demand for engineering and scientific manpower in Canada. This involves an analysis of the nature and relative importance of the various sources of supply and of the factors that have affected the distribution of such manpower among occupations and industries between 1931 and 1961. Particular attention will be paid to the 1951-61 period. It is hoped that the analysis will illuminate some of the processes and mechanisms by which this particular type of high-level manpower is allocated over time in relation to changes in the structure and operation of the economy.

The scope, method and the data used had to be mutually adapted. The wide variation in the types and quality of data available has dictated an approach that is eclectic. It is hoped, nevertheless, that the data available and the method employed are sufficient to provide useful information and insights into the operation of the long-term and short-term trends in the market for engineering and scientific personnel. For example, the short-term period of the 1950's, where better data are available, illustrates market processes at work more readily than the longer period for which data are scarcer. In addition, one object of the study is to indicate where data and research gaps remain to be filled. The conclusion of the study it is hoped will point up these deficiencies. Naturally, any conclusions derived from the present study may be confirmed, modified or rejected on the basis of more research and of more and better statistical data.

The selection of this topic was influenced by two considerations, one theoretical and the other practical. The proliferation of occupations including engineering and scientific occupations is part of the process of the division of labour in relation to changes in the economy. Economists have for many years observed this relationship. Marshall in particular has noted how changes in the methods of industry make predictions of labour demand a difficult task.[1/]

Economists have for a long time stressed the importance of investment in people.[2/] Currently, there is great emphasis on the contribution of human resources development to economic growth and one important aspect is the production and utilization of high-level

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1/ Adam Smith, Wealth of Nations, New York, Random House Inc., 1937, p. 260; Alfred Marshall, Principles of Economics, 8th Edition, London, Macmillan and Co. Ltd., 1956, p. 476; John Maynard Keynes, The General Theory of Employment, Interest and Money, London, Macmillan and Co. Ltd., 1936, p. 43.

2/ Adam Smith, op. cit., pp. 265-266; Alfred Marshall, op. cit., pp. 179, 469.

manpower, such as engineers and scientists.[3/] The present study will examine not only how changes in the economy have influenced the requirements for engineers and scientists but also how forces on the supply side have influenced the available quantity. This leads to the second consideration, namely, forecasting of the supply and requirements for scientists and engineers.

On the more practical side, there is a great deal of interest at the present time in improving manpower forecasting as a basis for planning investment in education, training and in other forms of human capital, such as health. The Organization for Economic Co-operation and Development has done pioneering work in this area in recent years, and the problems of forecasting supply and requirements for scientific and technical manpower have been included in these efforts. Because of the time lags in the formation of human capital, education planning must be long term and must be concerned with developing an adequate supply of persons in engineering and scientific occupations in relation to other types of support personnel, such as

3/ Frederick Harbison and Charles A. Myers, Education, Manpower and Economic Growth, Toronto, McGraw-Hill, 1964, pp. 3, 15; T.W. Shultz, "Reflections on Investment in Man", Journal of Political Economy, Vol. LXX, No. 5, Part 2, Supplement, October, 1962, pp. 1, 2.

technical, clerical and skilled manual workers. Also, further progress must be made in forecasting the supply and requirements for qualified manpower in relation to scientific advances and economic growth.[4/]

The information obtained from the analysis of past trends will be combined with global estimates derived from other studies in order to estimate future supply and requirements for engineering and scientific manpower. The possible implications of these projections for education, migration and labour market policies in Canada will also be examined.

2. The Scope of the Study

The study will consist of an examination of changes over time in engineering and scientific manpower in Canada in a supply and requirements framework. The study has four major parts: first, an evaluation of supply between 1931-61; second, an analysis of requirements over the same period; third, an examination of supply, requirements and utilization over the long run with an intensive analysis of the operation of the labour market for engineers and scientists in the 1950's; finally, projections of both supply and requirements to 1970.

4/ See H.S. Parnes, Forecasting Educational Needs for Economic and Social Development, Paris, Organization for Economic Co-operation and Development, 1962, pp. 8 and 9; Organization for European Economic Co-operation, Forecasting Manpower Needs for the Age of Science, Paris, O.E.C.D., 1960, p. 113.

There are six chapters. Chapter I is a critique of the main data sources for the study. In Chapter II, the sources of supply of engineering and scientific manpower are analyzed, including the main components such as graduation and net migration. An attempt is made to refine the analysis of supply by estimating attrition rates due to deaths, retirements and withdrawals from the labour force, and by estimating inter-occupational transfers. Chapter III focuses on changing requirements for engineering and scientific manpower. The number and distribution of engineers among and within industrial sectors is traced and an attempt is made to gauge the nature of changes in the deployment of engineers and scientists within industrial sectors. In Chapter IV, an evaluation of supply, requirements and utilization is attempted. This requires a careful examination of the operation of the market in particular during the 1950's, and of trends in the earnings for such personnel in relation to the supply and requirements data developed in Chapters II and III. The greater availability of data in more recent years permits an analysis of the operation of the market for such personnel in the short run, and an examination of the question of whether there was a shortage of these personnel in the middle of the 1950's. In Chapter V, the data in earlier chapters is used as a basis for estimates of future supply and requirements for engineering and scientific manpower. Finally, the possible implications of these findings for manpower policy relating to education, migration and the operation of the labour market are presented in Chapter VI.

3. Method

a. Analytical Framework

The problem outlined here is essentially a problem of labour market analysis or, more specifically, the analysis of an important portion of the labour market, that for engineers and scientists. A supply and demand framework is used in the analysis. To the economist the concepts of demand and supply are schedules or functions. In the simplest case, demand denotes an array of quantities asked for at varying prices, per unit of time, on the assumption that other things, for example, consumers' incomes, tastes and the prices of other goods, remain constant. In a free market, if these factors are allowed to vary they will tend to bring about an equilibrium of quantity supplied and quantity demanded. But since the historical data on the number of engineers and scientists depict both the quantity demanded and quantity supplied at any point in time, the problem is how to separate the determinants of supply and demand when we only know the intersection points of these curves. Following the method suggested by Blank and Stigler, we will not attempt to estimate supply and demand curves directly but instead will explore a variety of factors which general knowledge and observation suggest may be determinants of supply and demand of engineers and scientists.[5/]

5/ David M. Blank and George J. Stigler, The Demand and Supply of Scientific Personnel, New York, National Bureau of Economic Research, 1957, pp. 21-22.

Economic theory centres on the concept of the market. An economy may be considered as a system of interrelated markets including the markets for products and the markets for productive services.6/ The market for productive services including the market (or markets) for scientific manpower is (or are) linked to other markets for productive services by the possibilities of alternative uses for a particular productive service and by the possibility of substituting other productive services in producting a particular product. The markets for productive services are also linked with their product markets by the transformation of productive services into products.

Conditions for simultaneous equilibrium in all markets are set out by the economic statics approach, while the comparative statics method can be used to understand or trace how changes in the parameters such as taste, income and so forth, result in changes from one equilibrium position to another.7/ Reynolds also notes that the notion of a perfectly competitive labour market is an abstract concept which is useful for normative purposes and that recent discussion has run in

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6/ Lloyd G. Reynolds, The Structure of Labour Markets, New York, Harper and Bros., 1951, pp. 1-5; Leon Walras, Elements d'economie politique pure, Paris, 1874, cited in J.R. Hicks, Value and Capital, 2nd Edition, Oxford, Clarendon Press, 1946, pp. 57-61.

7/ Paul A. Samuelson, Foundations of Economic Analysis, Cambridge, Mass., Harvard University Press, 1947, p. 257.

terms of workable but less than perfect competition. He suggests that the important issues relate to the nature and extent of imperfections in labour markets and to how the labour market structure can be improved.[8]

b. Assumptions

Although the study by Reynolds was limited to manual labour only, a good part of the analytical structure, conceptual schema and questions raised are applicable also to the professional and technical labour force as well. Hence, the techniques that seemed to be appropriate for the study were those that permitted an analysis of the labour market for persons in these occupations over time. The analysis is based initially on a number of simplifying assumptions.

1) Pure competition in the labour market (or markets) for engineers and scientists. This implies the absence of labour unions on the one hand among engineers and scientific employees and, on the other, an absence of monopsonistic salary determination by employers.[9]

8/ Lloyd G. Reynolds, op. cit., pp. 223-224.

9/ I think that when dealing with the national market, this assumption is more reasonable than assuming the absence of competitive conditions. The vast majority of engineers and scientists are employees rather than self-employed. For example, in 1959 only 7 per cent of those in engineering and science (7.5 and 6.6 per cent respectively) were self-employed. See: Department of Labour, Economics and Research Branch, Engineering and Scientific Manpower Resources in Canada, Their Earnings, Employment and Education, 1959, p. 90. There is an almost complete absence of collective bargaining employee associations among engineers and scientists. On the employer side, Reynolds and Taft note the probability of employers monopsony power under non-union conditions. See: Lloyd G. Reynolds

2) It is also assumed that a market exists for these personnel which is national and, to some degree, international in scope.[10/]

3) That the imperfections which may exist in the market for engineers and scientists do not alter the general direction of the adjustments in salaries and in the numbers of engineers and scientists employed that would result from the impact of market forces. As the analysis proceeds, the validity of these assumptions and the degree to which they seem to hold will be examined.[11/]

9/ (Cont'd)
and Cynthia Taft, The Evolution of Wage Structure, New Haven, Yale University Press, 1956, p. 369. However, there is no evidence that these monopsonistic forces are strong enough to invalidate or to reverse the above assumption. Cf. Blank and Stigler, *op. cit.*, pp. 30 and 31.

10/
The degree to which this is true is open to question. There is, however, evidence of a national market for such personnel. One bit of evidence is the extent to which inter-regional movement (in this case, graduates from one province who become employed in another) occurs. In 1959, for example, net losses or gains as a per cent of employment ranged from plus or minus 6 to 70 per cent for the various regions in Canada. See: Department of Labour, Economics and Research Branch, Engineering and Scientific Manpower Resources in Canada, Their Earnings, Employment and Education, 1959, pp. 38-39. This finding is corroborated by Rosenbluth who found that regional immobilities on the supply side of the engineers' market were a negligible influence upon salaries. There was, however, evidence of a somewhat greater degree of immobility among industries. See: G. Rosenbluth, "Salaries of Engineers and Scientists", Canadian Political Science Association, Conference on Statistics, 1960, Papers, Toronto, University of Toronto Press, 1962, pp. 179-180. However, only from one fifth to two thirds of the variation in salaries was accounted for by the four factors utilized in the model, experience, function, industry and region. The degree of "price discrimination" is thus left open. See: Rosenbluth, ibid., p. 153.

11/
The third assumption will be relaxed, for example, in an attempt to determine whether a "market" for engineers and scientists is in fact a series of sub-markets between which there is less than perfect mobility of buyers and sellers. As Bain notes, labour is not a homogeneous commodity, but rather a series of commodities which are differentiated by types of skills and training, by

c. The Approach

The approach taken to the problem is theoretical, historical and statistical. Theory is used as a guiding framework to suggest the factors that should be assessed in examining the market for these persons. The factors are in turn treated in the context of a 30-year span of time. In tracing the relevant variables through time, statistics will be used wherever possible. However, it will not be possible to provide statistics for many variables that would add breadth and depth to the analysis, first, because some of these variables are qualitative and not easily subject to measurement; secondly, because the historical series are not available for certain data nor for certain periods of time.

4. The Data

The data on engineering and scientific manpower used in this study are based on several sources. The main ones are: the decennial Census; the Department of Manpower and Immigration Register of Scientific and Technical Personnel; immigration statistics from the Department of Manpower and Immigration; enrolment and graduation statistics from the Dominion Bureau of Statistics; salary data from the

11/ (Cont'd.) quality and location. See: Joe S. Bain, Pricing, Distribution and Employment, Revised Edition, New York, Henry Holt and Company, 1953, p. 504.

Canada Manpower Division of the Department of Manpower and Immigration (formerly the National Employment Service) and from the National Research Council. These data have been assessed in terms of three criteria: conceptual relevance, that is, how closely do they fit the concept that they are supposed to represent; internal consistency of the data over time; finally, comparability, i.e., the degree of comparability of various series with each other.

a. The Census

The data from the decennial Censuses provide the longest time series on occupations and are the only source of information on long-term trends in industrial distribution by occupation. The 1961 Census asks: "What kind of work did you do in this industry?", which describes persons in the labour force according to the kind of work they did, not in terms of their qualifications.[12/] This means that persons trained in engineering and science may be placed within other occupational classifications such as "owners and managers, n.e.s." or "professors and college principals".

The only occupations in engineering and science that are comparable or available between 1931 and 1961 are engineering, total,

12/ Dominion Bureau of Statistics, Occupational Classification Manual, Census of Canada, 1961, p. 9.

and civil, electrical and mechanical engineering. In order to achieve comparability of the Census occupations, it was decided to adjust the data for 1931, 1941, and 1961 to the 1951 occupational and industrial classification. This was done for two reasons. First, at the time of writing, the Dominion Bureau of Statistics had adjusted a number of occupational classes used in the study to the 1951 basis. Secondly, the 1951 occupation and industry classification was followed in two other sets of data used in this study, the Register of Scientific and Technical Personnel, and immigration statistics from the Department of Manpower and Immigration.

Census data have some additional limitations besides errors made by the respondent, by the Census enumerator and the coder. First, a particular occupation class may be too heterogeneous, composed of a large number of specific occupations. In the case of the 1951 Census, for example, the classification of "chemists and metallurgists" included druggists, pharmacists and prescription clerks. In view of the resulting range in the educational level and types of work performed, it was decided not to use this particular classification.

Secondly, there are residual categories in the Census which are large and which are not homogeneous. In the 1951 Census occupational classes such as biologists, geologists and physicists were included in the category "other professional occupations" where they were inaccessible. However, in this respect, the 1961 Census was an improvement over 1951 because these particular occupational classes were shown separately.[13/]

b. The Register of Scientific and Technical Personnel

Membership in the Register of Scientific and Technical Personnel of the Department of Manpower and Immigration includes those who either are graduates in recognized courses in engineering, natural science, architecture and veterinary medicine, or who are non-graduate members of professional associations, most of whom have passed qualifying examinations of these associations.[14/] Thus the register in contrast to the Census attempts to include all those who have professional status in the scientific and technical fields, regardless of what kind of work they are presently doing.

13/ See Appendix I-B, for a description of the occupational classes used in the Census.

14/ Department of Labour, Economics and Research Branch, Engineering and Scientific Manpower Resources in Canada, Their Employment, Earnings and Salary Rates, 1960-61, Professional Manpower Report No. 10, June, 1961, p. 3.

However, data on those in the register are also available by field of employment specialization which is closer to the concept of occupation as used in the Census. The register also employs an adaptation of the 1951 Census classification of industries in the surveys conducted since the middle of the 1950's.[15]

There are three main limitations of the register as a source of information. First, apart from broad fields and some data on selected fields between 1943 and 1963, detailed comparisons of field and industry are available only from 1957 to 1963. Second, the register operations probably have less than 100 per cent of eligible persons because registration is voluntary. There are also technical problems of maintaining up-to-date addresses. Third, the non-response to survey questionnaires runs close to 25 per cent.

Two analyses of the possible effect of non-response on the results of the survey have been made.[16] Although some bias with respect to certain characteristics such as income, function, and

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15/ See Dominion Bureau of Statistics, Standard Industrial Classification Manual, Ottawa, 1948.

16/ Department of Labour, Economics and Research Branch, Engineering and Scientific Manpower Resources in Canada, Their Earnings, Employment and Education, 1959, Professional Manpower Report No. 9, March, 1961, pp. 69-76; Employment and Earnings in the Scientific and Technical Professions, 1958-61, Professional Manpower Report No. 12, September, 1962, pp. 25-31.

attachment to professional work was evident, the lack of response did not appear to affect the survey results to a great degree. For example, the effect upon median income of the existence of non-respondents and their somewhat different characteristics was estimated to be less than 1 per cent. Furthermore, there is no reason to suppose that any bias which exists has changed from one survey to another.

Despite these limitations the register is the only available source of extensive detail on individuals in scientific and technical fields.

c. Immigration and Emigration Statistics

The immigration statistics used from the Department of Manpower and Immigration are based on the 1951 Census Classification of Occupations[17/] which was adopted in 1953 and used until 1962 when the 1961 Census Classification of Occupations was adopted.[18/] For the

17/ Dominion Bureau of Statistics, Classification of Occupations, Ninth Census of Canada, Ottawa, 1951.

18/ Dominion Bureau of Statistics, Occupational Classification Manual, Census of Canada, 1961. The Dominion Bureau of Statistics has prepared a tabulation of the 1962 data on immigration on the 1961 classification basis in the Canada Year Book, 1963-64, pp. 207-208. The data for 1963 have also been classified on the 1951 basis. See Louis Parai, Immigration and Emigration of Professional and Skilled Manpower During the Post-War Period, Special Study No. 1 prepared for the Economic Council of Canada, June, 1965, p. 98.

period, 1946-52, only the annual number of immigrants intending to enter professional occupations was given. The distribution by professional occupations has been estimated by the Department of Citizenship and Immigration (now Manpower and Immigration) on the basis of the distribution in 1953.[19/]

Information on emigrants from Canada to the United States by detailed professional occupation categories is available from 1950 to 1963.[20/]

d. Enrolment and Graduation Data

Data on enrolments and graduations by faculty are available from the Dominion Bureau of Statistics for the period 1920 to 1963. The categories available separately for this period include engineering and pure science in the scientific and technical specialties covered in this study.

From 1940 to 1963 the Economics and Research Branch of the Department of Labour (now the Department of Manpower and Immigration)

19/ See Department of Labour, Economics and Research Branch, The Migration of Professional Workers Into and Out of Canada, 1946-50, Professional Manpower Report No. 11, October, 1961, p. 9.

20/ United States Department of Justice, Immigration and Naturalization Service, special tabulations sent to the Economics and Research Branch, Department of Labour (now the Department of Manpower and Immigration).

has accumulated statistics on recipients of undergraduate degrees in engineering and honour science courses based upon the annual survey of the graduating classes in these specialties.

From 1957-63, information on individual fields of study within engineering and science at undergraduate and post-graduate including the master and doctorate levels is available.21/

e. Other Sources of Data

Some other sources of data referred to below are the survey of starting salaries offered by employers conducted by the Canada Manpower Division (formerly the National Employment Service) of the Department of Manpower and Immigration, and the survey of salaries of engineers and scientists in research conducted by the National Research Council.22/ Some information on vacancies and applicants for

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21/ Changes in the number of graduates in pure science have occurred because of changes in the way universities report their statistics over time. For example, a university which formerly reported science graduates under the arts faculty may begin to report them as receiving degrees in the science faculty, which means that for the first time data on science degrees are separately available. It may also be noted that the concept "pure science" is broader than "honour science" and includes many students who do not take honours degrees. Many of these students may nevertheless continue on to post-graduate level education. See Wallace R. Brode, "Approaching Ceilings in the Supply of Scientific Manpower", Science, Vol. 143, No. 3604, January 24, 1964, p. 34, where he indicates that non-ACS (American Chemical Society) certified B.S. chemistry graduates accounted for 22 per cent of Ph.D.'s in chemistry in the United States over a 5-year period.

22/ This survey is now conducted by the Pay Research Bureau of the Civil Service Commission.

engineering jobs was obtained from the reports of the Dominion Bureau of Statistics on "Labour Demand and Supply". Data on investment in manufacturing industries were obtained from a recent study by the Dominion Bureau of Statistics on capital flows and stocks.[23/]

f. Fields of Specialization and Occupations Used

The first step in any study of engineering and scientific manpower is to specify what fields or occupations are to be included as well as the criteria adopted for selecting who should be included in the engineering and scientific manpower pool. Broadly, the fields and occupations included can be defined as those whose subject matter is natural science and its applications.

One is immediately confronted with the problem of vague boundaries among these fields and occupations. They merge into each other. In addition, it is possible for persons to enter these occupations by various routes in terms of type of education and

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23/ Dominion Bureau of Statistics, Business Finance Division, Estimates of Fixed Capital Flows and Stocks, Manufacturing, Canada, 1926-60, to be published soon.

training, e.g., engineering versus science or other specializations; university versus non-university level. Thus, there are two basic criteria for determining whether a person is in the engineering and scientific manpower pool:

1) Does he have the education in natural science or its applications and/or other equivalent qualifications, e.g., membership in a professional association?

2) Is he engaged in a type of work which can be considered an engineering or scientific occupation?

It may be noted that no list of fields of educational specialization will correspond exactly with a list of fields of employment specialization or occupations for at least four reasons. First, some courses of study, engineering physics, for example, have no precise counterpart in a field of employment or vice versa. Second, some graduates in certain courses, e.g., physics may become employed in another field of employment specialization, e.g., university teaching or management. Thirdly, graduates may enter fields for which university education is not required or may leave the labour force altogether.[24/] Fourthly, certain fields such as civil engineering may have persons employed who did not take a university degree and who were upgraded to these engineering jobs.

24/ Dael Wolfle, America's Resources of Specialized Talent, New York, Harper, 1954, p. 12.

The expression "engineering and scientific manpower" encompasses the fields of engineering, natural sciences and applied biological fields. An illustrative outline of the content of these specialties has been given by Wolfle.[25/] A breakdown is given in terms of specialized fields used in analysing and reporting information as well as subject of college study included in each specialized field.

Each of the three main sources of data used in this study, the Census, the Dominion Bureau of Statistics list of university fields of study and the Register of Scientific and Technical Personnel has a particular classification of occupations or specializations oriented either to educational background or to occupation, or to a combination of both. The register employs some 565 fields of employment specialization in natural sciences, engineering, architecture and veterinary medicine grouped into 22 broad categories.[26/] The composition of this list reflects both work done and course specialties followed at university.

25/ Dael Wolfle, op. cit., pp. 13-14.

26/ See Appendix I-A for more details. This list of specialties has recently been expanded for the new survey of professional scientific and technical manpower.

The 1961 Census of Canada has a total of 15 professional occupations[27] which corresponds approximately to the fields of employment specialization covered in the register.[28]

Historical statistics on university enrolments and graduations in engineering and science are available from the Research Branch of the Department of Manpower and Immigration and from the Dominion Bureau of Statistics.[29]

27/ Dominion Bureau of Statistics, Occupational Classification Manual, Census of Canada, 1961, p. 16. See also Appendix I-B for more details.

28/ A useful description of the content of occupations used in the study may be found in International Standard Classification and Occupations, International Labour Office, Geneva, 1958.

29/ Dominion Bureau of Statistics, Survey of Higher Education, Part II, 1962-63, p. 53; Dominion Bureau of Statistics, Survey of Higher Education, (earlier issues). Data are available in some detail at the undergraduate level in the case of the Department of Manpower and Immigration series, and at both the undergraduate and post-graduate levels from the Dominion Bureau of Statistics. It was decided to use a system of classification for both sets of statistics which is adapted mainly from the Dominion Bureau of Statistics undergraduate classification. This has the advantage of enabling more precise comparisons to be made between data derived from these sources.

In order to achieve a greater measure of comparability, these series of occupations and fields of specialization have been grouped into a number of broader groups:30/

Engineering, Total
- Chemical
- Civil
- Electrical
- Mechanical
- Other

Science, Total
- Biology
- Chemistry
- Geology
- Mathematics
- Physics
- Other

The purpose of any classification system is to permit the organization and aggregation of data into classes in a way that will permit analysis and meaningful interpretation. This usually results in a certain lack of intra-class homogeneity. The merit of any system, and this includes the one used here, must be judged by the purpose for

30/ For a description of the occupations and fields included in the above groups in relation to the Censuses, see Appendix I-A. See also, H.S. Parnes, Forecasting Educational Needs for Economic and Social Development, Paris, Organization for Economic Co-operation and Development, October, 1962, p. 77, Appendix B, "An Occupational Classification System for the Mediterranean Regional Project", for an alternative grouping of scientific and technical occupations. The scope of the present project and the limitations of comparable data precluded the use of the number of occupations used by Parnes.

which it is employed. In the present case, it is felt that an aggregation of data in this way facilitates the sort of broad comparisons of fields and courses which are attempted.

g. Comparison of Census and Register

Professor D.N. Solomon and Mrs. A.M. Fergusson have discussed the possibility of making a comparison of data from the 1951 Census with data from the 1957 survey based on the Register of Scientific and Technical Personnel of the Department of Labour. It is concluded that the differences precluded such a comparison.[31/]

It should be noted at the outset that the difference in concepts used in the Census as opposed to the register - occupation or work done in the case of the Census compared with scientific and technical education in the case of most who are included in the register - would tend to lead to differences in coverage between these two sources.

When the article by Solomon and Fergusson was written, the 1961 Census data were not available. They pointed out the need of

31/ David N. Solomon and Agnes M. Fergusson, "The Distribution and Functions of Canadian Engineers and Scientists", Canadian Political Science Association Conference on Statistics, 1960, Papers, E.F. Beach and J.C. Weldon, Editors, Toronto, University of Toronto Press, 1962, pp. 183-216.

making a comparison of Census and register data. A comparison is made in Table I-1. The distribution of engineers by occupation, i.e., by "kind of work" performed in the Census and by field of employment rather than education specialization in the register indicates that in this respect the Census and register data are fairly similar.

The level of education indicated in the Census and the register is discussed in Chapter II below. Those with no university degrees represented 28 per cent in the case of the 1961 Census and only 5 per cent in the case of the register, based on data from the 1961 Survey of Scientific and Technical Personnel.

It would seem that a sufficient degree of similarity exists between these two sources of data to permit useful comparisons to be made. However, the conceptual differences between them indicate that comparisons must be made with the greatest care.[32/]

It was decided to make a direct comparison of the influence of the Census "occupation" concept compared with the register concept of "field of academic" and "field of employment specialization". One would expect that some who were classified as "engineers" according to the register would appear, for example, as "managers" or "sales" in

32/ For a further discussion of the problems of comparing data from the Census and the register, see Appendix I-B.

Table I-1

Distribution of Engineers, Census
and Register, 1961

Field of Employment Specialization (Register) or Occupation (Census)	1961			
	Register1/		Census2/	
	Number	Per Cent	Number	Per Cent
Engineering Total...	9,707	100	43,066	100
Chemical..........	636	7	2,996	7
Civil.............	2,713	28	11,917	28
Electrical........	2,245	23	8,763	20
Mechanical........	2,440	25	12,099	28
Other.............	1,673	17	7,291	17

Sources: (1) Department of Labour, Economics and Research Branch, Survey of Scientific and Technical Professions, 1962, unpublished data.

(2) Dominion Bureau of Statistics, Census of Canada, 1961, Labour Force Bulletin 3.1-9, Table 17.

the Census. Those who were reported as engineers in the 1961 Survey of Scientific and Technical Personnel were divided into two groups, those who reported that they were not in scientific and technical fields of employment, the "non-technical", and those who reported that they were, the "technical" group. A random stratified sample was selected from each group - 108 non-technical and 116 technical - and the results were compared with the results enumerated in the returns from the 1961 Census.[33/]

The results indicated that three out of ten of the engineers reported as being in scientific and technical fields in the register were reported in the Census in other than engineering occupations. Conversely, seven out of ten were reported as engineers both in the Census and in the Survey of Scientific and Technical Professions. In the case of those in the Survey of Scientific and Technical Professions who reported themselves as not being in scientific or technical fields, the proportion who were not in engineering occupations in the Census was 84 per cent. This suggests that in a comparison with the Census it is best to use the field of employment specialization concept for

33/ The comparison was done internally by the Dominion Bureau of Statistics as a special study and the results were released statistically in such a way that individuals could not be identified See Appendix I-B.

register data which automatically excludes those who are employed outside these fields, rather than the academic specialization concept which includes such persons.[34]

5. Concluding Note

The choice of particular engineering and scientific occupations or fields of specialization has of necessity been guided primarily by the availability of comparable data over time. Because of changes in classification and the absence of data for certain occupations, generally the longer the time period the smaller is the amount of data available for these specialties.

Thus, the Census data are used to indicate the broad changes in the distribution of engineers among industries over time. On the other hand, the register data are the only available source of detail on characteristics such as work functions, detailed level of education, and thus are useful in providing a qualitative dimension to the analysis.

34/ For a fuller discussion of this special study, see Appendix I-B.

It may be noted that an approach similar to the above has been followed in other studies.35/

35/ David M. Blank and George J. Stigler, op. cit.; Canada, Royal Commission on Canada's Economic Prospects, Department of Labour, Economics and Research Branch, Skilled and Professional Manpower in Canada, 1945-65; United States, National Science Foundation, Scientists, Engineers and Technicians, Requirements and Supply, Washington, D.C., United States Government Printing Office, 1963; Dael Wolfle, op. cit.

CHAPTER II

SUPPLY OF ENGINEERING AND SCIENTIFIC MANPOWER, 1931-61

The objective of this chapter is to describe and analyze the factors that have affected the supply of persons in engineering and scientific occupations. This will require an assessment of the relative impact upon supply of such variables as demographic changes, participation in engineering education at university, net migration and attrition rates. An important variable, namely, the trend in relative earnings in these occupations, will be treated later as part of an overall evaluation of trends in supply and demand.

This chapter is made up of seven sections. First, the concept of supply is discussed. Second, the main demographic and labour force changes over the last 30 years are outlined. Third, the impact of trends in university enrolment and graduation in engineering upon supply is assessed, while the fourth section is concerned with an estimate of the importance of net migration. The fifth section examines geographic and occupational mobility. The sixth section deals with the influence of attrition due to deaths, withdrawals and retirements. The last section attempts to pull together some threads of the above analysis, to assess the elasticity of supply in engineering and scientific occupations, and to establish a framework for projections of future supply.

1. Introduction: The Concept of Supply

Since the examination of engineering and scientific manpower is being conducted within the framework of a demand and supply model, it will be useful at the outset to examine the concept of supply in order to assess the relevance of the data available relating to supply. The general term "supply" as used in economics refers to a schedule of various quantities of a good or productive factor which the seller is willing to offer on the market at various possible prices per unit of time. The supply of a given type of labour may be considered as the number of man-hours of labour of average efficiency which will be supplied at various levels of wage rates per hour. The number of man-hours in turn results from the interaction of the two dimensions of labour supply, the number of persons and the number of hours they work.

Since the above theoretical concept of the supply of labour in the schedule sense is not easy to measure, it is necessary for analysis to utilize concepts of the labour supply which are measurable, for example, engineers and scientists who are in the labour force. This latter concept differs from the theoretical concept of the supply of labour because it refers to people, not hours of labour and because it includes the employed plus the unemployed.[1/]

1/ "The civilian labour force includes that portion of the civilian non-institutional population 14 years of age and over who, during the survey week, were employed or unemployed", Dominion Bureau of Statistics and Department of Labour, "The Labour Force Employment-Unemployment", Joint Press Release, April 24, 1962.

This concept of the supply of labour may also be applied to a particular occupation or field of specialization, for example, engineering or science. In view of the heterogeneity of the total supply of labour, comprised as it is of different occupations, it is necessary to examine occupations such as engineering and science occupations in order to determine if the supply of labour for these occupations has distinctive characteristics compared with other professional occupations or with the labour force as a whole.

Given the population and its age distribution, in the short run the elasticity or shape of the short-run supply curve for an occupation will depend upon inter-occupational transferability and relative wages in other occupations. This in turn will depend upon the extent to which persons in other occupations possess or can quickly acquire the necessary education or skill. It will also be affected by the importance of relative non-monetary advantages of various occupations, for example, pension rights and the cost involved in making the transfer.

In the long run for any occupation, all of the above factors operate but the supply of workers tends to be more elastic in the long run than in the short run, not only because of the greater possibility of those already employed shifting among occupations but also because of changes in the flow patterns of new entrants into the educational stream who have time to alter their career choices. The elasticity of supply is therefore a function not only of time but also of the cost and length of the training period, supply being less elastic in those occupations requiring a long and expensive period of training. In some instances the number of persons trained rather than those employed in engineering or science will be utilized as indicators of the size or of changes in its composition of labour supply for these specialties. In such cases, an attempt will be made to keep the data both internally consistent over time and comparable as far as possible with other occupational and labour force data.

It will be assumed that the long-run supply curve for labour in the occupations being considered here has the usual shape and slopes upward and to the right.[2/]

One of the main purposes in the examination of supply of engineering and scientific manpower is to select those aspects of supply which may be useful in making projections. Supply itself may be considered for this purpose as either a stock of manpower at a given time[3/] or as a flow which increases or diminishes the stock over a

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2/ Kenneth E. Boulding, Economic Analysis, Revised Edition, New York, Harper and Brothers, 1958, pp. 230 and 240.

3/ Herbert S. Parnes, Planning Education for Economic and Social Development, O.E.C.D., The Mediterranean Regional Project, Paris, 1962, p. 76, observes that the number of workers employed at a particular moment of time is a measure of both the supply and the demand.

Professor de Wolff, Employment Forecasting: International Seminar on Employment Forecasting Techniques, O.E.C.D., Brussels, June, 1962, p. 82, explains that "In accordance with international practice, manpower supply at a certain moment is defined to be equal to the size of the economically active population at that moment. According period of time.4/ The stock of engineering and scientific manpower at a point of time is the result of the number of persons in that category at some earlier point of time plus inflows minus outflows in between. Inflows consist of persons with engineering and science degrees who enter engineering and scientific occupations in the labour force; persons with other than engineering and science degrees or without university degrees of any kind who enter engineering and science occupations and persons who immigrated from abroad. Outflows from the stock consist of transfers to other occupations; other withdrawals from the labour force, for example, women who become housewives, emigration to other countries and deaths and retirements. The above catalogue of supply components is examined below. Both aspects of occupational mobility including in-transfers and out-transfers are examined together and the same is done for immigration and emigration. This is done in

3/ (Cont'd)
to this definition, the unemployed (both registered at labour exchanges and unregistered) form part of the supply. The same holds for permanent and temporary military personnel. On the other hand, housewives and other persons not professionally occupied are left out."

4/ Herbert S. Parnes, Forecasting Educational Needs for Economic and Social Development, O.E.C.D., The Mediterranean Regional Project, Paris, 1962, pp. 42-44.

order to determine net occupational transfers and net migration.[5/] These supply components provide a framework for examining the supply side of engineering and scientific manpower in this chapter.

2. Demographic and Labour Force Changes

a. Population Growth and Changes in the University-Age Population

The total number of persons who are potentially available as members of the economically active population is influenced not only by the absolute size of the population but also by its age distribution. The proportion of the population in the younger age groups, for example, from ages 15 to 24 years of age in any given year, other things being equal, will have an important influence on the number of new entrants to the labour force. In the same way, the number of persons in the university-age population 18 to 24 years of age will be one of the basic determinants of the numbers who will enroll in university in any given year.[6/] Even though the emphasis in this analysis is on the proportion

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5/ For a discussion of the components of supply, see H.S. Parnes, Forecasting Educational Needs for Economic and Social Development, pp. 42-44; U.S. National Science Foundation, A Program for National Information on Scientific and Technical Personnel, Washington, D.C., Government Printing Office, August, 1958, pp. 29-30; United Kingdom, Advisory Council on Scientific Policy, Committee on Scientific Manpower, Statistics Committee, The Long-Term Demand for Scientific Manpower, London, Her Majesty's Stationery Office, October, 1961, pp. 5-7.

6/ Approximately four fifths of full-time students are between 18 and 24 years of age, inclusive. See: Edward F. Sheffield, Enrolment to 1976/77 in Canadian Universities and Colleges, 1963 Projection, Canadian Universities Foundation, 1964, p. 5.

of persons who graduate from particular university courses of engineering and then enter the labour force, it will be useful to examine the basic changes of population in this particular age group, indicated in Table II-1.

Between 1931 and 1961, males and females in the 18-24 age group declined from 13.0 to 9.4 per cent of the total population. The relative decline in the proportion was greatest in the last two decades. By 10-year periods, the decline was greatest in the 10 years following World War II during which the proportion declined from 12.4 to 9.8 per cent of total population or 2.6 per cent. The absolute number of persons in the age group itself actually declined from 1,526,600 to 1,511,800 between 1946 and 1951 and remained relatively stationary between 1946 and 1956. The university-age population reflects the birth rate of approximately 20 years earlier. From 1921-25 to 1936-40 live births per thousand population declined from 27.4 to 20.5.[7/] The drop in the university-age group in the early 1950's simply reflected the low birth rate of the 1930's. From 1951 to 1956 university enrolment increased by only 6,000 compared with a rise of 42,000 between 1956 and 1961.

7/ Canada, Dominion Bureau of Statistics, Canada Year Book, 1956, p. 201 and ~~op. cit.,~~ Canada Year Book, 1965, p. 207.

Table II-1

Total Population, Population 18-24 Years of Age and Total University Enrolment, Canada, 1931-1961

(thousands)

Year	Males and Females				Male			Female		
	Total	Age 18-24	18-24 as Per Cent of Total	Total University Enrolment	Total	Age 18-24	18-24 as Per Cent of Total	Total	Age 18-24	18-24 as Per Cent of Total
1931 (1)	10,376.7	1,317.0	12.7	32.9	5,374.5	669.0	12.4	5,002.2	648.0	13.0
1936	10,934.0	1,435.6	13.1	35.1	5,635.7	723.4	12.8	5,298.3	712.2	13.4
1941	11,506.7	1,474.7	12.8	36.4	5,900.6	740.8	12.6	5,606.1	733.9	13.1
1946	12,268.0	1,526.6	12.4	64.7	6,246.9	761.6	12.2	6,021.1	765.0	12.7
1951	13,984.4	1,511.8	10.8	68.6	7,074.4	749.3	10.6	6,910.0	762.5	11.0
1956	16,080.8	1,577.6	9.8	74.3	8,151.9	792.8	9.7	7,928.9	784.8	9.9
1961	18,238.3	1,712.6	9.4	116.5	9,218.9	854.6	9.3	9,019.4	858.0	9.5

(1) Includes Yukon and Northwest Territories in 1931, 1941, 1951, 1956 and 1961.

Sources: 1. Dominion Bureau of Statistics, Population Estimates 1921-1952, Reference Paper No. 40, Ottawa, 1953; Population Estimates 1952-1960, Reference Paper, Ottawa, 1962.

2. Dominion Bureau of Statistics, Survey of Higher Education, 1962-63, Part II, pp. 36-37.

b. Trends in the Labour Force and in Engineering and Scientific Occupations

(i) Trends in Selected Occupations

Changes over the long term from 1931 to 1961 in the stock and proportion of those in the various occupational classes in the Canadian labour force are available only from Census data. Data for the whole period are available only for the engineering portion of the scientific and engineering manpower pool but not for natural scientists. These trends are shown in Table II-2[8/] and in Figure II-1.

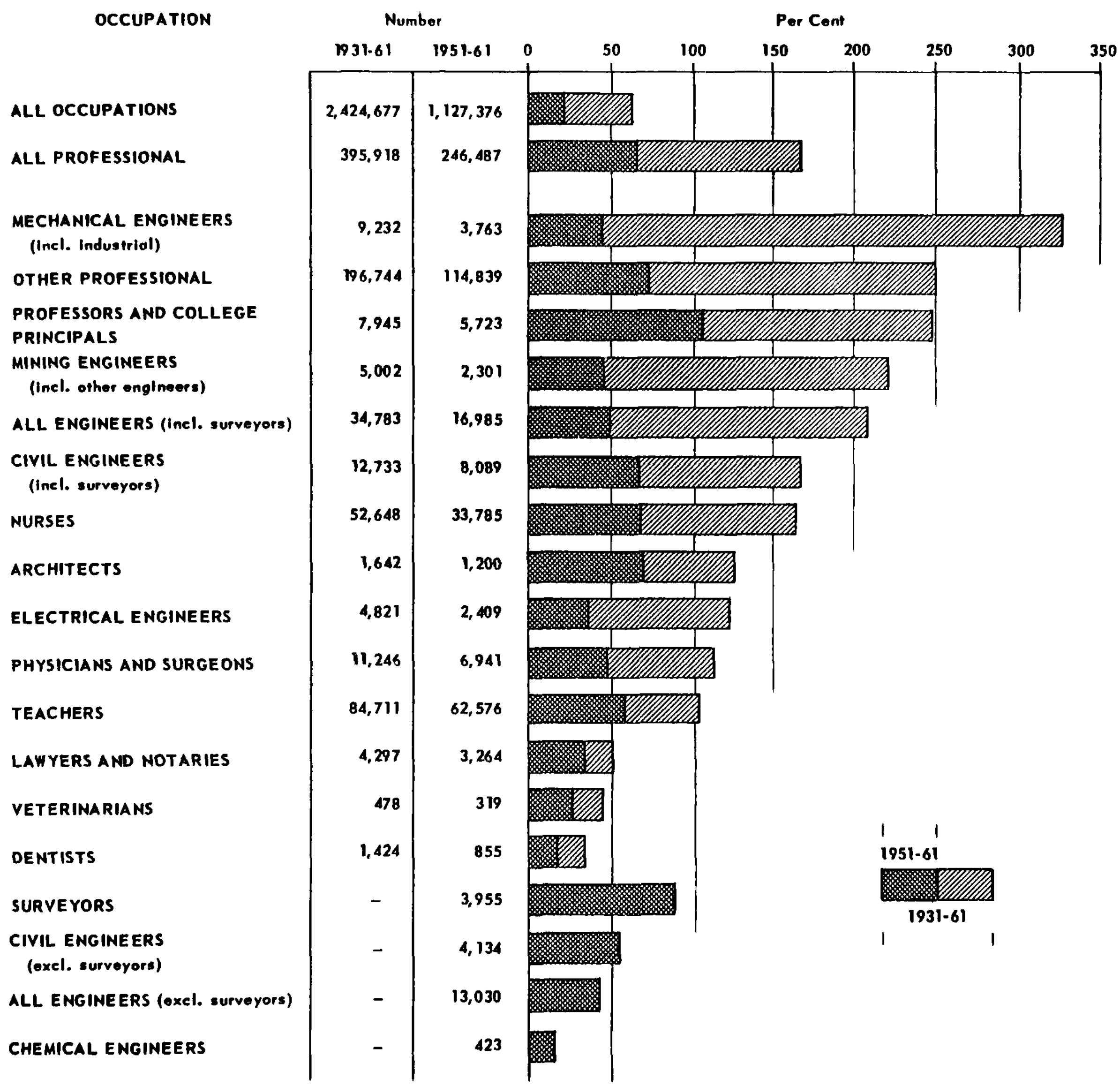
From 1931 to 1961 the total labour force rose by 62 per cent, the professional labour force by 166 per cent and the various engineering occupational classes as a group increased by almost 210 per cent.[9/] During this period the professional occupational group as a whole rose from 6.1 to 10.0 per cent of the labour force while engineers rose from 0.4 to 0.8 per cent of the labour force. The only selected occupational class shown here which increased at a faster rate during

8/ See Appendix Tables II-A-1 to 4 for further details.

9/ Surveyors are included with civil engineers for this period in order to achieve comparability over time. They were included with civil engineers in 1931 and 1941 and it was impossible to remove them. It was therefore decided to include them in 1951 and 1961 for purposes of comparison from 1931 to 1961.

Figure 11–1

NUMERICAL AND PERCENTAGE CHANGE IN THE LABOUR FORCE
BY SELECTED PROFESSIONAL OCCUPATIONS, CANADA
1931-1961 AND 1951-1961



Source: Table II–2

Table II-2

Numerical and Percentage Distribution of Males and Females in the Labour Force[1] by Selected Professional Occupations, Canada,[2] 1931-1961

Occupation	Total Number (thousands)				Per Cent of All Occupations				Percentage Increase			
	1931	1941	1951	1961	1931	1941	1951	1961	1931-1941	1941-1951	1951-1961	1931-1961
All occupations	3,917.6	4,196.0	5,214.9	6,342.3	100.0	100.0	100.0	100.0	7.1	24.3	21.6	61.9
All professional occupations	238.4	282.8	387.8	634.3	6.1	6.7	7.4	10.0	18.6	37.1	63.6	166.1
Architects	1.3	1.2	1.7	2.9	*	*	*	0.1	-7.4	44.8	69.0	126.5
Engineers (incl. surveyors)	16.6	19.8	34.4	51.4	0.4	0.5	0.7	0.8	19.3	73.7	49.4	209.7
Engineers (excl. surveyors)	..	..	30.0	43.0	..	..	0.6	0.7	..	..	43.5	..
Chemical engineers	..	..	2.6	3.0	..	..	0.1	0.1	..	..	16.4	..
Civil engineers (incl. surveyors)	7.5	6.7	12.2	20.3	0.2	0.2	0.2	0.3	-10.7	81.0	66.5	169.2
Civil engineers (excl. surveyors)	..	..	7.7	11.9	..	..	0.2	0.2	..	..	53.4	..
Electrical engineers	3.9	4.6	6.3	8.8	0.1	0.1	0.1	0.1	15.7	39.3	37.9	122.5
Mechanical engineers (incl. industrial)	2.9	4.5	8.3	12.1	0.1	0.1	0.2	0.2	58.0	84.3	45.2	322.9
Mining engineers	2.3	4.0	5.0	2.3	0.1	0.1	0.1	*	76.2	24.4	46.3	220.6
Other engineers				4.9				0.1				
Veterinarians	1.0	1.1	1.2	1.5	*	*	..	*	0.4	14.8	26.5	45.7
Other professionals	219.4	260.7	350.5	578.5	5.6	6.2	6.7	9.1	18.8	34.4	65.1	163.6
Dentists	4.0	3.7	4.6	5.5	0.1	0.1	0.1	0.1	7.4	23.2	18.6	35.3
Law	8.6	8.4	9.6	12.9	0.2	0.2	0.2	0.2	-2.4	14.7	33.9	50.0
Nurses	31.9	38.5	50.8	84.5	0.8	0.9	0.9	1.3	20.7	31.8	66.6	165.1
Physicians and surgeons	10.0	10.7	14.3	21.3	0.3	0.3	0.3	0.3	7.0	33.6	48.5	112.2
Professors and college principals	3.2	4.1	5.4	11.1	0.1	0.1	0.1	0.2	29.2	31.1	105.6	248.3
Teachers	83.0	86.5	105.1	167.7	2.1	2.0	2.0	2.6	4.2	21.6	59.5	102.1
Others[3]	78.7	108.8	160.6	275.4	2.0	2.6	3.1	4.4	38.2	47.7	71.5	250.0

* Less than 0.05 per cent .. not available or not appropriate or applicable.

1/ 14 years of age and over for 1931, 1941 and 1951; 15 years of age and over for 1961.

2/ Not including Yukon and Northwest Territories. Includes Newfoundland in 1951 and 1961. Persons on active service excluded from 1931, 1941, 1951 and 1961.

3/ Persons in occupations which were not comparable over time are included here.

N.B.: The "gainfully occupied" rather than the "labour force" concept was used prior to 1951 for determining labour force status. The labour force includes a few persons seeking work who have never been employed. Occupations for 1931, 1941 and 1961 were arranged on the 1951 classification basis.

Sources: Canada, Dominion Bureau of Statistics, Ninth Census of Canada, 1951, Vol. X, Table 63.
Dominion Bureau of Statistics, Occupation and Industry Trends in Canada, 1954, SP-8; Labour Force, Occupations by Sex, 1961 Census of Canada, 1963.

1931-61 was that of "professors and college principals" which increased by over 248 per cent. The residual group "other" representing a collection of miscellaneous professional occupations rose by 250 per cent.[10/]

These changes may be contrasted with increases from 1931 to 1961 of about 35 per cent, 50 per cent and 112 per cent for dentists, lawyers and physicians and surgeons respectively. It is clear that for this 30-year period the increase in the engineering occupational class as a group has been among the largest of any professional occupational class.

The pattern of change decade by decade among the occupations selected here varied considerably. From 1931-41 the percentage increase in the number of engineers was about 19 per cent compared with about 74 per cent for 1941-51. The rate of increase for engineers, however, slowed from 1951-61 with the professional occupation group increasing

10/ For the most part the latter increase represents the proliferation of new professional occupations rather than a large increase within the individual occupational classes included in the residual group. From 1951 to 1961, the total number of professional occupational classes increased from 37 to 50, the number of occupational classes included in the residual "other" group shown in Table II-2 increased from 21 to 32. The number of engineering occupational classes (excluding surveyors) rose from 5 to 7 and the number of engineering occupations from 139 to 267. See: Dominion Bureau of Statistics, Classification of Occupations, Ninth Census of Canada, 1951; Occupational Classification Manual, Census of Canada, 1961.

by two-thirds while the engineering occupation class increased by less than 50 per cent from 1951-61. In contrast from 1951-61 the number of "professors and college principals" increased by over 105 per cent.

Within the engineering group there were also considerable variations over time. For example, between 1951 and 1961 the number of civil engineers (excluding surveyors) rose by over 53 per cent while the number of electrical engineers rose by only 38 per cent.[11/]

(ii) Females in Engineering and Scientific Occupations

An important characteristic of the engineering and science group of occupations is the very small proportion of females. As Table II-3 reveals, in 1961 the percentage of females in all occupations was 27.8 per cent, 43 per cent approximately in the case of professional occupations, but only 0.3 per cent in the case of engineers. This proportion represents an increase from zero in 1931. From 1951 to 1961 the proportion of female engineers (excluding surveyors) rose from 0.1 to 0.3 per cent, still a negligible proportion.

11/ See: Department of Labour, Economics and Research Branch, Occupational Trends in Canada, 1931 to 1961, Report No. 11 in the Research Program on the Training of Skilled Manpower, September, 1963, Table 4, pp. 40-44 for more detailed information on the trends within the professional occupational group and for a comparison with other professional and non-professional occupational classes.

Table II-3

Females as a Per Cent of Persons in Selected Occupations, 1931-1961

Occupation	Number in Occupation								Females as Per Cent of Total			
	1931		1941		1951		1961					
	Total	Females	Total	Females	Total	Females	Total	Females	1931	1941	1951	1961
All occupations..	3,917,612	66[illegible],302	4,195,951	832,840	5,214,913	1,163,893	6,342,289	1,760,450	17.0	19.8	22.3	27.8
Professional....	238,[illegible]66	117,784	28[illegible],766	130,076	387,797	167,774	634,284	273,796	49.4	46.0	43.3	43.[illegible]
Architects.......	1,29[illegible]	2	1,202	16	1,740	43	2,940	66	0.2	1.3	2.5	[illegible]
Engineers (incl. surveyors)..	1[illegible],587	-	19,791	-	34,385	44	51,370	174	-	-	0.1	0.3
Engineers (excl. surveyors).	-	-	-	-	29,960	23	42,990	116	-	-	0.1	0.3
Physical scientists......	..	..	..	..	..	..	11,062	591		-		5.3
Biologists and agricultural professionals...	..	..	..	..	..	..	5,936	360	-	-	-	6.1
Dentists	[illegible],039	32	3,740	45	4,608	68	5,463	235	0.8	1.[illegible]	1.[illegible]	[illegible]
Physicians and surgeons	10,[illegible]20	203	10,723	384	14,325	660	21,266	1,452	2.0	3.6	4.6	6.8
Professors and college principals	3,[illegible]00	2[illegible]	4,135	277	5,422	812	11,145	2,366	8.1	6.7	15.0	21.2
Teachers.....	82,[illegible]	64,709	86,453	64,465	105,118	75,796	167,694	113,413	78.0	74.6	72.1	67.[illegible]
Veterinarians..	1,0[illegible]6	-	1,050	-	1,205	27	1,524	26	-	-	2.2	1.7

.. = not available.

Sources: 1941 Census, Vol. VII, Table 5.
1951 Census, Vol. IV, Table 11.
1961 Census, Bulletin 3.1 - 9, Tables 6 and 17.

The proportion of physical scientists and biological and agricultural professionals who were females was about 5 and 6 per cent respectively. Although Census data for scientists are not available for earlier Census years, the numerically small total for females relative to males in 1961 indicates that the absolute numerical increase could not have been large.

The proportion of engineers, physical scientists and biological and agricultural scientists in Canada in 1961 who were females - 0.3, 5.3 and 6.1 per cent was markedly lower than in the U.S. U.S. Census data for 1960 show that females represented 0.9 per cent of those in engineering occupations and 10.7 per cent of those in natural science occupations.[12/]

One factor contributing to the small proportion of females in scientific occupations both here and in the United States is the high rates at which they withdraw from the labour force soon after graduation. One study of women in engineering and science specialties found that 58 per cent had withdrawn from the labour force during the 10 years following graduation.[13/] However, the small proportion in

12/ U.S. Department of Commerce, Census of Population, 1960, Occupation by Industry, Washington, D.C., U.S. Government Printing Office, 1963, p. 7.

13/ Department of Labour, Economics and Research Branch, "Survey of Geographic Mobility of 1955 University Graduates, 1965", unpublished data.

engineering and scientific occupations who are females means that the effect of these labour force withdrawals on supply is relatively small and has been neglected, for example, in the calculations of supply of engineers. However, where females represent a large proportion in any of these occupations, the high rate of their labour force withdrawals should be taken into account.

3. Education - Engineering and Science

The purpose of this section is to assess the importance of both formal and informal education to the supply of engineers and scientists. An analysis of the factors that have affected the level and quality of this most important source of supply in the past should help in an assessment of possible future changes.

a. Trends in the Level of Schooling

The level of schooling is one of the important qualitative aspects of occupations. Not only is the level of education an index of the traditional quality of training, but is also an index of the investment in human capital made in those persons in a particular occupation. It is possible to gain some idea of this factor by examining the level of schooling of persons in engineering and science occupations. In the case of engineering and science, there are two available sources of data on levels of schooling - the decennial Censuses and the Register of Scientific and Technical Personnel. In the case of the latter, however, although much more detailed data are available on the level of education than in the Census, the time span is only 1958 to 1963.

It is apparent from Table II-4 that the level of education of the scientific and technical group while considerably higher than the professional and technical group as a whole, exhibits a somewhat lesser degree of homogeneity than the occupational class "physicians and surgeons" for example. In the case of physical scientists and engineers, three out of four who were reported in the 1961 Census as being in this occupation have a university degree. If the group with some university education is included, the proportion with a university background rises to 83 per cent of engineers and 85 per cent for physical scientists.

The level of education of engineers and scientists in 1961 as reported in the Census and the register was somewhat different. Those with no degrees represented 28 per cent of the engineers in the case of the 1961 Census, and only 5 per cent in the case of the register, based on data from the 1961 Survey of Scientific and Technical Personnel. In civil engineering those with no degrees made up 19 per cent in the Census and only 4 per cent in the case of the register. In electrical engineering, the "no degree" proportion was 26 per cent in the Census, and 6 per cent in the register. It appears that this wide discrepancy is in considerable part a result of the

Table II-4

Level of Education, Selected Occupations and Fields of Specialization, 1961 Census and 1961 Survey of Scientific and Technical Professions

Occupation or Specialization	Census, 1961 [1]				Survey of Scientific and Technical Professions, 1961 [2]		
	Total	No University	Some University	Degree	Total	No University or Some University	Degree
	(per cent)						
Professional and technical	100.0	51.5	17.5	31.0	-	-	-
Engineers, total.....	100.0	17.0	10.7	72.3	100.0	4.7	95.3
Civil.....	100.0	9.1	9.8	81.1	100.0	4.0	[illegible]
Electrical..........	100.0	15.4	10.7	73.9	100.0	6.2	93.8
Mechanical..........	100.0	28.8	12.1	59.1	100.0	7.3	92.7
Science total...	100.0	13.6	12.2	74.2	100.0	2.1	97.9
Physical scientists	100.0	14.5	12.4	73.1	-	-	-
Chemists	100.0	18.8	14.9	66.3	100.0	5.8	94.2
Biological scientists	100.0	7.5	11.2	81.3	100.0	0.0	100.0
Physicians and surgeons	100.0	1.7	2.7	95.6	-	-	-

Sources: (1) Dominion Bureau of Statistics, Census of Canada, 1961, Labour Force Bulletin 3.1-9, Table 17.
(2) Department of Labour, Economics and Research Branch, Survey of Scientific and Technical Professions, 1961, unpublished tabulation.

criteria used to designate an "engineer" - "job" in the case of the Census and employer surveys and "education" or "equivalent qualification" in the case of the register.[14/]

For data on education for the longer-term period it is necessary to utilize Census data.[15/]

14/ For a detailed discussion of the Census and the register as data sources, see Chapter I above. It is interesting to note that in the U.S. a follow-up study of engineers in the 1960 Census revealed that 45.5 per cent had no university degree. This compares with 2.7 per cent of all scientists without degrees as indicated in the U.S. National Register of Scientific and Technical Personnel. The generally higher educational qualifications of those in the register is illustrated by the fact that only 3.6 per cent of the group "Sanitary Engineering" in the U.S. National Register have no university degrees. See U.S. National Science Foundation, Scientific and Technical Manpower Resources, Washington, D.C., U.S. Government Printing Office, 1964, p. 86.

15/ The Census data on education refer to years of schooling completed. These data are available for 1941, 1951 and 1961. In 1931 information on the number of years of school attendance was obtained only for the population who are not attending school. For 1941 and 1951 these data reflect "the number of years attended school". In 1961 the data obtained were "highest grade attended". The 1941 and 1951 data did not distinguish between the different time periods for high school completion in some provinces. In addition, if students repeated grades this would tend to make the "years attended" greater than "grades attended". In addition, in 1961 there were data on the number of years of university education as well as on that in high school. In order to achieve a greater degree of comparability the amount of schooling was used and the 1961 figures were adjusted to the 1951 basis by including those who had university education in the "13 or more years of schooling" classification.

See: N.M. Meltz, Changes in the Occupational Composition of the Canadian Labour Force, 1931-1961, Department of Labour, Economics and Research Branch, Occasional Paper No. 2, March, 1965, pp. 53-54 for educational discussion on this point.

Table II-5 outlines the changes in level of schooling from 1941 to 1961 for selected occupations. The most striking change in these occupations occurred from 1941 to 1951. In the case of electrical engineers, the proportion with 13 or more years of schooling rose from about 58 per cent of the total to 93 per cent between 1941 and 1951. In the case of mechanical engineers, the rise was from 49 to 87 per cent from 1941 to 1951. During the 20-year period the overall pattern in these occupations was a substantial rise in the number with 13 or more years of schooling between 1951 and 1961. However, the category "13 years of school and over" is so broad that it indicates only in a general way the changes in the level of education of those in professional occupations including engineering.

The data on those with 13 or more years of schooling have been broken down into three levels of schooling for 1961, those with 5 years of secondary education, those with some university and those with a university degree.[16/] The majority of engineers with 13 or more years of schooling in 1961 are persons with a university degree and only a small proportion between 2 and 9 per cent have had no university education. The rise in the proportion with 13 or more years of schooling from 1941 to 1961 probably reflects a rapidly rising proportion with university degrees.

16/ These data have also been adjusted to the 1951 basis for the professional occupational group and for the selected occupations.

Table II-5

Percentage of Persons in Selected Occupations in the Labour Force with 13 or More Years of Schooling, 1941, 1951, 1961

Occupation	Per Cent with 13 or More Years of Schooling					
				Type of Schooling - 1961		
	1941	1951	1961	5 Years Secondary	Some University	University Degree
All occupations..........	7.3	10.2	16.3	7.5	4.5	4.3
Professional.............	47.5	59.3	66.0	17.8	17.4	30.7
Architects...............	62.0	79.2	92.8	5.0	9.1	78.7
Chemical engineers.......	N.A.	97.1	96.3	1.6	7.7	87.0
Civil engineers..........	N.A.	95.3	93.8	3.0	9.8	81.1
Electrical engineers.....	58.3	93.1	90.0	5.4	10.7	73.9
Mechanical engineers.....	49.1	87.1	79.6	8.5	12.1	59.1
Dentists.................	90.3	99.4	96.9	0.7	3.0	93.1
Physicians and surgeons..	95.4	99.7	98.7	0.4	2.7	95.6
Professors and college principals............	87.8	97.4	97.4	3.8	9.1	84.4
Teachers, school.........	47.6	59.4	77.7	26.3	28.0	23.4
Veterinarians............	65.7	93.4	94.8	2.2	7.2	85.4

Sources: Dominion Bureau of Statistics, 1941 Census, Vol. VI, Table 5.
Dominion Bureau of Statistics, 1951 Census, Vol. IV, Table 11.
Dominion Bureau of Statistics, 1961 Census, Bulletin 3.1-9, Table 17 and unpublished tabulation from the Census Division, Dominion Bureau of Statistics.

Another way to get an idea of changes in the level of education of engineers and scientists over time is to examine the data on schooling by age group. A rising level of education for those who are new entrants to an occupation will have the effect of increasing the average level of education in a particular occupation and, of course, this effect will be reinforced if the educational level of those in the older age groups is lower.

Table II-6 suggests that the proportion of engineers and scientists who have no university training is over 50 per cent higher in the case of those 35 to 54 years of age compared with those in the 25 to 34 age group, 12.4 and 19.8 per cent respectively. The proportion of engineers in the 25 to 34 age group who have university degrees is 78 per cent, compared with 61 per cent for those 55 to 64 years of age in 1961.

The combined effects of the differences in level of education of those entering and those withdrawing from the labour force at different age levels have in the past tended to raise the average level of education in engineering and science occupations. These effects will probably continue to occur in the future.

One possible way to gauge the impact of graduates over the long run is to relate the actual increases in the stock of professional persons and engineers to the flow of graduates. This is done in Table II-7. A number of factors can affect the stock-flow relationship besides the number of graduates, including the number of graduates who

Table II-6

Males and Females in Selected Occupations
by Age and Level of Education, 1961

Age Group	Engineers Total	Engineers No University	Engineers Some University	Engineers University Degree	Physical Scientists Total	Physical Scientists No University	Physical Scientists Some University	Physical Scientists University Degree
				Number				
Total	43,066	7,349	4,595	31,122	11,062	1,608	1,367	8,087
15-19	68	23	42	3	99	40	59	-
20-24	3,125	268	679	2,179	1,200	209	350	641
25-34	15,248	1,892	1,410	11,946	4,400	557	455	3,388
35-54	20,982	4,152	2,083	14,747	4,747	659	438	3,650
55-64	2,890	813	306	1,771	496	114	47	335
65+	752	201	75	476	120	29	18	73
				Per Cent				
Total	100.0	51.5	17.5	31.0	100.0	14.5	12.4	73.1
15-19	100.0	33.8	61.8	4.4	100.0	40.4	59.6	0.0
20-24	100.0	8.6	21.7	69.7	100.0	17.4	29.2	53.4
25-34	100.0	12.4	9.2	78.4	100.0	12.7	10.3	77.0
35-54	100.0	19.8	9.9	70.3	100.0	13.9	9.2	76.9
55-64	100.0	28.1	10.6	61.3	100.0	23.0	9.5	67.5
65+	100.0	26.7	10.0	63.3	100.0	24.2	15.0	60.8

Source: Dominion Bureau of Statistics, 1961 Census of Canada, Bulletin 3.1-13, Table 19.

Table II-7

Graduates as a Proportion of Increase in the Stock of Professional and Engineering Occupations, 1931-1961

Occupation	Year	1 Increase in Stock No.	2 Graduates No.	3 Graduates / Stock %
All professionals	1931-41 1932-41	45,000	65,512	145.6
	1941-51 1942-51	105,000	108,755	103.6
	1951-61 1952-61	246,000	151,568	61.6
	1931-61 1932-61	396,000	352,835	89.1
Engineers (including surveyors)	1931-41 1932-41	3,204	6,145	191.8
	1941-51 1942-51	14,594	15,792	108.2
	1951-61 1952-61	16,985	17,603	103.6
	1931-61 1932-61	34,783	39,540	113.7

Sources: Col. 1 - Table II-A-2
Col. 2 - Table II-A-9.

actually enter or leave professional or engineering occupations, the number of non-graduates who enter these occupations, net migration, and losses due to deaths and retirements. Therefore, the data here merely indicate the changing relationship of graduations and stock during various periods of time.

Two points stand out. First, between 1931 and 1961 the ratio of graduates to increases in stock has been lower for all professionals as a group than for engineers, 0.89 compared with 1.14 per cent. This suggests that sources other than university graduates appear to have been drawn upon to augment the stock of all professional occupations more than in the case of engineers. Second, in relation to the output of graduates, the increase in the stock of both professional persons and engineers was less during 1931-41 than it was in later decades, especially during 1951-61. This would suggest that in 1951-61, for example, sources other than graduates, possible immigrants or native-born non-graduates, have been used to augment the stock of professional and engineering occupations to a relatively larger extent than in earlier periods of time.

For a more detailed examination, we must turn to the Register of Scientific and Technical Personnel. The annual surveys of the Department of Labour's Register of Scientific and Technical Personnel provide a more detailed picture of the changes in level of education of those in engineering and scientific fields of specialization. This is shown in Table II-8.

Table II-8

Level of Education, Engineering and Science, 1958, 1961 and 1963

Academic Specialization and Level of Education(1)	1958	1961	1963
	%	%	%
Engineering			
No degree......	5.3	4.7	2.8
Bachelor.......	87.8	85.6	86.6
Master.........	6.1	8.7	9.2
Doctor.........	0.8	1.0	1.4
Total..........	100.0	100.0	100.0
Total number...	7,123	9,442	9,953
Science(2)			
No degree......	2.2	1.8	2.1
Bachelor.......	55.1	53.5	49.8
Master.........	19.2	19.5	20.8
Doctor.........	23.4	25.2	27.2
Total..........	100.0	100.0	100.0
Total number...	2,631	3,114	3,256

(1) Non-graduates were classified according to field of employment specialization.

(2) Excludes agriculture and forestry.

Source: Department of Labour, Surveys of Scientific and Technical Personnel, unpublished tabulation.

The most notable change was in the proportion of engineers and scientists with post-graduate degrees. In engineering, the proportion rose from about 7 per cent in 1958 to almost 11 per cent in 1963. In science specialties, the group of graduate degrees rose from over 42 per cent in 1958 to 48 per cent in 1963. The proportion with doctorates in science rose from over 23 per cent to over 27 per cent during this 5-year period. Clearly, there was a striking improvement in the quality of engineering and science labour force as measured by level of education in recent years.

b. Formal Education in Canada in Engineering and Science

The previous analysis has indicated that over the past 30 years the number of persons in engineering occupations has grown at a high rate, and at the same time the average educational level of the stock has risen. There are two main sources of supply, domestic and foreign. The domestic source of supply, as well as the foreign, in turn consists of two groups - those holding a bachelor's degree, usually in engineering and those who do not. In general, the main prerequisite for entry into these professions is the receipt of a bachelor's degree in engineering or science.

Given the number in the college age population, the role of the formal education system in the domestic supply of trained engineering and scientific manpower may be regarded initially as a process which involves two stages, first, the decision to enroll in an engineering or science course at university; secondly, the completion of the course and graduation. It is useful to consider these stages separately because, although in the long run enrolments and degrees received have maintained a fairly stable relationship, they may move in opposite directions for periods of time in the short run and thus negate any simple predictions, say, of graduations based only on enrolments. For example, in the case of the engineering classes who graduated in 1960, the rise in the number of graduates caused by an increase in the percentage of students enrolled in engineering was cancelled out by a fall in the number of graduates caused by a higher drop-out rate.[17/]

The long-term patterns of engineering enrolments and graduations are illustrated in Table II-9. A comparison is made between first degrees and enrolments in all undergraduate courses and in engineering. To facilitate the comparison a small adjustment was made. Degrees were lagged 3 years, that is, total enrolment in year t was compared with total graduations in year t + 3. There is assumed to be an average 3-year lag between total enrolment data which includes first, second, third and fourth years, and data on the receipt of a first degree. The choice of a 3-year lag is based on an estimate of an average length of time for 4 years between first-year enrolment and

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17/ See: Appendix Table II-A-5.

Undergraduate Enrolment and First Degrees in Engineering as a Proportion of Total Undergraduate Enrolment and First Degrees, 1932-1961

Year[1]	1 Total Undergraduate Enrolment	2 Engineering Enrolment	3 Total First Degrees	4 Engineering Degrees	5 Engineering Enrolment / Total Enrolment Col.2÷Col.1	6 Engineering Degrees / Total Degrees Col.4÷Col.3	7 Total Degrees / Total Enrolment Three Years Earlier Col.3÷Col.1	8 Engineering Degrees / Engineering Enrolment Three Years Earlier Col.4÷Col.2
	No.	No.	No.	No.	%	%	%	%
1932........	32,862	3,755	5,552	462	11.4	8.3	19.6	17.1
1936........	33,522	3,387	6,441	566	10.1	8.8	19.4	15.3
1941........	34,817	4,381	6,576	697	12.6	10.6	19.1	17.4
1946........	61,861	10,884	8,192	1,006	17.6	12.3	23.0	18.5
1947........	76,237	13,609	9,830	1,096	17.8	11.1	28.0	22.2
1948........	79,346	14,373	13,733	1,690	18.1	12.3	35.8	31.9
1949........	75,807	12,874	17,841	2,999	17.0	16.8	28.8	27.6
1950........	69,111	10,595	18,081	3,589	15.3	19.8	23.7	26.4
1951........	64,036	8,367	15,754	2,425	13.1	15.4	19.9	16.9
1952........	59,849	7,468	13,288	1,770	12.5	13.3	17.5	13.7
1953........	60,046	8,135	12,575	1,337	13.5	10.6	18.2	12.6
1954........	61,198	9,098	12,083	1,252	14.9	10.4	18.9	15.0
1955........	65,032	10,309	12,967	1,337	15.8	10.3	21.7	17.9
1956........	69,310	11,256	13,770	1,597	16.2	11.6	22.9	19.6
1957........	75,046	12,704	14,783	1,741	16.9	11.8	24.2	19.1
1958........	82,699	14,096	16,062	1,930	17.0	12.0	24.7	18.7
1959........	90,[illegible]	14,334	17,080	2,057	15.8	12.0	24.6	18.3
1960........	[illegible],640	14,121	18,720	2,171	14.6	11.6	24.9	17.1
1961........	107,339	14,632	20,240	2,412	13.6	11.9	24.5	17.1
1932-1946...	565,748	59,914	96,028	10,138	11.8	10.6	19.2	17.6
1947-1961...	1,028,398	147,218	226,807	29,393	14.3	13.0	23.3	21.3
1932-1961...	1,535,146	207,132	322,835	39,531	13.5	12.2	21.9	20.2

[1] Data on degrees are lagged three years.

Sources: (1) Dominion Bureau of Statistics, Survey of Higher Education, 1962-63, Part II, p. 36.
(2) Dominion Bureau of Statistics, Survey of Higher Education, 1936-38, p. 79; 1938-40, p. 38; 1940-42, p. 38; 1942-44, p. 59; 1944-46, p. 76; 1946-48, p. 50; 1948-50, p. 63; 1950-52, p. 55; 1952-54, p. 57; 1954-61, p. 29; 1962-[illegible], p. 31.
(3) Unpublished data from Higher Education Section, Education Division, Dominion Bureau of Statistics. In some cases, revised figures from unpublished documents of the Higher Education Section were used in place of published figures.

receipt of a first degree.[18/] This simply means that total enrolment for the year 1929 is related to total degrees in 1932 rather than in 1929.

Some indication is given of the higher drop-out rate in engineering as compared with total courses in Table II-9. In all courses from 1932-61, degrees represented 22 per cent of total enrolment. In engineering, degrees represented only 20 per cent of total enrolments during this period of time. At the same time the relative proportion of degrees to enrolments in engineering as compared with total undergraduate courses has remained relatively stable. From 1932-46, the difference between these rates was (19.2 minus 17.6) 1.6 per cent and from 1947 to 1961 it was (23.3 minus 21.3) 2.0 per cent.

18/ An examination of first-year engineering enrolment revealed that 72, 66, and 63 per cent were enrolled in 4-year courses in 1947-48, 1952-53, and 1957-58 respectively. See: Engineering Institute of Canada, "The Engineering Journal", Vol. 25, Nos. 1 and 12, January and December, 1942; Vols. 26-43, No. 12, December, 1943-60; Vol. 45, No. 1, January, 1962. Ideally, it would be preferable to use first-year total enrolment but these data are not available, except for short periods in 1950 to 1955. Therefore, total enrolment is used instead. In the short or intermediate run, the effect of rapidly rising (or falling) enrolment will tend to exert a downward (or upward) bias to the proportion that first degrees represent of enrolment. But over the long-run period chosen here, these biases will tend to cancel each other out. Since total enrolment consists of those in the first, second, third and fourth years the average length of time until those in all university years as a group receive a degree is actually 2.5 years. This has been rounded to 3 years, since some are in 5 year engineering courses.

(i) Undergraduate Enrolments - Total, Engineering and Science

Another phenomenon illustrated by Table II-9 is the long-term rise in enrolments and graduations in engineering as a proportion of total enrolments and graduations. From 1932 to 1946, enrolment in engineering as a per cent of total enrolment increased from 11.4 to 17.6 per cent. Graduations increased by a similar proportion. It would appear that the stable long-term relationship between enrolments and graduations indicates that for purposes of projection of future supply, either graduations or enrolments may be usefully employed in assessing long-term educational output.

During the 30-year period from 1931 to 1961 undergraduate engineering enrolments as a per cent of total undergraduate enrolments, as indicated in Table II-10, have more than kept pace with increases in total enrolments, rising from 11.3 per cent in 1931 to 13.6 per cent in 1961. But during short periods of time the pattern has been uneven, rising from 12.6 per cent in 1941 to 17.6 per cent 5 years later and subsequently dropping to 13.1 per cent in 1951.

Another noteworthy trend is the increase in the proportion of total undergraduate enrolment in pure science, more than double the relative increase in engineering. There is also a growing emphasis on scientific and post-graduate work in engineering education. One reason suggested for the increased proportion enrolled in science is undoubtedly due to the rapidly rising enrolment in universities plus the probability

Table II-10

Undergraduate Enrolment, Total, Engineering and Pure Science, 1929-1959

Academic Year Ending	Undergraduate Enrolment			Per Cent of Total	
	Total	Engineering	Pure Science	Engineering	Pure Science
1929	28,306	2,706	669	9.6	2.4
1934	32,596	3,471	894	10.6	2.7
1939	35,164	4,274	1,103	12.2	3.1
1944	35,132	4,948	2,472	14.1	7.0
1949	75,807	12,874	4,612	17.0	6.1
1954	61,198	9,098	5,012	14.9	8.2
1959	90,444	14,334	8,103	15.8	9.0
1930-1939	330,524	36,224	9,021	11.0	2.7
1940-1949	507,851	80,732	29,374	15.9	5.8
1950-1959	696,771	106,362	51,016	15.3	7.3
1930-1959	1,535,146	223,318	89,411	14.5	5.8

Sources: See Table II-9 above, sources 2 and 3.

that science faculties may be more easily expanded than engineering faculties.[19] The increased emphasis on science and advanced study in engineering education itself is due to the increasing complexity of technology, and the need for an increased study of scientific subjects by engineering students.[20]

(ii) First Degrees - Total, Engineering and Science

The domestic output of bachelor's degrees in engineering and pure science from 1931 to 1961 is shown in Table II-11. During this 30-year period the 39,500 engineering degrees granted by Canadian universities represent 12.2 per cent of all undergraduate degrees and pure science degrees, 20,365, represent 6.3 per cent. The pre-war and post-war pattern is characterized by an overall rise in engineering bachelor degrees as a percentage of total undergraduate degrees from 9.8 per cent to 11.6 per cent between 1932-41 as compared with 1952-61. But the general average conceals wide variations in the proportion of engineering degrees of all undergraduate degrees over time. In 1936 engineering degrees represented 8.8 per cent of total undergraduate degrees compared with 12.3 per cent 10 years later in 1946 and 15.4 per

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19/ See: "O.E.C.D. Observer", No. 10, June, 1964, p. 39.

20/ Organization for Economic Co-operation and Development, "Report of the International Seminar on Applied Mathematics for Engineers", Paris, January 5, 1965, p. 8 (mimeographed).

Table II-11

Bachelors Degrees, Total, Engineering and Pure Science, 1931-1961

Academic Year Ending	Bachelor Degrees			Per Cent of Total	
	Total	Engineering	Pure Science	Engineering	Pure Science
1931	5,290	420	252	7.9	4.8
1936	6,441	566	320	8.8	5.0
1941	6,576	697	342	10.6	5.2
1946	8,192	1,006	576	12.3	7.0
1951	15,754	2,425	1,069	15.4	6.8
1956	13,770	1,597	791	11.6	5.7
1961	20,240	2,412	1,614	11.9	8.0
1932-1941	62,512	6,145	3,057	9.8	4.9
1942-1951	108,755	15,792	7,389	14.5	6.8
1952-1961	151,568	17,604	9,919	11.6	6.5
1932-1961	322,835	39,541	20,365	12.2	6.3

Sources: See Table II-9 above, sources 2 and 3.

cent in 1951. A sharp drop occurred between 1951 and 1956, with engineering as a percentage of total degrees declining from 15.4 to 11.6 per cent reflecting the proportionate decline in engineering enrolments noted earlier in Table II-9. But pure science degrees, in contrast to engineering increased as a proportion of total bachelor degrees, from 6.8 to 8.0 per cent between 1951 and 1961.

(iii) Comparison of Enrolment and Degrees, Engineering and Other Faculties

Some idea of the relative long-term attrition rates of students in engineering compared with those in all courses is indicated in Table II-12. From 1932-61, engineering degrees represented 17.7 per cent of average engineering enrolment 2 years earlier, compared with 21.0 per cent of total undergraduate degrees as a percentage of total undergraduate enrolment 2 years earlier. Clearly, attrition as defined by the shortfall between enrolments and graduations is higher in engineering than in other undergraduate courses. The long-term pattern indicates a decline in attrition from 1931 to 1946. However, the last 10 years have been marked by a rising attrition rate which reached a new peak in 1961 with engineering degrees representing only 16.8 per cent of total enrolment 2 years earlier compared with 22.4 per cent for all undergraduate degrees as a percentage of total undergraduate

Table II-12

Bachelors Degrees as a Per Cent of Undergraduate Enrolment, Total, Engineering and Pure Science, 1931-1961[1]

Academic Year Ending	Total, All Courses	Engineering[2]	Pure Science
1931.......	18.7	15.5	37.7
1936.......	19.8	16.3	35.8
1941.......	18.7	16.3	31.0
1946.......	23.3	20.3	23.3
1951.......	20.8	18.8	23.2
1956.......	22.5	17.6	15.8
1961.......	22.4	16.8	19.9
1932-1941..	18.9	17.0	33.9
1942-1951..	21.4	19.6	25.2
1952-1961..	21.8	16.6	19.4
1932-1961..	21.0	17.7	22.8

(1) Enrolment data are lagged two years. For example, degrees for 1932-1941 are related to enrolment for 1930-1939, etc.

(2) Excludes Architecture, Community Planning. Includes Engineering Chemistry, Electrical Communications, Mining (Geophysics), Mining Exploration Aeronautical and Aerophysics, Engineering n.e.s., Mining and Metallurgy, and Surveying.

Sources: 1. See Table II-9 above, sources 1, 2 and 3.
2. Department of Labour, Economics and Research Branch, Annual Surveys of Graduating Classes in Engineering and Science, 1940-1962 unpublished data.

enrolment 2 years earlier. In recent years the "drop-out" or attrition rate in engineering relative to other undergraduate courses would appear to be somewhat higher than it has been over the last 30 years.[21/]

The data presented above relating degrees to average enrolments 2 years earlier present a fairly accurate picture of one long-term period of time compared with another. In the short run within these time spans, however, such data tend to give an upward bias to attrition rates in periods of rising enrolments and a downward bias to attrition rates in periods of falling enrolments. A more precise indication of a "true" academic attrition or drop-out rate in the recent past can be obtained by a comparison of first-year enrolments with subsequent degrees.

A comparison of drop-out rates[22/] in engineering between the class of 1950-54 and the class of 1959-63 was recently

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21/ For a discussion of influences affecting the drop-out rate, see, Department of Labour, Economics and Research Branch. Drop-out Rates in University Engineering Courses. Professional Manpower Bulletin No. 3, October, 1963.

22/ The drop-out rates were computed by subtracting the enrolment in each year from the enrolment the previous year taking the difference as the percentage of the first-year enrolment. Three main limitations of these data should be noted. In the first place, graduations refer to academic year graduates which include, in addition to the Spring graduates of an academic year, graduates of the previous Fall. However, since the proportion of Fall graduates is relatively constant, this disparity is felt to be negligible. The second limitation concerns transfers of students into second or later year of engineering courses from other Canadian universities, from other faculties or from other countries. In the case of transfers from other universities, this would not affect the over-completed.[23/] These data are illustrated in Table II-13. These data support the conclusion based on Table II-12 that in general the drop-out rate in engineering has been higher during the period of time covered than in most of the other courses and faculties indicated. In addition, the loss rate from engineering courses has risen sharply during the last 10 years, rising from 31 per cent in 1954 to 50 per cent in 1961 and 46 per cent in 1963. The absolute size and variable nature of this drop-out rate in the short and intermediate run has had a large impact upon subsequent graduations and must be examined carefully when projected degrees are based on enrolment data.

(iv) Factors Associated with Changes in Engineering and Sciences Classes, 1950-54 to 1960-64

One of the questions to which this analysis is addressed is: What factors have been associated over time with changes in the supply

22/ (Cont'd)
all drop-out rate in the country. Transfers and foreign students appear to be few in number and probably do not influence the overall rate appreciably. In the case of students enrolled in the second and third years in engineering courses in universities in the Atlantic provinces who take their final 2 years at another university, the students are not considered as transfers. The exclusion of students in the first year of 5-year courses in this case would slightly understate the drop-out rates. Finally, it might be noted that the drop-out rate from a single class would be biased downward by drop-outs from a previous class who have enrolled. However, over the long term in the average these year-to-year differences should cancel out.

23/
Department of Labour, Economics and Research Branch, Drop-out Rates in University Engineering Courses, Professional Manpower Bulletin No. 3, October, 1963.

Table II-13

Drop-Out Rates in Engineering and Other Faculties, 1954-1963

(per cent)

Class Graduating in Year(1)	Engineering(2)	Arts and Science	Agriculture	Commerce	Dentistry	Medicine	Law
.954	31	37	28	34	10	5	22
.955	31	39	34	34	8	6	23
.956	41	41	27	36	7	6	28
.957	41	42	22	33	8	8	29
.958	41	42	25	36	8	9	29
.959	45	41	25	32	9	10	29
.960(3)	50	. .	. .	. .	. .	. .	. .
.961(3)	50	. .	. .	. .	. .	. .	. .
.962(3)	45	. .	. .	. .	. .	. .	. .
.963(3)	46	. .	. .	. .	. .	. .	. .

. . = Not available.

(1) For engineering, first year enrolment represents first year of a four-year course and second year of a five-year course. In other faculties, length of courses vary so starting years are not shown. The drop-out rates for faculties other than engineering are based on data which enable only rough estimates to be made.

(2) Includes all universities, except the University of Waterloo.

(3) Data on first-year enrolments were obtained from the Dominion Bureau of Statistics, Education Division, Full-Time Undergraduate Enrolments at Canadian Universities, Annual Reports, 1950 to 1958. Data on first-year enrolments in [illegible] are available from 1950 to 1958, but only from 1950 to 1955 for total first-year enrolments in other faculties.

Sources: Department of Labour, [illegible] Branch, Professional Manpower Bulletin No. 3, [illegible]-Out [illegible] Classes of 1954-1962, October 1963, pp. [illegible] and 3.

of engineering and science graduates? Three of these factors have been selected for examination: total enrolment in universities; the percentage of those who enroll at universities who choose engineering or science courses; and the drop-out rate in engineering and science courses. Although the three variables may be considered as jointly determining the number of engineers or science graduates in a given year, they merely reflect changes that arise from more fundamental sources. Among other things total enrolment at universities is affected by changes in total population and its age distribution. The percentage who choose engineering courses is probably affected by economic or more properly by socio-economic changes. Drop-out rates from engineering courses are probably affected by changes within the educational system itself, for example, the student-teacher ratio. Since changes in population growth, its age distribution as well as qualitative changes in society (e.g., the factors behind rising demand by students and their parents for more education) and within the educational system itself are taken as given and are beyond the scope of this study, it was thought useful to separate the factors behind changes in engineering graduates from year-to-year for the period 1950-54 to 1960-64 into three proximate variables:

1) year-to-year changes in total university enrolment (male);

2) year-to-year changes in the percentage of males who enroll at university who choose engineering courses;

3) year-to-year changes in the drop-out rates from engineering courses.

Table II-14[24/] is an attempt to "factor out" the effects of these variables on actual graduations in engineering from 1950-54 to 1960-64. In order to facilitate a comparison of these effects upon graduations, the numerical changes have been converted to ratios of actual net changes in graduations during this period.

The "gross increase" represents the extent to which year-to-year actual graduations have increased in all years during this 11-year period, and the "gross decrease" represents the opposite. The chief factors associated with year-to-year changes in graduations are changes in total enrolment and changes in the per cent who decide to enroll in engineering in a given year, with the latter factor being the major one.

The "net changes" represent the net effects of changes in these three variables on actual graduations during this period of time. The bulk of the actual changes in graduations have been in a positive direction. But this prevailing positive trend masks a variety of negative and positive influences. Total enrolment has tended to exert a large positive and steadily upward influence on graduations. Although the per cent who decide each year to enter engineering courses has had

24/ See also, Appendix Table II-A-5 for a more detailed breakdown of the factors behind the changes in engineering graduations over time.

Table II-14

Changes in Annual Bachelor Graduations in Engineering Due to Changes in Total Male Undergraduate Enrolment, Per Cent Enrolled in First Year Engineering, and Drop-Out Rates, 1950-54 to 1960-64

Type of Change in Annual Graduations	Change in Annual Graduations During the Period			
		Factors Associated With Changes		
	Actual Change	Total Enrolment	Per Cent Enrolled in Engineering	Drop-Outs
	No.	No.	No.	No.
Gross Increase (+)	1,327	1,053	1,387	255
Gross Decrease (-)	212	191	907	482
Net Change (+) or (-)	+1,115	+862	+480	-227
		Ratios (Actual Net Change = 1.00)		
Gross Increase (+)	1.19	0.93	1.24	0.23
Gross Decrease (-)	0.19	0.16	0.81	0.43
Net Change (+) or (-)	+1.00	+0.77	+0.43	-0.20

Source: Appendix Table II-A-5.

a net upward effect upon graduations, it has exerted a strong upward and downward effect on graduations from year-to-year. Drop-out rates have also varied from year-to-year, but their net effect during the period has been to depress graduations.

The net result of these three factors can now be summed up. Of the increase in engineering graduations between 1954 and 1964, 77 per cent can be accounted for by net increases in total enrolments, 43 per cent by net increases in the per cent who choose to take engineering courses and -20 per cent by a rising drop-out rate.

However, as Table II-A-5 revealed, in the short-run, variations in engineering graduations are due more to changes in the decisions of students to enter or not to enter engineering courses than any other single factor.

In the long-run, although changes in decisions to enter engineering courses and also changes in drop-out rates tend partially to cancel out, these two factors do have a substantial effect on graduations so they must be taken into account in making projections of future graduations which are based on historical data.

(v) Graduate Degrees, Total Engineering and Science

In addition to the quantitative aspect of engineering and pure science degrees indicated by numbers, there is the qualitative dimension of formal education. Such changes in engineering and science curricula would aim at upgrading these courses and incorporating to an over-increasing extent the newer areas of scientific and technical knowledge.[25/]

Another aspect of the changing quality of engineering and science formal education over time is illustrated by changes in the proportion who have post-graduate degrees. Unfortunately, the data on graduate degrees by type of specialty is available only from 1957 to 1963. The long-term trends indicate that in the case of all types of graduate degrees as a group, there has been an increase in the proportion of those with such degrees over time. For example, Table II-15 indicates that master's degrees as a percentage of bachelor's degrees rose from 8.3 in 1932-36 to 10.7 per cent in 1957-61, while doctorates as a percentage of bachelor's degrees rose from 1.3 to 1.6 per cent of total bachelor's degrees between these periods of time.

25/ For example, if the growth of earnings of younger workers occurred because of the embodiment of new technology in their education, this could raise their earnings more rapidly than that of older workers and affect the cross-sectional age-earnings profile of workers. This would occur even in a time series profile of earnings which was adjusted for growth in per capita earnings. See Gary S. Becker, Human Capital, New York, Columbia University Press, 1964, pp. 138-143.

Table II-15

Bachelors, Masters and Doctors Degrees, Total, Engineering and Pure Science, 1931-1963

Course and Level of Degree	Year					
	1932-36	1942-46	1952-56	1957-61	1957-61	1957-63
	No.				% Change	
All Courses						
Bachelors	30,382	33,516	64,683	86,885	36.9	70.6
Masters	2,505	3,163	7,307	9,263	63.1	110.1
Doctors	401	499	1,275	1,434	4.5	44.2
	%					
Masters / Bachelors	8.3	9.4	11.3	10.7	-	-
Doctors / Bachelors	1.3	1.5	2.0	1.6	-	-
	No.				% Change	
Engineering (1)						
Bachelors	2,964	3,993	7,293	10,311	40.2	30.5
Masters	. .	. .	. .	750	113.4	196.9
Doctors	. .	. .	. .	81	58.3	116.7
	%					
Masters / Bachelors	. .	. .	. .	7.3	-	-
Doctors / Bachelors	. .	. .	. .	0.8	-	-
	No.				% Change	
Pure Science (2)						
Bachelors	1,437	2,063	3,930	5,989	82.[illegible]	152.2
Masters	. .	. .	. .	2,[illegible]	48.4	82.7
Doctors	. .	. .	. .	920	[illegible].9	42.1
	%					
Masters / Bachelors	. .	. .	. .	36.[illegible]	-	-
Doctors / Bachelors	. .	. .	. .	15.4	-	-

. . = Not available.

(1) Excludes Architecture, Community Planning [illegible]. Includes Engineering [illegible], Chemistry, Electrical Communications, Mining (Geo[illegible]ies), Mining [illegible], Aero[illegible] and Aerophysics, Engineering n.e.s., Mining and Metallurgy, and Surveying.

(2) Including all biological, agricultural and health specialties [illegible] under "biological sciences", and all other physical sciences not [illegible] specified.

Sources: 1. Dominion Bureau of Statistics, Survey of Higher Education, 1962-1963, Part II, pp. 31, 36, 45, 47, 57-59.

2. Dominion Bureau of Statistics, Survey of Higher Education, 1936-38, p. 79; 1938-40, p. 38; 1940-42, p. 38; 1942-44, p. 59; 1944-46, p. 76; 1946-48, p. 50; 1948-50, p. 63; 1950-52, p. 55; 1952-54, p. 57; 1954-61, pp. 29, 44, 52-57.

3. Unpublished data from Higher Education Section, Education Division, Dominion Bureau of Statistics. In some cases, revised figures from unpublished documents of the Higher Education Section were used in place of published figures.

The recent trends in graduate degrees in engineering and pure science are illustrated in Table II-16 by reference to bachelor's degrees granted 3 years earler.[26/] For engineering, the increase in engineering bachelor's degrees was over 73 per cent, of masters almost 197 per cent and of doctors in engineering, almost 117 per cent. For master's and doctor's degrees in all courses the corresponding percentage increases were 110 and 44 per cent. The rates of increase for graduate degrees in engineering were therefore considerably faster than both the increase in engineering bachelor's degrees and the increase in other graduate degrees. Additional data are presented in Table II-17 which illustrates the most recent relatively rapid increase in engineering graduate degrees.

The increase in graduate degrees in engineering is probably associated with the increasing complexity of technology and the growth in research and development activities. This, in turn, requires engineers as well as scientists who have post-graduate level training. In addition, more universities began to offer post-graduate degrees in engineering in the early 1960's. The number of Canadian universities

26/ In this case a time lag of 3 years, which is more appropriate for doctor's degrees, was used in the case of both master's and doctor's degrees, since master's degrees in both engineering and pure science were not available for 1956. This should not bias the percentage increase in master's degrees since the general trend seems to be steadily upward.

Table II-16

Bachelors Degrees, Total Engineering(1) and Pure Science(2)
1954-1960 and Masters and Doctors Degrees, 1957-1963

Year	Bachelors Degrees, 1954-60			Year	Graduate Degrees, 1957-63					
					Total		Engineering		Pure Science	
	Total	Engineering	Pure Science		Masters	Doctors	Masters	Doctors	Masters	Doctors
	No.	No.	No.		No.	No.	No.	No.	No.	No.
1954	12,083	1,252	756	1957	1,500	292	97	12	376	202
1960	18,720	2,171	1,311	1963	3,152	421	288	26	687	287
Per Cent Increase	%	%	%		%	%	%	%	%	%
1954-60	54.9	73.4	73.4							
1957-63	-	-	-		110.1	44.2	196.9	116.7	82.7	42.1

(1) [illegible] Community Planning. Includes Engineering Chemistry, Electrical Communications, [illegible] ([illegible]), Mining Exploration, Aeronautical and Aerophysics, Engineering n.e.s., [illegible], and Surveying.

(2) [illegible] all biological, agricultural and health specialties specified under "biological sciences", [illegible] other physical sciences not exactly specified.

Source: 1. [illegible] Table II-9, source No. 2.
2. [illegible] Bureau of Statistics, Survey of Higher Education, 1954-1961, pp. 44, 52-57; 1962-63, Part II, pp. 46, 47, 57-59.

Table II-17

[illegible] uate Degrees, Total, Engineering[1] and Pure Science[2], 1957-1963

Year	Total Graduate Degrees: Masters	Total Graduate Degrees: Doctors	Engineering Graduate Degrees: Masters No.	Engineering Graduate Degrees: Doctors No.	Pure Science Graduate Degrees: Masters No.	Pure Science Graduate Degrees: Doctors No.	Engineering as Per Cent of Total: Masters %	Engineering as Per Cent of Total: Doctors %	Pure Science as Per Cent of Total: Masters %	Pure Science as Per Cent of Total: Doctors %	Grad[illegible] as Per Cent of Pure Science: Masters %	Grad[illegible] as Per Cent of Pure Science: Doctors %
[illegible]	[illegible]	[illegible]	97	[illegible]	376	202	6.5	4.1	25.[illegible]	69.[illegible]	2[illegible].8	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	14	495	193	8.5	5.0	23.6	68.7	35.8	7[illegible]
196[illegible]	3,[illegible]	[illegible]	[illegible]	36	687	267	9.1	6.2	21.8	68.[illegible]	[illegible]	[illegible]
			Per Cent I[illegible]									
1957-60	[illegible]	[illegible]	[illegible]	[illegible]	31.6	-4.5						
1960-63	[illegible]	4[illegible]	[illegible]	[illegible]	38.[illegible]	[illegible]						
1957-63	[illegible]	[illegible]	196.	[illegible]	82.7	[illegible]						

(1) [illegible] Engineering Chemistry, Electrical Communications, Mining [illegible] Engineering [illegible], Mining, and Surveying.

(2) [illegible] specified under "biological sciences" and all [illegible]

[illegible]

offering master's degrees in engineering increased from 11 to 15 between 1955 and 1961. In 1955 only three offered doctoral degrees in engineering compared with nine in 1961.

c. Student Migration

(i) Enrolments, Canada and Abroad

The distribution of enrolment of all students, foreign students in Canada and of Canadian students abroad for all courses and for engineering and science courses is given in Table II-18. One purpose of this comparison is to estimate the possible numerical gains and losses from student exchange between Canada and other countries. In order to do this, it is necessary first to look at the overall numbers involved and then to make an estimate of the number who do not return home. In 1961-62 the number of students from outside Canada was 7,900 compared with about 7,700 Canadians studying abroad.[27/] The most important country for this purpose is the United States. In 1959-60, for example, the available data show that of all Canadians studying abroad, 85.5 per cent were in the United States, 6.9 per cent were in the United Kingdom and 7.6 per cent were in other countries.[28/]

27/ This estimate for 1961-62 is composed of 7,130 Canadians studying in the United States and the United Kingdom plus an estimate of 587 for those studying in other countries. The latter estimate was derived from the proportion who were studying outside the United States and the United Kingdom in 1959-60, when numbers reported appeared to be more complete. See: Dominion Bureau of Statistics, Survey of Higher Education, Part II: Degrees, Staff and Summary, 1962-63, Table 22, p. 45.

28/ Dominion Bureau of Statistics, Survey of Higher Education, Part II: Degrees, Staff, and Summary, 1962-63, Tables 20 and 21, pp. 44-45.

Table II-18

Enrolment at the Undergraduate and Graduate Levels, Total All Courses, Engineering and Science: Total for Canada, Foreign Students Studying in Canada, and Canadians Studying in the United States and the United Kingdom, 1961-62

Level and Course	(1) Total Canada	(2) Foreign Students in Canada	(3) Canadians in The United States	(4) Canadians in The United Kingdom
			(Number)	
Total, All Courses	128,894	7,900	6,571 (1)	559
Total Undergraduate	121,547	(6,020)	4,063	117
Total Graduate	7,347	(1,880)	2,235	442
Engineering - Undergraduate	14,631	(975)	610	9
Engineering - Graduate (2)	(808)	(233)	249	110
Science - Undergraduate	12,215	(1,156)	324	21
Science - Graduate (3)	(2,616)	(912)	771	143
			(Per Cent)	
Engineering Undergraduate / Total Undergraduate	10.1	16.2	15.1	7.7
Science Undergraduate / Total Undergraduate	12.7	19.2	8.0	17.9
Total Graduate / Total - All Courses	5.7	23.8	34.0	79.1
Engineering Graduate / Total Graduate	11.0	12.4	11.2	24.9
Science Graduate / Total Graduate	35.6	48.5	34.6	32.4

(1) Includes 126 special students and 147 for whom no information on academic status was available.

(2) Architecture included in engineering.

(3) Includes "health sciences" (dentistry, medicine, nursing, pharmacy, other health sciences), agriculture and veterinary science.

Sources: Column 1. D.B.S., Survey of Higher Education, Part II: Degrees Staff and Summary, 1962-63, October, 1964, Tables 3, 13, 18, 20 and 21, pp. 19, 30, 43, 44 and 45.

National Research Council of Canada, Statistical Summary of Students Registered in the Graduate Schools of Canadian Universities in Physical and Earth Sciences in Architecture and Engineering and in Life Sciences, Ottawa, December 1963.

tnotes Table II-18 (Cont'd.)

Canadian Universities Foundation, Graduate Students in the Humanities and Social Sciences Registered at Canadian Universities, 1963-64, Ottawa, 1964.

Engineering and science graduate enrolments, both numbers and per cent, were estimated from the proportion and numbers of students enrolled at the graduate level, as shown in the publications by the National Research Council and the Canadian Universities Foundation shown above. An estimate of graduate enrolment had to be made since data on graduate enrolments were not available from the Dominion Bureau of Statistics. The data from the N.R.C. and C.U.F. publications were available on a comparable basis only for 1963-64 since the data on enrolments other than engineering and science were only available for this year. The graduate enrolment in engineering and science was then totalled for 1963-64 and an estimate was made of these enrolments as a percentage of total graduate enrolment. This proportion was then applied to 1961-62.

Column 2. Dominion Bureau of Statistics, Survey of Higher Education, Part II: Degrees, Staff and Summary, 1962-63, October, 1964, Table 18, p. 40.

Dominion Bureau of Statistics, University Student Expenditure and Income in Canada, 1961-62, Part I - Non-Canadian Students, May 1963, Table 6, p. 19.

The data on numbers estimated at the various levels of education were calculated on the basis of the data given in the above publication by the D.B.S. on university student expenditure.

Column 3. Dominion Bureau of Statistics, Survey of Higher Education, Part II: Degrees, Staff and Summary, 1962-63, October, 1964, Table 20, p. 44.

Unpublished data received from the Institute of International Education, New York, based on the Annual Census of Foreign Students carried out by the Institute.

The figure on Canadians in the United States "total of all courses" was taken from D.B.S., Survey of Higher Education, ibid. The other data were taken from unpublished data obtained by the Department of Labour, Economics and Research Branch, from the Institute of International Education.

Column 4. Dominion Bureau of Statistics, Survey of Higher Education, Part II: Degrees, Staff and Summary, 1962-63, October, 1964, Table 21, p. 45.

From 1958-59 to 1962-63 the number of foreign students in Canada equalled the number of Canadians studying in the United States plus those studying in other countries.[29] In other words, for every 100 foreign students here there were about 83 Canadian students in the U.S., and 17 Canadian students studying abroad in countries other than the U.S. Therefore, in overall terms the number of students studying here versus all those studying abroad is in approximate balance.[30]

(ii) Distribution by Level of Education and by Faculty

The numerical balance was not quite the same at the under-graduate and post-graduate levels in 1961-62. Table II-18 indicates

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29/ Dominion Bureau of Statistics, Survey of Higher Education, Part II: Degrees, Staff, and Summary, 1962-63, Tables 18 and 20, pp. 40-44.

30/ The overall balance may be somewhat different if more complete information were available both on the number of Canadians studying in other countries and particularly on the number of students from outside Canada who were landed immigrants. "A student from outside Canada was defined as one who was temporarily residing in Canada for the purpose of obtaining education. This definition was followed by most reporting institutions. In some cases, and especially for some European countries, landed immigrants were included." See, Dominion Bureau of Statistics, Survey of Higher Education, ibid., Table 18, p. 42. Although the proportion who were not "students from outside Canada" is not indicated in the regular annual data, the proportion who were either repatriated Canadian students or landed immigrants in 1961-62 appears to have been almost 19 per cent. See, Dominion Bureau of Statistics, University Student Expenditure and Income in Canada, 1961-62, Part I - Non-Canadian Students, May, 1963, p. 7.

that there were about 50 per cent more foreign students studying at the undergraduate level in Canada than there were Canadian undergraduate students studying abroad. At the post-graduate level, the number of Canadians abroad exceeded foreign students in Canada by an approximately similar margin.

By faculty, the student migration pattern at the undergraduate level in engineering and science is in the same direction as for all faculties taken together. There is a concentration of foreign students in Canada in science at the undergraduate level. The same is true for engineering. At the post-graduate level, the differences by faculty are even more striking. Numerically, there are approximately the same number of foreign students studying science in Canada as there are Canadians studying science abroad. But in the case of engineering, there are almost 50 per cent more Canadian post-graduates studying engineering abroad than foreigners studying graduate engineering courses here.

While the numerical balance gives an indication of the international flow of students by faculty, it is also instructive to examine the relative concentration of students in engineering and science in Canada and abroad. Four broad generalizations can be made. First, the flow of students to and from Canada not unexpectedly is relatively much higher at the graduate than at the undergraduate level. Second, compared to all Canadian students, the concentration of foreign students in Canada is relatively higher in the science and engineering faculties.

Third, Canadians who go to the United States appear to concentrate in engineering and science to about the same extent as students who remain and study in Canada.[31/] Fourth, a large proportion of Canadian students who go to the United Kingdom as graduate students, over 57 per cent, take engineering or science courses compared with about 47 per cent in the case of Canadian graduate students studying in Canada. One reason among others may be the Athlone Fellowships which are offered for graduate study in engineering in the United Kingdom. In 1963, for example, there were 80 Canadians holding these fellowships studying in the U.K.

Data on post-graduate enrolments in Canada over time are not available for all faculties by level of degree sought. However, some information relating to 1963-64 is given on recent post-graduate enrolments in science and engineering faculties in Canada and of Canadians studying science and engineering in the United States at the master's and doctor's levels in Table II-19. Taking science and engineering students as a group there are a greater proportion of Canadians studying these subjects at the graduate level in the United States who are enrolled in engineering rather than in science. This is particularly noticeable at the doctorate level. In Canada, of all doctoral

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31/ There is some difference, however, if the master and doctorate levels are examined separately. See Table II-19 below.

Table II-19

Graduate Enrolments in Engineering and Science in Canada, and for Canadians Studying in the United States, 1963-64

Specialization	Masters (1) Total		Masters (2) Canadians in the U.S.		Doctors (3) Total		Doctors (4) Canadians in the U.S.	
	Total	Canada			Total	Canada		
	No.	%	No.	%	No.	%	No.	%
Biological Science	1,415	38.2	168	36.5	881	37.6	212	33.3
Physical Science	1,184	32.0	124	27.0	1,135	48.5	294	46.2
Engineering	1,105	29.8	168	36.5	325	13.9	131	20.6
Total	3,704	100.0	460	100.0	2,341	100.0	637	100.0

Sources: Cols. (1) and (3): National Research Council, Statistical Summary of Students Registered in the Graduate Schools of Canadian Universities in Physical and Earth Sciences in Architecture and Engineering and in Life Sciences, Ottawa, December 1963.

Cols. (2) and (4): Unpublished data received by the Department of Labour, Economics and Research Branch from the Institute of International Education, New York.

graduate students in science and engineering there are almost 14 per cent enrolled in engineering, compared with over 20 per cent of Canadian doctoral students in science and engineering in the United States who are enrolled in engineering. The heavier emphasis on engineering for those Canadian engineers and scientists following doctoral studies in the U.S. suggests that there may be a lack of doctoral level engineering courses in Canada. But the rapid expansion recently in doctoral programs in engineering at Canadian universities will undoubtedly diminish this gap in the future.

(iii) Gains and Losses from Student Migration

The "balance sheet" of foreign students studying in Canada and Canadians studying abroad illustrated for 1961 in Table II-18 only gives the potential gain or loss. A further question is: What is the net gain or loss to Canada in terms of numbers from such movement? Mobility begins at the early stages of students' careers.[32/] Therefore, it would be desirable to obtain precise data on the number and proportion of foreign students who remain in Canada after graduation

32/ Scientists begin their geographic movements while they are students. See, U.S. Department of Labor, Bureau of Labor Statistics, Occupational Mobility of Scientists, Bulletin 1121, Washington, D.C., U.S. Government Printing Office, February, 1963, p. 4.

and on the number and proportion of Canadian students who remain abroad following graduation. Statistics on this flow are not available. However, some estimates can be made in the case of selected specialties, for example, engineering.

Those who received engineering and science degrees from Canadian universities in 1961 were asked, as part of the Department of Labour Annual Graduating Class Survey, to indicate their intentions following graduation. The graduating class that year included 452 "foreign students". For this purpose, a foreign student was defined as one who was not a Canadian citizen. Table II-20 shows that for engineering, 28 per cent stated that they had found employment in Canada, while 29 per cent were seeking employment here. In the case of science, 9 per cent had found employment here and 12 per cent were seeking employment in Canada. It was decided to follow up the engineers and see how many of the 57 per cent who planned to enter the Canadian labour force were here almost 3 years later.[33/] A check of the disposition of the 184 who were foreign citizens at the time of

33/ Foreign students in the class of 1961 who indicated their intention to remain in Canada (about two-thirds) were put into the Register of Scientific and Technical Personnel, and the others were not. It was possible to follow up a one-third sample of those who were put into the register through the regular Survey of Scientific and Technical Personnel which was done early in 1964, almost 3 years after graduation. The remainder who were not put into the register were also traced by means of professional association membership lists and in other ways.

Table II-20

Intentions of Foreign Students in Engineering and Scientific Courses
Who Received Bachelors Degrees in Canada in 1961

Intentions	All Courses		Engineering		Science(1)		Other(2)	
	No.	%	No.	%	No.	%	No.	%
Further Study in Canada.....	148	32.8	30	16.3	98	50.8	20	26.7
Further Study Abroad........	58	12.8	12	6.5	34	17.6	12	16.0
Found Employment in Canada..	75	16.6	52	28.3	17	8.8	6	8.0
Found Employment Abroad.....	20	4.4	10	5.4	6	3.1	4	5.3
Seeking Employment in Canada	96	21.2	54	29.4	23	11.9	19	25.3
Seeking Employment Abroad...	42	9.3	21	11.4	13	6.8	8	10.7
Other Plans.................	13	2.9	5	2.7	2	1.1	6	8.0
Total, All Intentions.......	452	100.0	184	100.0	193	100.0	75	100.0

1) Includes general science, excludes agriculture and forestry.

2) Includes 5 in architecture, 53 in agriculture, 10 in forestry, 6 in veterinary science and 1 who did not state course.

Source: Unpublished data from the Department of Labour annual Survey of the Graduating Class in Engineering and Science, 1961.

graduation revealed that, on the basis of the survey procedure, the total was divided up into three parts of 61-63 approximately in each part.[34/] Of these, 41 were put into the register and 22 were not. When the check was made it was found that 21 out of 63, or 33 per cent, of these foreign students who graduated in 1961 were employed in Canada in 1964, 18 out of 41 of those who entered the register and 3 out of 22 of those who were not put into the register. This estimate of 33 per cent is somewhat higher than an earlier estimate of 14 per cent of foreign students who said they would like to settle permanently in Canada.[35/] The above estimate, of course, referred to foreign students in all faculties, not just engineering. In addition, it may be argued that less than 3 years after graduation is too short a time to decide whether residence is or is not permanent. Nevertheless, it is felt that these data do give an order of possible magnitude of the gain from this particular source.

An additional source of data on this subject is the two surveys conducted by the National Research Council of the after-graduation plans of those receiving graduate degrees in science and

34/ It was not possible to get an exact matching of the register and the punch card counts but the discrepancy is negligible.

35/ Dominion Bureau of Statistics, University Student Expenditures and Income in Canada, 1961-62, Part I - Non-Canadian Students, May, 1963, p. 7.

engineering in 1960 and 1961, and also in 1965. The surveys on which the data were based covered graduate students enrolled at the master and doctorate levels in science and engineering at Canadian universities in 1960 and 1961, as well as 1965. Companion surveys covered Canadian students enrolled in United States universities.[36/]

A comprehensive picture of mobility from the Canadian standpoint even at the graduating student level, requires an examination of international movement to and from all areas. The losses at the graduating or near-graduating level are composed of two groups: 1) Canadians going abroad to work after graduation in Canada; 2) Canadians staying abroad after graduating abroad. The gains, in turn, have two aspects: 3) foreigners staying to work in Canada after graduation in Canada; 4) foreigners coming here from abroad after graduating abroad.

36/ One limitation relates to the survey coverage of the source of names chosen, namely, the Department of Labour Directory of Canadians Studying in the United States. The 18 per cent who did not respond to this survey were not listed in the directory. The 76.9 per cent response to the National Research Council survey based on the 82 per cent of the Canadians studying in the United States represents about 63 per cent net of Canadians who were studying in the United States. Thus, assuming that the non-respondents are likely respondents, the National Research Council data on Canadians studying in the United States would have to be increased by about 50 per cent to allow for those who are not included, if estimates are to be made.

A second limitation on these data is that they give only a partial picture of the international gains and losses of high-level manpower. This question can best be considered as an aspect of the mobility of high-level manpower which in turn has two dimensions, temporal and spatial. First, mobility is a process that takes place over time and student mobility represents the early stages of a

The National Research Council report provides data at a point of time, at graduation, on what happens to doctoral graduates in groups 1, 2 and 3 above.[37/] The big gap in data is for group No. 4, a group that would be included in general immigration statistics. But these statistics are not sufficiently detailed, for example, to enable immigrant Ph.D.'s in engineering and science to be identified by age level and year of bachelor graduation. Despite these limitations, the National Research Council data do provide valuable information on the plans of recipients of Ph.D.'s at the time of graduation.

Table II-21 illustrates the greater propensity of Canadians who receive doctor's degrees in engineering and science in the United States to seek employment there. In 1965, for example, about 19 per cent of the science graduates in Canada at the Ph.D. level compared with about 37 per cent of Canadians who received Ph.D. degrees in the United States planned to take jobs in the United States. The proportion for engineering doctorates is of a similar order of magnitude. For Canadian citizens who received doctoral degrees in

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36/ (Cont'd)
process which may go on over many years. Therefore, in order to get a more complete picture of this process, it would be necessary to follow these graduates over several years. Alternately, if a cross-sectional rather than a longitudinal picture is desired, the analysis would have to include high-level manpower at various age levels.

37/
For the No. 2 group above, coverage is only for the United States where, the vast majority of our graduate students are.

Table II-21

Intended Country of Employment, Doctoral Graduates From Canadian Universities and Canadian Doctoral Graduates From United States Universities, 1965

Country of Employment and Field of Specialization	Place of Education					
	Total		Canada		United States	
	No.	%	No.	%	No.	%
Engineering						
Total	90	100.0	64	100.0	26	100.0
Canada	60	66.7	45	70.3	15	57.7
U.S.	25	27.7	14	21.9	11	42.3
Other	5	5.6	5	7.8	-	-
Science						
Total	382	100.0	307	100.0	75	100.0
Canada	260	68.1	216	70.3	44	58.7
U.S.	87	22.8	59	19.2	28	37.4
Other	35	9.1	32	10.5	3	3.9
Engineering and Science						
Total	472	100.0	371	100.0	101	100.0
Canada	320	67.8	261	70.3	59	58.4
U.S.	112	23.7	73	19.7	39	38.6
Other	40	8.5	37	9.9	3	3.0
Engineering and Science (Canadian Citizens)						
Total	. .	. .	234	100.0	. .	. .
Canada	. .	. .	193	82.5	. .	. .
U.S.	. .	. .	38	16.2	. .	. .
Other	. .	. .	3	1.3	. .	. .
Engineering and Science (Foreign Citizens)						
Total	. .	. .	137	100.0	. .	. .
Canada	. .	. .	68	49.6	. .	. .
U.S.	. .	. .	35	25.5	. .	. .
Other	. .	. .	34	24.9	. .	. .

. . = Not available.

Source: National Research Council, After Graduation Plans of 1965 Doctorates of Science and Engineering, Ottawa, NRC 8618, November, 1965, pp. 9 and 21.

Canada in these fields, about 15 per cent planned to take jobs in the United States, compared with 37 per cent as indicated above for Canadians who took doctoral degrees in the United States.

From a "gain-loss" standpoint, Canada lost 41 Canadian citizens who received engineering and science doctoral degrees to other countries, 38 to the United States and 3 to other countries, but gained 68 foreign citizens who received doctoral degrees in Canada, a net gain of 27. But if the loss of 42 doctorates among Canadians who received degrees in the United States is taken into consideration, the net gain of 27 is converted into a net loss of 15. To arrive at a more complete picture for recent graduates, it would, as argued above, be necessary to include on the plus side of the balance sheet foreigners who recently graduated with doctorates in other countries and who then came to Canada.

Table II-22 suggests that those who receive doctorates - both those in Canada and Canadian students in the United States - have a higher propensity than those who receive master's degrees to seek employment in the U.S. Fifteen per cent of those who received doctor's degrees in Canada in 1960-61 in the fields of engineering and science planned to take employment in the United States, compared with 5 per cent of those who received master's degrees. Only 1 per cent of the Canadian citizens who received bachelor's degrees in engineering and honour science in Canada in 1961 and who planned to enter the labour

Table II-22

Per Cent of Master and Doctoral Graduates in Engineering and Science Planning to Obtain Employment in the United States 1960-61 and 1965

Field of Specialization and Level of Degree	Place of Education and Per Cent Planning to Obtain Employment in the U.S.							
	Canada				United States			
	1960-61		1965		1960-61		1965	
	No.	%	No.	%	No.	%	No.	%
Engineering								
Master	. .	. .	. .	. .	. .	. .	. .	. .
Doctor	5	17	14	22	9	43	11	42
Science								
Master	. .	. .	. .	. .	. .	. .	. .	. .
Doctor	40	14	59	19	18	28	28	37
Engineering and Science								
Master	16	5	. .	. .	19	22	. .	. .
Doctor	45	15	73	20	27	32	39	39
Doctor (Canadian Citizens)	29	15	38	16	. .	. .	. .	. .
Doctor (Foreign Citizens)	16	16	35	26	. .	. .	. .	. .

. . = Not available.

Sources: (1) National Research Council, After Graduation Plans of 1960 and 1961 Doctorates and Masters of Science and Engineering, Ottawa, NRC 6927, June, 1962, pp. 8, 16 and 25.

(2) Same as Table II-20.

force immediately intended to become employed in the United States.[38] Apart from the net balances over time, this suggests that at least at the time of graduation there is strong evidence of a direct relationship between the strength of the southward pull on Canada's most highly qualified manpower and the level of qualification.

A recent case study conducted by the Department of Labour, Economics and Research Branch of the 1955 graduating class in engineering and science provided some information which enabled a comparison to be made between the level of education of those who leave Canada[39] and those who remain. The results are shown in Table II-23. All who were included in the study were Canadian citizens at the time of bachelor graduation. The level of education in 1965 of those in the Canadian labour force was then compared with the educational level of those who were in the labour force abroad, mainly in the United States.

The scientific and technical people who go abroad tend to have a considerably higher level of education than those who remain here, which suggests that the loss as measured by level of education is greater than the loss as measured by numbers alone.

38/ See Department of Labour, Economics and Research Branch, Professional Manpower Bulletin No. 5, After-Graduation Plans of Final-Year Students in Engineering and Science Courses, 1958-1963, Table 5.

39/ The survey did not provide information on whether those who left Canada had taken up permanent residence abroad. However, there is no reason to suppose that there is any substantial difference in educational level between those who will later return to Canada and those who have taken up permanent residence abroad.

Table II-23

The 1955 Graduating Class in Engineering and Science by Level of Education and Place of Employment, 1965

	Engineering					
	Total		Canadian Labour Force		Foreign Labour Force	
	No.	%	No.	%	No.	%
Bachelor's	1,003	81.1	943	83.7	60	54.7
Master's	175	14.2	141	12.5	34	30.2
Doctor's	58	4.7	42	3.7	16	15.1
Total	1,236	100.0	1,126	100.0	110	100.0
	Science					
Bachelor's	46	23.1	44	25.4	2	7.7
Master's	43	21.6	38	22.0	5	19.2
Doctor's	110	55.3	91	52.6	19	73.1
Total	199	100.0	173	100.0	26	100.0

Source: Department of Labour, Economics and Research Branch, "Survey of Geographic Mobility of 1955 University Graduates, 1965", unpublished data.

d. Sources of Supply Outside the Formal Educational System

In addition to formal education, there are other routes to employment in a scientific and technical field. Because of the criteria of the possession of the university degree or certification by a professional association which is required for entrance into the Register of Scientific and Technical Personnel, it does not include those who are regarded by their employers as working in engineering or science jobs but who do not have a degree or professional certification.

In order to determine precisely whether a person is employed in an engineering or science field, a detailed evaluation of the job would be required. Presumably this would reveal both some who are not being utilized as engineers or scientists even though they may be formally qualified as such as well as others who are being so utilized, despite the fact that the latter may not be qualified by education or professional certification.[40/]

Some indication of the importance of this route for the supply of engineering and scientific manpower may be gained from Table II-24 which shows that of the stock of engineering and science

40/ In Table II-24 the data are based on the employer's opinion concerning whether an employee was an engineer or a scientist. It may be noted that on-the-job training both historically and at present can be included along with formal education as an integral part of the process of investment in manpower. See: Jacob Mincer, "On-the-Job Training: Cost, Returns and Some Implications", Journal of Political Economy, Supplement, Vol. LXX, No. 5, Part 2, October, 1962, pp. 50-52.

Table II-24

Type of Qualification of Those Employed as Engineers and Scientists, 1962

Type of Qualification	Engineers	Scientists
University Degree	86.7	96.8
Certification by a Professional Association	4.0	1.2
No Degree or Certification	9.3	2.0
Total %	100.0	100.0
No.	29,196	13,052

Source: Department of Labour, Economics and Research Branch, Employment Outlook for Professional Personnel in Scientific and Technical Fields, 1962-1964, Professional Manpower Report No. 13, December, 1962, pp. 25 and 26.

manpower included in that survey, over 13 per cent of the engineers and 3 per cent of the scientists, including agriculture and forestry, had no university degree. Over 9 per cent of the engineers but only 2 per cent of the scientists, apparently, had neither university degree nor professional certification. It was stated above (in Table II-4) that the register and Census estimates of engineers without degrees range from 5 to 28 per cent, and from 2 to 26 per cent for scientists. Some of these may actually be employed as technicians.

But the tentative conclusion may be drawn that in calculating the supply of manpower to engineering and science occupations, at least some allowance must be made for those who entered these occupations by informal routes.

4. International Migration

A second major dimension of supply in engineering and science occupations is the contribution of immigration. The purpose of this section is to analyze the available statistics on international migration of scientific and technical manpower during part of the post-war period in order to indicate the effects of post-war immigration and emigration on the stock of scientific and engineering manpower.[41]

41/

Immigration is defined to mean gross immigration and this means the total number of foreign-born persons entering Canada as immigrants during a specified period of time.

Emigration to the United States refers to gross emigration and consists of all those including Canadian-born and those who were not Canadian-born who leave Canada and go to the United States as immigrants to that country.

Table II-25 shows the foreign-born as a proportion of persons in various occupational classes and groups as reported in the 1961 Census. A more precise measure of the contribution of immigration could be obtained if data were available on the age of immigrants by year of permanent entry and, ideally, by level of education attained prior to entry. This would enable a more precise assessment to be made of the amount of human capital in the form of education and training immigrants brought with them on their arrival in Canada. Some who were born abroad will have received a portion of their education in Canada. It is felt, however, that while the concept of birth place may overstate the absolute level of contribution of immigrants to an occupation,

41/ (Cont'd)
Migration as used here refers to both gross immigration and gross emigration.

Estimated net migration is the difference between gross immigration into Canada and estimated emigration from Canada. It is therefore the net movement of population arising from migration and from the flow of returning residents.

Recorded net migration refers to the difference between gross immigration to Canada and gross emigration to the United States. This, of course, does not include the overall net movement of people, since emigration to countries other than the United States and the movements of returning residents are excluded. Therefore, recorded net migration differs from estimated net migration. This partial net movement is used to a considerable extent in this study because it is based on the available detailed statistics on migration and therefore is composed of a good part of what is available from existing statistics. In addition, this incomplete information may be combined with other data sources, such as Census data, in order to yield information on some of the effects of migration.

See: Louis Parai, Immigration and Emigration of Professional and Skilled Manpower during the Post-War Period, Special Study No. 1, Economic Council of Canada, June, 1965, pp. 5-7, for a more complete discussion of some of these concepts.

Table II-25

Foreign Born as a Per Cent of Persons in Total, Professional, Engineering and Science Occupations, 1961

Occupation or Field of Specialization	Total	Foreign Born	Foreign Born as a Per Cent of Total
Census 1961			
All Occupations................	6,471,850	1,385,285	21.4
Professional..................	628,911	119,610	19.0
Architects....................	2,940	1,249	42.5
Professional Engineers........	43,066	14,216	33.0
Physical Scientists...........	11,062	3,588	32.4
Biologists and Agricultural Professionals...............	5,936	1,182	19.9
Survey of Scientific and Technical Personnel, 1961			
Engineering...................	8,674	2,210	25.0
Science.......................	1,943	437	22.0

Sources: 1. Dominion Bureau of Statistics, 1961 Census of Canada, Bulletin 3.1-15, Table 21.

2. Unpublished data from Department of Labour Survey of Scientific and Technical Personnel, 1961.

it would probably not affect the relative contribution among occupations, unless there is a tendency for children of immigrants to choose occupations in a different way than the children of native-born Canadians.[42/]

The foreign-born represented over 21 per cent in the labour force in 1961, compared with 19 per cent in the case of professional and technical occupations as a group. The foreign-born represented one third of those in engineering occupation classes as a group, over 32 per cent in the case of physical scientists and almost 20 per cent in the case of biologists and agricultural scientists. It is therefore apparent that the contribution of the foreign-born to the stock of persons in the engineering and science occupations in Canada in 1961 has been substantial.

Some data from the Department of Labour Survey of Scientific and Technical Personnel on a sample of engineers and scientists also suggest roughly similar orders of magnitude for the foreign-born contribution to engineering and science manpower.

42/ For example, since Census data on immigrants are in terms of "place of birth", a "foreign-born" person in any occupation could have migrated at an early age and received all his education in Canada.

a. The Data

The limitations of the data available on migration call for comment. Three limitations of these data relate respectively to the countries covered, the time period covered, and the scope and quality of the occupational data. Very little information is available on emigration from Canada to countries other than the United States where the bulk of our emigrants appear to go. Immigration data by occupation are available only from 1953 onwards, although estimates have been made for some of the earlier post-war years. Emigration data by occupation are available from 1950 onwards. The occupation data on immigrants to Canada relate to "intended" occupation and this, of course, may not be the same as actual occupation followed.[43/] Finally,

43/ A study of the 1959 citizenship applicants from Toronto and Montreal, a total of 6,969 individuals, were compared as part of a study, "The Last Occupation Abroad and Occupation in Canada". In the case of professionals, for example, they represented 5.6 per cent in terms of occupation abroad and 6.0 per cent in terms of last occupation in Canada. Of the 391 persons whose occupation abroad was in the professional category, and who had not moved into managerial occupations in Canada, approximately 6 per cent had not been able to integrate themselves horizontally into their professional occupations. Seventy-nine professionals had become managers and 130 persons had received professional education, at least in part, in Canada and entered professional occupations in Canada, a form of upward mobility. These data suggest that there is, in net terms, a fairly close relationship between the number of immigrants who came as professionals in terms of their occupation abroad and those who actually practise their occupation in Canada as far as professionals are concerned. This, of course, assumes that their intended occupation was a close reflection of, or was related closely to the occupation they pursued abroad.

See, Department of Citizenship and Immigration, Economic and Social Research Division, The 1959 Citizenship Applicants from Toronto and Montreal, Report CR-2, March, 1961, pp. 34-36.

the data on immigration and occupation over time are on the basis of the 1951 occupational classification. This facilitates comparison with 1951 Census data on occupations and permits the use of a longer time series covering a 9-year period.

The immigration data on physical and biological scientists are limited to chemists for the 1950's. It is therefore not possible to compare net migration data for scientists with those for engineers.

Despite these limitations, these data are used here because it is believed that if the changes in immigration, for example, are large (and they are), they are not wholly the result of data inaccuracies and are sufficiently precise to give an indication of long-term trends.

b. The Occupational Pattern of Migration

The broad occupational pattern of migration during the decade of the 1950's suggests that there is a considerably larger numerical inflow as compared with outflow which has resulted in net gains, as defined above, in total, professional and engineering "net migration". Net numerical gains, however, have varied between the first and second halves of the decade, declining slightly in the case of all occupations, rising slightly in the case of professional occupations and declining greatly in the case of engineers, from about 4,700 to under 2,200 from the first to the second half of the decade. This decline in the gain from net migration of engineers, as

Table II-26 indicates, is due chiefly to a drop in the proportion of professional immigrants who were in engineering occupations, from 20.4 per cent for 1951-55 to 9.8 per cent for the period 1956-60, while the proportion of emigrants in professional occupations who were in engineering occupations increased from 14.2 per cent in 1951-55 to 18.7 per cent in 1956-60.

Thus, the so-called "brain drain" in the latter 1950's as far as engineers were concerned was in the nature of a "brain gap" which resulted more from a decline in the number of immigrants rather than from a drain of emigrants.

c. The Variability of Net Migration by Selected Professional Occupation Class, 1951-60

Table II-27 summarizes this variability by professional occupation class for the period 1951-60. The algebraic sum of the differences between the annual and average annual net migration is taken as a proportion of the sum of the annual net migration from 1951-60 to yield a measure of average annual variation. Engineering net migration ranks fourth behind graduate nurses, laboratory technicians, and accountants and auditors in average variability at 63 per cent, but considerably above the 47 per cent for professional occupation classes as a group. Chemists, at 44 per cent, and physicians and surgeons, at 34 per cent, rank considerably below engineers.

Table II-26

Total Professional and Engineering Immigration, Emigration, and Net Migration(1) to Canada, 1951-1960

Year	Labour Force Total	Professional	Engineering	Professional / Total	Engineering / Total	Engineering / Professional
	No.	No.	No.	%	%	%
igration						
51-55....	431,911	35,497	7,225	8.2	1.7	20.4
56-60....	412,752	47,319	7,306	11.5	1.8	9.8
51-60....	844,663	82,816	14,531	9.8	1.7	17.5
gration						
51-55....	85,804	17,771	2,523	20.7	2.9	14.2
56-60....	115,079	27,492	5,128	23.9	4.5	18.7
51-60....	200,883	45,263	7,651	22.5	3.8	16.9
Migration(1)						
51-55....	346,107	17,726	4,702	5.1	1.4	26.5
56-60....	297,673	19,827	2,178	6.7	0.7	11.0
51-60....	643,780	37,553	6,880	5.8	1.1	18.3

Total immigration to Canada minus emigration to the United States.

rces: See Appendix, Tables II-A-6, 7 and 8.

Table II-27

Variation in Annual Net Migration[1] in
Selected Professional Occupations, 1951-1960

Occupation	Σ Annual Net Migration, 1951-60	Σ Differences Between Annual Net Migration and Average Annual Net Migration - 1951-60	Σ Differences / Σ Annual Net Migration
	No.	No.	%
Accountants and Auditors	1,357	1,035	76
Architects	1,265	547	43
Chemists	1,287	565	44
Dentists	215	105	49
Draughtsmen and Designers	5,918	3,500	59
Engineers	6,879	4,361	63
Laboratory Technicians	1,031	987	96
Graduate Nurses	733	2,581	352
Physicians and Surgeons	1,965	661	34
Teachers and Professors	6,501	2,162	33
Other Professions	10,416	3,064	29
Total	37,567	17,773	47

1) Total immigration less emigration to the United States.

Source: See Tables II-A-6, 7 and 8.

From 1957 to 1959, net migration of engineers dropped from 1,838 to -527. As a percentage of net migration and engineering graduations taken together,[44] net migration declined from over 51 per cent to almost -35 per cent of total new supply. For all professional occupations the corresponding numerical drop was from 9,789 to 1,354. In percentage terms net migration of professionals as a per cent of net migration of professionals plus bachelor graduations declined from about 40 per cent to just over 7 per cent.[45]

The net migration of those intending to enter engineering occupations in Canada has been characterized by a relatively high degree of variability in the net gain to Canada from net migration in the short run. This variability is particularly characteristic of immigration rather than emigration. The factors associated with these large short-run changes are probably associated with and affected by changes on the demand side, for example, changes in job openings for engineers, since a high proportion of these migrants have engineering job offers before they move. A decline in the level of economic activity and a corresponding decline in job openings would tend to discourage immigration. These factors will be examined further in Chapter IV.[46]

44/ Considered as new supply in this context.

45/ See Table II-A-9.

46/ Unfortunately the occupational classes for scientists given in immigration statistics during the 1950's do not permit a similar calculation of net migration.

d. The Contribution of Net Migration to the Supply of Professional and Engineering Manpower During the 1950's

The contribution may be summarized in three statements. First, Canadian graduates have been the largest source of the increments to the supply of total professional and engineering manpower during the 1950's, contributing about 80 per cent and 72 per cent respectively to professional and engineering manpower.[47/]

Second, there has been an overall down trend in net migration as a proportion of total supply of total professional and engineering manpower during the longer run, notably during the latter part of the 1950's. This decline has been relatively greater in the case of engineers.

Thirdly, net migration has been a source of very rapid changes in the supply of total professional and engineering manpower during the 1950's. In the short run net migration has been a changeable source of supply whereas graduations in Canada have been much less variable. Net migration has demonstrated great potential as the chief source of

47/ These estimates of the contribution of immigrants to total manpower supply are in terms of orders of magnitude. A more precise estimate would include separate calculations of attrition through deaths and retirements and immigration and emigration for both the foreign- and the native-born, as well as additional sources of supply, for example, upgradings to professional status and the correspondence between stated and actual occupation of immigrants.

flexibility in the supply of professional and engineering manpower in the short run during this period of time. And, if for the moment, the impact of upgrading of persons to engineering and science jobs without a university degree or professional certification is ignored, the increments to supply may be considered to consist principally of graduations and net immigration.[48/]

In addition to the estimate of the proportion of foreign-born in the stock of engineering and scientific manpower obtained from Census and register data,[49/] it is useful to examine the flows in order to assess the impact of graduations, immigration, emigration and net migration on manpower supply over time.

Table II-28 summarizes and compares the variation in total university graduates and those in engineering with net migration as the two main sources of supply to total professional and engineering occupations. One would expect that the flow pattern of immigration from 1951-60 would approximate that of the stock since the majority of recent immigrants to Canada, from 1931-60 72.7 per cent, entered

48/ It will be shown below that the bulk of new supply to engineering and science occupations - roughly 80 to 95 per cent - came from these two sources. The estimates of the net proportion ultimately depends upon the definition of a "scientist" or an "engineer". If this definition excludes those who lack a degree or professional certification, then upgrading by definition becomes nil.

49/ See Table II-25 above.

Comparison of Bachelor Graduations, Immigration, Emigration and Net Migration,(1) for Professional and Engineering Occupations, 1951-1960

Occupation and Year	(1) Graduations	(2) Immigration	(3) Emigration	(4) Net Migration	(5) Total (Graduation Plus Net Migration)	(6) Per Cent Graduations of Total	(7) Per Cent Immigration of Total	(8) Per Cent Emigration of Total	(9) Per Cent Net Migration of Total	(10) Total (Graduation Plus Net Migration)
Professional and Technical										
1951-1955...	66,667	35,497	17,757	17,740	84,407	79.0	42.0	21.0	21.0	100.0
1956-1960...	80,415	47,319	27,492	19,827	100,242	80.2	47.2	27.4	19.8	100.0
1951-1960...	147,082	82,816	45,249	37,567	184,649	79.7	44.9	24.5	20.4	100.0
1955-1957...	41,520	32,542	15,694	16,848	58,368	71.1	55.8	26.9	28.9	100.0
1957-1958...	30,845	23,593	11,035	12,558	43,403	71.1	54.4	25.4	28.9	100.0
Engineers										
1951-1955...	8,121	7,225	2,523	4,702	12,823	63.3	56.3	19.7	36.6	100.0
1956-1960...	9,486	7,305	5,128	2,177	11,663	81.3	62.6	44.0	18.6	100.0
1951-1960...	17,607	14,530	7,651	6,879	24,486	71.9	59.3	31.2	28.1	100.0
1955-1957...	4,675	6,102	2,832	3,270	7,945	58.8	76.8	35.6	41.2	100.0
1957-1958...	3,671	4,112	1,984	2,128	5,799	63.3	70.9	34.2	36.7	100.0

(1) Total immigration less emigration to the United States.

Source: Cols. 1 to 4: Table II-A-9.

Canada during the 10-year period 1951-60.[50/] The stock data in Table II-25 above, relating to the 1961 Census, show that 19 per cent of all those in professional occupations and 33 per cent of those in engineering occupations were foreign-born. The flow data, i.e., annual immigration from 1951-60 agree closely with the 1961 Census and show that net immigration of professional and technical workers from 1951-60 represented over 20 per cent of that portion of new supply comprised of total graduations plus net migration. Net migration of engineers from 1951-60 represented just over 28 per cent of new supplies, i.e., total bachelor graduations in engineering plus net migration.[51/] Net migration therefore represented a higher proportion of the new supply of engineers than of all professional occupations between 1951 and 1960.

e. The Annual Pattern of Net Migration of Professionals and Engineers During the 1950's

A clearer picture of the pattern of net migration is obtained if annual changes during the decade are examined.[52/] For both total professionals and engineers peak net migration occurred in 1953-54 and

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50/ See, Dominion Bureau of Statistics, Canada Year Book, 1965, p. 206.

51/ Net migration of chemists from 1950 to 1960 represented about 100 per cent of graduates in honour chemistry during this period. See Department of Labour, Economics and Research Branch, The Migration of Professional Workers Into and Out of Canada, October, 1961, p. 43.

52/ See Table II-A-9 in the Appendix.

in 1957. Since 1957, net migration as a source of supply of both professional and engineering manpower has declined in relative importance. But the decline has in percentage terms been relatively greater for engineers with net migration as a percentage of graduates plus net migration dropping almost 60 percentage points, from 51 to almost -8 per cent compared with a drop of about 31 percentage points from under 40 per cent to 9 per cent for all professional net migration. Engineering net migration has exhibited relatively larger year-to-year variability than most of the professional occupational classes selected.

f. The Quality of the Foreign-Born as Measured by Level of Education, Engineering and Science Occupations

A special tabulation of 1961 Census returns was done comparing the level of education of the foreign-born with the total in a given professional occupation. These data are shown in Table II-29 and Appendix Table II-A-10. In professional occupations as a whole, and in most science occupations, the foreign-born had a somewhat higher level of education than the total in these occupations. In engineering and architecture the opposite was true. One of the reasons on the supply side for the difference is undoubtedly related to the large percentage of engineering immigrants who come from the United Kingdom where an

Males and Females in Selected Occupations with University Level Education,
Total and Foreign Born, 1961

Occupation	Per Cent with Some University		Per Cent with University Degree		Per Cent with Some University or University Degree	
	Total	Foreign Born	Total	Foreign Born	Total	Foreign Born
Professional Engineers................	10.7	12.9	72.2	66.7	82.9	79.6
Civil Engineers.....................	9.8	10.7	81.0	77.2	90.8	87.9
Mechanical Engineers................	11.2	14.3	66.0	60.3	77.2	74.6
Industrial Engineers................	13.9	17.1	44.7	41.8	58.6	58.9
Electrical Engineers................	10.7	13.2	73.9	67.6	84.6	80.8
Mining Engineers....................	9.6	8.8	80.4	80.4	90.0	89.2
Chemical Engineers..................	7.7	8.5	87.0	84.0	94.7	92.5
Professional Engineers n.e.s........	11.6	14.9	67.9	60.8	79.5	75.7
Physical Scientists..................	12.4	12.3	73.1	76.7	85.5	89.0
Chemists............................	14.9	15.3	66.3	70.5	81.2	85.8
Geologists..........................	10.1	8.4	85.4	87.6	95.5	96.0
Physicists..........................	4.3	3.3	90.8	93.8	95.1	97.1
Physical Scientists n.e.s...........	9.8	10.6	70.0	74.9	79.8	85.5
Biologists and Agricultural Professionals......................	12.3	9.8	72.0	74.7	84.3	84.5
Biological Scientists...............	11.2	9.8	81.4	82.1	92.6	91.9
Veterinarians.......................	7.2	4.3	85.4	87.5	92.6	91.8
Agricultural Professionals n.e.s....	15.8	14.4	59.0	55.5	74.8	69.9
Architects...........................	9.1	9.4	78.8	75.7	87.9	85.1
Total Professional and Technical.....	17.5	17.5	31.0	35.6	48.5	53.2

Source: Appendix Table II-A-10

engineer less frequently has a university degree than in Canada.[53/] On the demand side there may have been a particular requirement in Canada for technical personnel with less than a university education, in the absence of a large technological training program during the 1950's.[54/]

The level of education of foreign-born engineers and scientists in the Department of Labour Register of Scientific and Technical Personnel is shown in Table II-30. It would appear that in 1961 the foreign-born have contributed most heavily at both ends of the educational spectrum. In the case of engineers, the foreign-born who represented a total of 25 per cent of engineers in the register, represented 70 per cent of those with no university degree and 49 per cent of those with Ph.D.'s. The pattern in science specialties is

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53/ From 1953 to 1963, 56 per cent of immigrants who intended to enter engineering occupations were British. Between 1956 and 1961, only 32 per cent of those who became qualified as "technologists" in Great Britain had university degrees. See, Louis Parai, op. cit., p. 45; Advisory Council on Scientific Policy, Scientific and Technological Manpower in Great Britain, 1962, London, H.M.S.O., 1963, pp. 54-55; For a good discussion of engineering education in Britain, see George Louis Payne, Britain's Scientific and Technological Manpower, Stanford, Stanford University Press, 1960, Chapters V and VI, especially pp. 192-193.

54/ Canada, Royal Commission on Canada's Economic Prospects, Department of Labour, Economics and Research Branch, Skilled and Professional Manpower in Canada, 1945-1965, pp. 103-104.

Table II-30

Foreign Born by Level of Education, Engineering and Science,(1) 1961

Field of Employment Specialization and Level of Education	No.	Born Outside Canada No.	Born Outside Canada %
Engineering			
No Degree	419	292	70
Bachelor	7,444	1,561	21
Master	721	313	43
Doctor	90	44	49
Total	8,674	2,210	25
Science			
No Degree	52	27	52
Bachelor	1,065	177	17
Master	372	97	26
Doctor	454	136	30
Total	1,943	437	22

(1) Excludes agriculture and forestry.

Source: Unpublished data from Department of Labour Survey of Scientific and Technical Personnel, 1962.

similar but less extreme, with foreign-born representing 52 per cent of all scientists in the register with no degree compared with 30 per cent of those with doctorates. Immigration has made an important contribution to the quality of engineering and scientific manpower at the highest levels of education.

5. Other Sources of Supply Flexibility

Another aspect of the flexibility of scientific manpower supply is inter-occupational mobility. An indication was given above in Table I-4, based on a special study of engineers in the 1961 Census, which revealed that in the sample only 70 per cent of the engineering graduates who were employed in a science or technical field were reported in engineering Census occupations. An adjustment for the proportion who were not employed in a scientific or technical field revealed that 66 per cent of the total engineering graduates in the sample were reported in engineering occupations while most of the others had moved to other occupations. Sixteen per cent of the technically employed[55/] engineers and 68 per cent of the non-technical group were reported as being in managerial occupations.

55/ Those employed in scientific and technical fields.

Naturally, most engineers and scientists tend to remain within their specialties but, even so, it is felt that there is enough movement to warrant taking it into account in making estimates of the supply of persons in these fields.

Table II-31 reveals a narrower aspect of occupational movement, that among engineering and science graduates by field of employment specialization based on the Register of Scientific and Technical Personnel in 1961. It is narrower than the previous Census data show because an engineer or a scientist could be reported as technically employed according to the register, but might possibly be in a managerial occupation according to the Census.[56/] It should also be noted that "movement" as defined here between academic course and employment specialization or field may not be, strictly speaking, occupational. For example, in some cases the distinction between field of employment (e.g., chemistry and chemical engineering) is somewhat blurred. Despite these limitations, in most cases (e.g., civil engineering, biology) the distinction is sharp enough to suggest when a move has been made between dissimilar specialties.

56/ In addition, a person, for example, might be upgraded to an engineering job without professional certification or a university degree without being included in the register.

Table II-31

Mobility Among Academic Course and Field of Employment Specialization, Engineers and Scientists(1) 1961(2)

Academic Course Background	Field of Employment Specialization			
	Engineers		Scientists	
	No.	%	No.	%
otal	10,781	100.0	3,187	100.0
on-Movers who Graduated in imilar Specialization	9,047	83.9	1,787	56.1
1-Movers	1,734	16.1	1,400	43.9
From Engineering Courses	-	-	411	12.9
From Science Courses	372	3.5	-	-
From Other Scientific and Technical Courses(3)	288	2.7	475	14.9
From Non-Technical Courses	932	8.6	445	14.0
Course Not Stated	142	1.3	69	2.1
Field of Employment Specialization Entered	Academic Course Background			
otal	10,736	100.0	2,706	100.0
on-Movers who Graduated in milar Specialization	9,047	84.3	1,787	66.0
t-Movers	1,689	15.7	919	34.0
To Engineering Fields	-	-	372	13.7
To Science Fields	411	3.8	-	-
To Other Scientific and Technical Fields(3)	180	1.7	218	13.7
To Non-Technical Fields	950	8.8	292	8.1
Field Not Stated	148	1.4	37	10.8

) "Scientists" includes those who were employed in: biology, chemistry, geological sciences, mathematics, physics and engineering physics, or who graduated in: bacteriology, biochemistry, biology, botany, zoology, chemistry, chemistry and physics, geology, mathematics, physics, and physics and mathematics.

) These data relate to the stock of engineers and scientists in the Department of Labour Survey of Scientific and Technical Personnel, 1961.

) "Other Scientific and Technical Fields" include: architecture, agriculture, forestry, geography, "other science" and veterinary medicine. "Other scientific and technical courses" includes, in addition to the above, regional planning, general science, and metallurgical science.

urce: Department of Labour, Economics and Research Branch, "Survey of Scientific and Technical Personnel, 1962", unpublished data.

About 16 per cent of those employed in engineering specialties came from outside engineering, and about the same proportion of those trained in engineering, moved from engineering to other employment specialties.

In the case of scientists, almost 44 per cent came from other occupational backgrounds, while about one-third moved out of science specialties as defined. In the case of engineering, about half, 8.6 per cent, moved out of engineering and science into non-technical fields and the proportion was 8.1 per cent for science.

A second way of looking at the problem is to compare the proportion of engineering and science graduates who are employed in their respective fields according to the Register of Scientific and Technical Personnel. Transfers of engineering graduates to other fields amounted to 15.7 per cent for engineers and 34.0 per cent for scientists. Movement of those with other non-engineering or non-scientific university degrees into these fields amounted to 14.3 per cent for engineering and 41.8 per cent for science. Thus, there is an approximate balance of movement among university course specializations in the case of engineering and some net gain in the case of science.

These shifts between specializations may occur just after graduation or the transfer may occur after they become employed in their fields. Data on transfers are incomplete, but the little information available suggests that annual losses to stock of engineers and scientists from transfers are in the vicinity of 0.5 per cent per year.

For example, it was estimated that for engineers in the United States from 1950-59, losses from transfers amounted to 27,137, compared with an initial stock of 542,743 engineers. Graduates during this period were 276,150.[57/]

Some data on withdrawals from engineering and science occupations and specializations based on Census and register data are indicated in Table II-32. About 66 per cent of all graduate engineers in the Register of Scientific and Technical Personnel in 1961 were classified in "engineering" occupations in the 1961 Census compared with 77 per cent of the more recent graduates who graduated during the previous decade.[58/]

6. Analysis of Deaths and Retirements

Table II-33 indicates the average age of engineers and scientists as indicated in the 1961 Census. Both engineers and scientists were quite typical of all occupations with regard to average age but in the case of physical scientists, average age was slightly lower.

57/ United States, National Science Foundation, Scientists, Engineers and Technicians in the 1960's, Requirements and Supplies, Washington, D.C., 1963, p. 15, where allowances were made both for "non-entry" into these occupations as well as for transfers after entry.

58/ Appendix I-E, the special study matching Census and register data.

Table II-32

Estimates of Withdrawals from Engineering and Science Occupations, 1961

Occupations Indicated in the 1961 Census by a Sample of Engineers from the 1961 Survey of Scientific and Technical Personnel Who Graduated in Engineering Courses 1/

Occupation	All Years of Bachelor Graduation No. 2/	%	Those Who Graduated After 1950 No.	%
Total	8,984	100.0	3,490	100.0
Managerial	1,836	20.4	408	11.7
Professional Engineers	5,954	66.3	2,692	77.1
Other Professional	336	3.7	78	2.2
Other Occupations	858	9.5	312	8.9

Employment Specializations Indicated in the 1961 Survey of Scientific and Technical Personnel by Engineers and Natural Scientists Who Graduated in Engineering or Natural Science Courses Respectively 3/

Employment Specialization	Engineering No.	%	Natural Science No.	%
Total	10,736	100.0	2,706	100.0
Engineering	9,047	84.3	372	13.7
Natural Science	411	3.8	1,787	66.0
Other Scientific and Technical	180	1.7	218	8.1
Non-Technical	950	8.8	292	10.8
Not Stated	148	1.4	37	1.4

1/ Persons in the sample were matched with their corresponding census return. For a more detailed description, see Appendix I-E.

2/ The number was estimated in the following manner. Those who were not located and could not be matched - 56 out of 224 - were broken down by age group, then added to each respective age group, and pro-rated according to the occupation of those who were located. The resulting totals in each occupation were then multiplied by the reciprocal of the sampling ratio to estimate total numbers.

3/ "Natural Science" excludes agriculture and forestry.

Sources: D.B.S. and Department of Labour, unpublished data obtained by a matching of 1961 Census and Register Records.

Department of Labour, unpublished data from Survey of Scientific and Technical Personnel, 1961.

Table II-33

Average Age of Males in Selected Professional Occupations, 1961

Occupation	Average Age
All Occupations	39
Professional and Technical	38
Architects	36
Engineers	38
Physical Scientists	36
Biologists and Agricultural Professionals	39
Veterinarians	40
Law Professionals	44
Dentists	46
Physicians and Surgeons	42
Professors and College Principals	40

Source: D.B.S., 1961 Census of Canada, Vol. III, Bulletin 3.1-9, Table 17.

Estimates of deaths and retirements of engineers and scientists is necessary as a basis for calculating replacements in these occupations. In order to estimate the importance of replacement needs arising from deaths of engineers and scientists, age specific death rates in 1961 for males[59/] were applied to the distribution of engineers and scientists by age groups in the Register of Scientific and Technical Personnel in 1963.[60/] The death rates in 1963 for engineers and scientists as a group were 0.49 and 0.5 per cent, respectively, as shown in Table II-34.

Retirements represent an additional source of replacement needs. Assuming an average retirement age of 65, the retirement rate for engineers of the 1961 stock would average 0.8 per cent per annum.[61/] Assuming that death rates and age distributions would change very little for 1961-63, and that the 1961 retirement rate could be applied to 1963, the annual replacement rate due to deaths and retirements would be

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59/ No occupational specific death rates have been published for Canada. In addition, these death rates for males were applied to total engineers and total scientists but the possible distortion that could arise from the slightly lower death rate for females is negligible, since only 0.3 per cent of engineers and 5.3 and 6.1 per cent of physical and biological scientists, respectively, were females in 1961. See Table II-3, above.

60/ When these rates were also applied to the age distribution of male engineers in the 1961 Census, the overall death rate was 4.7 per thousand, compared with 4.9 for the Register of Scientific and Technical Personnel in 1963.

61/ An estimate of retirements of engineers and scientists was obtained by the Department of Labour for 1961 from an employer-type survey. Retirements during the year were estimated to be 0.5 per cent for

Table II-34

Computation of Death Losses of Engineers and Scientists, 1963

Age	Engineers No.	Engineers Deaths per 1,000[1]	Scientists No.	Scientists Deaths per 1,000[1]
Total, All Ages	10,419	4.9[2]	3,225	5.0[2]
20-24	362	0.6	110	0.2
25-29	1,732	2.6	389	0.6
30-34	1,662	2.7	489	0.8
35-39	2,004	4.6	618	1.4
40-44	1,854	6.3	573	1.9
45-49	1,057	6.1	437	2.5
50-54	731	7.0	281	2.7
55-59	524	8.0	212	3.2
60-64	370	8.9	99	2.4
65+	123	4.4	17	0.6

1/ Deaths for individual age groups computed by applying death rates for males in Canada, 1961.

2/ Deaths for "total, all ages" computed by adding deaths in specific age groups and taking the resulting total as a per cent of the total number in all age groups.

Sources: Department of Labour, unpublished data on age distribution from Survey of Scientific and Technical Personnel, 1963.

D.B.S., Vital Statistics, 1961, August, 1963, pp. 130-131.

1.3 per cent for engineers. A more complete analysis of the separations due to deaths and retirements for engineers and scientists, including projections of future needs, will be done in Appendix V-2, of Chapter V.

Although the death rate for engineers is considerably lower than that calculated recently for other occupations[62/] the main reason is that engineers are younger as a group than physicians, for example. Other studies have brought out the decisive effect that the age composition of a group can have on death and retirement rates.[63/] A recent study estimated a composite death and retirement rate for engineers of 1.5 per cent during the 1960's.[64/]

7. The Composition and Responsiveness of Supply

The purpose of this section is to examine the main past sources of the supply of engineers in relation to each other. It is hoped that a study of past trends will provide a better basis for making the assumptions necessary for projections of future supply.

61/ (Cont'd)
engineers and 0.6 per cent for scientists. Department of Labour, Economics and Research Branch, Professional Manpower Report No. 13, Employment Outlook for Professional Personnel in Scientific and Technical Fields, 1962-64, December, 1962, pp. 23-24.

62/ S. Judek, *op. cit.*, p. 54.

63/ U.S. Bureau of Labor Statistics "Tables of Working Life - Length of Working Life for Men", 1950.

64/ U.S. National Science Foundation, Scientists, Engineers and Technicians in the 1960's, p. 65.

a. Sources of Recruitment - A Framework for Supply Projections

In order to gain a better perspective on the various sources of supply of scientific manpower and to provide a framework for future projections, the various elements are brought together in Tables II-35 to II-37.

Table II-35 outlines the sources of recruitment of engineers, scientists and architects as a group during 1959 which were reported by employers in a survey conducted early in 1960.[65] Although the data refer to a particular year, they suggest in a general way the relative importance of certain sources of new manpower supply. The 22.7 per cent that came from outside the country agrees closely with the information on stock data from the Register of Scientific and Technical Personnel which was indicated in Table II-30 above. However, it is less than the 33 per cent reported in the 1961 Census in Table II-24 above.

65/ The results of this survey were published in: Department of Labour, Economics and Research Branch, Professional Manpower Report No. 8, Employment Outlook for Professional Personnel in Scientific and Technical Fields, 1960-62, December, 1960. Architects were included with engineers and scientists as a group, and could not be separated.

Table II-35

Sources of Recruitment of Engineers, Scientists and Architects, 1959

		No.	%
(1)	Total Recruitment	5,524	100.0
(2)	New University Graduate	2,072	37.5
(3)	Experienced Canadian Professionals	2,117	38.3
(4)	Recent Immigrants	590	10.8
(5)	Obtained Outside Canada	185	3.3
(6)	Upgradings, Total	560	10.0
(7)	By Obtaining a University Degree	87	1.5
(8)	Through Experience	385	7.0
(9)	By Professional Association Membership	88	1.6
(10)	Total "New" Recruitment /Rows (2) + (4) + (5) + (6)/	3,407	
(11)	Total "New" Recruitment - Domestic Sources /Rows (2) + (6)	2,632	
	Proportion Without Degrees from New Recruitment - Domestic Sources /Rows (8) + (9) ÷ Row (11)/	-	18.0
	Proportion of New Recruitment from Outside Sources /Rows (4) + (5) ÷ Row (10)/	-	22.7

Source: Department of Labour, Economics and Research Branch, Employment Outlook for Professional Personnel in Scientific and Technical Fields, 1960-1962, Professional Manpower Report No. 8, December, 1960, pp. 23 and 24.

Table II-36

Alternative Estimates of the Proportion of Engineers and Scientists Without a University Degree

Data Source	Engineering		Science		Engineering and Science	
	No.	%	No.	%	No.	%
Census(1)	43,166	27.7	16,998	27.3	60,004	27.6
loyment Outlook Survey, ecruitment, 1959(2)	N.A.	-	N.A.	-	2,632	18.0
loyment Outlook Survey, ock, 1962(3)	29,196	13.3	13,052	3.2	42,248	10.2
vey of Scientific and echnical Personnel, 1951(4)	7,123	4.7	2,631	1.8	9,754	3.9

Census of Canada, 1961, Labour Force, Bulletin 3.1-9, Table 17.

Department of Labour, Economics and Research Branch, Professional Manpower Report No. 8, Employment Outlook for Professional Personnel in Scientific and Technical Fields, 1960-62, December 1960, pp. 23-24.

Department of Labour, Economics and Research Branch, Professional Manpower Report No. 13, Employment Outlook for Professional Personnel in Scientific and Technical Fields, 1962-64, December 1962, pp. 25-26.

Department of Labour, Economics and Research Branch, Professional Manpower Report No. 12, Employment and Earnings in the Scientific and Technical Professions, 1958-61, September 1962, p. 12.

Table II-37

Computation of Engineering Entrants, 1951-1961

	1951 Employment and 1952-61 Gains No.	Losses 1952-61 No.	1961 Employment No.	1961 Employment %
Engineering Employment, 1951(1)				
Total	29,960			
Deaths and Retirements(2)		4,810		
Transfers to Other Fields(3)		1,514		
Survivors in 1961			23,636	
New Engineering Entrants, 1952-61, Total			25,094	100.0
(New Engineering Entrants, 1952-61, Revised Total)			(20,790)	(100.0)
Engineering Graduates, 1952-61	17,600			
Separations - Deaths, Retirements, Transfers(2)(3)		1,030		
Survivors in 1961			16,570	66.6
(Assuming 75% in Census Occupation "Engineering")(4)			(12,430)	(59.8)
Non-Engineering Graduates, 1952-61(5)	1,366			
Separations - Deaths, Retirements, Transfers(2)(3)		80		
Survivors in 1961			1,286	5.1
(Assuming 75% in Census Occupation "Engineering")(4)			(965)	(4.6)
Net Migrants, 1951-60(6)	6,879			
Separations - Deaths, Retirements, Transfers(2)(3)		400		
Survivors in 1961			6,479	25.8
(Assuming 75% in Census Occupation "Engineering")(4)			(4,860)	(23.4)
Upgradings 1952-61(7)	810			
(Assuming Upgradings = 15.3% of Graduates)(8)	(2,693)			
(Separations - Deaths, Retirements, Transfers)(2)(3)		51		
(Separations - Assuming Upgradings = 15.3%)		(158)		
Survivors in 1961			759	[illegible]
(Assuming Upgradings Equal 15.3% of University Graduates)(8)			(2,535)	(12.2)
Totals(9)	56,615	7,885	48,730	
(Revised Total)(10)			(44,426)	

Estimate based on 1951 census.

Deaths computed from 1955-57 life tables, [illegible] retirement age of 65. Deaths [illegible] age at entry to be 27. [illegible] average of net migrants and some veterans.

Estimate based on data from the [illegible] National Science Foundation, [illegible] per cent per year.

See footnote (2), Table II-27. Of those [illegible] register matching study, 77 per cent were [illegible] engineering occupation classes. The estimate was rounded to 75 per cent.

otnotes Table II-37 (Cont'd.)

) Assumed to be equal to transfers out of engineering, from information in Department of Labour Register of Scientific and Technical Personnel, 1961. Transfers out of engineering represented 15.7 per cent and transfers into engineering 16.1 per cent of engineering graduates and those in engineering fields respectively.

) Immigration minus emigration to the United States. Since heavier immigration occurs in the latter part of the year, the period 1951-1960 was chosen for net migration in comparison with graduations.

) Estimate based on proportion of new recruits to engineering and science upgraded to professional status by membership in a professional association as a per cent of graduates as reported in a survey of employers in 1961.

) Assuming upgradings include, in addition to professional association members those who had, according to employers, adequate work experience.

) Based on Rows 4, 7, 11, 15 and 21.

) Based on Rows 4, 8, 12, 16 and 22.

rces:

1 - D.B.S., Census of Canada 1951, Vol. LV, Labour Force, Table 11.

2 - D.B.S., Canadian Life Tables, 1950-1952-1955-1957, July, 1960, pp. 6 and 7.

3 - U.S. National Science Foundation, Scientists, Engineers, and Technicians in the 1960's, Requirements and Supply, Washington, U.S. Government Printing Office, 1963, p. 15.

5 - Table II-11

s 8, 12, and 16 - Department of Labour and Dominion Bureau of Statistics, Special Match of Records in the Register of Scientific and Technical Personnal 1961 with 1961 Census records, November, 1965, unpublished.

13 - Table II-22(a)

s 17, 18 and 21 - Department of Labour, Economics and Research Branch, Employment Outlook for Professional Personnel in Scientific and Technical Fields, 1962-1964, Professional Manpower Report No. 13, December, 1962, p. 24.

In 1959, 18 per cent of the new recruitment from domestic sources consisted of engineers and scientists who were upgraded to professional status without having university degrees. This estimate is presented, together with some alternative estimates in Table II-36.[66/]

The opinions of employers have been chosen to serve as a guide in estimating the proportion of engineers and scientists who are performing engineering and scientific work without university degrees. The most comprehensive estimate was made in 1962 when employers of over 42,000 engineers and scientists estimated that about 13 per cent of the engineers and 4 per cent of the scientists had no degrees and were presumably upgraded to professional status.[67/]

66/ One possible reason for the wide variation is the difference in the concept of an "engineer" and a "scientist" in each of these data sources as discussed above in Chapter I. Another and possibly additional reason is simply a difference in the population covered in each of these studies, in particular the non-degree population. The Census, with over 27 per cent, and the register with under 4 per cent represented extremes in the proportion of engineers and scientists without university degrees. The estimates of employers fall somewhere in between these extreme values. More data are needed to establish more precisely the number of non-degree engineers and scientists.

67/ A more complete description of the question of upgrading of persons to engineering and scientific status will be undertaken in Chapter IV. The upgrading of persons to professional status must be understood in a supply and demand context. The utilization of engineering and scientific manpower essentially involves a decision by management as to whether a particular function, for example engineering, can ceteris paribus be more efficiently or economically performed by persons with an engineering or science education compared with other persons. These decisions by management are made in the light of demand, supply, factor prices and production functions prevailing at a particular time.

An estimate of the main elements in the supply of engineering entrants for 1951-61 is made in Table II-37 as an illustration of a possible framework for projections of engineers and scientists in Chapter V. It also summarizes the composition of the supply of engineers during this period. Engineers were chosen rather than scientists for three reasons: First, more precise and complete data on supply of engineers were available than for scientists. Second, given the data and resources available for the study, more time would be required to produce an equivalent framework for science. Finally, one of the main purposes of the study is to illustrate more precisely the parameters on which better projections can be made for certain types of engineering and scientific personnel. The data for engineers, it is felt, are sufficient to illustrate the method.

After allowing for separations due to deaths, retirements and transfers to other fields, it was assumed that new engineering entrants from 1952-61 came from four sources: engineering graduates; graduates in other fields who entered engineering; net migration; and upgrading. Two estimates of the stock of engineers in 1961 were available, one from the Department of Labour Register of Scientific and Technical Personnel and the other from the 1961 Census. Accordingly, two variants of the flow estimates were made, the first employing "Register" concepts and the second "Census" concepts. The first estimate of stock in 1961 assumed that most graduates remained in engineering fields with upgradings of non-degree holders at a minimum. The resulting estimate of 48,730 engineers may be compared to an estimate of 48,476 which was based on a hand count of the Register of Scientific and Technical Personnel in 1961.68/ The second estimate of stock in 1961 assumed that following the Census occupational concepts, engineering graduates would "move" into other occupations to a greater extent and that, according to Census concepts, upgrading of non-degree holders would form a larger proportion of the flow. The resulting estimate of stock in 1961 was 44,426 which was reasonably close to the 1961 Census figure of 43,066. The possibility of error in such flow data means that at this stage the above estimates must be considered as orders of magnitude.

Based on these estimates, it can be seen that about one-half of the total stock of engineers in 1961 was made up of those who entered the profession in Canada during the decade of the 1950's. About two-thirds of the new entrants, in turn, consisted of new university graduates in engineering, about one-quarter were foreign-born and the remainder either new graduates from other fields or persons upgraded to engineering status without university degrees.69/

68/ Department of Labour, Economics and Research Branch, Professional Manpower Report No. 10, Engineering and Scientific Manpower Resources in Canada, Their Employment, Earnings and Salary Rates, 1960-61, June, 1961, p. 63.

69/ In the short run when budgets tend to be more rigid, the quality of recruits may adjust to fit the demand-supply situation rather than an adjustment being made in price of the services of engineers or scientists. An example of this phenomenon is given in the

b. Summary

The purpose of this chapter was to describe and analyze the supply of engineers and science manpower in order to provide a better basis for making projections of future supply. The method followed was to utilize stock and flow data in order to analyze the various components of supply. This, in turn, enables a judgement to be made of changes in their relative importance to overall supply over time.

It has been shown that a considerable degree of potential and actual short- and long-term flexibility is built into the supply side of scientific and technical manpower.[70] The long-run increase in the numbers of scientific and technical manpower in Canada has not only been large in relation to most other occupational classes, but has also varied markedly over shorter periods of time.

69/ (Cont'd.)
context of another type of market for high-level manpower, the market for college teachers. "The quality standards set by the Department Chairmen are loose so that if the realities of the marketplace demand, a poorer candidate can be hired. But the salary maxima set by the Deans remain steadfast. The elastic element in the demand function for professors is neither price nor quantity, but quality." David G. Brown, The Market for College Teachers, Chapel Hill, North Carolina, The University of North Carolina Press, 1965, p. 250.

70/
Although data on the analysis of flexibility of supply are available mainly for engineers, it is assumed that they are relevant for scientists as well. In addition, engineers represent a large proportion of the engineering and scientific manpower pool.

This chapter examined the main components of the supply of scientific and technical manpower which gave rise to this flexibility: 1) graduations; 2) net migration; 3) other sources of supply outside the formal education system; 4) occupational and geographic transfers.[71/]

Attention must be directed to certain crucial "decision points" or "transition proportions". This means that on the way to entering an occupation there are certain times when crucial decisions are made. First, which course of study will be chosen, for example, arts vs. science, engineering vs. pure science; second, the occupational choice, engineering vs. managerial occupations, for example; third, the place of work chosen, for example, Canada vs. the United States. A knowledge of these transition proportions is essential before reliable projections can be made. These proportions in turn have been included in a framework of four components which, together, determine the flexibility of scientific manpower supply. These components are in turn comprised respectively of sub-components: 1) total enrolments which are affected by the decisions of students to enroll in engineering or science courses at university, as well as by drop-out rates; 2) the

71/ Separations and withdrawals due to deaths and retirements while not specifically related to supply flexibility are, of course, an important element in estimating past and future supply.

volume and occupational composition of immigration and emigration; 3) decisions of employers to upgrade the people to professional status; 4) decisions by persons to move from one occupation or geographic region to another.

The most important single element on the supply side in the case of engineering has been engineering graduations and these are becoming an even more important element. Since these appear to have accounted for about two-thirds of the supply of engineering manpower in the last decade and since this element of supply has exhibited greater long-run stability than net migration, the possibility of making more accurate numerical long-run projections is increased.

In the shorter run, however, the proportion who choose to enter engineering courses and the percentage who do not complete engineering courses can lead to large and rapid changes in the number of engineering graduates. In the long-run, however, these changes have tended to counterbalance one another leaving total enrolment as a useful parameter for projections of future engineering graduations and, therefore, future supply of engineers.

Non-university graduates, on the other hand, have been declining as a source of supply in the case of both engineering and science occupations, which further enhances the significance of university graduations as an indicator of the supply of engineering and scientific manpower. In order to estimate the impact upon supply of those who enter engineering occupations without a university degree, two estimates of the number of non-degree engineers were made based alternately upon the "education" and the "employment" criterion. The latter concept results in an intermediate size estimate of engineering supply which is almost 10 per cent above the former estimate based on "education".

The relatively large proportion of the supply of engineering manpower which came from net migration, at least one-quarter, means that this more variable source of supply must be estimated with great care in making long-run projections. In addition, this supply component has great potential for creating substantial changes in the supply of engineering manpower in the short-run.

Occupational transfers, that is, the transfers from engineering to other occupations and vice versa appear equal to each other in numerical terms and have had, on balance, a neutral long-run effect on the supply of engineering manpower.

The responsiveness of supply especially in the short-run is limited by the long-run nature of the decisions to enroll in engineering. This suggests the importance of "demand-side" adjustments in the matching of demand and supply. The implication is that measures should be examined to improve geographic, occupational and industrial mobility and also to improve the utilization of scientific and technical manpower by business firms and other types of employers.

In addition to numerical changes in engineering and science manpower, the data suggest that the qualitative changes in supply may be just as important. The most striking fact is the increase in the level of education of engineers and scientists and in particular the recent rapid increase in the number who obtain post-graduate education. At the undergraduate level, the most significant change has been a more rapid increase in the numbers of students graduating in pure science compared with engineering. The combined effect of the greater propensity of students to take science degrees, and to obtain post-graduate training in engineering, plus greater reliance on domestic as opposed to supply from abroad suggests the following: given the present proportion of Canadians studying in Canada as compared to those studying abroad, and assuming that this proportion will remain the same in the future, the maintenance of future supply of engineering and science manpower will require a relatively larger expansion of educational facilities in engineering and science in Canada at the post-graduate level than we have seen to date.

Net migration, especially the emigration component, has been relatively heavier for engineers and scientists with higher degrees. This means that the loss of manpower through emigration has been greater than the numbers alone would suggest. If the educational investment in these emigrants in engineering and science fields is considered, the human capital loss assumes greater magnitude.

In order to make better projections, it is necessary to trace the past internal changes in the components of supply and, if possible, to forecast their future trends. The partial picture given by the large changes in the amplitude of first-year engineering enrolments and in net engineering migration during the 1950's, for example, needs to be filled in. This in turn raises questions about the factors which may influence students' decisions about whether to enter or not to enter certain courses; whether there are certain reservoirs of talent for these courses, the dimensions of supply of scientific and technical manpower, for example, where do technicians fit in; whether the inter-occupational mobility patterns will continue into the future. In addition to the internal aspects of the composition of supply, the external environment is undoubtedly an important conditioning influence. The components of supply may respond to a common external force in the economy. Supply changes are complex and interrelated with requirements, therefore, they cannot be completely understood without reference to changes in demand and requirements, factor prices and productivity. The utilization of technicians vs. engineers and scientists or in conjunction with them, including the question of upgrading to professional status, involves a number of these influences as well as supply.

A more complete understanding of the supply changes in scientific and technical manpower calls for a study of the dynamic aspects of demand and requirements as a necessary next step in reformulating our knowledge of past trends and future prospects.

CHAPTER III

DISTRIBUTION OF ENGINEERING MANPOWER BY INDUSTRY 1931-61

The aim of this chapter is to examine changes in the distribution by industry of persons in engineering occupations between 1931 and 1961 and to suggest some of the factors that were responsible. This will require an examination of the changing deployment of engineers by occupation class among and within industry groups. The trends in relative earnings in these occupations are important to an understanding of such changes. This chapter will help to set the stage for the more detailed examination of supply, requirements, utilization and earnings in Chapter IV, and the projection of requirements for engineers in Chapter V.

This chapter has five sections: first, the concept of demand; second, a discussion of methods of approaching a study of demand; third, general economic developments between 1931 and 1961; fourth, changes in the distribution of engineers among and within detailed industry groups 1931-61; fifth, the conclusion.

1. The Concept of Demand

It is essential in any discussion of past, present or future "needs" for engineering and scientific manpower to clarify what concept of need is being used. Frequently the term "requirements" as well as the term "demand" has been used in the literature to describe two alternative approaches to an assessment of manpower needs.[1] To the economist the "demand" for engineers, for example, means a schedule of relationships between various numbers of engineers and various possible salary rates per unit of time. The important assumption is that employers will ceteris paribus tend to hire different numbers of engineers depending on their salary rates.

The "requirements" for engineers, on the other hand, relate in the strict sense to the number of engineers needed to meet certain social or economic targets. It is a concept, as Parnes notes, with more of a technological than an economic basis.[2]

Under purely competitive conditions in factor markets, the demand schedule of an employer for a particular type of labour will depend upon the marginal revenue product schedule for that type of labour. The theory tells us that the firm will attempt to hire that total quantity of labour at which the marginal revenue product is equal to the marginal outlay on the workers, i.e., the marginal wage. Since the demand for labour is a derived demand, it will depend in turn upon the elasticity of demand for the product, upon the technical conditions of production, i.e., the shape of the production function and upon the

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1/ H.S. Parnes, Forecasting Educational Needs for Economic and Social Development, Paris, Organization for Economic Co-operation and Development, 1962, pp. 17-19; David M. Blank and George J. Stigler, op. cit., pp. 19-24.

2/ H.S. Parnes, op. cit., p. 18.

substitutability of labour for other factors.[3/] Other things remaining equal, the longer the period of time the more elastic the demand is likely to be because of the possibility of substituting labour for capital and adjusting the quality of capital goods in relation to the supply of labour available.

A study of the demand side of engineering manpower is complicated by the familiar problem of the interdependence of economic phenomena, for example, of the level of supply, demand and the price of productive factors. An increase in the supply of engineers would ordinarily tend to reduce the earnings of engineers. If an increase in demand occurred, which was proportionately greater than the increase in supply, the relative earnings of engineers could rise due to the interaction of an increase in supply and an increase in demand. The problem would be to disentangle the effects of these two changes which operate in opposite directions with regard to their effect on earnings of engineers. Demand in the schedule sense is not easy to determine. It

3/ The relevance of the price of a factor of production as a measure of its contribution to the social product has been questioned sharply at a recent O.E.C.D. Conference. However, the alternative to an acceptance of the marginal productivity approach seems to be the absence of a universal law to guide resource allocation, i.e., empiricism. There is a need, therefore, to qualify any policy conclusions based on the marginal productivity analysis to the extent that the postulates of the theory are unrealistic. See Organization for Economic Co-operation and Development, Study Group in the Economics for Education, The Residual Factor and Economic Growth, Paris, Organization for Economic Co-operation and Development, 1964, p. 275.

is necessary to utilize measurable concepts such as requirements,[4/] industrial and functional distribution over time, as preliminary or approximate indicators of demand. These must be cross-checked with other data such as supply and salaries in order to estimate the impact of demand.[5/]

2. Methods of Studying Demand

Certain information would be needed ideally in order to do a study of future "demand" in the economic sense for engineering and scientific manpower. A good knowledge is needed of the present numbers and distribution of manpower by occupation and industry. The approach to future requirements also involves a study of the three key ingredients in determining the demand or requirements for this type of manpower: first, the level and distribution of aggregate demand among industry sectors in the economy; second, production functions, that is, the relation between the factor inputs and outputs in each industry; third, the relative prices of the different productive factors. These

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4/ One definition of employers requirements is that it refers to "what employers think they need at what they think are prevailing salaries". United States National Science Foundation, Scientific Manpower, 1958, Papers of the Seventh Conference on Scientific Manpower, Washington, D.C., U.S. Government Printing Office, 1959, Article by William H. Chartener, "An Appraisal of Short-Run Manpower Requirements and Supply Indicators", p. 46.

5/ For additional discussion, see: Kenneth E. Boulding, Economic Analysis, Revised Edition, New York, Harper, 1948, pp. 671-707; George J. Stigler, The Theory of Price, Revised Edition, New York, Macmillan, 1952, pp. 187-193.

three key factors interact and together determine the demand for particular types of labour including engineers and scientists. The impact of a change in technology such as labour-saving automation upon the demand for a particular type of labour will depend not only upon the changes in the production functions but also upon changes in output distribution and in relative prices of all the factors of production, leading to the substitution of one factor for another.

What are the possibilities of obtaining data on the three key factors of output, production functions and factor prices which determine the demand for a particular type of labour? A good deal of information is available on manpower distribution and output. Decennial Census data contain information for certain occupations, e.g., engineers, cross-classified by industry. The data available on output distribution, present and projected, do not constitute a demand curve or curves in the theoretical sense, since a more complete knowledge would require an investigation of domestic versus foreign prices and demand elasticities for domestic and foreign products, and so on.

The problems involved in obtaining data on production functions and relative factor prices are more serious. At the root of this difficulty is a lack of knowledge of the nature and direction of the causes and effects of technological change. A study of the "best-practice" techniques in industry reveals the interaction of technical advances and changing factor prices and the difficulty of separating the two.[6/] There is, however, strong evidence of an association between the level and quality of scientific and technical manpower and progressive and innovative activities in firms and industries,[7/] but the nature and causal directions of the association are not yet clear. For example, do firms engage in research and development because they employ research and development engineers and scientists, or do they engage engineers and scientists because they wish to engage in research and development? Or is the association of the numbers of engineers and scientists with research and development a case of both being jointly caused by a third factor or factors, for example, progressive management or large-scale operation and/or monopoly power? Both research and development and increases in productivity may be among a number of possible options chosen by oligopolists to maintain or increase their share of the market. Further, the majority of engineers and scientists are not engaged in research and development. The relation between research, development and productivity itself is not clear. One study has found that engineering and science ratios to total employment were related

6/ W.E.G. Salter, Productivity and Technical Change, Cambridge, University Press, 1960, pp. 24-25.

7/ C.F. Carter and B.R. Williams, Industry and Technical Progress: Factors Governing the Speed of Application of Science, London, Oxford University Press, 1957, pp. 178-184.

significantly to research and development but not to productivity ratios.[8/] The state of the economic art is such that we simply do not know the precise causes and effects of technological change and in particular the production function for new technology. Nor can we separate the effects of technological progress on growth from the effects of the accumulation of capital. Working out the manpower or more specifically the science and engineering manpower implications of such changes calls for even greater caution.

In order to incorporate relative factor prices into the analysis the data should be standardized for the influence of education, experience and geographical location. Some knowledge of the marginal rates of technical substitution among factors would also be needed ideally since changes in technology and relative prices of factors could have substantial effects on the demand for engineering and science manpower.

8/ For a discussion of a number of these problems see the following: John W. Kendrick, Productivity Trends in the United States, Princeton, N.J., Princeton University Press, 1961, p. 187; Jesse W. Markham, "Market Structure, Business Conduct and Innovation", American Economic Review, Vol. LV, No. 2, May, 1965, p. 324; Nestor E. Terleckyj, "Sources of Productivity Change. A Pilot Study based on the Experience of the American Manufacturing Industries, 1899-1953", Unpublished doctoral dissertation for Columbia University, 1959, cited in Kendrick, op. cit., p. 184; Jacob Schmookler, "Technological Changes and Economic Theory", American Economic Review, Vol. LV, No. 2, May, 1965, pp. 335-338; Nicholas Kaldor, "Comments on Mr. Ingvar Svennilson's Paper", in Organization for Economic Co-operation and Development, Study Group in the Economics of Education, The Residual Factor and Economic Growth, Paris, Organization for Economic Co-operation and Development, 1964, pp. 138-142.

It was decided that a second-best method must be used to study demand, i.e., that a "requirements" rather than a "demand" approach was appropriate. Changes in the number of engineers over time will be analyzed by examining two processes: changes in the distribution of total employment among industries with different occupational patterns; and shifts in the occupational composition within different industries. This approach will permit the long-term outlook for engineering manpower to be treated within the framework of total manpower resources where weight can be given to trends in the distribution of the labour force by industry and by occupation.

Changes in the total employment of engineers over time will be examined in relation to general economic developments between 1931 and 1961. Then changes in the engineering occupations will be considered in relation to total labour force by separate industries. Increases in the number of engineers employed may be attributed to industry growth, for example, growth in those industries employing high ratios of engineers to total employment,[9/] however, if productivity changes in these industries were positive, the actual impact of industry growth may be understated. The impact of productivity changes upon the composition of broad occupational groups has been studied by N.M. Meltz.[10/] However,

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9/ In one study it was found that one third of the employment increases for engineers could be attributed to this factor. See David M. Blank and George J. Stigler, op. cit., pp. 48-56.

10/ Noah M. Meltz, Changes in the Occupational Composition of the Canadian Labour Force, 1931-61, Occasional Paper No. 2, Ottawa, Department of Labour, March, 1965, pp. 71-102.

the impact of productivity changes was assumed to be neutral with respect to the occupational structure of each industry's labour force.[11/] Differential changes in the distribution of total labour force among industries will include the effect of differential changes in productivity as between industries. Changes in occupational structure within industries, for example, an increase in the percentage that engineers represent of total employment in a particular industry will measure the impact of both production function changes within industries as well as changes in relative factor prices. At this level of aggregation they cannot be separated. Nevertheless it is felt that changes in the proportion of engineers within industries can be identified as general indicators of changes in "utilization" of persons in this occupation.

It should be emphasized that analysis in this study will be preliminary. It is also hoped that it will fit in with any more detailed and extended analysis which might be done at the level of the firm or the establishment.

3. General Economic Developments

Changes in the industrial distribution of total and engineering labour force over time are part of the broad process of the growth of Canada's national output which may be understood in terms of

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11/ *Ibid.*, p. 73.

a growing stock of productive factors and an increase in their productivity.[12] The growth process can be studied in terms of rising output, incomes and changes in the industrial structure.[13]

Between 1931 and 1961 the Canadian economy experienced both substantial overall growth as well as structural changes. These changes are shown in Table III-1. Population grew from 10.3 to 18.2 millions, about 77 per cent, while the labour force increased by about 62 per cent. Gross National Product in constant 1949 dollars rose from 7.6 to 26.5 billion, an increase of 250 per cent. The 30-year period was one of great economic changes ranging from depression through war mobilization to a peacetime economy experiencing inflationary pressure and recessions.

It must also be noted that the long-term data on occupation by industry are based on the Censuses and that each Census represents a different state of short-term economic conditions. The year 1931 was in the middle of a large economic decline; 1941 represented the early stages of a sharp upturn; in 1951 the economy was moving sharply upward; whereas 1961 marked a low point following 4 years of sluggish economic growth.

12/ R.E. Caves and R.H. Holton, The Canadian Economy, Prospect and Retrospect, Cambridge, Mass., Harvard University Press, 1959, p. 61.

13/ O.J. Firestone, Canada's Economic Development, 1867-1953, London, Bowes and Bowes, 1958, pp. 6-27.

Table III-1

Population, Civilian Labour Force, Unemployment and Gross National Product, 1929-1963

Year	(1) Population	(2) Labour Force	(3) Unemployment	(4) Gross National Product
	(000's)	(000's)	(% of labour force)	(millions of dollars 1949)
1929..	10,029	3,964	2.4	9,061
1930..	10,208	4,060	7.1	8,679
1931..	10,376	4,151	12.9	7,567
1932..	10,510	4,211	18.6	6,798
1933..	10,633	4,275	20.0	6,359
1939..	11,267	4,649	14.8	9,536
1940..	11,381	4,607	11.9	10,911
1941..	11,507	4,466	3.5	12,486
1942..	11,654	4,569	-	14,816
1943..	11,946	4,567	-	15,357
1949..	13,447	5,158	2.8	16,343
1950..	13,712	5,163	3.6	17,471
1951..	14,009	5,217	2.4	18,547
1952..	14,459	5,315	2.9	20,027
1953..	14,845	5,383	3.0	21,186
1959..	17,483	6,228	6.0	25,242
1960..	17,870	6,403	7.0	25,849
1961..	18,238	6,518	7.2	26,466
1962..	18,570	6,608	5.9	28,083
1963..	18,896	6,737	5.5	29,380

Sources:

Col. 1 - D.B.S., Canada Year Book, 1965, p. 160.

Col. 2 - D.B.S., Canada Year Book, 1965, p. 723.

Col. 3 - 1929-1943: T.M. Brown, Canadian Economic Growth, A Study for the Royal Commission on Health Services, 1964, pp. 194-195.

1949-63: D.B.S., Special Tables, Special Surveys Division.

Col. 4 - D.B.S., Canada Year Book, 1965, p. 1009.

The growth of Gross National Product over the period was accompanied by changes in the industrial composition of Gross Domestic Product.[14/] These broad changes are illustrated in Table III-2. The most striking change is the relative decline in agriculture from 8.0 to 4.6 per cent of Gross Domestic Product between 1931 and 1961. The decline in agriculture has been accompanied by a rise in construction, manufacturing and public administration and defence especially in 1941. The decline in trade, construction and services in 1941 reflect the wartime distortions while subsequent peacetime years indicate a return to the pre-war pattern.

4. Changes in the Distribution of Engineering Employment Among and Within Industries, 1931-61

Theoretically, total employment changes by industry represent the combined effect of output and productivity changes. Since the framework proposed for projections is total employment by industry, which includes estimates of productivity changes, productivity estimates are incorporated in any projections which may be made of total employment and therefore it is not necessary for our purposes to separate these effects for the historical series which is to be used as a basis for projections in Chapter V.

14/ Gross Domestic Product is a measure of total production within the geographic boundaries of Canada and is comparable with Gross National Product. Gross Domestic Product at factor cost is equal to Gross National Product minus indirect taxes less subsidies minus income received from non-residents plus income paid to non-residents.

Table III-2

Percentage Distribution of Gross Domestic Product
at Factor Cost by Industry,
1931, 1941, 1951 and 1961

Industry	1931	1941	1951	1961
1. Agriculture...............	8.0	9.2	12.5	4.6
2. Forestry..................	0.9	1.5	2.3	1.1
3. Fishing and Trapping......	0.5	0.6	0.5	0.3
4. Mining, Quarrying and Oil Wells...............	3.3	5.3	4.2	4.5
5. Manufacturing.............	22.4	29.9	28.6	25.7
6. Construction..............	4.8	3.5	4.8	5.3
7. Transportation...........)			7.1	6.5
8. Storage..................)			0.3	0.3
9. Communication............)	13.2	12.1	1.6	2.4
10. Electric Power, Gas and) Water Utilities........)			2.3	3.5
11. Wholesale Trade...........	4.5	3.9	4.4	4.6
12. Retail Trade..............	10.0	7.8	8.1	9.4
13. Finance, Insurance and Real Estate.............	11.9	7.7	7.8	10.7
14. Public Administration and Defence.................	5.2	8.7	5.2	7.5
15. Service...................	15.3	9.8	10.3	13.6
16. Total.....................	100.0	100.0	100.0	100.0

Source: D.B.S., National Accounts, Income and Expenditures, 1926-1956, pp. 28-29; ibid., 1962, p. 23.

The impact of differential changes in the total labour force may be separated from those changes which are associated with different rates of growth of total employment in particular industries. Finally, the impact of changes in the percentage of engineers to total employment within industries - more or less intensive "utilization" - will then be calculated.

a. General Pattern of Changes, 1931-61

It was observed above in Chapter II, Table II-2 that the percentage increase in the engineering labour force between 1931 and 1961 was about three times as large as the increase in the total labour force. The first objective of this section is to explain the increase in terms of the impact of total employment in those industries which employ engineers. As Table III-3 indicates, 52 per cent of total labour force compared with 95 per cent of engineering labour force in 1931 were in six industry groups including mining and quarrying, manufacturing, construction, transportation and communication, government, and community, recreation and personal services. These industries expanded their relative share of total employment to over 66 per cent in 1961. The relatively more rapid growth of industries where the vast majority of engineers were concentrated has itself tended ceteris paribus to increase the requirements for engineers over the 30-year period.

The concentration of engineers relative to total labour force is also evident within the manufacturing and service sectors. Paper products, iron and steel products, transportation equipment,

Industry	Total Labour Force			Engineers (Including Surveyors)			Engineers (Excluding Surveyors)		Engineers as a Per Cent of Total Labour Force (Including Surveyors)			Engineers as a Per Cent of Total Labour Force (Excluding Surveyors)	
	1931	1951	1961	1931	1951	1961	1951	1961	1931	1951	1961	1951	1961
	Per Cent			Per Cent			Per Cent		Per Cent			Per Cent	
Total All Industries[1].....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.42	0.66	0.81	0.57	0.68
1. Mining, Quarrying, Oil Wells..................	1.83	1.99	1.87	6.89	6.94	6.24	5.53	5.63	1.59	2.30	2.70	1.60	2.04
2. Manufacturing[2]............	18.45	26.09	23.13	25.06	38.75	34.50	43.62	40.60	0.57	0.98	1.21	0.96	1.19
3. Foods and Beverages......	2.15	2.94	3.10	0.86	1.13	0.92	1.30	1.10	0.17	0.25	0.24	0.25	0.24
4. Rubber..................	0.35	0.41	0.30	0.49	0.84	0.46	0.96	0.54	0.58	1.34	1.24	1.33	1.24
5. Textile..................	1.14	1.51	0.98	0.43	0.92	0.71	1.05	0.84	0.16	0.40	0.59	0.40	0.58
6. Wood....................	1.42	2.24	1.58	0.64	0.67	0.45	0.45	0.41	0.19	0.20	0.23	0.12	0.17
7. Paper....................	1.06	1.72	1.60	2.68	3.32	2.67	3.66	3.07	1.07	1.27	1.35	1.22	1.30
8. Iron and Steel Products[3]	3.69	6.15	5.55	13.38	18.94	16.32	21.57	19.34	1.53	2.03	2.38	2.02	2.36
9. Transportation Equipment.	2.72	3.58	2.77	2.73	5.15	5.22	5.88	6.21	0.42	0.95	1.53	0.94	1.52
10. Non-metallic Minerals.) 11. Petroleum and Coal....)[4]	0.70	0.95	0.98	1.37	2.74	2.70	3.01	3.09	0.83	1.89	2.24	1.82	2.15
12. Chemical................	0.40	0.98	1.10	1.50	3.52	3.54	4.01	4.21	1.57	2.37	2.59	2.35	2.58
13. Construction...............	6.37	6.73	7.35	14.29	10.18	10.32	9.17	7.61	0.95	1.00	1.14	0.78	0.70
14. Transportation, Storage, Communication............	7.07	7.72	7.20	11.24	6.66	7.04	6.96	7.73	0.67	0.57	0.79	0.52	0.73
15. Public Utilities..........	0.65	1.19	1.11	9.30	7.22	5.80	7.30	5.99	6.08	4.02	4.24	3.54	3.66
16. Service[5]..................	17.93	19.29	25.93	28.30	21.57	29.78	18.51	25.75	0.67	0.74	0.93	0.55	0.67
17. Community.............) 18. Business.............)[6]	6.36	8.26	11.97	15.34	10.64	15.80	9.34	14.31	1.02	0.85	1.07	0.65	0.31
19. Government..............	2.90	4.47	6.38	12.62	10.65	13.84	8.94	11.30	1.84	1.57	1.76	1.15	1.20

[1] In addition to selected industries shown below, "Total" includes Agriculture, Forestry, Fishing and Trapping, Trade, Finance and Unspecified.
[2] In addition to selected industries shown below, "Manufacturing" includes Tobacco Products, Leather, Knit Goods, Clothing, Furniture, Printing, Publishing and Allied Products and Miscellaneous Manufacturing Industries.
[3] Iron and Steel Industry includes Non-ferrous Metal Products and Electrical Apparatus and Supplies.
[4] Non-metallic Minerals and Petroleum and Coal cannot be separated for 1931.
[5] In addition to selected industries shown below, "Service" includes Recreation and Personal Service.
[6] Community and Business Service cannot be separated for 1931.

Source: Appendix Table III-A-1.

non-metallic mineral products, products of petroleum and coal and chemical products accounted for about 9 per cent of total labour force compared with 22 per cent of the engineering labour force in 1931. These industries increased their share of total labour force to 12 per cent in 1961. In the service industries, community and business service and government accounted for 9 per cent of total labour force compared with 18 per cent of the engineering labour force in 1931. These industries doubled their share of total labour force to 18 per cent in 1961 and thus, ceteris paribus, contributed to the requirements for engineers over this period of time.

Another aspect of the change in the number of engineers employed is the generally increasing proportion which engineers represented of the labour force within industries. Between 1931 and 1961 the proportion in the total labour force doubled from 0.4 to 0.8 per cent. In the industries examined above in which engineers were particularly concentrated, the proportion of engineers to total labour force also rose. The only exceptions were government and community and business service where the proportion declined.

From 1931 to 1961 the increase in the number of engineers employed can be viewed as the combined result of a larger than average increase in total employment in those industries which employed the vast majority of engineers plus the effect of an ever-increasing propensity of industries to employ on the average a greater proportion of engineers in relation to total labour force.

A more precise idea of the pattern of changing employment of engineers can be obtained by allocating this change in terms of the general growth of the labour force, changes in the distribution of total employment among industries and changes within industries in the occupational structure of employment. In Table III-4, an allowance is made for the general growth of the labour force in order to permit a measurement of the respective impact of employment changes among and within industries.[15/]

The relative importance of these factors between 1931 and 1961 is as follows. For every increase in engineering labour force of 100, 30 were needed to match the growth in the general labour force, 30 were associated with changes in the growth of employment in certain industries which was more rapid than that of the total labour force, and about 40 of the increase came from a tendency of industries to utilize more engineers in relation to total labour force.

In addition, Table III-4 indicates that between 1931 and 1961 more and more of the increase in the number of engineers employed was due to a more intensive utilization of engineers in relation to total labour force. Between 1931 and 1951, about 21 per cent of the increase

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15/ This approach is similar to that used by Gladys L. Palmer and Ann Ratner, Industrial and Occupational Trends in National Employment, Research Report No. 11, Industrial Research Department, University of Pennsylvania, Philadelphia, 1949. It was also used by N.M. Meltz, Factors Determining Occupational Trends in the Canadian Economy, Annual Meeting of the Canadian Political Science Association, Montreal, June, 1961 (mimeographed).

Occupation	Total		Net Changes		Source of Change					
	1931-1951									
	1931	1951	1931-1951		Labour Force		Distribution of Labour Force by Industry		Occupational Structure of Each Industry	
	No.	No.	No.	Per Cent	No.	Per Cent of Change	No.	Per Cent of Change	No.	Per Cent of Change
All Engineers............	16,587	34,385	17,798	100.0	5,469	30.7	8,649	48.6	3,680	20.7
Electrical Engineers......	3,937	6,349	2,412	100.0	1,301	53.9	2,585	107.2	-1,474	-61.1
Mechanical Engineers[1]...	2,859	8,328	5,469	100.0	942	17.2	1,467	26.8	3,060	56.0
	1951-1961									
	1951	1961	1951-1961							
All Engineers (Including Surveyors).............	34,385	51,370	16,985	100.0	7,434	43.8	3,516	20.7	6,034	35.5
All Engineers (Excluding Surveyors).............	29,960	42,990	13,030	100.0	6,478	49.7	2,484	19.1	4,068	31.2
Civil Engineers (Including Surveyors)..	12,168	20,257	8,089	100.0	2,633	32.6	2,902	35.8	2,554	31.6
Civil Engineers (Excluding Surveyors)..	7,743	11,877	4,134	100.0	1.675	40.5	1,825	44.2	634	15.3
Electrical Engineers......	6,349	8,758	2,409	100.0	1,372	57.0	61	2.5	976	40.5
Mechanical Engineers[1]...	8,328	12,091	3,763	100.0	1,801	47.9	-254	-6.7	2,216	58.8
	1931-1961									
	1931	1961	1931-1961							
All Engineers............	16,587	51,370	34,783	100.0	10,236	29.4	10,270	29.5	14,277	41.1
Electrical Engineers......	3,937	8,758	4,821	100.0	2,430	50.4	2,948	61.2	-557	-11.6
Mechanical Engineers[1]...	2,859	12,091	9,232	100.0	1,766	19.1	1,771	19.2	5,695	61.7

[1] Includes Industrial Engineers.

Sources: Dominion Bureau of Statistics: Seventh Census of Canada, Vol. VI, Table 58; Ninth Census of Canada, Vol. IV, Table 23; Tenth Census of Canada, Vol. III, Part 2, Table 15. Unpublished data obtained from the D.B.S. were used to supplement the above sources.

in engineering labour force was due to an increased utilization of engineers compared with over 35 per cent between 1951 and 1961. Put another way, industry structure changes as reflected in the differential growth of total employment was the most important factor, accounting for almost 50 per cent of the increase in the number of engineers between 1931 and 1951, while more intensive utilization of engineers accounted for about 20 per cent of the increase. Between 1951 and 1961, on the other hand, changes in industry structure have become less important, accounting for only 20 per cent of the increase in the number of engineers, while changes in the utilization of engineers have accounted for a 35 per cent rise in the number of engineers in all industries.[16/]

Although the pattern for the engineering occupations shown is somewhat different for electrical and mechanical engineering than for all engineers between 1931 and 1961, a basic similarity exists. As in the case of all engineers as a group, industry structure changes as

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16/ The amount of change in engineering employment ascribed to changes in the industrial distribution of total employment among industries varies inversely with the level of detail of the industries used. At the industry division level (agriculture, mining, manufacturing, construction, etc.) the amount of engineering employment ascribed to changes in occupational structure is 48 per cent between 1951 and 1961 compared with 41 per cent when the major groups in manufacturing and service are substituted for the industry divisions. This suggests that the impact on the number of persons in each occupation of changes in the occupational structure of each industry as indicated by Meltz might have been somewhat different had it been possible to examine the manufacturing division at the more detailed level of major industry groups (food and beverages, etc.). See Appendix, Table III-A-2. See also N.M. Meltz, op. cit., p. 130.

indicated by the distribution of total employment among industries were relatively more important in 1931-51 than for 1951-61. In the latter decade increased utilization of these engineers within industries assumed a relatively greater importance than in the previous two decades. Between 1931 and 1961 industry distribution of total labour force accounted for almost two-thirds of the rise in the number of electrical engineers compared with about one-third for all engineers. From 1931 to 1951 the bulk of the increase in electrical engineers was associated with the growth of total employment in industries employing them. However, between 1951 and 1961 the increase in the number of electrical engineers was associated much more strongly than in the previous two decades with increased utilization by industry. For mechanical and industrial engineers, the degree of utilization remained about the same over the 30-year period, accounting for between one-half and two-thirds of the total increase in their numbers. As in the case of electrical engineers, changes in the distribution of labour force among industries accounted for relatively larger positive increases in the number of mechanical engineers between 1931 and 1951 than from 1951 to 1961.

b. Pattern of Changes in the Number of Engineers by Selected Industries, 1931-61

The changes indicated in Table III-5 by selected industries fit in with the general pattern of industry development during the period described above. During the 20 years from 1931 to 1951 which included depression, war mobilization and post-war economic adjustment, there

Table III-5

Sources of Changes in the Number of Engineers, by Selected Industries, 1931-1951, 1951-1961 and 1931-1961.

Industry	1931-1951							
	Engineers, Including Surveyors							
	Net Changes	Labour Force	Distribution of Labour Force by Industry	Occupational Structure of Each Industry	Net Change	Labour Force	Distribution of Labour Force by Industry	Occupational Structure of Each Industry
	No.	No.	No.	No.	%	%	%	%
Total All Industries[1/]	17,798	5,469	-153	12,482	100.00	30.73	-0.86	70.13
Total Selected Industries	15,630	5,200	4,964	5,466	100.00	33.27	31.76	34.97
1. Mining, Quarrying, Oil Wells	1,242	377	131	734	100.00	30.35	10.55	59.10
2. Manufacturing[2/]	9,168	1,371	2,228	5,569	100.00	14.95	24.30	60.75
3. Foods and Beverages	247	47	70	130	100.00	19.03	28.34	52.63
4. Rubber	208	27	17	164	100.00	12.98	8.17	78.85
5. Textile	246	24	30	192	100.00	9.76	12.20	78.04
6. Wood	125	35	81	9	100.00	28.00	64.80	7.20
7. Paper	696	147	368	181	100.00	21.12	52.87	26.01
8. Iron and Steel[3/]	4,293	732	1,954	1,607	100.00	17.05	45.52	37.43
9. Transportation Equipment	1,319	149	183	987	100.00	11.30	13.87	74.83
10. Non-metallic Minerals) 11. Petroleum and Coal)[4/]	714	75	111	528	100.00	10.50	15.55	73.95
12. Chemical	963	82	472	409	100.00	8.52	49.01	42.47
13. Construction	1,132	781	181	170	100.00	68.99	15.99	15.02
14. Transportation, Storage, Communication	424	615	218	-409	100.00	145.04	51.42	-96.46
15. Public Utilities	942	508	1,708	-1,274	100.00	53.93	181.31	-135.24
16. Services[5/]	2,722	1,548	498	676	100.00	56.87	18.30	24.83
17. Community) 18. Business)[6/]	1,115	839	1,008	-732	100.00	75.25	90.40	-65.65
19. Government	1,569	690	1,734	-855	100.00	43.98	110.51	-54.49

Table III-5 (Continued)

Industry	1951-1961							
	Engineers, Including Surveyors							
	Net Changes	Labour Force	Distribution of Labour Force by Industry	Occupational Structure of Each Industry	Net Change	Labour Force	Distribution of Labour Force by Industry	Occupational Structure of Each Industry
	No.	No.	No.	No.	%	%	%	%
Total All Industries[1]......	16,985	7,434	40	9,511	100.00	43.77	0.24	55.99
Total Selected Industries...	16,721	6,789	1,178	8,754	100.00	40.60	7.05	52.35
1. Mining, Quarrying, Oil Wells	819	516	-169	472	100.00	63.00	-20.63	57.63
2. Manufacturing[2].............	4,396	2,881	-1,831	3,346	100.00	65.54	-41.65	76.11
3. Foods and Beverages.......	83	84	18	-19	100.00	101.20	21.69	-22.89
4. Rubber..................	-55	62	-98	-19	-100.00	112.73	-178.18	-34.55
5. Textile.................	47	69	-138	116	100.00	146.81	-293.62	246.81
6. Wood....................	0	50	-81	31	100.00	-	-	-
7. Paper...................	230	247	-97	80	100.00	107.39	-42.17	34.78
8. Iron and Steel[3].........	1,873	1,408	-770	1,235	100.00	75.17	-41.11	65.94
9. Transportation Equipment..	903	383	-486	1,011	100.00	42.18	-53.52	111.34
10. Non-metallic Minerals.....	117	77	15	25	100.00	65.81	12.82	21.37
11. Petroleum and Coal........	330	126	-6	210	100.00	38.18	-1.82	63.64
12. Chemical.................	605	262	187	156	100.00	43.30	30.91	25.79
13. Construction...............	1,800	757	401	642	100.00	42.05	22.28	35.67
14. Transportation, Storage, Communication............	1,330	495	-181	1,016	100.00	37.22	-13.61	76.39
15. Public Utilities...........	496	537	-194	153	100.00	108.26	-39.11	30.85
16. Services[5]................	7,880	1,603	3,152	3,125	100.00	20.34	40.00	39.66
17. Community................	107	43	80	-16	100.00	40.19	74.76	-14.95
18. Business.................	4,351	749	2,792	810	100.00	17.21	64.17	18.62
19. Government...............	3,447	792	1,896	759	100.00	22.98	55.00	22.02

Table III-5 (Continued)

Industry	1951-1961							
	Engineers, Excluding Surveyors							
	Net Changes	Labour Force	Distribution of Labour Force by Industry	Occupational Structure of Each Industry	Net Change	Labour Force	Distribution of Labour Force by Industry	Occupational Structure of Each Industry
	No.	No.	No.	No.	%	%	%	%
Total All Industries[1]......	13,030	6,477	-286	6,839	100.00	49.71	-2.19	52.48
Total Selected Industries...	12,832	5,900	339	6,593	100.00	45.98	2.64	51.38
1. Mines (incl. milling), Quarries and Oil Wells....	764	358	-115	521	100.00	46.86	-15.05	68.19
2. Manufacturing[2].............	4,388	2,825	-1,811	3,374	100.00	64.38	-41.27	76.89
3. Foods and Beverages.......	83	84	20	-21	100.00	101.20	24.10	-25.30
4. Rubber..................	-54	62	-98	-18	-100.00	114.81	-181.48	-33.33
5. Textile..................	47	68	-135	114	100.00	144.68	-287.23	242.55
6. Wood.....................	39	29	-45	55	100.00	74.36	-115.38	141.02
7. Paper....................	223	237	-93	79	100.00	106.27	-41.70	35.43
8. Iron and Steel[3]..........	1,853	1,397	-744	1,200	100.00	75.39	-40.15	64.76
9. Transportation Equipment..	908	381	-492	1,019	100.00	41.96	-54.19	112.23
10. Non-metallic Minerals.....	116	77	14	25	100.00	66.38	12.07	21.55
11. Petroleum and Coal.......	309	119	-6	196	100.00	38.51	-1.94	63.43
12. Chemical................	607	260	186	161	100.00	42.84	30.64	26.52
13. Construction...............	527	594	295	-362	100.00	112.71	55.98	-68.69
14. Transportation, Storage, Communication............	1,239	451	-161	949	100.00	36.40	-12.99	76.59
15. Public Utilities............	389	473	-171	87	100.00	121.59	-43.96	22.37
16. Services[5]................	5,525	1,199	2,302	2,024	100.00	21.70	41.67	36.63
17. Community................	99	40	96	-37	100.00	40.40	96.97	-37.37
18. Business................	3,256	565	2,110	581	100.00	17.35	64.81	17.84
19. Government...............	2,181	579	1,395	207	100.00	26.55	63.96	9.49

Table III-5 (Continued)

Industry	1931-1961							
	Engineers, Including Surveyors							
	Net Changes	Labour Force	Distribution of Labour Force by Industry	Occupational Structure of Each Industry	Net Change	Labour Force	Distribution of Labour Force by Industry	Occupational Structure of Each Industry
	No.	No.	No.	No.	%	%	%	%
Total All Industries 1/	34,783	10,237	-186	24,732	100.00	29.43	-0.53	71.10
Total Selected Industries...	32,351	9,734	7,526	15,091	100.00	30.09	23.26	46.65
1. Mining, Quarrying, Oil Wells	2,061	705	41	1,315	100.00	34.21	1.99	63.80
2. Manufacturing 2/	13,564	2,566	1,638	9,360	100.00	18.92	12.08	69.00
3. Foods and Beverages.......	330	88	104	138	100.00	26.67	31.52	41.61
4. Rubber..................	153	50	-22	125	100.00	32.68	-14.38	81.70
5. Textile.................	293	44	-16	265	100.00	15.02	-5.46	90.44
6. Wood....................	125	65	19	41	100.00	52.00	15.20	32.80
7. Paper...................	926	275	368	283	100.00	29.70	39.74	30.56
8. Iron and Steel 3/	6,166	1,370	1,800	2,996	100.00	22.22	29.19	48.59
9. Transportation Equipment..	2,227	279	7	1,941	100.00	12.53	0.31	87.16
10. Non-metallic Minerals..) 4/ 11. Petroleum and Coal.....)	1,161	140	146	875	100.00	12.06	12.58	75.36
12. Chemical.................	1,568	154	697	717	100.00	9.82	44.45	45.73
13. Construction...............	2,932	1,463	594	875	100.00	49.90	20.26	29.84
14. Transportation, Storage, Communication.............	1,754	1,151	43	560	100.00	65.62	2.45	31.93
15. Public Utilities...........	1,438	952	1,781	-1,295	100.00	66.20	123.85	-90.05
16. Services 5/	10,602	2,897	3,429	4,276	100.00	27.33	32.34	40.33
17. Community..............) 6/ 18. Business...............)	5,573	1,571	3,626	376	100.00	28.19	65.06	6.75
19. Government...............	5,016	1,292	462	3,262	100.00	25.76	9.21	65.03

were large and important changes in employment among industries. Between 1931 and 1951 agriculture declined from 29 to 16 per cent of total labour force, manufacturing rose from 19 to 26 per cent and government from 3 to between 4 and 5 per cent of total labour force. Table III-4 indicates that changes in the industrial distribution of total labour force were a particularly important source of change between 1931 and 1951 in the engineering labour force. In contrast, the decade from 1951 to 1961 exhibited in general less drastic changes in the total labour force among industries. But the rapidly increasing utilization of engineers during this last decade may reflect among other things a speed-up in the extent of a technological change and consequent requirements for engineers. Indeed, in Table III-5 a comparison of the two periods reveals that the tendency for an increasing utilization of engineers was more concentrated among industries in 1951-61 than during the earlier two decades. Iron and steel, transportation equipment, transportation, storage and communication and government which represented over 41 per cent of total engineering employment in 1951, together accounted for 36 per cent, i.e., 1,330 out of 3,680, of the increase in numbers of engineers associated with changes in the utilization of engineers (occupational composition changes) between 1931 and 1951 compared with 67 per cent or 4,021 out of 6,034, between 1951 and 1961.

These changes reflect the fact that those industries that already were heavy users of engineers in 1931 became even heavier users by 1961 in relation to other industries. The proportion of the engineering labour force they represented rose from 40 to over 42 per cent and the proportion of engineers to total labour force within these sectors increased relatively more rapidly than in the case of all industries as shown in Table III-3. These changes suggest that in studying the factors that are associated with increases in engineering employment, it would be useful to focus on particular industries where changes were quite marked and to contrast these changes with other industries where changes in engineering employment were of a lower order of magnitude.

c. Pattern of Changes in the Number of Engineers Within Selected Industries, 1931-61

Changes in occupational structure occur slowly and there is a large degree of stability over time in the ratios of engineers to total employment. In order to analyze the past trends for engineering manpower, industry-occupation matrices using engineering occupations were built up for the 1931, 1951 and 1961 Census years. It was decided to drop 1941 due to the dislocations in industries and occupations which arose from wartime conditions. These industry by occupation distributions are shown in Table III-6.

Due to changes in concepts and definitions from one Census to another, many adjustments by industry divisions were necessary in order to re-arrange 1931 and 1961 on a basis comparable with 1951. Each element in the table is a ratio of engineers plus or minus surveyors to the number in the occupation within a particular industry.

Table III-6

Engineers as a Per Cent of Labour Force by Industry, 1931, 1951, 1961

	1931 Engineers plus Surveyors Horizontal %	1951 Engineers plus Surveyors Horizontal %	1951 Engineers less Surveyors Horizontal %	1961 Engineers plus Surveyors Horizontal %	1961 Engineers less Surveyors Horizontal %
riculture.................	-	.01	.01	.01	.002
restry, Fishing, Trapping.	.21	.35	.24	.45	.28
ning, Quarrying...........	1.59	2.30	1.60	2.70	2.04
nufacturing...............	.57	.98	.96	1.21	1.19
Food and Beverage.........	.17	.25	.25	.24	.24
Tobacco...................	.16	.27	.27	.27	.27
Rubber....................	.58	1.34	1.33	1.24	1.24
Leather...................	.03	.07	.07	.09	.09
Textile...................	.16	.40	.40	.59	.58
Knit Goods................	.07	.15	.15	.07	.07
Clothing..................	.01	.03	.03	.03	.03
Wood......................	.19	.20	.12	.23	.17
Furniture.................	.07	.12	.12	.17	.17
Paper.....................	1.07	1.27	1.22	1.35	1.30
Printing..................	.07	.08	.08	.09	.09
Iron and Steel, etc.......	1.53	2.03	2.02	2.38	2.36
Transportation Equipment..	.42	.95	.94	1.53	1.52
Non-metallic Mineral...) 1/	.83	1.00	.99	1.06	1.05
Petroleum and Coal.....)		4.16	3.92	5.41	5.08
Chemical..................	1.57	2.37	2.35	2.59	2.58
Miscellaneous Manufacturing	.64	.99	.99	1.18	1.17
nstruction................	.95	1.00	.78	1.14	.70
ansportation, Storage, Communication.............	.67	.57	.52	.79	.73
ectric, Gas, Water........	6.08	4.02	3.54	4.24	3.66
ade.......................	.10	.28	.28	.21	.21
Wholesale.................	.25	.79	.78	.64	.63
Retail....................	.07	.08	.09	.02	.02
nance.....................	.06	.13	.10	.12	.11
rvice.....................	.66	.74	.55	.93	.67
Community..............) 2/	1.02	.05	.05	.05	.04
Business...............)		5.88	4.44	6.56	4.93
Government................	1.83	1.57	1.15	1.76	1.20
Recreation................	.08	.09	.08	.07	.06
Personal..................	.01	.02	.01	.01	.01
specified.................	.10	.09	.08	.18	.15
l Industries..............	.42	.65	.57	.80	.68

-metallic minerals and petroleum and coal are inseparable for 1931.
munity and business services cannot be reported for 1931.

s: Dominion Bureau of Statistics: Seventh Census of Canada, Vol. VI, Table 58;
Ninth Census of Canada, Vol. IV, Table 23;
Tenth Census of Canada, Vol. III, Part 2, Table 15.
Unpublished data obtained from the D.B.S. were used to supplement the above sources.

It is possible to examine the structure of the distribution of engineers within industry groups by comparing the percentage in one Census with another. The structure of the distributions for engineers plus or minus surveyors have been correlated for Census years 1931, 1951 and 1961. Between Census years 1931 and 1961 engineers plus surveyors are included since surveyors cannot be separated from engineers in 1931.

Between 1931 and 1961 as shown in Table III-7, the correlation between the percentage of engineers to the total labour force for 32 industry groups was r = 0.87. The correlation for 1931 and 1951 was r = 0.89 and for 1951 and 1961 it was r = 0.99. In general, the past stability of the inter-industry differences provides an initial basis for projection of these ratios into the future. Of course, many other factors must be considered when assessing future requirements, in particular whether these trends are likely to continue into the future.

d. Factors Associated with the Distribution of Engineers by Industry, 1931-61

The inter-industry differences of ratios of engineers to total employment naturally invite speculation as to the factors associated with them. It was suggested above that differences in output among industry groups are associated with changes in both total and engineering employment.

In 1931, 1951 and 1961 as Table III-8 shows, there were wide differences in the distribution of Gross Domestic Product, total employment and engineering employment among industry groups. In 1951, for

Table III-7

Correlation of Engineers as a Per Cent of Labour Force, 1931, 1951, and 1961

Periods	Relationship and Coefficients
1931-1951	Engineers plus Surveyors Utilities included: $Y = 0.30 + 0.73\ X$ $r = 0.89$ $r^2 = 0.79$ Utilities excluded: $Y = 0.10 + 1.19\ X$ $r = 0.90$ $r^2 = 0.81$ ($Y = 1931$) ($X = 1951$)
1931-1961	Engineers plus Surveyors Utilities included: $Y = 0.37 + 0.79\ X$ $r = 0.87$ $r^2 = 0.75$ Utilities excluded: $Y = 0.10 + 1.39\ X$ $r = 0.92$ $r^2 = 0.84$ ($Y = 1931$) ($X = 1961$)
1951-1961	Engineers less Surveyors $Y = -0.13 + 1.14\ X$ $r = 0.99$ $r^2 = 0.98$ Engineers plus Surveyors $Y = -0.003 + 1.14\ X$ $r = 0.99$ $r^2 = 0.98$ ($Y = 1951$) ($X = 1961$)

Source: Table III-6.

Table III-8

Distribution of Gross Domestic Product, Total Labour Force and Engineering Labour Force by Industry, 1931, 1951 and 1961

Industry	1931			1951			1961			1951/1931 Percentage Change			1961/1951 Percentage Change			1961/1931 Percentage Change		
	Gross Domestic Product	Total Labour Force	Engineering Labour Force	Gross Domestic Product	Total Labour Force	Engineering Labour Force	Gross Domestic Product	Total Labour Force	Engineering Labour Force	Gross Domestic Product	Total Labour Force	Engineering Labour Force	Gross Domestic Product	Total Labour Force	Engineering Labour Force	Gross Domestic Product	Total Labour Force	Engineering Labour Force
	Millions $	No.	No.	Millions $	No.	No.	Millions $	No.	No.									
Total - Dollars and Numbers ...	4,310	3,921,833	16,537	19,126	5,214,913	34,385	33,416	6,342,289	51,370	343.8	33.0	107.3	74.7	21.6	49.4	675.3	61.7	209.7
	Per Cent			Per Cent			Per Cent											
Agriculture............	8.0	28.7	0.1	12.5	15.9	0.3	4.6	10.1	0.1	594.5	-26.4	1,442.9	-35.1	-22.7	-67.6	351.0	-4[illegible]	[illegible]
Forestry............ 1/	1.4	2.5	1.2	2.9	3.5	1.9	1.4	2.3	1.3	813.3	85.1	214.7	-12.2	-20.8	1.7	701.7	46.7	220.1
Fishing and Trapping 1/																		
Mining, Quarrying, Oil Wells...	3.[illegible]	1.8	6.9	[illegible]	2.0	6.9	4.5	1.9	6.2	459.2	44.6	108.7	88.8	14.4	34.3	955.6	6[illegible].4	1[illegible]
Manufacturing........	22.4	16.5	25.1	[illegible]	26.1	38.8	25.7	23.1	34.5	466.7	88.0	220.5	57.0	7.6	33.0	789.4	102.7	326.3
Construction	4.5	6.4	14.3	4.8	6.7	10.2	5.3	7.3	10.3	349.3	40.4	47.8	93.3	32.8	51.4	768.3	86.5	123.7
Transportation, Storage and Communication...... 2/ Public Utilities........	13.2	7.7	20.5	11.3	8.9	13.9	12.6	8.3	12.8	280.0	53.5	40.1	94.5	13.4	38.3	639.2	74.2	93.7
Trade (Wholesale and Retail)...	14.5	9.9	2.3	12.4	13.6	5.8	14.0	15.0	3.9	281.0	83.2	422.0	95.9	33.7	-0.21	645.4	144.9	420.[illegible]
Finance, Insurance and Real Estate........	11.9	2.4	0.3	7.8	2.8	0.5	10.7	3.6	0.6	191.2	56.0	252.9	136.7	53.9	57.2	595.3	14[illegible].8	454.9
Government Service........	5.2	2.9	12.6	5.2	4.5	10.6	7.6	6.4	13.8	342.2	104.7	75.0	153.6	73.7	94.1	1,021.3	255.5	239.[illegible]
Community, Recreation and Personal Service........	15.3	15.0	15.7	10.3	14.8	10.9	13.6	19.6	15.9	198.3	31.1	44.3	130.7	60.4	118.1	588.2	110.4	214.6
Unspecified	-	4.3	1.0	-	1.3	0.2	-	2.5	0.6	-	-60.1	-65.1	-	134.1	378.3	-	-6.5	66.9

1/ Forestry and Fishing and Trapping are grouped together to compare with 1931 Census when they were inseparable.
2/ Transportation, Storage and Communication and Public Utilities are grouped together to compare with 1931 when the Gross Domestic Product figure for these two industries was inseparable.

Source: See Table III A 1 for data sources of labour force. Data on Gross Domestic Product is taken from Dominion Bureau of Statistics, National Accounts, Income and Expenditure, 1926-1956, p. 56, Ibid., p. 38.

example, agriculture accounted for over 12 per cent of Gross Domestic Product, 16 per cent of total employment but only 0.1 per cent of engineering employment. Manufacturing on the other hand represented 29, 26 and 39 per cent of Gross Domestic Product, total employment and engineering employment respectively in 1951. The question is: What factors seem to be associated with the inter-industry differences in the employment of engineers and therefore with the requirements for engineers?

The factors that together determine the demand for engineers in a particular industry as indicated above include the distribution of aggregate demand among industry sectors, the nature of production functions, and relative prices of different productive factors. The distribution of engineering employment, total employment and output in the cross-section comparison of industry groups at a point of time are markedly different. The relation over time, however, is more stable as we have seen above in examining the percentage of engineers to total employment. At the same time, the effect on the inter-industry distribution of engineers of the relative price of engineers in relation to other occupations and resources would probably be small because all industries would face a relatively similar price differential at a point in time.

This leaves one other factor as the main explanation of these inter-industry differentials in the utilization of engineers in relation to total employment, namely production functions.

If we take capital investment in machinery and equipment as a rough measure of the level of technological complexity in the various industry groups within manufacturing, the question is: Is engineering employment more closely correlated with total employment distribution or with the distribution of investment in machinery and equipment?

The demand for engineers like other types of labour, is a demand derived at least in part from product demand by industry. However, engineers are a type of high-level manpower which represent a heavy component of investment in human capital. To set up and operate physical capital embodying complex technology, it may be hypothesized, requires a corresponding investment in human capital embodied in engineers. Engineers and other types of high-level manpower are a complementary or joint input along with physical capital and other forms of technology.

A number of industries are examined in Table III-9 to see if a relationship exists at a broad aggregate level in 1951 and 1961 between the stock of investment in machinery and equipment and the degree of utilization of engineers for the twelve manufacturing industries selected. In both 1951 and 1961, the percentage distribution of engineers is correlated significantly with the distribution of both total capital stock and the stock of machinery and equipment but not significantly with total labour force. The strength of the association between engineering labour force and machinery and equipment capital stock tended to rise between 1951 and 1961. If machinery and equipment

Table III-9

Correlation[1] of the Percentage Distribution of Engineers With the Percentage Distribution of Capital Investment and Labour Force in 12 Manufacturing Industries, 1951 and 1961.

	Per Cent Distribution of Engineering Labour Force[2]	
	1951, r_r[3]	1961, r_r[3]
Total Stock of Capital, 1951............	0.73	-
Machinery and Equipment Stock, 1951.....	0.58	-
Total Labour Force, 1951................	0.30	-
Total Stock of Capital, 1961............	-	0.66
Machinery and Equipment Stock, 1961.....	-	0.68
Total Labour Force, 1961................	-	0.15
	Engineers per 10,000 Labour Force	
Investment, Machinery and Equipment per Member of Industry Labour Force, 1951.	0.36	-
Investment, Machinery and Equipment per Member of Industry Labour Force, 1961.	-	0.59

1/ Spearman's coefficient of rank correlation, r_r.
2/ Engineers not including surveyors.
3/ r_r 0.53 significant at P = 0.05 level of significance.
4/ 1961 not available.

Sources: (1) Total and engineering labour force: see Table III-A-1.

(2) Capital Stock, total, and machinery and equipment: see D.B.S., Business Finance Section, Estimates of Fixed Capital Flows and Stocks, Manufacturing, Canada, 1926-1960, Section VI, September 1 (to be published soon).

capital investment is accepted as a crude measure of the level of technology, the observable relation between the distribution of engineering employment and the relative level of technology in various industries obviously became more pronounced during the 1950's. This is also indicated by a rise in the rank correlation between investment in machinery and equipment and engineers per 10,000 labour force in the twelve industries from r = 0.36 in 1951 to r = 0.59 in 1961.

An adequate study of the association between investment in material and human capital would require a more thorough and detailed study at the micro or firm and establishment level. This is beyond the scope of the present study but offers a promising area for further investigation.

5. Conclusion

The purpose of this chapter is to examine changes in the distribution of persons in engineering and scientific occupations by industry between 1931 and 1961 and to suggest some of the factors which are associated with them.

In the absence of other changes, the number of engineers would tend to increase pari passu with growth in the economy and in the labour force. It is assumed that like other occupations, the demand for engineers and scientists is a derived demand. We do not assume that in the period with which we are concerned that supply creates its own demand to a significant degree.

The structure of the requirements for engineers is affected by their concentration in particular industries. In 1931, as we have seen, six industry groups which accounted for only 52 per cent of the total labour force accounted for 95 per cent of the engineers. In general, the very industries which accounted for the bulk of engineering employment were also the rapid growth industries over the 30-year period as indicated by the increasing proportion of the total labour force which they employed.

A third factor associated with the increasing requirements for engineers was the rising proportion of engineers to total labour force employed within industries. This factor, of course, is chiefly an indicator and does not represent a fundamental determinant of the change in demand for engineers. The importance of these three factors between 1931 and 1961 can be summed up by saying that for every additional ten engineers between 1931 and 1961, three were needed to match the growth of total labour force, three were associated with greater than average employment changes in industries employing engineers and four with increased utilization of engineers within these particular industries.

In addition, more of the growth in the number of engineers was associated with increasing utilization between 1951 and 1961 than in the 1931-51 period, which suggests that apart from general growth of industries, changes in the structure of industries associated with depression, war and post-war readjustments were the dominant influences on the requirements for engineers in the first two decades from 1931 to 1951, while an increasingly more intensive utilization of engineers occurred during the 1950's.

One of the main purposes of this chapter is to develop a framework for the projections of future requirements for engineers. The relative stability over time of the ratios of engineers to total labour force by industry suggests that these ratios can be employed in combination with the total employment or total labour force as a basis for projecting the future employment or labour force composed of engineers.

The changes in the proportion of engineers to labour force within industries over time are the net result of a number of complex factors. One of these is the level of technology as indicated by investment in physical capital. A cross-sectional comparison of the distribution of engineers by industry at points of time indicated that the distribution of engineers is more closely associated with the distribution of capital than with the distribution of total employment. This suggests, first, that the relation between physical and human capital investment is a complementary one and, second, that an explanation of changes over time in the utilization of engineers may be found in the utilization of capital equipment and in the level of technology in industries, firms and establishments.

The importance of the inter-relatedness of supply and requirements was noted above. The changes in requirements for engineers outlined here should, to achieve perspective, be examined in relation to supply and other indicators of the state of the market. In Chapter IV a more detailed examination of changes in requirements will be undertaken in a supply-demand or market framework in order to verify or reject the tentative conclusions on requirements which were reached in the more aggregative examination above.

CHAPTER IV

EVALUATION OF SUPPLY, DISTRIBUTION AND UTILIZATION OF ENGINEERING AND SCIENTIFIC MANPOWER, 1931-61

The objective of this chapter is to describe and analyze the market for engineers and scientists by examining the impact of changes in their supply, distribution and utilization. It is hoped that this will provide a better understanding of the structure and operation of the market or markets for these occupations.

Data on supply, distribution and earnings as well as other indicators of supply and requirements are examined in a supply-demand framework. The chapter will consist of five sections: first, the analytical framework is outlined; second, the impact of supply and requirements upon the proportion of engineers in the labour force between 1931 and 1961 is assessed; third, a more detailed analysis is made of the recent past, in particular the question of the alleged shortage of engineers and scientists in the mid-1950's; the fourth section will consist of an examination of the international dimensions of the market for engineers and scientists, and the final section is the conclusion.

1. A Simplified Model of a Purely Competitive Market

Since the examination of engineering and scientific manpower is being conducted within the framework of a supply and demand framework, it will be useful to outline briefly some of the characteristics of this framework. The concepts of supply and demand were discussed above in Chapters II and III. In the case of both of these concepts it was necessary to use less than perfect but measurable quantities as approximate indicators of each. The approach will be to analyze the behaviour of the determinants of the price and output of engineers as well as of scientists where data permit, by assuming purely competitive conditions in the factor market for engineers and by relaxing this assumption where necessary. This initial approach has the advantage of being simple and of providing a bench mark for judging the actual behaviour of the markets studied.[1/]

In a free market the factors which determine supply and demand functions will tend to equate quantity demanded and quantity supplied. For example, if the number of scientists that employers try to hire is greater than the number available then salaries of scientists will tend to rise. The rise in salaries will tend to reduce the number demanded and to increase the number of scientists who seek work thus bringing quantity supplied and quantity demanded to equilibrium.

1/ David M. Blank and George J. Stigler, op. cit., pp. 19-22; J.C. Davis, "Review of the Demand and Supply of Scientific Personnel by Blank and Stigler", Review of Economics and Statistics, Vol. 40, No. 2, 1958, p. 190. Blank and Stigler discussed the applicability of the demand and supply framework to the market for engineers. Davis gives a list of the typical characteristics of a "good" market. See also George J. Stigler, op. cit., pp. 187-202. See also M.W. Reder, "Wage Differentials: Theory and Measurement", in Aspects of Labour Economics, a conference of the Universities - National Bureau Committee for Economic Research, New York, Princeton University Press, 1962, p. 276 and pp. 299-300 for a good discussion of the "competitive hypothesis".

Before proceeding to utilize the above analytical apparatus two methodological problems must be considered. The first relates to the interaction of supply and demand. The historical data on engineers in the Census, for example represent an intersection point on the supply and demand schedules. The problem is to separate the determinants of these two schedules. The approach utilized here follows the one suggested by Blank and Stigler in which, although supply and demand curves cannot be estimated separately, the factors which may determine the supply and demand of engineers are examined in a systematic way which permits some judgment about these factors.[2]

The second problem is the extent to which the market for engineers and scientists is a "good" market. Is it free enough from imperfections, frictions and lags to assume that it is technically good in the economic sense? The evidence based on experience in the United States suggests that the market for engineers has operated tolerably well.[3] In Canada the evidence points in the same direction.

2/ Blank and Stigler, op. cit., pp. 19-22.

3/ Blank and Stigler, op. cit., p. 29; W. Lee Hansen, "The 'Shortage' of Engineers", Review of Economic Studies, Vol. 43, No. 3, August, 1961, pp. 251-256; M.W. Reder, op. cit., p. 306 notes that the competitive hypothesis can be applied even where there is monopoly power in markets as long as there are no changes in the degree of monopoly power. However, K. Arrow and W.M. Capron, "Dynamic Shortages and Price Rises: The Engineer-Scientist Case", Quarterly Journal of Economics, May, 1959, pp. 292-308, used a dynamic model with frictional lags to describe the market for engineers and scientists.

A case study of the 1955 graduating class in engineering and science indicated that in 1965 about 42 per cent of the engineers and over 50 per cent of the scientists were employed in a different province than the one in which they received their secondary education.4/ The geographic mobility rate is somewhat higher than that for the population as a whole or even for the younger age groups in the population.5/ Rosenbluth also found that regional immobility was not significant.6/

4/ Department of Manpower and Immigration, Research Branch, "Geographic Mobility of 1955 University Graduates in Science and Engineering Courses", to be published soon. Compare also Department of Labour, Economics and Research Branch, Engineering and Scientific Manpower Resources in Canada: Their Earnings, Employment and Education, 1959, Professional Manpower Report No. 9, March, 1961, p. 39.

5/ If 1950 is taken as the average year in which secondary education was received, the annual mobility during this period for engineers, for example, was about 2.1 per cent. The 1961 Census shows that for all males, the movers from one province to another from 1956-61 averaged about 0.8 per cent per year. For the age group 25-29, the annual average during this period as shown in the 1961 Census was about 1.2 per cent per year. See Dominion Bureau of Statistics, 1961 Census of Canada, Bulletin No. SX-4, September 4, 1964, Table 1.

6/ G. Rosenbluth, "Salaries of Engineers and Scientists, 1951", in Canadian Political Science Association Conference on Statistics, 1960, edited by E.F. Beach and J.C. Weldon, Toronto, University of Toronto Press, 1962, pp. 179-180.

Another aspect of the market is occupational mobility. The special study outlined in Appendix I-B which was based on the 1961 Census, indicated that 34 per cent of engineering graduates in the sample were reported in occupations other than engineering.

There is little direct evidence of the extent of mobility among employers. Rosenbluth found some evidence that for engineers and scientists, industrial mobility was less than regional mobility.[7] The magnitude of the changes in the proportionate distribution of engineers by industry sector between 1931 and 1961 which was noted in Table III-4 suggests that such large changes probably could not have been accomplished without a considerable degree of shifting among employers. This conclusion is supported by an examination of hiring and turnover data on engineers and scientists. During 1959, hirings of "experienced Canadian professional persons" constituted 5.2 per cent of total employment of these personnel. Employment turnover for reasons other than deaths or retirements among engineers and scientists during 1961 was 8.2 and 6.1 per cent respectively of total employment of engineers and scientists. Mobility among employers for experienced

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7/ Ibid., p. 180.

engineers and scientists appears to have been at least 5 per cent per year in the recent past.[8/] This combined with the approximately similar percentage of new graduates hired per year suggests that mobility at the margin is sufficient to allow the use of the supply-demand framework as outlined. In particular, it suggests that salaries and earnings of engineers can be used along with other data as an index of the state of the market over time.

2. Supply of and Demand for Engineers, 1931-61

The aim of this section is to ascertain whether a shift in the demand or the supply curve was the chief factor responsible for changes in the proportion of engineers to total labour force. The period 1931 to 1961 will be examined first and later in section three a more intensive analysis will be conducted of the operation of the market during the 1950's for which much more data are available. The analysis of the latter period will also provide an opportunity to test the results derived from the more general and cruder long-term analysis.

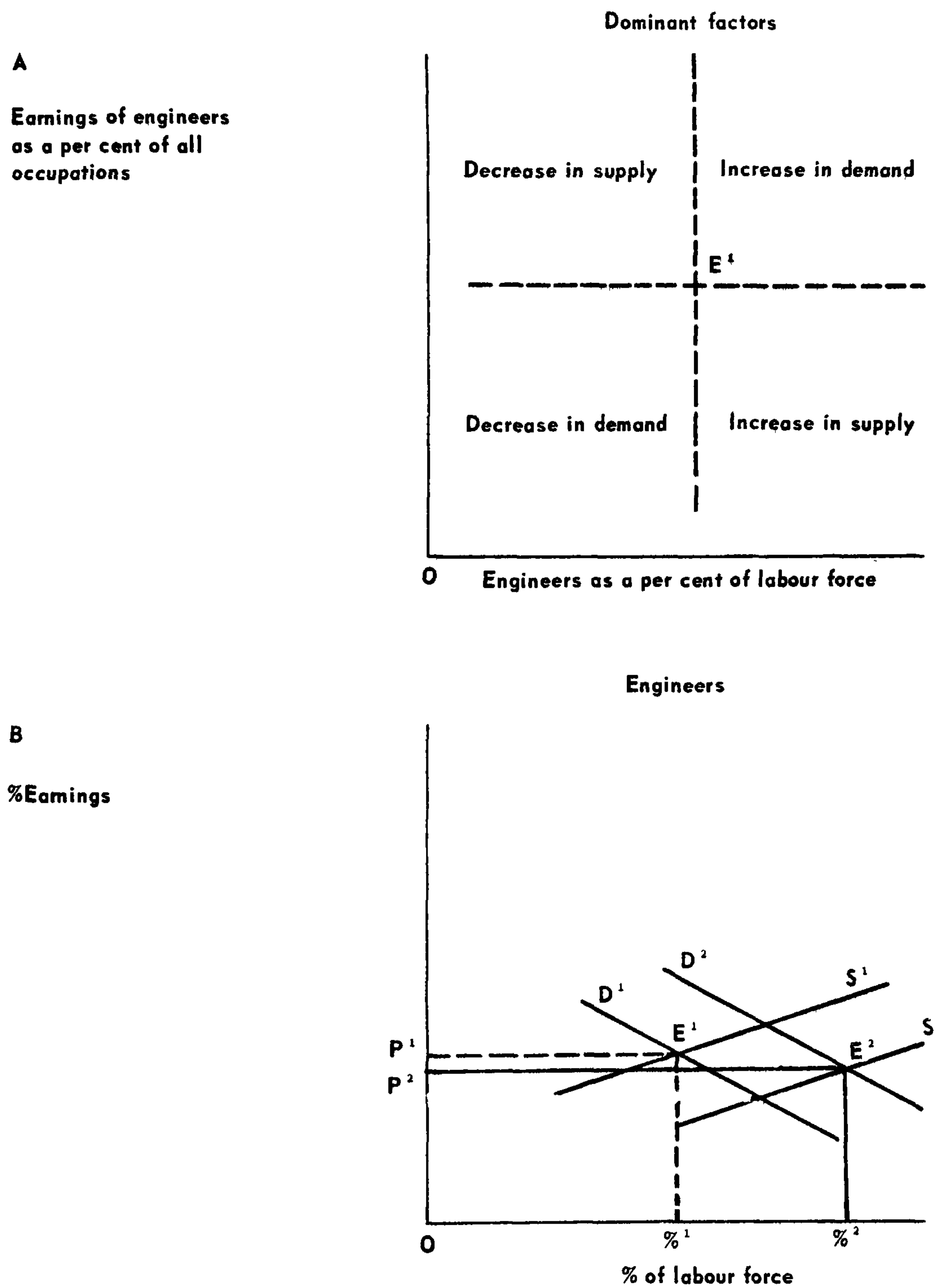
8/ Department of Labour, Economics and Research Branch, Employment Outlook for Professional Personnel in Scientific and Technical Fields, 1960-62, Professional Manpower Report No. 8, December, 1960, pp. 3 and 23; Employment Outlook for Professional Personnel in Scientific and Technical Fields, 1962-64, Professional Manpower Report No. 13, December, 1962, pp. 23 and 24.

The analytical apparatus will be a demand and supply framework. In this case the percentage of engineers to total labour force will be compared with relative earnings of engineers to all occupations.[9] This method can be illustrated as follows. In Chart IV-1 the position E^1 indicates a point where demand and supply are in equilibrium. When a new equilibrium occurs a rough determination of whether changes in demand or supply predominated can be determined. For example, in Figure IV-1, Part B, a drop in relative earnings of engineers combined with an increase in the percentage of engineers to total labour force would be shown as a move from E^1 to E^2, i.e., into the "increase in supply" quadrant. This would indicate that an increase in the supply of engineers was the predominant influence as Meltz has demonstrated, but not necessarily the only one. In the above example in Part B in Figure IV-1, an increase in demand occurred which was outweighed by the increase in supply.

The long-term trend in relative earnings in engineering and other occupations as indicated in the 1931, 1951 and 1961 Censuses is shown in Tables IV-1 and 2. The changes in selected engineering

9/ For an illustration of the use of this technique in relation to major occupation groups see N.M. Meltz, Changes in the Occupational Composition of the Canadian Labour Force, 1931-61, Occasional Paper No. 2, Economics and Research Branch, Department of Labour, 1965, pp. 35-39.

FIGURE IV-1
AN OUTLINE OF THE SUPPLY - DEMAND ANALYSIS



Source: N.M. Meltz, op.cit., pp 37 and 38

Table IV-1

Average[1] Earnings of Labour Force[2] by Selected Occupations, 1931-1961

Occupations	1931	1951	1961	1931	1951	1961	1931	1951	1961	1951/ 1931	1961/ 1951	1961/ 1931
	$	$	$	All Occupations = 100.0			Professional Occupations = 100.0			%	%	%
All Occupations	847	1,860	3,170	100.0	100.0	100.0	-	-	-	119.6	70.4	274.3
Professional, Total	1,426	2,329	4,443	168.4	125.2	140.2	100.0	100.0	100.0	63.3	90.8	211.6
Architects	2,590	3,664	6,632	305.8	197.0	209.2	181.6	157.3	149.3	41.5	81.0	156.1
Engineers Total (including surveyors)	2,469	3,636	6,623	291.5	195.5	208.9	173.1	156.1	149.1	47.3	82.2	168.2
Civil (excl. surveyors)	-	3,752	7,038	-	201.7	222.0	-	161.1	158.4	-	87.6	-
Electrical	2,443	3,816	7,316	288.4	205.2	230.8	171.3	163.8	164.7	56.2	91.7	199.5
Mechanical and Industrial	2,315	3,774	7,001	273.3	202.9	220.9	162.3	162.0	157.6	58.7	85.5	202.4
Veterinarians	2,218	3,669	6,315	261.9	197.3	199.2	155.5	157.5	142.1	65.4	72.1	184.7
Other Professionals	-	-	-	-	-	-	-	-	-	-	-	-
Dentists	1,915	4,095	6,064	226.1	220.2	191.3	134.3	175.8	136.5	113.8	[illegible]	216.7
Lawyers and Notaries	3,214	3,916	7,221	379.5	210.5	227.8	225.4	168.1	162.5	21.8	84.4	124.7
Physicians and Surgeons	3,095	4,007	6,575	365.4	215.4	207.4	217.0	172.0	148.0	29.5	64.1	112.4
Professors and College Principals	2,477	3,457	6,825	292.4	185.9	215.3	173.7	148.4	153.6	39.6	97.4	175.5
Teachers	1,066	1,887	4,040	125.9	101.5	127.4	74.8	81.0	90.9	77.0	114.1	279.0

1/ Median earnings 1951.

2/ 1931 - 10 years of age and over
   1951 - 14 years of age and over
   1961 - 15 years of age and over.

Sources: D.B.S., Census of Canada, 1931, Vol. 5, Table 28.
D.B.S., Census of Canada, 1951, Vol. 5, Table 21.
D.B.S., Census of Canada, 1961, Bulletin 3.3-7, Table 21.

Table IV-2

Relative Earnings, Proportion of the Labour Force and Impact of Supply and Demand Changes, Engineering Occupations, 1931-1961

	Average Annual Earnings[1]						Proportion of Labour Force			Impact of Supply and Demand During Period		
	1931	1951	1961	1931	1951	1961	1931	1951	1961	1931/1951	1951/1961	1931/1961
	$	$	$	%	%	%	%	%	%			
l Occupations..........	847	1,860	3,170	100	100	100	100.00	100.00	100.00	-	-	-
otal Engineering........	2,469	3,636	6,623	291	195	209	0.42	0.66	0.81	Increase in Supply	Increase in Demand	Increase in Supply
Civil Engineering (minus surveyors)...	-	3,752	7,038	-	202	222	-	0.15	0.19	-	Increase in Demand	-
Electrical Engineering	2,443	3,816	7,316	288	205	231	0.10	0.12	0.14	Increase in Supply	Increase in Demand	Increase in Supply
Mechanical Engineering	2,315	3,774	7,001	273	203	221	0.07	0.16	0.19	Increase in Supply	Increase in Demand	Increase in Supply

1/ Median earnings in 1951.

Sources: Table 11-2, Chapter 11; 1931 Census, Vol. V, Table 28; 1951 Census, Vol. V, Table 21; 1961 Census, Bulletin 3.3-7, Table 21. Unpublished data supplied by Census Division, D.B.S.

occupations as a proportion of the labour force in relation to relative earnings is given in Table IV-2.[10] These trends are based on Census data.[11] Between 1931 and 1951[12] relative earnings of engineers as a group as well as electrical, mechanical and industrial engineers declined but the proportion of the labour force in these occupations increased. In terms of Chart IV-1, this represents a shift into the "increased supply" quadrant and suggests that increased supply of persons to these occupations relative to others was the

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10/ It was noted above that the Census dates correspond to different phases of the business cycle. A period of high unemployment could lower the annual earnings by lowering the number of weeks worked. The possible effect of this was examined by Meltz, op. cit., pp. 44-47, and no effect on the results of the supply-demand analysis between 1931 and 1951 was observed for professional occupations as a group. In particular, the difference in mean weeks worked for all occupations was a little over one week, not enough to alter substantially the trend of engineers' earnings if we assume as seems likely that the number of weeks worked for engineers is not less stable over the cycle than for other occupations as a group.

11/ Only average earnings are available for 1931 and 1961, and only median earnings for 1951. Therefore, average earnings for 1931 and 1961 were compared with median earnings for 1951. This should not affect the trends greatly because relative and not absolute earnings are being compared. As a check, the ratio of median and average earnings of electrical engineers in relation to non-primary labourers were compared for 1941 when both were available. The index was 395 when based on average earnings and 389 when based on median earnings. Therefore, it was concluded that median earnings for 1951 could be used without affecting the trend data substantially.

12/ The year 1941 was not included in this table because of the possible distortion to trends which would result from wartime conditions.

major influence in the decline in relative earnings during these decades. From 1951 to 1961 in contrast, relative earnings in engineering occupations as a group and in civil, electrical, and mechanical and industrial engineering occupations rose along with the proportion of these occupations to total labour force. This represents a shift into the "increased demand" quadrant and indicates that demand factors were dominant during the latter decade. Over the whole period from 1931-61 increases in supply were the dominant factor in changes in relative earnings and in the proportion of engineers to all occupations.

The structure of relative earnings in occupation groups and classes over time may, however, be affected by three factors: occupational mix, educational distribution and age distribution. Shifts in occupational structure toward a greater proportion of high level occupations, for example, the professional occupations or within an occupational class toward higher levels of education or experience will tend to raise relative earnings.

Although a shift among occupations has occurred between 1931 and 1951 towards a greater proportion in higher paid occupations such as professional occupations, this factor has been allowed for by examining separately the changes in earnings by individual occupation groups and classes.

Moreover, it cannot automatically be assumed that a higher level of median or average educational supply in an occupation will raise earnings proportionately. Demand factors also play a determining role. But even if higher education levels are reflected in higher levels of earnings, this analysis will not be substantially changed. An examination of Table II-5 revealed that from 1931 to 1951 relative education rose more rapidly in engineering occupations than in the case of either professional or all occupations. Thus, the decline in relative engineering earnings occurred despite the rise in relative education levels. From 1951 to 1961 the opposite trend prevailed with relative earnings in engineering occupations rising relatively faster than all occupations.

Median age on the other hand has declined in engineering occupations relative to total professional occupations between 1931 and 1951 but has remained relatively constant over the last decade between 1951 and 1961. Between 1931 and 1951 median age for professional occupations rose from 32 to 34 years and declined from 36 to 33 years and from 40 to 34 years for electrical and mechanical engineers respectively. The gap between median age of engineers and total professionals declined from about 6 years to zero over this period of time. If we further assume that this would represent about 12 to 15 per cent decline in relative earnings of engineers,[13/] the index of

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13/ Calculated from Department of Labour, Economics and Research Branch, Employment and Earnings in the Scientific and Technical Professions, 1959-62, Professional Manpower Report No. 14, 1963, Table 5, p. 16.

relative earnings of engineers in 1951 as shown in Table IV-1 should be raised by a maximum of 15 per cent. For mechanical engineers for example, (a similar result would hold for electrical engineers) this would represent an index of 233 for 1951. The 1931-51 analysis would still hold but the 1951-61 analysis would be modified. Instead of a widening of the wage differential between mechanical engineers and all occupations from 203 to 221 it would narrow from 233 to 221. For all engineers the gap instead of widening from 195 to 209 would narrow from 224 to 209 between 1951 and 1961. However, it may be noted that the rate of decrease was much slower between 1951 and 1961 than between 1931 and 1951. Thus, the comparative analysis of the direction of overall change in the market between 1931 and 1961 is not substantially altered. For example, one could say that a relative strengthening of demand forces occurred between 1951 and 1961 which prevented relative earnings of engineers from declining as fast as they did between 1931 and 1951. The index of relative engineers declined at an average annual rate of 4.5 points between 1931 and 1951 compared with a decline of 1.5 points per annum using our adjusted index of 224 rather than 195 for 1951.

How do the conclusions from the demand-supply analysis articulate with the analysis of supply and demand conducted separately in Chapters II and III above? The increase in the supply of engineers from the main source, annual university graduations, rose gradually between 1931-51 from 420 to 2,425 and from 8 per cent to over 15 per cent of total bachelor degrees in 1951.[14/] During this time, from 1931-51, the Great Depression occurred when demand for engineers was undoubtedly at a low ebb. Despite the rising demand for engineers which accompanied both the tooling-up for war and the post-war boom, it would appear that the increase in supply from 1931-51 was sufficient to dominate the increase in demand.

A second question is: How do the results outlined above compare with other studies of the long-term behaviour of the occupational wage structure? A large number of studies have indicated that occupational relative wage differentials have tended to diminish over time.[15/]

The compression of the occupational wage structure in turn, is linked with the increase in the proportion of the labour force who are able to hold higher level jobs.[16/] It was indicated in Chapter II,

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14/ See Table II-11, Chapter II.

15/ See M.W. Reder, op. cit., p. 260, for a list of such studies. The narrowing of occupational wage differentials in Canada between 1931-51 is discussed in H.D. Woods and S. Ostry, Labour Policy and Labour Economics in Canada, Toronto, Macmillan, 1962, pp. 422-425.

16/ The positive impact of the rise of the educational level of persons in the labour force on the supply curve of professional occupations is discussed in N.M. Meltz, op. cit., pp. 53-61. Between 1931 and 1951, he found that the increase in the supply of workers in the professional occupation group, and the drop in their relative earnings, was linked to a large output of educated persons from the educational system who entered these occupations.

Table II-5, that between 1941 and 1961 the proportion of persons in professional occupations with 13 or more years of schooling, increased from 48 to 60 per cent. For electrical engineers, the proportion increased from 58 to 90 per cent and for mechanical engineers, from 49 to 80 per cent during the same time period. It would appear that engineering along with other high-level occupations was influenced by the number of persons with higher levels of education. The relative increase in the proportion of electrical and mechanical engineers with 13 or more years of schooling was greatest between 1941 and 1951. For electrical engineers, the percentage rose from 58 to 93 per cent and for mechanical and industrial engineers, it rose from 49 to 87 per cent. The proportion of electrical and mechanical and industrial engineers with 13 or more years of schooling actually declined to 90 and 80 per cent respectively between 1951 and 1961. The impact of higher levels of education upon the supply of engineers was therefore greater before 1951 than previously.

A further question is the nature of the process through which a matching of supply and demand took place, in particular between 1951 and 1961 when increases in demand were dominant. Table IV-3 indicates that the number of engineers and their earnings rose (or declined less rapidly) in relation to all occupations between 1951 and 1961. But as indicated above in Table II-5, Chapter II, the proportion of engineers with 13 or more years of schooling fell between 1951 and 1961 while graduates also declined in relation to total graduates. One possible

Table IV-3

Graduations and Relative Annual Earnings, Total, Electrical and Mechanical Engineers, Total and Professional Occupations, 1931-1961

Occupation and Specialization	1931	1951	1961	1931	1951	1961
	No.	No.	No.	$	$	$
All Occupations	3,917,000	5,215,000	6,342,000	847	1,800	3,170
Professional, Total	238,400	387,800	634,300	1,426	2,329	4,443
Engineers, Total	16,600	34,400	51,400	2,469	3,636	6,623
Electrical Engineers	3,900	6,300	8,800	2,443	3,816	7,316
Mechanical Engineers	2,900	8,300	12,100	2,315	3,774	7,001
Graduates, Total	5,290	15,754	20,240	-	-	-
Engineering, Total	420	2,425	2,412	-	-	-
Electrical Engineers	N.A.	478	574	-	-	-
Mechanical Engineers	N.A.	545	448	-	-	-
Ratios, All Occupations	All Occupations = 100 per cent					
Engineers, Total / All Occupations	0.40	0.70	0.80	292	196	209
Electrical Engineers / All Occupations	0.10	0.12	0.14	288	205	231
Mechanical Engineers / All Occupations	0.07	0.16	0.19	273	203	221
Engineering Graduates / All Occupations	.010	.046	.039	-	-	-
Electrical Engineering Graduates / All Occupations	N.A.	.009	.009	-	-	-
Mechanical Engineering Graduates / All Occupations	N.A.	.010	.007	-	-	-
Ratios, All Graduates or Professionals	All Graduates = 100 per cent			All Professionals = 100 per cent		
Engineering Graduates / All Graduates or Professionals	7.9	15.4	11.9	162.3	162.0	157.6
Electrical Engineering Graduates / All Graduates or Professionals	N.A.	3.034	2.835	171.[illegible]	163.[illegible]	164.7
Mechanical Engineering Graduates / All Graduates or Professionals	N.A.	3.459	2.213	162.3	162.0	157.6

N.A. = Not available.

Source: Chapter 11, Table 11-2, 5 and 11; Table IV-1.

interpretation is that a noticeable change in demand or utilization of engineers occurred between 1951 and 1961. The increase in demand which was reflected in a higher proportion of engineers to total labour force and also in their increased relative earnings was paralleled by a drop-off in graduations. The proportion of engineers with 13 or more years of schooling also declined. The increase in demand between 1951 and 1961 was therefore met through a combination of offers of higher salaries to engineers plus the hiring of some persons, native-born or immigrants, who had less than average qualifications. These adjustments illustrate the operation of a market for engineers faced by rising demand and the constraint of a relative decline in the availability of a supply of persons qualified to enter engineering occupations.

This completes the general analysis of the period 1931-61. In the next section of the chapter, a more detailed examination will be undertaken of the operation of the market for engineers and scientists during the 1950's.

3. An Evaluation of the Market for Engineers and Scientists During the 1950's

The purpose of this section is to examine the working of the mechanism of the market for engineers and scientists during the 1950's in order to evaluate the appropriateness of economic theory to explain these phenomena. The analysis will focus in particular on the "shortage" of engineers and scientists which occurred in the mid-1950's.

The importance of an examination of the short-run is two-fold. First, it helps to keep the long-run in historical perspective, that is, to differentiate between short-term and long-term phenomena and problems. Second, the short-run adjustment processes in the market for engineers and scientists are interesting in themselves because they provide a basis for assessing the role of the price mechanism as an allocator of resources.

First empirical evidence of shortages will be outlined. An examination of market adjustment processes will be followed by an evaluation of the efficiency of these processes in matching supply and requirements.

The association of short-term changes in economic activity and changes in the requirements for engineers has been observed in several studies.[17/] Canadian experience since 1946 is summarized in Figure IV-2. The indicators of demand for engineers comprise a non-price and a price indicator. The non-price indicator is based on ratios of unfilled vacancies to unplaced applicants for engineering jobs. These are annual averages based on monthly reports of the Department of Manpower and Immigration. The price indicator chosen is annual starting

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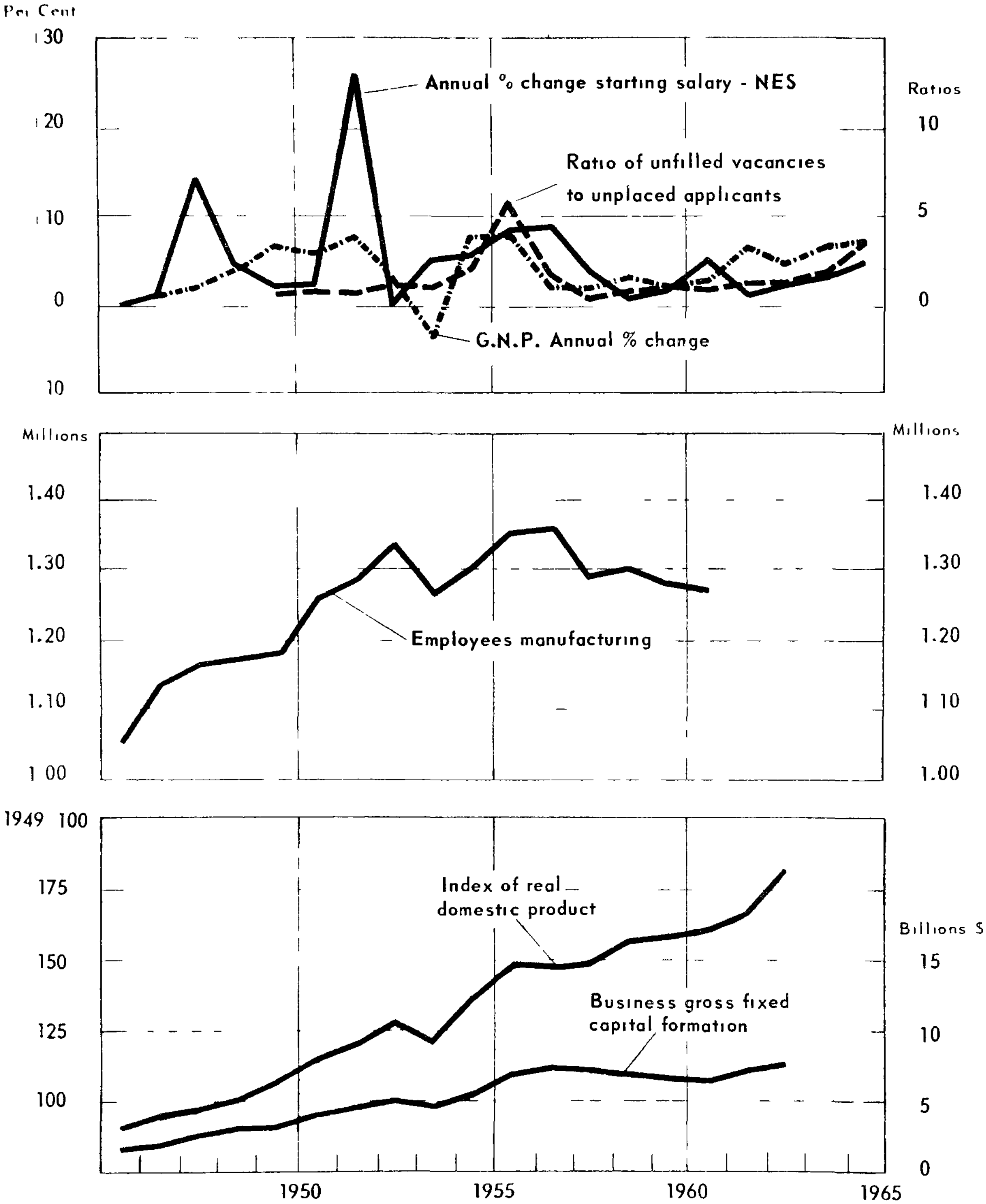
17/ For example, see W.H. Chartener, *op. cit.*, p. 52; Department of Labour, Economics and Research Branch, *Skilled and Professional Manpower in Canada, 1945-65*, Ottawa, Queen's Printer, 1957, p. 102.

FIGURE IV-2
INDICATORS OF DEMAND FOR ENGINEERS AND OF BUSINESS ACTIVITY
1946-1965



Source Table IV A 1

salaries offered by employers to newly graduating engineers. The reports on vacancies and applicants do not indicate the quantitative dimensions of vacancies to applicants because only a fraction were reported to the Department of Manpower and Immigration. However, they are useful primarily as an indication of the extent and direction of changes in the market situation when used in combination with other indicators. With a more complete reporting of both vacancies and applicants, the index could become an important indicator of the supply and requirements for engineers as well as for other occupations.

The starting salaries of engineers were chosen as the price indicator because they are more immediately responsive to changes in short-term market conditions than salaries of more experienced engineers.[18/]

The indicators of demand for engineers chosen reveal somewhat different patterns of timing and amplitude. In Chart IV-3 the actual monthly vacancies to applicant ratios are compared with business cycle peaks and troughs. In general, the changes in the vacancies to applicants ratio tend to lead the business cycle turning points by an average of about two months although there is a considerable variation around this average from a lead of twelve months in 1957 to a lag of

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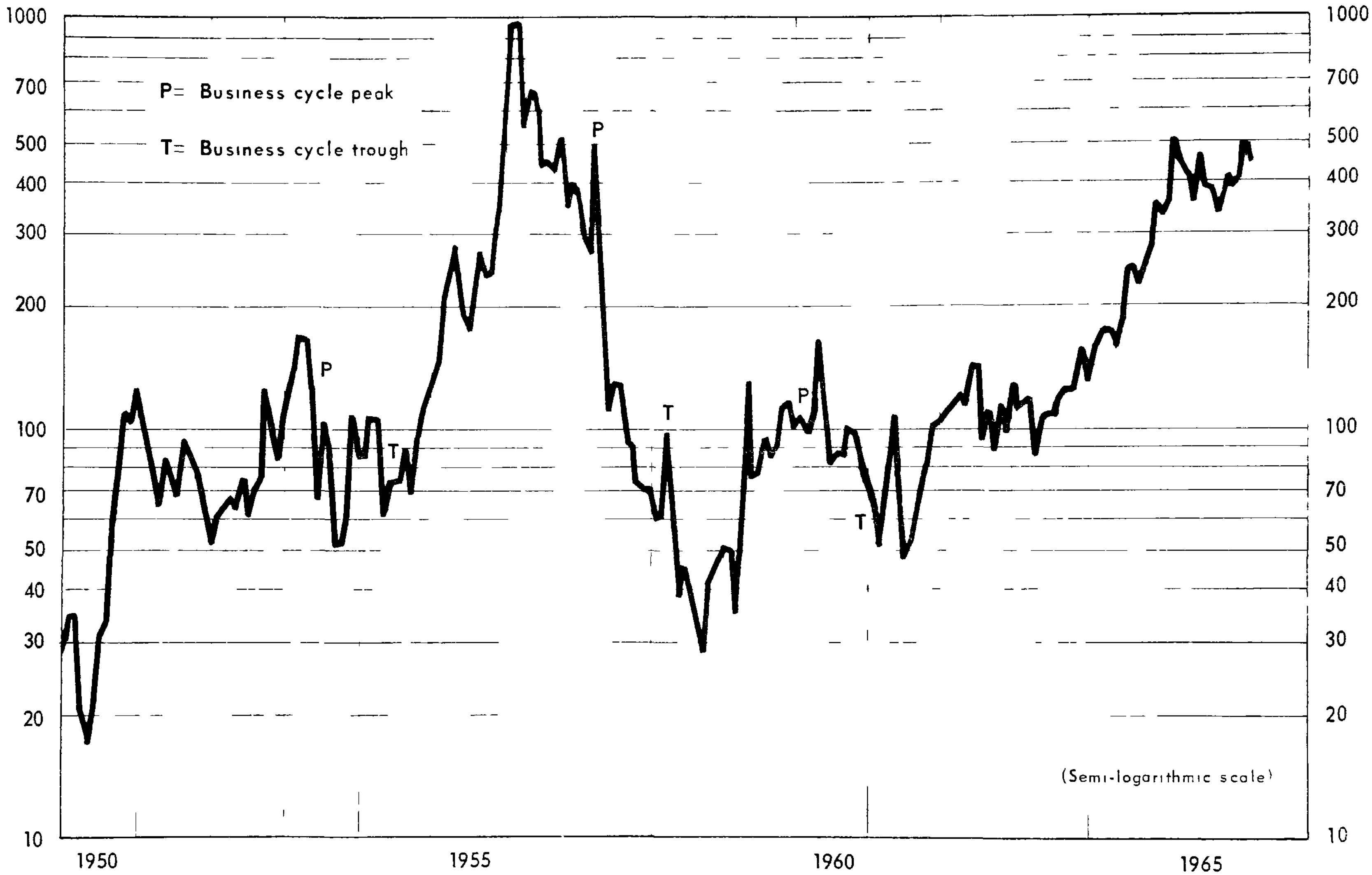
18/ For a discussion of some of the factors behind the responsiveness of starting salaries, see M.W. Reder, op. cit., pp. 271-276.

FIGURE IV-3
PERCENTAGE OF JOB VACANCIES TO UNPLACED APPLICANTS, ENGINEERS BY MONTH, JANUARY 1950 - MARCH 1966



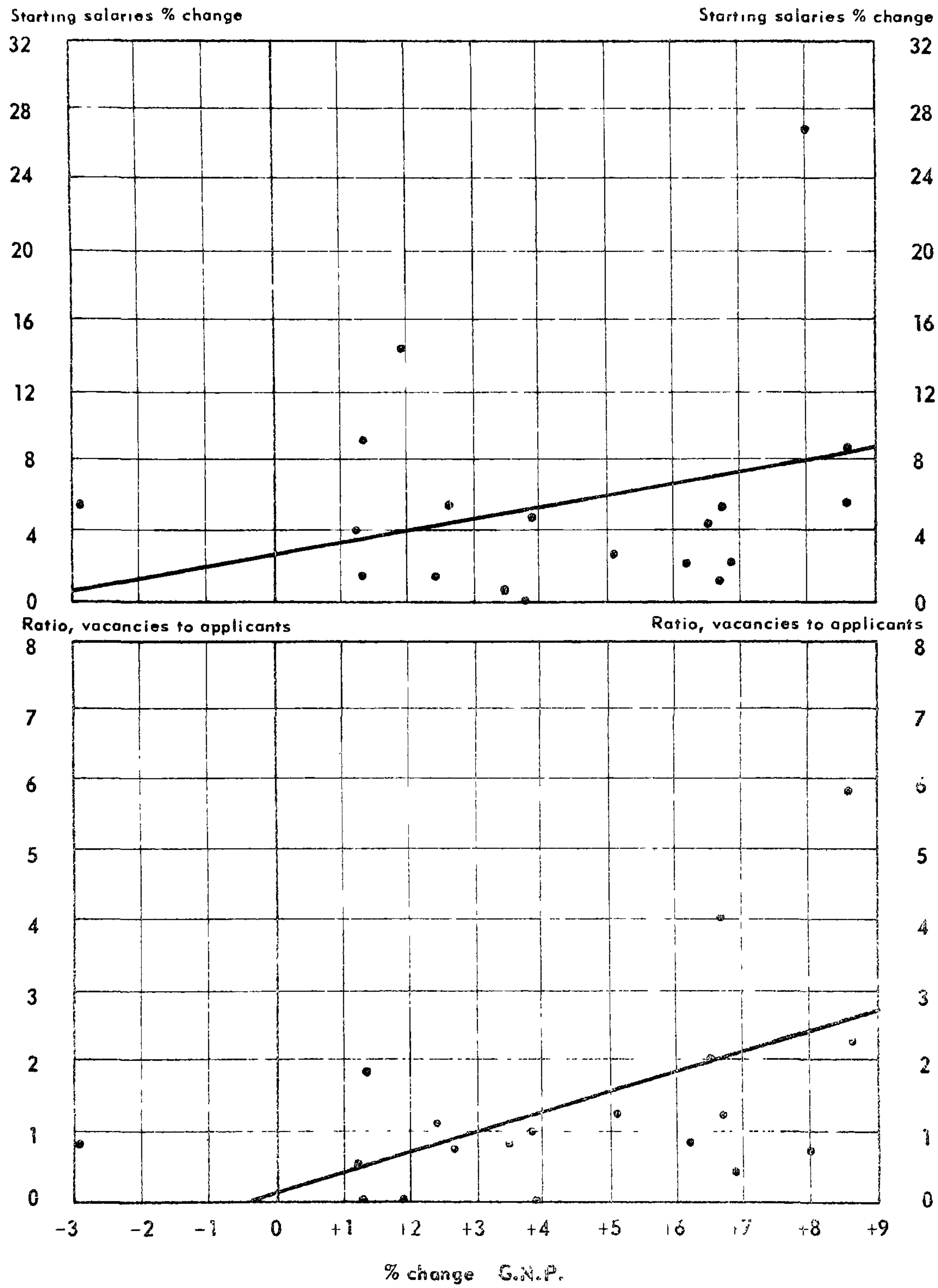
seven months in 1958. This pattern of activity may be associated with the tendency of firms to hire engineers in order to plan subsequent investment and other production projects.[19] A comparison of annual starting salaries of engineers with the ratio of average annual vacancies to applicants, in Table IV-A-2 below indicates that the timing of the salary changes tends to lag the business cycle turning points.

The amplitude of the changes in demand indicators for engineers is also illustrated in Figure IV-3. In general, the volatility of the changes in vacancies to applicants and in starting salaries can be explained in terms of the rapidity of short-run changes in demand combined with relative inelastic supply. An additional reason for large variations in amplitude in the case of the vacancy to applicant series is the tendency of employers to give notification of vacancies in a time of shortage while job seekers are less prone to do so. An illustration of the relation between changes in economic activity and changes in both vacancies to applicants and starting salaries for engineers is given in Figure IV-4, which relates annual

19/ Chartener, op. cit., criticises Blank and Stigler for the conclusion that short-run changes in demand for engineers are not closely associated with changes in business activity which they based on relating employment of engineers to changes in sales rather than to orders received. The analysis here also contradicts the findings of Blank and Stigler on this point.

FIGURE IV-4

RELATION BETWEEN ANNUAL PERCENT CHANGE IN GROSS NATIONAL PRODUCT, STARTING SALARIES AND JOB VACANCY TO APPLICANT RATIO, ENGINEERS, 1946-1965



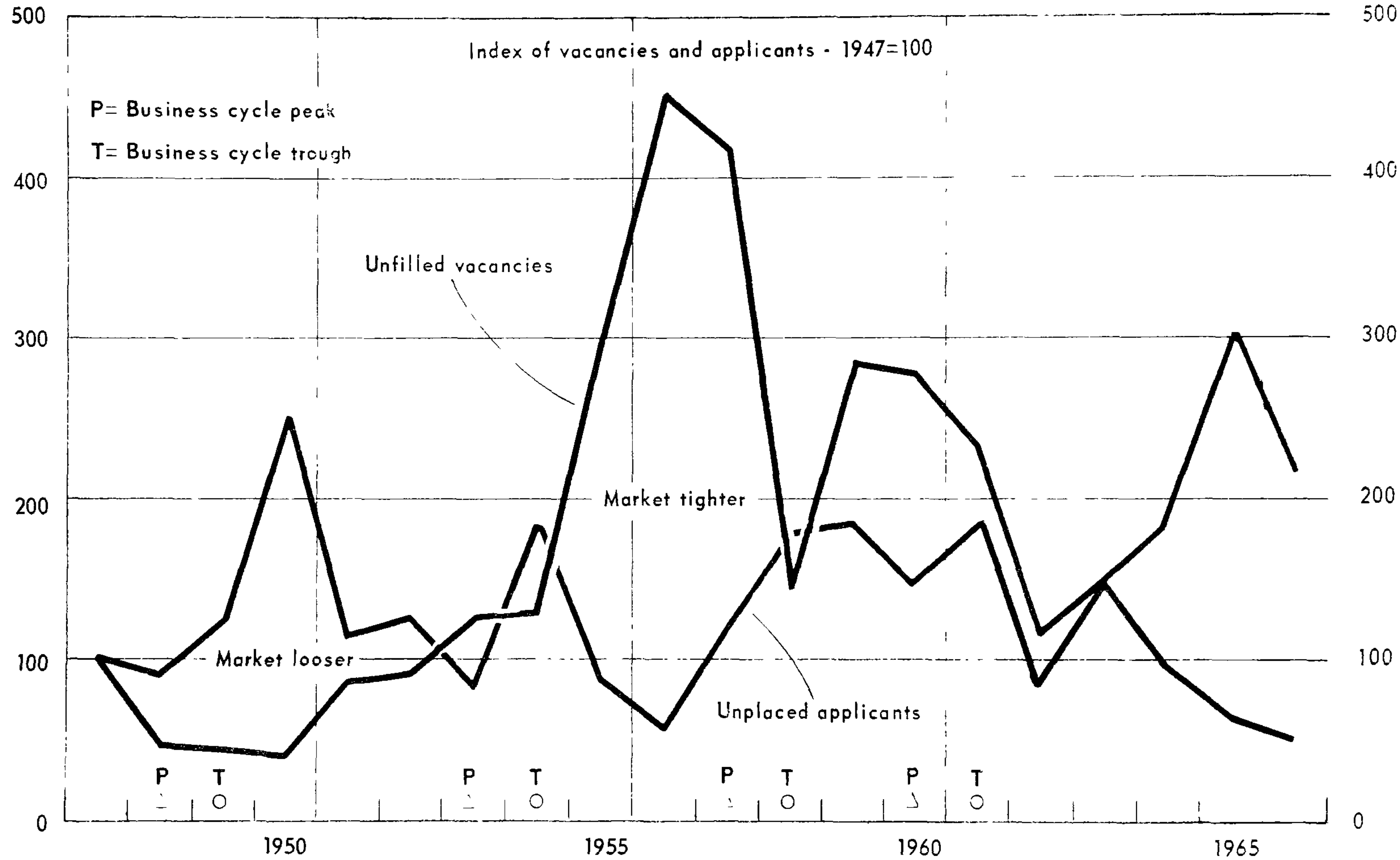
Source: Table IV - A - 1

percentage changes in Gross National Product and annual percentage changes in starting salaries of engineers. The shape of the curves dramatizes the effect of rapid increases in demand combined with inelastic short-run supply upon the supply price of newly graduating engineers. The indicators on the demand side of the market for engineers suggest that the responses are in the general direction of our expectations based on economic theory.

A further indication of the state of the market during the post-war period is given in Figure IV-5. The separate indexes of vacancies and applicants for engineering jobs provide an indication of the direction of change in the market for engineers. The large engineering graduating classes of the early post-war period plus a slump in business activity in 1949 set the stage for a lower level of demand relative to supply of engineers at this time but the opposite occurred in 1954-57 and again in the more recent period since 1961. The loosening or tightening of the market for engineers as economic activity moved from business cycle peaks to troughs or vice versa, is clearly evident.

The non-price indicators of the nature and extent of surpluses or shortages of engineers provide a bench mark against which the behaviour of salaries and other variables during this period of time can be evaluated.

FIGURE IV-5
A COMPARISON OF UNFILLED VACANCIES AND UNPLACED APPLICANTS, ENGINEERS, 1947-1966 (1) (WEEK ENDING NEAREST JUNE 1)



(1) Source: Basic data taken from: D.B.S. ' Labour Demand and Supply, various issues, 1947 to 1966

The question of short-term demand response raises the question if and how the supply of engineers responds to economic conditions. Since it is generally held that the largest component of supply, engineering graduates, tends to be relatively inelastic in the short-run, a longer period is more suitable for an inquiry into supply response. The fluctuations apparent in the annual post-war enrolments of engineering students at Canadian universities have led observers to suspect that a systematic relationship may exist between engineering enrolments and the business cycle. It has been suggested that the portion of beginning university students entering engineering courses tends to rise during periods of prosperity when the demand for engineers is high and earning prospects are good. Conversely, the portion tends to fall when business conditions and earnings and employment prospects seem less favourable.

In order to determine whether such a relationship does, in fact, exist, the ideal method of approaching this problem would probably be that of comparing the dates and amplitudes of the fluctuations in business activity and in the per cent of first year university enrolment comprised of beginning engineering students. If one discovers a close correspondence between dates in the two series, and if the amplitudes of the fluctuations seem to be reasonably large, then one would have some basis for believing that the enrolments of engineering students are to a degree affected by the business cycle. Although reference dates for the Canadian business cycle are available since

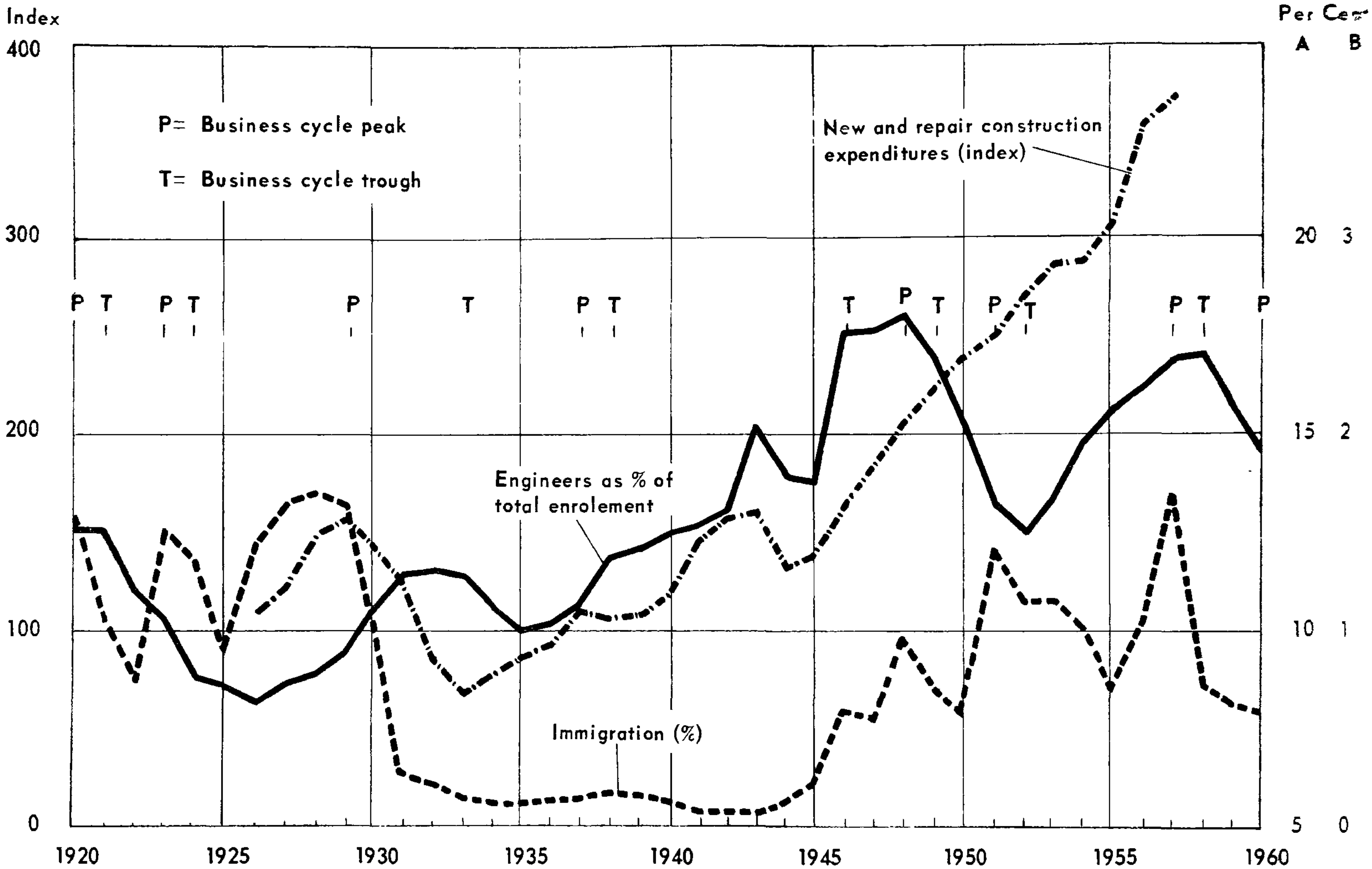
1919, along with some indicators of the magnitudes of the various fluctuations,[20] no data are available on the annual enrolments of first-year engineering students for the years prior to 1940, or on the annual enrolments of beginning university students in all courses.

A general idea of the relationship between engineering enrolment as a per cent of total university enrolment and business cycles for the period 1920-60 is given in Figure IV-6 and in Table IV-A-3 in the Appendix. Engineering enrolments do not correlate precisely with these business cycle reference dates. However, the data suggest that the fraction of students in engineering courses does exhibit fairly long-run cyclical behaviour that corresponds roughly with long-run cycles in business activity if some allowance is made for lags in engineering as a percentage of total enrolment due to the use of average rather than first-year enrolment. Three long cycles can be discerned in our data, occurring respectively over the periods 1926-35, 1935-52 and 1952-65. The fraction increased gradually from 1926-32, the increase coinciding with the business expansion of the 1920's, and then plunged sharply from 1932 to 1935, corresponding to the great business decline that occurred during this time. From 1935 on, it begins to climb slowly then accelerates very rapidly from 1943

20/ E.J. Chambers, "Canadian Business Cycles Since 1919: A Progress Report", in The Canadian Journal of Economics and Political Science, Vol. 24, No. 2, May, 1958, pp. 180-181; also unpublished data obtained from the Department of Trade and Commerce for the period 1954-61 by the author.

FIGURE IV-6

INDICATORS OF LONG-RUN SUPPLY OF ENGINEERS



Source: Table IV - A - 3

to a very high peak in 1948. This coincided with the slow business expansion of the late 1930's and the rapid expansion of the early 1940's. The fraction then falls off rapidly to a trough in 1952, this decline representing a return to peacetime conditions. From 1952, the fraction climbed again, the increase corresponding to the business expansion of the early 1950's, leveled out over the period 1955-58 which included the rapid business upswing of the middle 1950's and then fell off steadily from 1958 to 1965. This most recent decline corresponds with the business decline of the late 1950's and early 1960's.

Thus, despite the limited amount of relevant data available, it seems that a reasonable case can be made for the hypothesis that the fraction of beginning university students entering engineering courses behaves in a cyclical fashion, with the cycles corresponding approximately to broad cycles in business activity.

The longer run economic indicators as well as the shorter run non-price indicators have suggested that the post-war expansion of the 1950's was characterized by an upswing during the middle 1950's which tapered off in the latter part of the decade. How did the price, that is the earnings of engineers reflect, or better interact with these trends? There is no ideal single series for the annual earnings or salaries of engineers during the post-war era. It was therefore decided to present in Tables IV-4 and IV-5 a number of series for engineers' earnings which, while different, have tended to move in the same direction and at about the same time.

Table IV-4 tends to confirm the earnings data based on the Census information presented above. With 1951 as a base period, the index of starting salaries of engineers rose to 186 while average salaries of engineers and scientists reached 213 compared with 163 for average earnings of supervisors and office employees in manufacturing which were used as a bench mark. A further comparison with other selected professional occupations in Table IV-5 indicates that engineers' earnings increased relatively more rapidly than any selected occupations except dentists, between 1951 and 1961.

However, there were important changes in the earnings pattern of engineers relative to other occupations between 1951 and 1961 which presumably reflected changing market conditions. Between 1955 and 1957, for example, starting salaries of engineers rose by over 27 points from 141 to 168 compared with a rise of 121 to 136 for the average earnings of supervisory and office employees in manufacturing. Average earnings of engineers and scientists rose from 153 to 184. As Table IV-5 indicates, average salaries of engineers and scientists rose as a ratio of salaries of other selected occupations, from 1.48 to 1.59 of salaries of office and supervisory employees in manufacturing, from

Table IV-4

Indexes, Annual Earnings of Engineers, Selected Series and of Supervisory and Office Employees in Manufacturing, 1946-1965

Year	Supervisory and Office Employees in Manufacturing	Engineers Starting Salaries (N.E.S. Series)	Engineers and Scientists Average Salaries (N.R.C. Series)	Census	
				Total Engineering	Mechanical and Industrial Engineers
	Index: 1951 = 100.0				
1946....	-	-	-	-	-
1951....	100.0	100.0	100.0	100.0	100.0
1952....	106.6	126.7	126.7	-	-
1953....	112.5	126.7	132.4	-	-
1954....	116.9	133.3 or 140.9	148.5	-	-
1955....	121.1	140.9	152.5	-	-
1956....	128.1	153.3	169.1	-	-
1957....	135.6	167.6	184.1	-	-
1958....	144.8	174.2	191.1	-	-
1959....	151.6	175.6	198.3	-	-
1960....		178.2	205.8	-	-
1961....	162.7	186.2	213.0	182.2	185.5
1962....	-	190.7	223.6	-	-
1963....	-	196.0	228.0	-	-
1964....	-	204.4	-	-	-
1965....	-	215.6	-	-	-

Source: Table IV-A-4.

Table IV-5

Indexes of Ratios - Salaries of Engineers to Those in Selected Occupations, 1946-1965

Year	Total Engineering					Mechanical and Industrial Engineers					Engineers - Survey of Scientific and Technical Personnel					Engineers and Scientists - Average Salaries (N.R.C.)				
	Supervisory and Office Employees in Manufacturing	University Teachers	Dentists	Lawyers	Medical Doctors and Surgeons	Supervisory and Office Employees in Manufacturing	University Teachers	Dentists	Lawyers	Medical Doctors and Surgeons	Supervisory and Office Employees in Manufacturing	University Teachers	Dentists	Lawyers	Medical Doctors and Surgeons	Supervisory and Office Employees in Manufacturing	University Teachers	Dentists	Lawyers	Medical Doctors and Surgeons
1946....	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1951....	1.10	1.46	1.75	2.54	2.67	1.15	0.79	0.66	0.45	0.43	-	-	-	-	-	1.17	0.81	0.67	0.46	0.44
1952....	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.39	1.01	0.77	0.64	0.52
1953....	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.38	0.98	0.78	0.65	0.51
1954....	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.49	1.06	0.83	0.59	0.54
1955....	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.48	-	0.78	0.58	0.54
1956....	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.55	1.11	0.77	0.62	0.56
1957....	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.59	1.06	0.77	0.64	[illegible]
1958....	-	-	-	-	-	-	-	-	-	-	1.68	1.07	0.81	0.72	0.57	1.55	0.99	0.75	0.66	0.53
1959....	-	-	-	-	-	-	-	-	-	-	1.66	1.04	0.77	0.69	0.57	1.53	0.96	0.71	0.64	0.53
[illegible]	-	-	-	-	-	-	-	-	-	-	-	1.02	0.75	0.69	0.57	-	0.95	0.69	0.64	0.53
[illegible]	1.24	1.61	2.14	2.54	2.92	1.31	0.81	0.61	0.52	0.45	1.64	1.02	0.77	0.65	0.56	1.54	0.95	0.72	0.61	0.53
1962....	-	-	-	-	-	-	-	-	-	-	-	1.02	0.72	0.71	0.55	-	0.97	0.68	0.67	0.52
1963....	-	-	-	-	-	-	-	-	-	-	-	1.03	0.75	0.68	0.53	-	0.97	0.69	0.62	0.49
1964....	-	-	-	-	-	-	-	-	-	-	-	1.05	-	-	-	-	-	-	-	-
1965....	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Source: Table IV-A-4

a ratio of 0.58 to 0.64 in relation to lawyers and 0.54 to 0.56 in relation to medical doctors and surgeons. There was a slight decline in relation to average salaries of dentists from 0.78 to 0.77.

But the trend from 1957 to 1961 was in the opposite direction with average salaries of engineers declining in relation to the salaries of other occupations. Starting salaries of engineers rose only from 168 to 182 during this 4 year period compared with a rise for salaries of supervisory and office employees in manufacturing from 136 to 163 in relation to the base period 1951.

The earnings pattern for engineers during the 1950's coincides fairly closely with both the ups and downs of the business cycle and with the non-price indicators of the demand for engineers.

The impact of changing demand upon the salaries of engineers and scientists during the 1950's not only affected the relative increases of engineers salaries in relation to other occupations but also had a different impact on engineers with varying amounts of experience. This is illustrated in Table IV-6. During the years 1953-57 when demand conditions were tightening, average annual starting salaries of engineers and scientists rose by 7.5 per cent compared with an increase of 5.5 and 6.3 per cent for engineers with 5 and 10 years of experience respectively. Between 1957 and 1962 in contrast, starting salaries rose an average of 2.0 per cent per annum compared with increases of 7.4 and 2.3 per cent respectively for those with 5 or 10

Table IV-6

Annual Increases in the Salaries of Research Engineers and Scientists Employed by Industry by Years of Experience, 1953-54 to 1961-62

Year	Years of Experience					Mean Salaries
	0	5	10	15	20 and Over	
	%	%	%	%	%	%
1953-54...	(3.8)	(2.9)	(6.2)	(8.5)	(10.5)	(7.6)
1954-55...	(3.8)	(2.9)	(6.2)	(8.5)	(10.5)	(7.6)
1955-56...	12.2	8.9	7.9	7.7	6.7	10.8
1956-57...	10.2	7.3	4.9	7.9	6.9	8.9
1957-58...	1.6	2.2	3.2	4.1	3.9	3.8
1958-59...	0.4	0.9	2.0	2.1	2.4	3.8
1959-60...	3.2	4.1	2.9	3.1	3.1	3.8
1960-61...	3.6	1.9	0.6	1.4	3.6	3.5
1961-62...	1.3	2.9	3.0	4.4	5.7	5.0
1953-57...	7.0	5.5	6.3	8.1	8.6	8.7
1957-62...	2.0	7.4	2.3	3.0	3.7	4.0
1953-62...	4.5	3.8	4.1	5.3	5.9	5.9

Source: National Research Council, Surveys of Professional Salaries, Engineers and Scientists, 1952 to 1963, unpublished data.

years of experience. The price indicators in the market for engineers and scientists responded to demand changes[21] as we would expect and the greatest response plus or minus occurred precisely in the salaries of that group in the market most sensitive to demand changes and recruiting pressures, namely the starting salaries of newly-graduated engineers.

On the basis of price indicators, the market for engineers and scientists has responded to changes in underlying supply and demand conditions. The behaviour of engineering salaries indicates that there was a notable shortfall between supply and demand in the middle of the 1950's and that this situation changed quite rapidly towards the end of the decade.

The above analysis has so far dealt with changes in general economic conditions, in the demand for engineers and in engineering salaries during the 1950's. In order to round out the analysis, the supply of engineers will now be examined. The changes in requirements, supplies and earnings will then be brought together.

21/ For a discussion of the rapid increase in the requirement of employers for engineers in the mid-1950's and the tapering off later on, see Department of Labour, Economics and Research Branch, reports on Employment Outlook for Professional Personnel in Scientific and Technical Fields, various issues, 1958-60, 1960-62, and 1962-64, published in February, 1959, December, 1960, and December, 1962, respectively.

The behaviour of the supply of engineering manpower during the 1950's and early 1960's can be assessed more clearly if the main supply components, graduations, net migration and upgradings are examined separately since they may not change to the same degree or even in the same direction over given time periods.

The limitations of these supply components for analytical purposes were indicated in Chapter II above. Briefly, engineering graduations are not a precise indicator because of the mobility among engineers and other specializations and occupations. These movements seem, however, to cancel out to a considerable degree. Empirical evidence is lacking on net migration.[22/] However, this would not affect the analysis over time as long as we assume that the pattern of total gain and loss from this source has not varied over time.[23/]

22/ H.G. Grubel and A.D. Scott, "The Immigration of Scientists and Engineers to the United States, 1949-1961", Journal of Political Economy, Vol. LXXIV, No. 4, August, 1966, pp. 368-378.

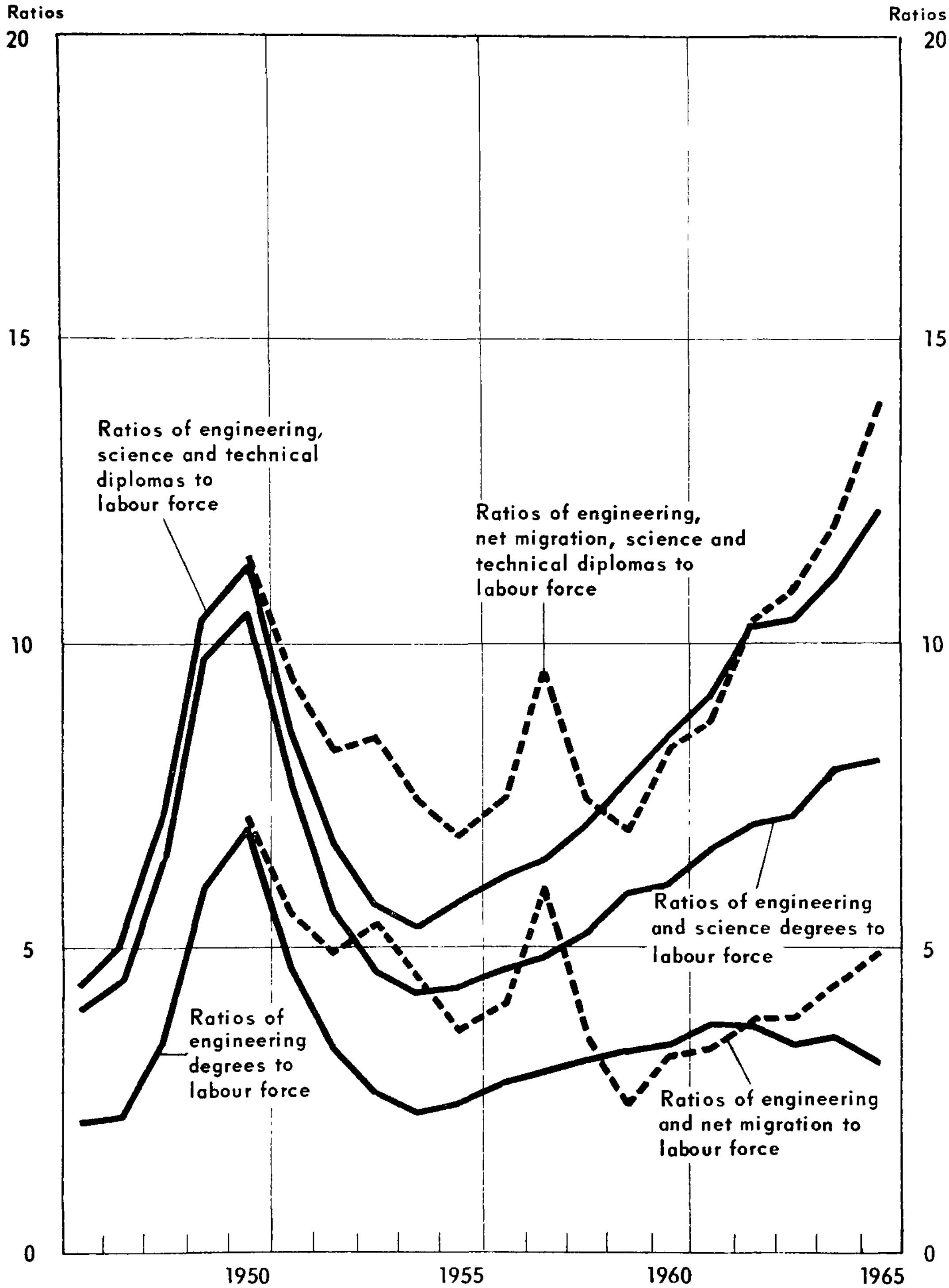
23/ Partial statistics on Canadians returning to Canada after having resided in the United States are available. Only Canadian citizens and British subjects who registered children as Canadian citizens who were born abroad and who were abroad at least twelve consecutive months and filled in forms to import personal or household goods were included. This total has remained a relatively constant proportion of emigrants from Canada to the United States between 1950 and 1963. In 1951 and 1961, for example, annual emigrants from Canada to the United States increased from 27,300 to 47,600 and Canadians returning to Canada as defined above increased from 3,600 to 6,300. See L. Parai, op. cit., pp. 202 and 219.

Unfortunately, these data do not completely confirm this assumption and further evidence is needed. Data on upgrading are scanty, yet this process represents a possible additional source of supply when market conditions for engineers change.

Trends in the major engineering supply components between 1946 and 1965 are indicated in Table IV-7 and Figure IV-7. First the overall trend between 1951 and 1961 is a decline in the major supply component graduates in engineering from 7.0 to 3.7 per cent of total labour force. If engineering graduates are added to net engineering migrants, the proportion declines from 7.1 to 3.3 per cent of total labour force. Those receiving degrees in science and diplomas in technology may be regarded as possible substitutes in certain cases for engineers. If the concept of supply is broadened, therefore, to include those who received degrees in pure science and diplomas in technology, the decline in supply between 1951 and 1961 is much less striking, from 11.3 to 9.1 per cent of the labour force. The "switching" of the technologically oriented students into pure science and technology has virtually offset the decline in engineering degree recipients between 1951 and 1961.

Second, the changes in graduates as a percentage of the labour force has tended to occur gradually. Between 1955 and 1957, for example, engineering graduates as a percentage of the labour force increased from 2.4 to 2.9 per cent. However, engineering graduates

FIGURE IV-7
GRADUATIONS AND NET MIGRATION, ENGINEERING, GRADUATIONS IN PURE SCIENCE AND TECHNOLOGY AS A PROPORTION OF THE LABOUR FORCE, 1946-1965



Source: Table IV A 5

Table IV-7

Graduations and Net Migration, Engineering, Graduations in Pure Science and Technology as a Proportion of the Labour Force, 1946-1965

Year	Total Labour Force (thousands)	Engineering Degrees Plus Pure Science Degrees	Engineering Degrees Plus Science Degrees Plus Technical Diplomas	Engineering Degrees Plus Net Migration	Engineering Degrees Plus Science Degrees Plus Technical Diplomas Plus Net Migration of Engineers	Ratios to Total Labour Force				
						Engineering Degrees	Engineering Plus Pure Science Degrees	Engineering Plus Science Plus Technical Diplomas	Engineering Degrees Plus Net Migration	Engineering, Net Migration, Science Plus Technical Diplomas
1946..	4,829	1,893	2,098	-	2,098	2.08	3.92	4.34	-	4.34
1947..	4,942	2,195	2,475	-	2,475	2.22	4.44	5.01	-	5.01
1948..	4,988	3,252	3,544	-	3,544	3.39	6.52	7.11	-	7.11
1949..	5,055	4,934	5,249	-	5,249	5.93	9.76	10.38	-	10.38
1950..	5,163	5,401	5,819	3,684	5,914	6.95	10.46	11.27	7.14	11.45
1951..	5,223	3,996	4,485	2,862	4,922	4.64	7.65	8.59	5.48	9.42
1952..	5,324	2,990	3,525	2,614	4,369	3.32	5.62	6.62	4.91	8.21
1953..	5,397	2,453	3,040	2,865	4,568	2.48	4.55	5.63	5.31	8.46
1954..	5,493	2,313	2,890	2,445	4,083	2.28	4.21	5.26	4.45	7.43
1955..	5,610	2,443	3,137	2,037	3,837	2.38	4.35	5.59	3.63	6.84
1956..	5,782	2,702	3,567	2,329	4,299	2.76	4.67	6.17	4.03	7.44
1957..	6,003	2,921	3,850	3,579	5,688	2.90	4.87	6.41	5.96	9.48
1958..	6,127	3,200	4,282	2,220	4,572	3.15	5.22	6.99	3.62	7.46
1959..	6,228	3,641	4,832	1,530	4,305	3.30	5.85	7.76	2.46	6.91
1960..	6,403	3,872	5,407	2,015	5,251	3.39	6.05	8.44	3.15	8.20
1961..	6,608	4,301	5,947	2,148	5,683	3.70	6.60	9.12	3.30	8.72
1962..	6,737	4,664	6,752	2,524	6,839	3.69	7.06	10.22	3.82	10.35
1963..	6,933	4,837	6,960	2,610	7,324	3.33	7.18	10.33	3.87	10.87
1964..	7,141	5,498	7,633	3,077	8,288	3.49	7.93	11.01	4.44	11.95
1965..	-	5,786	8,673	3,554	9,971	3.16	8.10	12.15	4.98	13.96

Source: Table IV-A-5.

plus net engineering migrants increased from 3.6 to 6.0 per cent of the labour force during this time. Engineering net migration has provided a source which permits a rapid response of the supply of engineers to changing market conditions. Engineering degrees, incidentally, did increase sharply as a proportion of the labour force from 2.8 to 2.9 per cent in 1956 and 1957 to 3.7 per cent in 1961 and 1962, a lag of about 5 years in relation to the economic upswing of 1955-67.

What about upgrading of those without formal qualifications to engineering status during this period of time? Theoretically, one would expect upgrading to constitute a short-run response to a current shortage situation. Persons without university degrees may be shifted into engineering jobs, for example. In Table IV-8, there was a larger amount of such shifting in the "shortage" situation in 1956-57 than there was in 1959 when the market was looser. This indicates that in the short-run, upgradings can serve as an alternative source of supply through a change in the utilization pattern of employees with lower qualifications. This tends to support the earlier analysis of the 1950's derived from Census data which indicated a decline in the median education level of engineers during the 1950's. In the face of increased demand during the 1950's and the relative decline of university graduates in engineering, employers would tend to utilize non-university graduates to a greater degree.

Table IV-8

Upgradings of Employees to Professional Status During 1956-1957 and 1959 by Major Employment Sector

	Through Experience and Ability		By Obtaining a University Degree		By Membership in a Professional Association	
	1956-1957	1959	1956-1957	1959	1956-1957	1959
	%	%	%	%	%	%
All Sectors..................	73.0	68.7	9.8	15.6	17.2	15.7
Total Private Industry........	75.0	73.4	8.3	13.3	16.7	13.3
Mining and Quarrying.......	93.0	97.3	3.0	-	4.0	2.7
Manufacturing..............	73.5	79.0	7.9	10.5	18.6	10.5
Construction...............	94.2	100.0	0.0	-	5.8	-
Transport and Public Utilities...............	66.7	47.6	15.3	30.2	18.0	22.2
Trade and Finance..........	-	-	0.0	-	-	-
Professional Service.......	58.3	66.4	18.0	15.1	23.7	18.5
Colleges and Universities.....	-	36.4	-	63.6	-	-
Government Agencies...........	62.3	47.6	16.7	21.4	21.0	31.0

Sources: Department of Labour, Economics and Research Branch, Employment Outlook for Professional Personnel in Scientific and Technical Fields, 1958-1960, Professional Manpower Bulletin No. 5, February 1959, page 29, and ibid., 1960-1962, Bulletin No. 8, page 24.

At the same time, a long-term trend was noted in Chapter II above for a larger proportion of engineers to acquire post-graduate education.[24] One possible interpretation is that the long-term trend towards higher levels of education may be punctuated by shorter-term periods of shortages when the opposite trend operates and those with lower levels of education are hired to a greater degree. Another interpretation is that the market for engineers is not in fact homogeneous, that is, those with higher levels of education, especially with post-graduate education, are not readily substitutable for those without degrees. Two distinct markets may exist.

Some idea of the homogeneity or lack of it in the market for engineers and scientists may be gained by a comparison of the changes over time in salaries and in recruitment difficulties for engineers and scientists with different levels of education, in different industries and fields of specialization. A greater imbalance in supply and demand for Ph.D.'s than for those with bachelor's degrees, for example, would ceteris paribus, tend to result in a change in the structure of relative earnings of engineers and scientists by level of education.

Table IV-9 indicates that in 1956 and 1957, a considerably larger increase in starting salaries occurred for engineers and scientists at the bachelor level than at the Ph.D. level. The overall

24/ See Chapter II, Table II-17.

Table IV-9

Annual Increases in Starting Salaries of Engineers
and Scientists, 1952-53 to 1961-62

Year	Bachelor's and Master's		Ph.D's		Bachelor's and Master's		Ph.D's	
	Government	Industry	Government	Industry	Government	Industry	Government	Industry
	$	$	$	$	%	%	%	%
1952............	-	3,370	-	-	-	-	-	-
1953............	3,529	3,534	4,791	5,508	-	4.9	-	-
1954............	-	3,815	-	5,840	-	8.0	-	6.0
1955............	3,718	3,804	5,082	5,956	-	-0.3	-	2.0
1956............	4,189	4,266	5,523	6,515	12.7	12.1	8.7	9.4
1957............	4,690	4,701	6,195	6,955	12.0	10.2	12.2	6.8
1958............	4,775	4,776	6,336	7,500	1.8	1.6	2.3	7.8
1959............	4,732	4,797	6,376	7,280	-0.9	0.4	0.6	-2.9
1960............	4,923	4,950	6,917	7,981	4.0	3.2	8.5	9.6
1961............	5,095	5,126	7,043	8,550	3.5	3.6	1.8	7.1
1962............	5,187	5,195	7,330	8,490	1.8	1.3	4.1	-0.7
1963............	4,995	5,325	7,355	8,680	-3.7	2.5	0.3	2.2
Average Annual Per Cent Change								
1953-57.......	-	-	-	-	8.2	8.3	7.3	6.6
1957-62.......	-	-	-	-	2.1	2.1	3.7	4.4

Source: National Research Council, <u>Surveys of Professional Salaries, 1952 to 1963</u>, various issues, (Unpublished).

tightness of the market at that time appeared to affect bachelor degree personnel who tend to be concentrated at the "production" level which is probably more affected by short-term changes in demand. However, for 1957-62, the opposite result occurred and the starting salaries of Ph.D.'s in research increased twice as fast as salaries of engineers and scientists with bachelor's degrees.

Data on annual average or median salaries are not available for engineers and scientists separately for the earlier part of the decade. For 1958-63, median annual earnings of scientists excluding those in agriculture and forestry rose by 29 per cent compared with a rise of only 20 per cent in salaries of engineers as a group.[25]

In view of the increasing supply of pure science compared with engineering graduates in the latter half of the 1950's, indicated in Table IV-7, combined with the more rapid rise in earnings of science graduates compared with engineers, one would expect that the demand by industry for those trained in science must have been relatively stronger than for engineers.

Table IV-10 indicates that the relative increase in employment of scientists relative to all engineers has declined slightly between

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25/ Department of Labour, Economics and Research Branch, Annual Earnings in the Scientific and Technical Professions, 1963, PM/6, Professional Manpower Bulletin, No. 6, July, 1964, Table 1.

Table IV-10

Annual Rates of Change in Actual Employment of Engineers and Scientists, 1955, 1957, 1959, 1962-1964

Specialization	1 1955	2 1957	3 1959	4 1962-1964
Engineers Total...	+9.9	+10.1	+4.2	+5.9
Scientists Total..	+5.6	+10.2	+4.1	+5.4
Biologists........	-	+6.3	+6.7	+5.7
Chemists..........	-	+9.8	+4.5	+6.0
Geologists........	-	+10.9	+0.9	+3.8
Mathematicians....	-	+12.7	+5.3	+10.5
Physicists........	-	+13.0	+3.6	+6.3
Agriculture.......	-	+5.9	+3.0	+3.3
Forestry..........	-	+10.6	+4.0	+2.9

Sources:

Col. 1 Department of Labour, Economics and Research Branch, Trends in Professional Manpower Supplies and Requirements, Professional Manpower Bulletin, No. 1, Aug. 1957, p. 23.

Col. 2 Department of Labour, Economics and Research Branch, Employment Outlook for Professional Personnel in Scientific and Technical Fields 1958-1960, Professional Manpower Bulletin, No. 5, Feb. 1959, p. 18.

Col. 3 Department of Labour, Economics and Research Branch, Employment Outlook for Professional Personnel in Scientific and Technical Fields 1960-1962, Professional Manpower Bulletin, No. 8, Dec. 1960, p. 19.

Col. 4 Department of Labour, Economics and Research Branch, Employment Outlook for Professional Personnel in Scientific and Technical Fields 1962-1964, Professional Manpower Report, No. 13, Dec. 1962, p. 20.

1957 and 1962-64. However, the "scientists, total" includes agriculture and forestry scientists with lower than average employment increases. Since "pure science" graduates exclude agriculture and forestry graduates, a more valid comparison is between "engineers, total" and "science" excluding agriculture and forestry. From 1957 to 1962-64, in the majority of cases the average annual increase in the employment of scientists has been greater than for engineers. There is some evidence, therefore, that the increased supply of scientists in the latter part of the 1950's was matched by increased requirements for scientists by employers.[26]

Some threads of the analysis of supply, requirements and earnings during the post-war period pulled together in Figure IV-8 and in Table IV-A-6 in the Appendix. Short-run changes in the market for

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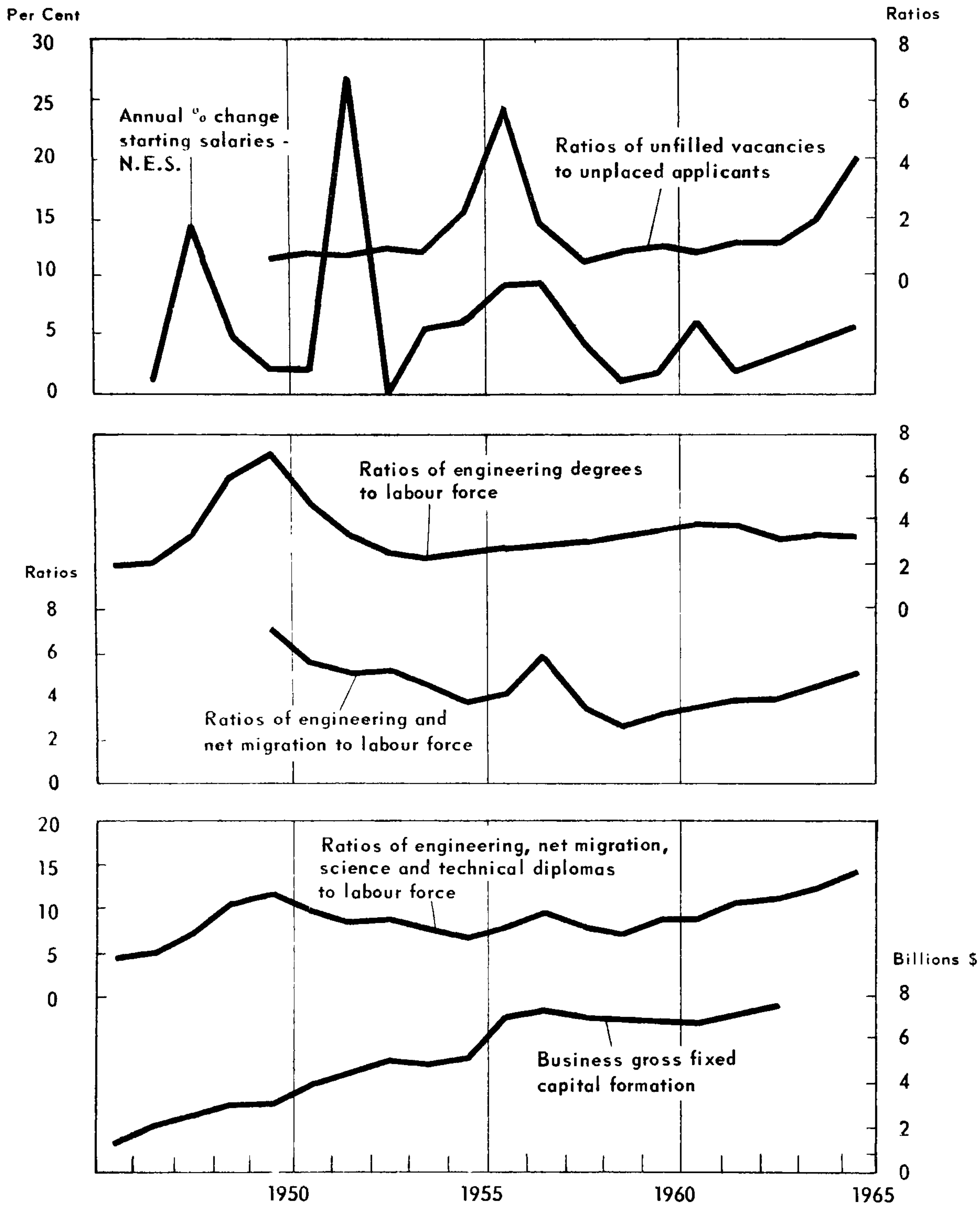
26/ It is of course possible that in a shortage situation a limitation of scientists could prevent increases in the actual level of employment. However, in the present case there seems to have been both an increased supply and an increase in requirements for scientists. In a surplus situation, an increase in employment of scientists could be interpreted as an increase in the supply, as it were, creating its own demand. That this does not appear to be the case is evident from an examination of the difficulties employers had in recruiting scientists and engineers. Between 1956-57 and 1960-62, the percentage reporting difficulties in recruiting scientists increased slightly from 16 to 16.8 per cent while the corresponding percentage for engineers declined from 16 to 13.5 per cent. See Department of Labour, Economics and Research Branch, *Employment Outlook for Professional Personnel in Scientific and Technical Fields, 1958-1960*, February, 1959, p. 22; *Ibid., 1960-1962*, December, 1960, p. 22.

FIGURE IV-8
INDICATORS OF DEMAND AND SUPPLY, ENGINEERS, AND OF BUSINESS ACTIVITY, 1946-1965



Source: Tables IV 5 and IV A . 4

engineers during this period of time are evaluated by employing selected indicators of supply, demand and price. The most sensitive price indicator of changing market conditions is starting salaries of newly graduating engineers.[27/] Starting salaries indicate that there was a slight tightening of the market for engineers between 1950-53 which coincided with the period of the Korean War. This was followed by a looser market in 1954, followed by a rapid tightening in the mid-1950's up to 1956-57. This was followed by a looser market in the latter 1950's and early 1960's with a tightening up from 1961-65. The non-price indicator of vacancies to applicants confirms this picture. For example, the index of vacancies to applicants peaked at 5.8 vacancies for every recorded job opportunity in engineering in 1956, a period with an increase in annual starting salaries of 9.3 per cent. One year later in 1957, business gross fixed capital information, which we have seen is a good indicator of general economic conditions associated with changes in the demand for engineers, peaked at 6.8 to 7.3 billion dollars in 1956-57. At the same time, the ratio of both engineering degrees to labour force and of engineering and science plus technical diplomas to labour force reached a low point in 1955 just prior to the greatly increased demand for engineers thus intensifying

27/ However, there is a lag of about one year in the average reaction of starting salaries of engineers to short-run changes in requirements as indicated by changes in business gross fixed capital formation and by ratios of unfilled vacancies to applicants.

the shortage. The ratio of engineering degrees plus net migration increased sharply between 1955-57 from 3.6 to 6.0 per cent of total labour force, but it was apparently not sufficient to meet the increased requirements as indicated by the sharp rise in the ratio of vacancies to applicants and in starting salaries. Thus, we are justified in saying that all the indicators pointed to a shortage of engineers (or rather, of technologically trained persons) in the mid-1950's due to a combination of a drop in supply and a rise in requirements. In the early 1960's, there was a considerable increase in demand as indicated by the increase in business gross fixed capital formation. But there was also a large increase in the supply of those trained in science and technology who could presumably be substituted for engineers. The available indexes suggest that a growing "shortage" existed but that it was modified by a relatively smaller change in demand and by an increase in supply, especially if the supply of those who can be substituted for engineers is added to engineers.

Between 1958 and 1962 annual increases in earnings differed widely among the detailed fields of specialization within engineering and science. These are shown in Table IV-11. The annual increases varied from 4.1 per cent for chemists, 2.4 per cent for mining engineers, 8.5 per cent for mathematicians and 5.0 per cent for geologists. By employment sector, in the case of scientists, for example, the annual increase in median earnings between 1959 and 1962 varied from 4.0 per cent in private industry to 6.6 per cent in universities.

Table IV-11

Annual Increases in Median Earnings of Engineers and Scientists by Specialization, 1957-1958 to 1961-1962

	1957/1958	1958/1959	1959/1960	1960/1961	1961/1962	1957/1962
	%	%	%	%	%	%
All Engineers....................	1.3	3.7	3.6	2.2	4.5	3.1
Aeronautical..................	-	-	-	-	-	-
Metallurgical.................	0	0	5.8	2.2	6.4	2.9
Chemical......................	5.3	3.7	3.6	3.4	4.5	4.1
Mechanical....................	-1.2	3.7	2.4	1.2	4.6	2.1
Electrical....................	2.5	5.0	1.2	3.5	3.4	3.1
Civil.........................	3.9	2.5	3.7	2.4	4.6	3.4
Mining........................	-2.2	4.5	6.5	0	3.1	2.4
All Scientists...................	2.8	5.5	5.2	3.7	4.8	4.4
Mathematicians................	12.7	14.1	1.2	3.7	10.6	8.5
Physicists....................	8.4	4.0	7.5	10.5	3.2	6.7
Biologists....................	11.7	7.5	5.6	2.6	9.0	7.3
Chemists......................	2.7	9.3	4.9	1.2	10.3	5.7
Mathematicians and Physicists..	-	-	12.5	3.3	8.6	8.1
Geologists....................	6.4	2.4	4.7	5.6	5.3	5.0

Sources: (1) Department of Labour, Economics and Research Branch, Engineering and Scientific Manpower Resources in Canada, Professional Manpower Bulletin, No. 7, June 1959, p. 33.

(2) Department of Labour, Economics and Research Branch, Employment and Earnings in the Scientific and Technical Professions, 1958-1961, Professional Manpower Report, No. 12, September 1962, pp. 6 and 7.

(3) Department of Labour, Economics and Research Branch, Employment and Earnings in the Scientific and Technical Professions, 1959-1962, Professional Manpower Report, No. 14, June 1963, p. 10.

It would therefore appear that the market for engineers and scientists is, in fact, composed of a variety of sub-markets which may exhibit quite different tendencies from time to time. A "shortage" of engineers or scientists, for example, is a composite of a variety of sub-shortages in specific industries, fields of specialization and levels of education. These specific, as opposed to general, shortages probably arise out of industrial, occupational and other types of immobilities and the remedies to them that consequently suggest themselves are increases in these types of mobility.

4. The International Market for Engineers and Scientists

Up until now the discussion of the market for engineers and scientists has been larely confined to the domestic one. However, the foreign-born represent 19 per cent of all persons in professional occupations, 33 per cent of engineering occupations and 32 per cent of physical science occupations according to the 1961 Census.[28] The ratio of immigrant engineers to Canadian university engineering graduates from 1951 to 1960 was 59 per cent, and the corresponding ratio of engineering emigrants from Canada to the United States was 31 per cent, which indicates the importance of these sources of manpower

28/ See Chapter II, Table II-25.

flows.[29] In Chapter II it was found that there is (as far as data permit us perceive) a substantial two-way process of immigration and emigration between Canada and the rest of the world but that the greatest portion of the flow is naturally between Canada and the United States.[30]

In this section the purpose is simply to indicate briefly the scope of an adequate study of the international market for scientific and technical personnel from the Canadian point of view and the possible implications of this for the Canadian market for such personnel. The problem of international mobility may be considered from three aspects: first, the extent of such migration; second, the factors that seem to be associated with it; thirdly, the reasons why mobility occurs.

The data on the extent of total migration flows between Canada and the United States are not complete. Some attempts have been made on the basis of comparisons of inter-censal stocks and flows

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29/ See Chapter II, Table II-28.

30/ A large number of studies have examined the interdependence of the Canadian and United States economies. See, for example, R.E. Caves and R.H. Holton, op. cit., pp. 79-120. For a recent treatment see George W. Wilson, Scott Gordon and Stanislaw Judek, Canada: An Appraisal of its Needs and Resources, Toronto, University of Toronto Press, 1965, pp. 154-209. For a recent study of immigration and emigration, see L. Parai, op. cit.

to estimate the unrecorded flows of international migration between Canada and the United States. The bits of evidence available suggest that the recorded emigration of the Canadian-born to the United States, for example, tends to overstate the amount of loss to Canada through migration chiefly because most Canadians returning to Canada are not recorded.[31]

It was shown in Chapter II above that the flow of recorded emigration from Canada to the United States as well as the proportion which engineers represented of the total has increased somewhat during the 1950's. Engineers as a proportion of professional occupations have declined slightly during this period of time. In contrast, the percentage of engineers to total immigrants has remained steady but the proportion of immigrant engineers to total professional immigrants has declined from 26.5 to 11.0 per cent between the first and second halves of the decade. The flows of engineering migrants moving into and out of Canada depend not only on the total flow of all immigrants but also on special factors which have tended especially in the latter part of the 1950's to decrease the proportion which engineers represent of total professional immigrants including immigrants to Canada.

31/ P. Camu, E.P. Weeks and Z.W. Sametz, Economic Geography of Canada, Toronto, Macmillan, 1964, p. 69, have attempted to estimate total emigration by using Census data. For a critique of this approach see B.W. Wilkinson, Studies in the Economics of Education, Occasional Paper No. 4, Department of Labour, Economics and Research Branch, 1965, pp. 58-65.

It could be hypothesized that since the demands for engineers are particularly senstive to changes in the rate of economic growth, the slow-down in the rate of economic growth in Canada combined with the post-war economic resurgence of Europe, Canada's main source of immigrants have led to the sharp contraction in the percentage of engineers to total professional immigrants. At the same time, the pull of the United States has tended to remain steadier due to the sustained influence of such factors as defense expenditures in that country. An alternative hypothesis which is perhaps more consistent with the view that most, possibly eight out of ten Canadian-born emigrants to the United States return to Canada,[32] is that a variety of factors many of them non-economic, account for the two-way flow between Canada and the United States and that these flows tend to be less affected by relative economic conditions in the two countries than the flow across the Atlantic. These two hypotheses are of course not necessarily mutually exclusive.

A recent study based on tabulations by the United States National Science Foundation and by data from the Organization for Economic Co-operation and Development compared the number of immigrant

32/ P. Camu, E.P. Weeks and Z.W. Sametz, op. cit., p. 69; see also K.V. Pankhurst, "Migration Between Canada and the United States", The Annals of the American Academy of Political and Social Science, Vol. 367, September, 1966, p. 56.

scientists and engineers who went to the United States between 1957 and 1961 with the stock of engineers and number of graduates both by country of last residence. Immigrants whose country of last residence was Canada represented an average of about 30 per cent of first degrees granted in Canada during this 5 year period, which was the highest of the twelve countries (mostly European) listed. At the same time, the proportion of immigrants to the United States who were born in Canada represented only 50 per cent of those who last resided here, the lowest for any country shown. Despite this, Canada still ranked second behind Norway in the proportion of immigrants by country of birth in relation to total domestic stock of engineers and scientists.[33/] This indicates first that the recorded flow of engineers and scientists from Canada to the United States is important relative to other sources of supply such as Canadian university graduates and that Canada appears to serve as a staging area for re-emigration of those not born in Canada to the United States.[34/] The O.E.C.D. is at present attempting to accumulate data on international migration on high level manpower by having various countries simultaneously assess and report on their

33/ H.G. Grubel and A.D. Scott, "The Immigration of Scientists and Engineers to the United States, 1949-1961", Journal of Political Economy, Vol. LXXIV, No. 4, August, 1966, pp. 368-378.

34/ This point is also made by B. Thomas, "From the Other Side: A European View", The Annals of the American Academy of Political and Social Science, Vol. 367, September, 1966, p. 69.

stocks of high level manpower of foreign origin.35/ Data submitted by the United States to the O.E.C.D. from the National Register of Scientific and Technical Personnel for 1964 indicate that 64 per cent of the natural scientists (excluding agriculture and forestry scientists) in the United States National Register whose country of birth and secondary schooling was Canada, held Ph.D. degrees, 1,103 out of 1,737.36/

According to the most recent tabulation from the Canadian Register of Scientific and Technical Personnel in 1963, the percentage of natural scientists as defined above, who held Ph.D. degrees represented 27 per cent of the total.37/ It seems that the movement from Canada to the United States is particularly significant for scientific and technical manpower at the upper levels of education. The factors associated with these movements have not been quantified

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35/ O.E.C.D., Organization for Economic Co-operation and Development Committee for Scientific and Technical Personnel, International Movement of Scientific and Technical Personnel, STP (65)19, Paris, August, 1965.

36/ O.E.C.D., International Movement of Scientific and Technical Personnel, notes on O.E.C.D. migration study based on the preliminary analysis of national data, September 23, 1966, unpublished manuscript.

37/ See Chapter II, Table II-8.

precisely but in addition to possible differentials between Canada and the United States in income and job opportunities, the large proportion of those who receive post-graduate education in the United States and who remain there appears to be an important factor associated with the movement south of the border.[38/]

Some price and quantity indicators of the recent trends in the market for engineers in the United States and Canada are given in Table IV-12 and Figure IV-9.

The price and non-price series selected for Canada and the United States exhibit some divergences but frequently move in the same direction. These similarities of course do not prove that the two markets interact, because the indicators could be moving parallel in response to a third more general influence, for example, the business cycle. It may be hypothesized that if the markets are linked, the Canadian indicators would tend to move in the same direction as those in the United States because of the impact of the large United States economy on Canada. In the case of immigration and emigration of engineers, by and large they have tended to move together with the exception of 1959 and 1962-65. In 1959 the sharp rise in the

38/ See National Research Council, After-Graduation Plans of 1960 and 1961 Doctorates and Masters of Science and Engineering, June, 1962, pp. 10 and 16. Canadian Ph.D.'s graduating from United States universities according to this survey were about twice as likely to enter employment in the United States as were Ph.D. scientists and engineering graduates from Canadian universities.

Selected Indicators Relating to the Market for Engineers and Scientists, Canada and the United States, 1948-1965

	1	2	3	4	5	6	7	8	9	10	11
	Starting Salaries								Ratio, Starting Salaries, U.S.A./Canada		
	Engineers		All Engineers and Scientists - B.A.'s & M.A.'s in Industry		All Engineers and Scientists - Ph.D.'s in industry		Immigrant Engineers Per 100,000 Labour Force 1961	Emigrant Engineers Per 100,000 Labour Force 1961	Engineers U.S.A./ Canada	All Engineers and Scientists - B.A.'s and M.A.'s in Industry - U.S.A./Canada %	All Engineers and Scientists - Ph.D.'s in Industry U.S.A./Canada %
Year	Canada	U.S.A.	Canada	U.S.A.	Canada	U.S.A.			Col. 2/ Col. 1	Col. 4/ Col. 3	Col. 6/ Col. 5
	$ Monthly	$ Monthly	$	$	$	$					
1948...	205	250	-	-	-	-	-	-	1.22	-	-
1949...	215	261	-	-	-	-	-	-	1.21	-	-
1950...	220	260	-	-	-	-	5.0	3.5	1.18	-	-
1951...	225	270	-	-	-	-	12.4	5.5	1.20	-	-
1952..	285	305	3,370	-	-	-	21.8	8.5	1.07	-	-
1953..	288	325	3,534	-	-	-	32.4	8.3	1.13	-	-
1954...	300	355	3,815	-	5,840	-	26.6	7.8	1.18	-	-
1955...	317	371	3,804	4,954	5,956	7,000	20.7	9.7	1.17	1.30	1.18
1956...	345	415	4,266	5,250	6,515	8,350	26.6	15.0	1.20	1.23	1.28
1957	377	454	4,701	5,820	6,955	8,500	48.9	19.9	1.20	1.24	1.22
1958...	392	472	4,776	5,964	7,500	8,652	15.9	11.4	1.20	1.25	1.15
1959..	395	480	4,797	6,372	7,280	9,492	12.3	20.7	1.22	1.33	1.30
1960...	401	-	4,950	6,636	7,981	10,068	11.4	13.9	-	1.34	1.26
1961...	419	-	5,126	6,816	8,550	10,500	8.6	12.8	-	1.33	1.23
1962.	429	-	5,195	7,116	8,490	11,172	15.2	13.9	-	1.37	1.32
1963.	441	-	5,325	7,416	8,680	12,096	18.9	13.2	-	1.39	1.39
1964.	4[illegible]0	-	-	-	-	-	23.3	12.9	-	-	-
1965...	485	-	-	-	-	-	35.5	15.1	-	-	-

Sources:

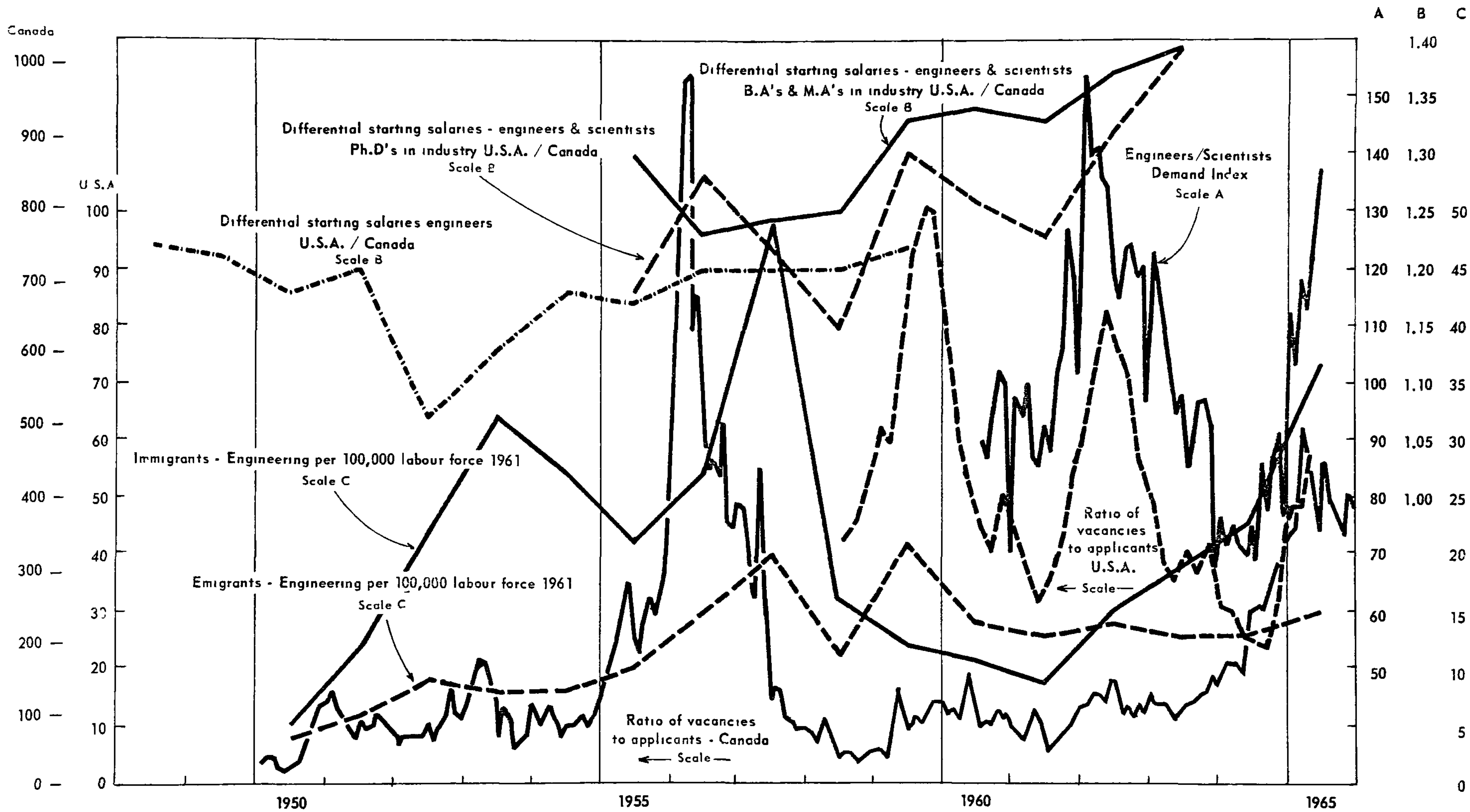
Col. 1 : Table IV-A-1.

Col. 2 : Frank S. Endicott, "Trends in the Employment of College and University Graduates, 1959". Scientific Manpower, 1958, "Paper of the Seventh Conference on Scientific Manpower, National Science Foundation, 1959, p. 12".

Cols. 3-6 : National Research Council, Surveys of Professional Salaries, 1952-1963, unpublished.

Cols. 7 and 8: Table IV-A-5.

FIGURE IV-9
SELECTED INDICATORS RELATING TO THE MARKET FOR ENGINEERS AND SCIENTISTS
CANADA AND THE UNITED STATES, 1948-1965



Source Table 10 12 D.B.S. Labour Division, ' Labour Demand and Supply,'' various issues 1950-1965, unpublished data, United States. Department of Labour ''Operating Data of the United States Employment Service on Supply and Demand for Engineers, 1965, unpublished work Sheets Deutch & Shear's Engineer (Scientist Demand Index July, 1960 – June, 1965 (1961 = 100,0), Deutch and Shea Inc., New York, N.J. (Mineograph) emigration of engineers was due chiefly to the large number of engineers who went to the United States following the cancellation of the Avro Arrow contract in 1958. The period since 1961-62 in Canada has been characterized by a substantial rise in job opportunities, and judging by the vacancies to applicant ratios here and in the United States, the relative expansion of job opportunities in Canada increased at a more rapid rate than previously which would tend to keep engineers at home.

Vacancies and applicants, although based only on partial data in both countries, have tended to expand and contract together with the exception of 1963-64.

The data indicate that starting salaries for engineers, however, have tended to rise more rapidly in the United States over the longer term. However, the data on which this trend is based particularly from 1958-63 refer to salaries of engineers and scientists as a group, many of whom are doing research and development work in industry. The fact that starting salaries of Ph.D.'s who tend to be concentrated in research, increased more rapidly in the United States relative to Canada between 1958 and 1963 tends to support this explanation.

One can therefore say that the market indicators chosen do lend weight to the argument that the market for engineers and scientists in Canada is part of an international one.

From the evidence available on stocks of Canadians of foreign origin who formed part of the United States high level manpower pool, and from the data on recorded flows of immigrants and emigrants, there can be no doubt that the general openness of the Canadian economy in the area of foreign trade and capital movements has its counterpart in an active international market for high level manpower of which Canada forms a part. What is less clear is the precise amount and direction of "human capital" flows that are taking place and the impact of these flows on the market for engineers and scientists.

Of equal importance from a policy viewpoint is the character of the flows. Engineers and scientists with the highest educational qualifications seem to be more prone to emigrate to the United States than those with lower levels of education. At the same time, the proportion of engineers, for example, who immigrate has fallen in relation to the total number of immigrants in professional occupations although the proportion of engineering immigrants to total immigrants has remained relatively constant during both halves of the 1950's owing to the rising proportion of professional to total immigrants. It may, therefore, be suggested tentatively that a policy which would aim at encouraging/discouraging the immigration/emigration of the most highly qualified engineers and scientists should not only be concerned with total percentage of those, say, in high level occupations but also with special factors which may affect the movements of engineers and scientists.[39]

Possible policies could involve the quality and availability of post-graduate education and research opportunities for engineers and scientists. The support of applied research in industry and universities might be increased. More strenuous efforts can be made to establish and maintain communications with those Canadians who are studying or working abroad with a view to encouraging them to return to Canada.

Any judgments about emigration of such manpower would require a very careful assessment of the causes and effects of such movements in relation to Canada's economic and social goals. Scott and Grubel have pointed out that one possible approach is to calculate the net effects of such movement on the migrants as well as on those left

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39/ H.G. Grubel and A.D. Scott, op. cit., p. 375. Found that engineers and scientists from the eight countries selected were about ten times as likely to emigrate to the United States as are people in other occupations. For Canada the likelihood was twelve times as great that people in engineering and science occupations would emigrate to the United States as for people in all occupations.

behind.[40/] But the "externalities", i.e., the social benefits of these highly qualified manpower may be important but are not easily quantified. Even the net economic effects of such migration are by no means obvious.

No attempt will be made here to derive specific policy proposals on immigration and emigration of engineers and scientists. Much more research and in particular more empirical work is required before this would be possible. But even the limited data available indicate the importance of developing any policy measures with a full awareness of the openness of the Canadian market to the international market for high level manpower.

5. Conclusion

In the first part of this chapter, the broad supply-demand analysis based on Census data indicated that during the decade of the 1950's there was an increase in the earnings of engineers relative to all occupations as a group. This ~~analysis~~ has been confirmed by the more detailed analysis. In addition, it appeared that the influence of demand was predominant in the changes that affected the market for engineers. The detailed analysis suggests that there was indeed a strong upward surge of demand for engineers during the 1950's as indicated by relative earnings. At the same time, supply has been

40/ Herbert B. Grubel and Anthony D. Scott, "The International Flow of Human Capital", American Economic Review, Vol. LVI, No. 2, May, 1966, pp. 273-274.

maintained or at least prevented from falling as much as it otherwise would by a relatively rapid rise of immigrants during short-term periods of shortages and toward the latter part of the decade by the availability of graduates in science and technology courses.

Moreover, the more detailed analysis reveals important aspects about the trends in supply and demand components which are concealed in the broader analysis, for example, how an equilibrium between supply and requirements was achieved. In the longer term, a fundamental change in supply seems to have occurred in the direction of an increasing orientation to science. This is indicated by the increasing proportion of pure science graduates and also by the rising number of both engineers and scientists with post-graduate degrees. The decline in the number of engineering graduates relative to other graduates has been offset by a rise in the proportion of pure science graduates, of engineering graduates with post-graduate degrees and of non-university diploma graduates.

In the short-run an equilibrium of supply and requirements has been achieved through a combination of increased migration and increased upgrading of persons without degrees into engineering level jobs. At the same time, the market for engineers has signalled rising shortages and surpluses in the traditional way, that is by changes in average and especially in starting salaries. A more detailed analysis of possible changes in utilization patterns of engineers at the level of the firm and the establishment would of course require additional data that would go beyond the scope of this study. The evidence that is available from business establishments and in particular the evidence of increased upgrading in times of shortages suggests that changes in utilization at the micro level probably occurred.

Analysis of the operation of the market for engineers and scientists ~~internationally~~ suggests that the adjustments that were made domestically in response to surpluses and shortages cannot be fully understood without an examination of the impact of international flows of engineering and scientific manpower. These manpower flows have tended to be high in times of rapid economic growth and emphasize the sensitivity of the domestic market for engineering and scientific personnel to economic conditions and opportunities abroad and of course vice versa.

Some implications of the above analysis for educational, migration and labour market policy may be tentatively suggested. The various criteria employed suggest that given changes in demand or requirements, a considerable degree of adjustability and flexibility is exhibited by the market especially in the longer run. At the same time, short-run inelasticities on the supply side relative to rapid changes in demand have tended to create short-term disequilibria. The mechanism of adjustment or the policy alternatives which are appropriate may be quite different for a "chronic-long-run" in contrast to an "acute-short-run" type of market disequilibrium. In the longer run, qualitative changes can be made in supply by changing the proportion of graduates in one field of specialization versus another, for example, technicians versus engineers.[41/] But this sort of change will do little to solve a short-run shortage. Long-run changes may also occur (or be encouraged) in the proportion of engineers and scientists who receive post-graduate education, or who simply receive university degrees rather than non-university type certification. In the short run, the qualitative adjustments in supply that come most readily to mind are: changes in net migration, upgrading, and industrial and geographic mobility.

In so far as education policy is geared to manpower needs, its influence on the composition of supply must be conceived as a long-term process in view of the "gestation period" of human capital, i.e., the time needed to turn out highly trained engineers and scientists. Its contribution to short-term market flexibility is primarily in terms of producing broadly-trained and adjustable individuals.[42/]

41/ This of course is assuming that an appropriate incentive system is established which influences the free choice of individuals in the desired direction.

42/ See O.E.C.D., "The Utilization and Deployment of Scientific and Technical Personnel", a statement prepared by the Economic and Research Branch, Department of Labour, Canada, for the Committee for Scientific and Technical Personnel, Paris, June, 1963, p. 7.

Policies that affect total immigration and emigration can have an immediate short-term influence on supply. However, the long-run composition of immigration in terms of the occupational and educational structure appears to change rather more slowly although not as slowly as the composition of university graduates. Policies aimed at influencing the flows of particular types of immigrants and emigrants, e.g., high level manpower may face severe constraints imposed by the existence of an active international market for these scarce personnel.

The lack of homogeneity that various indexes indicate exists in the market for engineers and scientists suggests that there is scope for policies aimed at improving the operation of the labour market for these personnel in the short run by means of increasing the level of information and by removing barriers to mobility of various kinds.

At the same time, it is essential that policies affecting engineering and scientific manpower be designed to keep the long-run and short-run developments in perspective since the policy implications of these may be quite different. For example, a policy of increasing the net migration of less than fully qualified engineers, designed to solve a short-run problem such as a shortage may exacerbate a long-run problem such as a need for increased education and training to lessen the impact of the obsolescence of engineering and scientific education.

CHAPTER V

ESTIMATES OF SUPPLY AND REQUIREMENTS FOR ENGINEERING MANPOWER IN 1970 AND 1976

1. Introduction

One of the purposes of the examination of the supply and requirements for engineering and scientific manpower in Chapters II and III was to develop a basis for making projections. This chapter will consist of projections of the numbers of engineering personnel who will be needed or forthcoming based on certain assumptions. A forecast should be distinguished from a projection. The former is a statement of what will occur while the latter is an estimate of what might occur under certain assumptions.

Projections may be made: to determine a need for the expansion of educational facilities and activities; to assist in working out policies relating to the recruitment and utilization of engineering and scientific workers and the scope of the research programs; to serve as a background for the guidance of young people in school.

Projections of the supply and requirements for engineers involve the general problems which are common to all long-range economic projections as well as some special difficulties. Briefly the general problems are the lack of a generally accepted theory of economic growth which can serve as a conceptual basis for the projections; the inadequacies of basic statistics; unpredictable exogenous factors such as wars and recessions.

Special problems in estimating the future supply of engineering manpower arise from the concept of the supply of labour to an occupation, which can be defined as including both those who are employed in it plus those who are capable and willing to work in it at current pay and working conditions. This definition of labour supply raises problems in measuring marginal groups. Some with broad training and multiple skills may shift from one occupation to another, which means that the number in those occupations may vary from time to time.

Others, for example, married women (quantitatively more important in science) and the retired, may enter or leave the labour force under certain conditions and the number who may do so is hard to determine.

Finally, the flexibility of employers' standards means that workers who are considered qualified at one time may not be under different circumstances. Technicians, for example, may be hired for engineering and scientific jobs in a tight labour market characterized by shortages but not when the opposite situation exists.

The main question in projecting the requirements for engineers and scientists is whether the rapid growth in their numbers in recent years will continue into the future. In the long-run, the demand for engineers and scientists appears to be related to factors such as changes in technology, the rate of economic growth, the size of the educational sector, and government and private policies concerning the utilization of engineers and scientists. The demand for engineers and scientists arises from various sectors of the economy and it is affected by the functions performed by engineers and scientists within these sectors. The availability of data on the employment of engineers and scientists which can in turn be related to other factors such as labour force and national income changes is of crucial importance in any study of requirements.

Despite these difficulties, projections of supply and requirements are often made in an attempt to reduce the uncertainties that are involved in plans for future manpower and educational policies.

2. Methodology

a. Supply Projections

A projection of manpower supply involves the measurement of three variables: the level of current supply, inflows and outflows. The level of current supply of engineers, for example, can be estimated from a number of sources including the decennial Censuses, and from the number of persons with university degrees or equivalent professional qualifications in the Department of Manpower and Immigration Register of Scientific and Technical Personnel which is based on a variety of sources such as surveys of graduates, and membership lists supplied by professional associations. Another source of information is surveys of employers conducted by the Department of Labour. A comparison of Census and register data on the stock of engineers revealed that by adjusting the Census engineering total to allow for an understatement of those with engineering degrees who transferred to other occupations plus an overstatement of those who had no university degrees, the Census and register numerical totals could be made quite similar.[1/] The current stock estimate used, however, was based on adjusted totals from the Register of Scientific Personnel which were inflated to allow for those not included in the register.

This adjustment in the concept of current supply was in turn followed in the estimates of inflows and outflows. Allowances were made for occupational transfers and for those who entered engineering occupations without university degrees which would make the stock and flow data consistent with each other. These estimates in turn can be examined within the broad framework of all occupations in the labour force as provided by the Census.

Inflows consist of graduations in engineering, immigrants, graduates in other than engineering fields and non-graduates.

Outflows consist of deaths, retirements, emigration, transfers to other occupations and an allowance for "non-entrants", those graduates in engineering courses who did not enter engineering occupations.

b. Requirements Projections

Future requirements for engineers involve estimates of both growth of employment and the number needed to fill existing shortages,

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1/ See Table II-37 above.

if any. Although a number of techniques may be used in forecasting the growth in requirements for high-level manpower,[2] basically the limitations of time and resources available for this study plus the available data and techniques reduced the options to two. First, estimates based on manpower trends; second, relating occupational requirements to a variable that can be independently estimated such as population or output.

A number of studies of future requirements for engineers have attempted to deal with particular facets of the problem outside of the general framework of the distribution of labour force by industries and occupations.[3] One of the problems with this approach to requirements is that it does not provide a framework for considering the long-term allocation of engineering manpower in terms of total manpower resources. The importance of integrating the manpower requirements for engineers

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2/ For a discussion of some of these methods, see: Organization for Economic Co-operation and Development, Forecasting Manpower Needs for the Age of Science, Paris, Organization for Economic Co-operation and Development, 1960, pp. 30-37. Also, H.S. Parnes, Forecasting Educational Needs for Economic and Social Development, Paris, Organization for Economic Co-operation and Development, 1962, pp. 17-36; Ozay Mehmet, Methods of Forecasting Manpower Requirements, Toronto, Ontario Department of Labour and the Centre for Industrial Relations, University of Toronto, 1965; R.K. Srivastava, Projecting Manpower Demand, A Review of Methodology, India, Ministry of Home Affairs, Directorate of Manpower, 1964.

3/ For example, see Blank and Stigler, op. cit.; Department of Labour, Economics and Research Branch, Skilled and Professional Manpower in Canada, 1945-1965, Ottawa, Royal Commission on Canada's Economic Prospects 1957.

and scientists into the framework of total labour force and productivity estimates in order to provide consistency with other projections has been noted by several authors.[4/]

Ideally the following information would be needed to provide a broad framework for projections of future employment of engineers:

1) projections of the level and distribution of aggregate demand by industry sector;

2) future production functions, i.e., the relation between future inputs and outputs in each industry;

3) future relative prices of different factors of production including engineering manpower.

Unfortunately data on 2) and 3) are not available.

This reduced the projection method to two options. First, an estimate may be made based on manpower trends consisting of projections for the future which are based on past trends in total employment by branch of industry which have been qualified for expected changes in the structure of production. Given projected output and productivity trends in the various industrial sectors of the economy, total manpower requirements can be calculated. Then a projection may be made of

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4/ See for example G. Bombach, "Comments On the Paper by Messrs. Tinbergen and Bos", Organization for Economic Co-operation and Development, Study Group in the Economics of Education, The Residual Factor and Economic Growth, Paris, O.E.C.D., 1964, pp. 174-179; H. Goldstein, "Methods of Forecasting the Demand for and Supply of Scientists and Engineers", Paris, O.E.E.C., 1958, STP(58)1, pp. 33-34 (mimeographed); U.S. National Science Foundation, Scientists, Engineers and Technicians in the 1960's Requirements and Supply, Washington, D.C., U.S. Government Printing Office, 1963, p. 5.

occupational composition by industry sector. The projection may be based either on past ratios of particular occupations to total employment or on current differences in manpower structure among different firms in the industry, for example, "progressive" versus "backward" firms may have different manpower structures.

Second, requirements may be related to an independently estimated variable.[5/] For some occupations such as physicians and teachers, it has been argued that they are "population related" in the sense that assuming certain standards of medical care and instruction as well as organizational structure and technology, future requirements can be set out.[6/]

The approach proposed in this study will incorporate elements of both of the above methods. First, a projection following Method No. 1 will be made. It was decided to employ a "requirements" approach as outlined in Chapter III. The occupational structure of the

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5/ For an example of a study which used this method among others, see: Stanislaw Judek, Medical Manpower in Canada, Ottawa, Royal Commission on Health Services, 1964.

6/ There may be exceptions to the predictability in the case of occupations such as teachers, especially in the short run when parameters, such as pupil-teacher ratios, may be quite flexible within limits. See, G. Bombach, "Comments on the Paper by Messrs. Tinbergen and Bos", in Organization for Economic Co-operation and Development, Study Group in the Economics of Education, The Residual Factor and Economic Growth, Paris, Organization for Economic Co-operation and Development, 1964, p. 173.

labour force, and by inference the number in any occupation such as engineering in relation to total labour force, is due to changes in the distribution of employment among and within different industries. This approach permits the long-term outlook for engineering occupations to be considered within the framework of the labour force by industries and occupations. Such a broad framework is available but only to 1970.[7/] It was therefore decided to make 1970 the terminal date for the requirements projections.[8/]

It will not be possible at this point to obtain detailed data by doing a thorough analysis of industry requirements at the level of the firm.[9/] Second, following Method No. 2, the occupational forecasts of certain types of engineering and scientific manpower, e.g., those with post-graduate training, will be done on the basis of industry

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7/ In N.M. Meltz, "Occupational Statistics for the Canadian Labour Force, 1931 to 1961 Together with Projections to 1970", a report prepared for the Department of Manpower and Immigration, 1966, to be published soon.

8/ Consideration was given to projecting requirements for engineers to 1976, in order to have a longer term comparison of supply and requirements. This was rejected on two grounds. First, no projection of total employment by industry to 1976 exists in which the industry sector is broken out in sufficient detail. Second, one of the purposes of the study is to test the usefulness of the methodological framework developed for the projections. This can be done just as well with 1970 as the terminal date, and once the data for 1975 and 1976 become available the projections can easily be extended.

9/ See U.S. Bureau of Labor Statistics, Scientists, Engineers and Technicians in the 1960's, Requirements and Supply, for an example of the limited use of this approach in order to validate and modify manpower projections by industry sectors.

sectors which will allow estimates to be made separately for "population-related" sectors such as education and government and "output-related" sectors such as private industry.

Estimates of the numbers of engineers needed to fill existing shortages will be included in the final estimate of future requirements.

Consideration was given to conducting a survey in which employers would be asked to estimate their future requirements for engineers. This approach was ruled out for the present study on three grounds. First, such a survey would go beyond the resources available for the study. Second, there are serious problems in obtaining unbiassed estimates of future requirements from employers. Experience indicates that employers' estimates are most useful when they are used in conjunction with an analytical approach in which projections are developed on an economy or industry-wide basis by studying factors affecting future demands.[10/] Third, some information on future requirements of employers for engineers and other high-level occupations is

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10/ D. Hartle, The Employment Forecast Survey, Canadian Studies in Economics No. 14, Toronto, University of Toronto Press, 1962, for an analysis of the employment forecast survey of the federal Department of Labour; a discussion of the experience of the United Kingdom and Sweden in surveys of employers' future requirements for engineers is contained in H. Goldstein, "Methods of Forecasting Demand for and Supply of Scientists and Engineers", Paris, cf. supra. He concludes that information from employers while useful must be carefully reviewed in conjunction with "analytical" or "global" methods.

available for all or part of the period 1961 to 1970.11/ The estimates developed by our "analytical" method can be cross-checked to some extent with these estimates derived from employers.

It must be stressed that any estimates of future needs at this stage will of necessity be tentative and subject to modification on the basis of additional research, which might be based on improved data at the macro level of the various broad industry sectors in the economy or on further information at the micro level of the individual firms.12/

11/ Department of Labour, Economics and Research Branch, Employment Outlook For Professional Personnel in Scientific and Technical Fields 1962-1964, Professional Manpower Report No. 13, December 1962. Employers made estimates of their requirements for engineers between 1962 and 1967. See also B.A. Keyes and H.H. Wright, Manpower Planning in Industry, A Case Study, Staff Study No. 18, Economic Council of Canada, Ottawa, August 1966. Employers were asked to give future requirements for post-graduates, first degree holders and technical institute graduates for the period 1965 to 1970.

12/ For an interesting treatment of the concept of manpower projections see W. Lee Hansen, "Labour Force and Occupational Projections", in Industrial Relations Research Association, Proceedings of the Eighteenth Annual Winter Meeting, New York, December 28-29, 1965, New York, Industrial Relations Research Association, 1966, pp. 12-20. He explains the necessity of obtaining information on "availables", i.e., supply in the sense used here along with information on "requirements". He feels however, that the ex post adjustments of supply, requirements and factor prices which are hard to predict make ex ante occupational projections of any kind particularly difficult.

The projections were made on the basis of some general assumptions:

1) that there will be no wars, catastrophes or serious economic recessions over the next 10 years;

2) that relatively high and stable levels of output and employment will be maintained, i.e., that the economy will move closer to the rate of growth needed to reach estimated potential by 1970 - an average percentage change in output of 5.5 per cent and of 3.0 per cent in employment and 3.0 per cent per man-hour;13/

3) that the scientific and technical advances experienced in recent years will be maintained and that research and development expenditures will continue to increase;

4) that there will be no abrupt structural changes in the economy;

5) that relationships between the salary levels of engineers and related occupations will continue to be substantially the same.

3. Projections of the Supply of Engineers, 1970 and 1976

a. Stock

The first step in projecting the supply or requirements of engineers is to establish the initial stock of engineers, scientists or other manpower in the base year. The stock in an occupation or field of specialization in turn depends upon the labour supply concept which is used. In the case of engineers and scientists, for example, the stock may be defined to include not only those who are occupationally employed as engineers or scientists, but also those who have

13/ B.J. Drabble, Potential Output, 1946 to 1970, Study No. 2 prepared for the Economic Council of Canada, Ottawa, 1964.

:en trained as such. The first concept would exclude those who are lucated but not employed in the occupations related to their education ad would include those who, while not formally educated as engineers r scientists, are employed in that capacity. The second concept would nclude all those who have been formally trained or who received profes-ional recognition as engineers or scientists. The stock and supply lata used for this projection will follow the former concept of :onsidering only those employed as engineers or scientists.

The most accurate way to arrive at a figure on the stock of engineers and scientists employed as such at a particular time is through a comprehensive survey of employers. No survey of employers in Canada has provided data on the total stock of those personnel.[14/]

It was felt that the best estimate of stock that could be made at this time was that based on the data from the Department of Labour Register of Scientific and Technical Personnel for those employed in scientific and technical fields. An allowance was made for a possible understatement of those without university degrees who are employed in engineering fields but who may not have been included in the register.

14/ The "Survey of Employment and Requirements, Engineering and Scientific Manpower", conducted by the Department of Labour, covers mainly those employers with a hundred employees and over with the exception of some consulting firms. See Department of Labour, Economics and Research Branch, Employment Outlook for Professional Personnel in Scientific and Technical Fields, 1962-1964, Professional Manpower Report No. 13, Ottawa, December 1962, pp. 1-2.

As Appendix V-A-1 indicates, depending upon the definition used, the stock of engineers in 1961 may range from a numerical total of about 30,000 to over 48,000. It is felt that estimates Nos. 1 and 2 are too low. Estimate No. 1 is low because many employers of engineers and scientists were excluded from this survey while estimate No. 2 excludes those who have no university degrees. Estimate No. 6, on the other hand, appears to be too high because it includes some who are not in the labour force. Estimates Nos. 3 and 5, while numerically close, are quite different in educational composition with almost 28 per cent of those in engineering or science holding university degrees compared with under 5 per cent of engineers and under 2 per cent of the scientists as indicated in the 1961 Survey of Scientific and Technical Personnel.[15/]

It was decided to base the stock estimate for engineers upon estimate No. 4 with an additional allowance of 8.6 per cent for those employed as engineers who have no university degrees, giving a stock figure of 41,100 for 1961.[16/]

15/ See Table II-36 above.

16/ The number of persons employed in engineering fields of employment specialization in 1961, 37,857, was estimated by adding to the number of engineers tabulated the number of late replies, those removed from the labour force, the "no replies" and the "moved" who were estimated to be in the labour force. The resulting number was multiplied by three since the survey covered a one-third portion of those in the register. An allowance of 8.6 per cent was made for those who were employed as engineers, but who were not in the register which increased the total to 41,100. The 8.6 per cent

b. Inflows

(i) Graduations in Engineering

The largest inflow component is graduation. It was estimated that for 1952 to 1961, engineering graduations comprised between 60 and 67 per cent of new engineering entrants.[17/] A good part of the burden of constructing a reliable inflow projection rests on the projection of engineering graduations. The number of engineering graduations in turn has been affected in the past by three main variables, total university enrolments, proportion at university who choose to enroll in engineering courses, and the proportion of those enrolled in engineering courses who graduate in engineering. The change in total enrolment in the past has been the factor most closely associated with long-term changes in engineering graduations and has accounted for 77 per cent of the net changes in engineering graduations between the years 1954 and 1964.[18/] However, variations in the proportion who choose to enroll in engineering and variations in the proportion who graduate have resulted

16/ (Cont'd.)
allowance was arrived at by the difference between those without university degrees as indicated in the 1961 Survey of Scientific and Technical Personnel, 4.7 per cent, and the percentage indicated by the 1962 Employment Outlook Survey of Employers. See Table II-36 above.

17/
See Table II-37 above.

18/
See Table II-14 above.

in a considerable degree of instability in the numbers of engineering graduates in recent years. Projections of engineering degrees to 1976 were developed in the following manner.[19]

The main source of data were first the various historical statistics on education prepared by the Dominion Bureau of Statistics for university enrolments and graduations. The estimates of engineering graduations were based partly on projections of bachelor and first professional degrees to 1976-77 by R.D. Mitchener.[20] These estimates in turn were based on the projections of university enrolments to 1976-77 which were made by E.F. Sheffield.[21] It was found that historically total bachelor and first professional degrees provided a better long-term basis for estimating engineering degrees than any other variable including total male university enrolments as well as first year enrolment in engineering. The latter, however, was used for the short-term period from 1966 to 1968.

The most difficult variable to estimate proved to be the proportion of students who were expected to enroll in engineering

19/ See Appendix 2 and Appendix Table V-A-2.

20/ R.D. Mitchener, First Degrees Awarded by Canadian Universities and Colleges, Projected to 1976-77, Ottawa, Canadian Universities Foundation, 1964.

21/ E.F. Sheffield, Enrolment to 1976-77 in Canadian Universities and Colleges, Ottawa, Canadian Universities Foundation, 1964.

courses. In the projections by Mitchener, the estimated percentage of students graduating in engineering courses for the period 1964 to 1977 was influenced largely by the decline in the graduations in engineering between 1958 and 1963. It is assumed that the percentage of all male (and total) graduates with engineering degrees will continue to decline. However, recent evidence on first-year enrolment in engineering indicates that this decline is "bottoming out" and that a levelling off or even an upturn in the percentage of males who will graduate with engineering degrees may be imminent. This assumption is reflected in the two alternative projections of engineering degrees made in this study. Projection A assumes that the proportion choosing engineering will remain at the point reached in the recent past, and the other projection, Projection B, assumes that there will be an upturn in the proportion after 1968.

Another assumption is that the proportion of women graduating in engineering will not change substantially. The total number of women graduates is expected to grow about one-third faster than the number of male graduates from 1963 to 1977.[22/] But since the proportion of female engineering graduates averaged only 0.2 per cent of all engineering graduates between 1961 and 1963, even a relatively large change in the proportion of females enrolling in engineering courses would have a

22/ R.D. Mitchener, op. cit., p. 12.

negligible effect on total engineering graduates. Therefore, total projected graduates in engineering have been related to total male graduates.

It was shown above[23/] that in the recent past, for example, for 1958-59 to 1962-63, the number of foreign students studying in Canada was approximately equal to the number of Canadians studying abroad. It will be assumed that the net effect of student migration on graduations in engineering will continue to be approximately zero.

It will also be assumed that the number of new graduates in non-engineering courses who enter engineering fields of employment from year to year will equal the number of engineering graduates who move into other scientific and technical fields.[24/] However, a "once-and-for-all" allowance of 15 per cent will be made for engineering graduates who do not enter engineering occupations.[25/] An allowance will also be made for the proportion of those in the total stock of engineers in 1961 who are assumed to transfer to other occupations. It was indicated above in the special study of register and Census data that many of those who entered engineering specializations subsequently moved to other occupations, in particular to managerial occupations.

23/ See Table II-17 above.

24/ See Table II-31 above.

25/ See Table II-37 above.

The final component affecting engineering graduations is the drop-out rate which has been relatively stable over the past 5 years at around 46 per cent of first-year enrolment in engineering courses and it was assumed that this would continue into the future. The year-by-year results of the projection of engineering graduations to 1976 are shown in Table V-1 and Figure V-1.

The two variants shown as Projections A and B suggest a rise in the annual number of engineering graduates between 1965 and 1976 from 2,256 to between 5,100 and 6,300. The percentage increase in engineering graduations is between 124 and 179 per cent or between 11.3 and 16.3 per cent per annum. Total graduations during this period of time range between 41,200 and 49,300. An estimate mid-way between the A and B Projections, Projection C gives a numerical increase in annual graduations from 2,256 to 5,700, a percentage increase of 152 per cent, or 13.8 per cent, per annum. The average or mid-point estimate is 45,200, an average of 4,100 engineering graduates per year between 1966 and 1976.[26/]

26/ See Appendix Table V-A-3 for an estimate of the number who will receive pure science degrees between 1956 and 1976.

Table V-1

Projections of Engineering Degrees to 1976

Academic Year Ended	(1) Total Male Bachelor and First Professional Degrees	(2) Engineering Degrees			(3) Engineering Total		
	Number		Number			Per Cent	
1946	5,992		1,006			16.8	
47	7,250		1,096			15.1	
48	10,574		1,690			16.0	
49	14,468		2,999			20.7	
1950	14,836		3,589			24.2	
51	12,554		2,425			19.3	
52	10,258		1,770			17.3	
53	9,637		1,337			13.9	
54	9,190		1,252			13.6	
55	9,886		1,337			13.5	
56	10,619		1,597			15.0	
57	11,324		1,741			15.4	
58	12,249		1,930			15.8	
59	12,992		2,057			15.8	
1960	13,963		2,171			15.5	
61	15,029		2,412			16.0	
62	16,782		2,437			14.5	
63	18,168		2,246			12.4	
64	20,716		2,422			11.7	
65	23,840		2,256			9.5	
66	24,600		2,400(e)				
67	27,700		2,700(e)				
68	31,000		2,800(e)				
		(A)	(B)	(C)	(A)	(B)	(C)
69	34,500	3,100	3,900	3,500			
1970	38,200	3,400	4,300	3,900			
71	41,600	3,700	4,700	4,200			
72	45,200	4,100	5,100	4,600			
73	48,500	4,400	5,400	4,900	9.0	11.2	10.1
74	51,400	4,600	5,800	5,200			
75	54,000	4,900	6,000	5,500			
76	56,200	5,100	6,300	5,700			
otal, 1966-76	452,900	41,200	49,400	45,400			
ercentage Change, 1965 to 1976	135.7	126.1	179.3	152.7			
verage Annual Percentage Change, 1965 to 1976	12.3	11.5	16.3	13.9			

e) = estimates based on first year enrolment, 1962-63 to 1964-65.

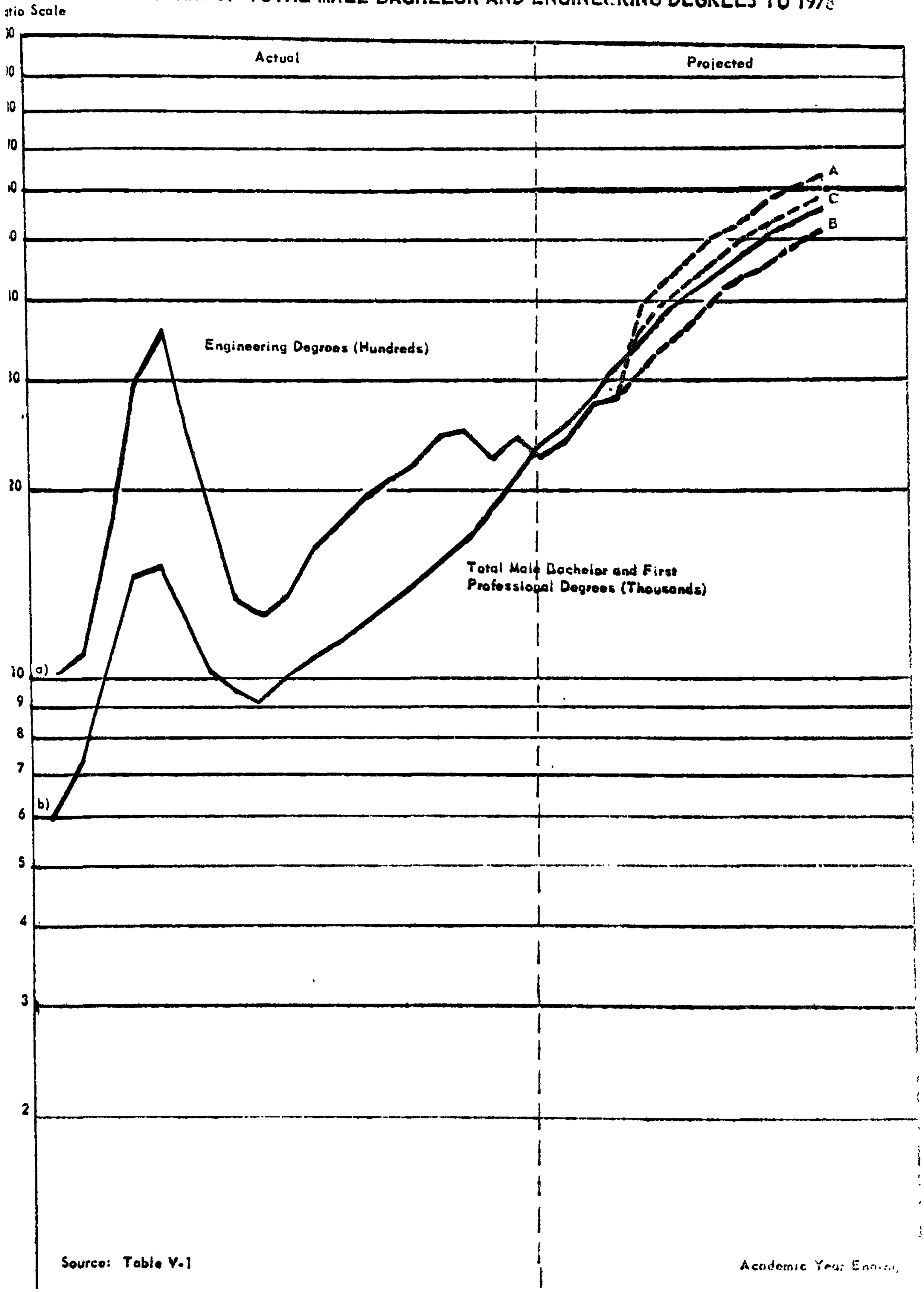
ources: Col. 1: 1946-65, DBS, Survey of Higher Education, various reports.
1966-76, R.D. Mitchener, First Degrees Awarded by Canadian Universities and Colleges Projected to 1976/77, Ottawa, Canadian University Foundation, 1964.

Col. 2: Col. (1) x Col. (3).

Col. 3: Variant A, based on engineers as a per cent of total male bachelor and first professional degrees, 1965. Estimate based on first year engineering enrolment, 1964-65 as per cent of total enrolment.
Variant B, calculated same as A, but based on 1963-65 experience.
Variant C, is an average of A and B.

Figure V-1

PROJECTION OF TOTAL MALE BACHELOR AND ENGINEERING DEGREES TO 1978



It is interesting to compare these graduation projections with those recently developed in the United States.[27] A decline in the proportion of engineering to total enrolment in recent years has also been experienced in the United States, and it is assumed that the decline there will level off between 1961-62 through 1968-69 to 1975. Historically, changes in total and engineering enrolment and degrees in Canada and the United States have tended to move in the same general direction even though the actual proportions may be somewhat different at any one time.[28]

(ii) Immigration and Emigration to the United States

The next major source of inflows is net immigration. The concept used here corresponds with the available data and refers to "recorded net migration", that is, the difference between gross immigration and gross emigration to the United States.[29]

27/ United States, Bureau of Labor Statistics, Scientists, Engineers and Technicians in the 1960's, Requirements and Supply, Washington, D.C., National Science Foundation, 1963, p. 21; United States, Department of Health, Education and Welfare, Office of Education, Earned Degrees by Field of Study and Level Projected to 1975, Washington, D.C., U.S. Government Printing Office, 1964, p. 5.

28/ See also U.S., National Science Foundation, Comparisons of Earned Degrees Awarded, 1901-1962 - with Projection to 2,000, Washington, D.C., National Science Foundation, 1964, pp. 8 and 9.

29/ See Chapter II above for a discussion of this point.

The historical record of emigration and immigration and net recorded immigration from 1950 to 1965 is given in Table V-A-4. The estimates of 125,000 annual immigration and 75,000 emigration with net immigration of 50,000 per year were based on the levels assumed in Staff Study No. 1, prepared for the Economic Council of Canada.[30/] It was decided to relate the projections of immigration and emigration of engineers to total immigration and emigration respectively rather than to net immigration since the ratio of engineers to total immigrants and emigrants respectively is rather different and this in turn can make a substantial difference in the projected number of engineers who are net immigrants. For example, from 1961 to 1965, engineers represented 1.3 per cent of all immigrants compared with 1.8 per cent of all emigrants to the United States.[31/]

The results of the projection given in Table V-2 are based on the respective percentages of engineers to total immigrants and

30/ Frank T. Denton, Yoshiko Kasahara and Sylvia Ostry, Population and Labour Force Projections to 1970, Staff Study No. 1 prepared for the Economic Council of Canada, Ottawa, December 1964, p. 5.

31/ Assuming a constant net immigration of 50,000 per annum and using the proportion of engineers to total immigration, the net immigration of engineers could range from 650 with immigration at 50,000 and emigration at zero to a loss of 100 engineers per annum with immigration of 200,000 per year and emigration of 150,000. Thus, the proportion of immigration to emigration itself can have a substantial influence on the net immigration of engineers.

[illegible]
Projected to 1976

Immigrants to Canada 1952-65

Period[1]	Total Immigrants	Destined to Labour Force	Professional and Technical Workers	Engineering	Professional	Engineering	Professional	Engineering	Engineering
					Total	Total	Total Labour Force	Total Labour Force	Professional
	No.	No.	No.	No.	%	%	%	%	%
1952-56	762,396	409,564	40,640	8,126	5.33	1.07	9.92	1.98	20.00
1957-61	689,743	356,522	44,672	6,167	6.48	0.89	12.53	1.73	13.81
1962-66	552,101	275,499[2]	59,852	7,520	10.84	1.36	21.72	2.73	12.56
1967-71	625,000	-	-	8,125	-	1.30	-	-	-
1972-76	625,000	-	-	8,125	-	1.30	-	-	-

Emigrants from Canada to the United States by Major Occupational Groups, 1952-65

Period[3]	Total Emigrants	Destined to Labour Force	Professional and Technical Workers	Engineering	Professional	Engineering	Professional	Engineering	Engineering
					Total	Total	Total Labour Force	Total Labour Force	Professional
	No.	No.	No.	No.	%	%	%	%	%
[illegible]	187,8[illegible]6	95,131	20,117	3,129	10.71	1.67	21.15	3.29	15.55
[illegible]	221,0[illegible]	116,075	27,500	4,986	12.44	2.26	23.69	4.30	18.13
[illegible]	274,135	139,669[2]	33,112	4,841	12.08	1.77	23.71	3.47	14.62
19[illegible]-71	375,000	-	-	6,750	-	1.80	-	-	-
19[illegible]-7[illegible]	375,000	-	-	6,750	-	1.80	-	-	-

Net Migration,[4] 1952-65

Period	Total Net Migration	Destined to Labour Force	Professional and Technical Workers	Engineering	Professional / Total	Engineering / Total	Professional / Total Labour Force	Engineering / Total Labour Force	Engineering / Professional
	No.	No.	No.	No.	%	%	%	%	%
1952-56	574,498	314,4[illegible]	20,523	4,997	3.57	0.87	6.53	1.59	24.35
1957-61	458,713	240,447	17,172	1,181	3.66	0.25	7.14	0.49	6.88
1962-66	277,966	135,830	26,740	2,679	9.62	0.96	19.69	1.97	10.02
1967-71	250,000	-	-	1,375	-	0.55	-	-	-
1972-76	250,000	-	-	1,375	-	0.55	-	-	-

Sources: 1/ 1952-[illegible] - Department of Labour, Economics and Research Branch, Professional Manpower Report No. 11, The Migration of Professional Workers Into and Out of Canada, 1946-60, page 9; Immigration to Canada by Intended Occupation and Province of Destination, calendar years 1940-55, inclusive; Department of Citizenship and Immigration, Immigration 1961, 1962, 1963, 1964 and 19[illegible]5.

1966-[illegible] - Projection A is based on engineers as a per cent of total immigrants during 1953-65. Projection B is based o[illegible] the 1961-65 period.

2/ [illegible] to labour force for 19[illegible] was estimated as 50 per cent of immigrants and 51 per cent of emigrants, based on the average fr[illegible].

3/ 195[illegible] - Emigration compiled from special tabulations prepared by the Immigration and Naturalization Service, U.S. Department of Justice. The [illegible] six months of 1965 were based on an estimate by the author.

1[illegible] - Projection A is based on the 1953-65 period and Projection B on the 1961-65 period. Only one variant is shown for professionals, [illegible] both base periods gave nearly identical results.

4/ Immigra[illegible] emigration.

total emigrants in the 1961-65 period, assuming that the net immigration level will continue beyond 1970 up to 1976.[32/] From 1966 to 1976, projected immigration of engineers is 1,625 per annum, emigration is 1,350 per annum leaving net immigration of 275 per annum which compared with engineering graduations (Projection C) of 4,500 per annum. Projected net immigration of engineers for 1966 to 1975 is 6.1 per cent of projected graduations plus net immigration compared with a similar proportion of 37 per cent between 1951 and 1955, 19 per cent between 1956 and 1960 and 15 per cent between 1961 to 1965.[33/] The decline in net immigrants as a proportion of total supply suggests a continuation of the long-term trend of the past 15 years and implies that total projected supply will in the future exhibit greater sensitivity to changes in engineering enrolments and graduations.

(iii) Other University Graduates

It has been assumed[34/] that the number of scientific and technical graduates who enter engineering and the number of engineering

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32/ A. Stukel, "Population Projections, Canada, 1961-1991", Appendix E in T.M. Brown, Canadian Economic Growth, a study prepared for the Royal Commission on Health Services 1964, p. 379. The population estimates used by the Royal Commission on Health Services were based on an assumed net immigration of 50,000 per annum.

33/ Table II-18 and Table V-A-6.

34/ Table II-32 above.

graduates who enter other scientific and technical fields is approximately in balance and so this source of engineering supply is not included.

(iv) Non-Graduates Who Enter Engineering

An analysis of this source of supply was made in Chapter II and it was estimated that upgradings of non-university graduates to engineering occupational status amounted to 15 per cent of university graduates.[35/] It was assumed that this source of supply would continue but at a lower rate beyond 1971.

c. Outflows

Outflows or withdrawals from the supply of engineering manpower consist of deaths, retirements, emigration and engineering graduates who transfer to other fields. Allowances have been made for transfers between fields and for those who do not enter engineering occupations. No adequate basis exists for making estimates of emigrants in engineering occupations to countries other than the United States nor of former emigrants who return home to Canada from other countries, especially the United States. These flows in any case are in opposite directions and would tend to cancel out to some extent. Net recorded migration was treated above under the "inflow" sector. This leaves

35/ Table II-37 above.

deaths and retirements as the only remaining sources of withdrawals that shall be considered. These have been calculated for the initial stock, graduations, and net migrants for the period 1956 to 1976.[36/]

d. Projection of the Stock of Engineering Manpower, 1961-76

The results of the above analysis of the elements which constitute or affect the supply of engineering manpower have been brought together in Table V-3 which outlines the projected stock of engineering manpower by source of supply for 1966-71 and 1976. The implications of the projections are a rise in the stock of engineering manpower from 41,000 to 85,000 from 1962 to 1976. The growth rate will average about 5.2 per cent per annum from 1962 to 1966, 5.1 per cent per annum from 1967 to 1971 and 6.1 per cent from 1972 to 1976. The rapid rise in the rate of increase from 1972-76 reflects the sustained growth in engineering graduations projected for this period. This is also reflected in the projected increase in graduations as a proportion of total new supply from 71 per cent during 1961-66 to 86 per cent for 1972-76.

It is interesting to compare the pattern of graduates in relation to initial stock for the 1960's with the pattern during the 1950's. During the decade of the 1950's, the 12,400 engineering

36/ Appendix 3 for a discussion of the calculations of deaths and retirements and also Appendix Table V-A-5.

Table V-3

Projected Supply of Engineers, 1961-1976

	1	2	3	4	5	6
			Source of Supply			
Year	Number of Engineers	Attrition	Graduations	Net Immigrants	Upgradings	Total Supply
961..	41,000	-	-	-	-	-
962..	42,800	1,021	2,437	87	300	2,824
963..	44,700	997	2,246	364	300	2,910
964..	47,100	1,028	2,422	655	300	3,377
965..	49,900	1,008	2,256	1,298	300	3,854
966..	51,900	1,035	2,400	275	300	2,975
967..	54,000	1,094	2,700	275	287	3,262
968..	56,200	1,149	2,800	275	287	3,262
969..	59,000	1,294	3,500	275	287	4,062
970..	66,100	1,394	3,900	275	287	4,462
1971..	65,400	1,479	4,200	275	287	4,762
972..	69,100	1,580	4,600	275	436	5,311
973..	72,900	1,765	4,900	275	436	5,611
974..	76,900	1,950	5,200	275	436	5,911
975..	81,000	2,135	5,500	275	436	6,211
976..	85,100	2,305	5,700	275	436	6,411

Sources:

Cols. 2 and 5: Table II-36 and V-A-5.

Col. 3 : Table V-1.

Col. 4 : Table V-A-4.

graduates who were estimated to have entered engineering occupations represented 41 per cent of the initial stock of 29,960 engineers.37/ The projected graduation for the 1960's of 21,100 38/ would represent 51 per cent of an initial stock of 41,000.39/ This difference reflects the decline in total university enrolment during the 1950's in contrast to the rising university enrolment in the 1960's. The numerical effects of the decline in engineering graduations as a proportion of total male enrolment in the 1960's upon the supply of engineers will probably be offset by the large rise in total university enrolment including male enrolment in the 1960's and early 1970's.

Apart from net immigration and upgradings, the accuracy of the projection depends to a large extent upon the assumption of a levelling off in the percentage of male university students who will receive engineering degrees. If the proportion continues to decline then an adjustment in the projection would, of course, be required.40/

37/ Table II-37 above.

38/ Using an estimate of 25 per cent non-entrants into engineering occupations to keep it comparable with the earlier estimate in Table II-37.

39/ Table V-3 above.

40/ For a comparison of the results of an earlier projection with actual results, see a summary of the results of the projection of the supply of engineers which was done 10 years ago for the Royal Commission on Canada's Economic Prospects. Table V-A-6 below.

Projected "net immigration" is a long-run estimate based on a study done by Kasahara for the Economic Council of Canada. (See Appendix 3, below.) The annual short-run deviations may be large. In 1965, "net immigration" was high owing to a sharp rise in total immigration combined with a rise in the proportion of immigrants who were engineers.

4. Projections of Requirements For Engineers, 1970

Once the current stock of engineers is established, the next step in projecting future requirements is to estimate the future growth of engineering employment or labour force. The addition of the net increase in employment plus estimates of existing shortages if any, is equal to total future requirements.

a. Trend Projection of Future Requirements for Engineers

The trend in the proportion of engineers to total labour force as indicated in Census data was examined between 1931 and 1961 to see if this provided an adequate basis for a projection. The ratio of engineers to total employment as noted in Chapter III exhibited a considerable degree of stability intercensally but the closet relationship in the ratios was between the 1951 and 1961 Censuses. Also in view of the economic changes such as depression and war which occurred in the 1931-1951 period, it was felt that the last 10 years would provide the best basis for a projection based on Census data.

The next question was the reliability of Census data as a basis for ratios of engineering to total labour force. Some data are available on the distribution of engineers by industries in 1961, 1962 and 1965 from three other sources, the Department of Labour Survey of Scientific and Technical Personnel for 1961, the Department of Labour Survey of Employment and Requirements for Engineering and Scientific Manpower 1962, and the Department of Labour Annual Survey of Wage and Salary Rates, 1965. A comparison of unpublished data from these sources in relation to the 1961 Census revealed for example, that the proportion of engineers (not including surveyors) in manufacturing was 40.6 per cent in the 1961 Census, 37.9 per cent in the 1961 Survey of Scientific and Technical Personnel, 45.2 per cent for the Requirements Survey and 47.0 per cent for the Wage Rate Survey. Allowing for the fact that the latter two surveys do not cover very small establishments while the Survey of Scientific and Technical Personnel is based on a survey of individuals, it would seem that the most relevant comparison is probably between the latter survey and the 1961 Census. The distribution of engineers by industry in the Census seems to be reasonably representative of the real situation.[41/]

41/ The data from the 1961 Census were obtained from the Dominion Bureau of Statistics, Census of Canada, 1961, Vol. III, Part 2, Table 15. Special unpublished tabulations based on the returns to the Survey of Scientific and Technical Personnel 1961 were obtained by the author. The data for the Requirements Survey was taken from the Department of Labour, Economics and Research Branch, Employment Outlook for Professional Personnel in Scientific and Technical Fields, 1962-1964, cf. supra, p. 5. The data for the Wage Rate Survey were obtained from a special tabulation supplied to the author by the Economics and Research Branch, Department of Labour.

One explanation is that the proportion of engineers in the "community service" sector (Table V-4 below), 0.4 per cent of the labour force of the sector in 1961, would be closer to 1.6 per cent of the sector labour force if university engineering teachers were included. However, these are excluded from engineering occupations according to the occupational definition used in the 1961 Census. The overall effect of their inclusion in estimates of the requirements for engineers would be small because in 1961 only 2.6 per cent of those trained in engineering were in universities.[42/] To keep the supply and requirements estimates consistent, an allowance is made on the supply side for those who do not enter engineering occupations such as teachers and managers. That is, they are not included as part of "supply". Therefore those not in engineering occupations are excluded from both the supply and requirements side in the estimates that follow.

A further problem relates to the level of detail available on the distribution of engineers by industry in 1970. It was observed in Chapter III, Table III-A-2 that the finer the breakdown of the

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42/ Department of Labour, Economics and Research Branch, Engineering and Scientific Manpower Resources in Canada, Their Employment, Earnings and Salary Rates, 1960-61, Professional Manpower Report No. 10, June 1961, p. 17.

distribution of engineers by industry, the greater the observed impact of changing industrial employment structure on the proportion of engineers in relation to total labour force.[43/] However, it may be observed that the more aggregative ratios of engineers to total labour force that are used here do reflect the influence of these factors. And it was also noted that the influence on engineering employment of the changing structure of employment by industry tended to decrease markedly between 1951 and 1961 compared with 1931 and 1951. It may be supposed that this factor will continue to operate in the 1960's. It is not possible a priori to estimate how a more detailed industry breakdown would affect the projections except to say that it would make possible a more detailed check of the outlook in each industry in relation to the projection for that industry.

The projections of the number of engineers by industry sectors to 1970 is given in Table V-4. It is based in turn on a projection of

43/ Between 1951 and 1961 for all engineers minus surveyors for example, the changing industrial distribution of the labour force accounted for 3.9 per cent of the increase in the numbers of engineers when industry major groups were used compared with 19.1 per cent when the calculations were done by taking the detailed industry sectors within manufacturing and service. The effect of such changes in the employment structure within the industry groups between 1961 and 1970 upon projected requirements for engineers would naturally depend upon the direction and degree of such changes.

Table V-4

Projection of Requirements for Engineers,[1] by Industry, 1961-1970

All Sectors	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
1. Agriculture......................	19	14	10	5	1	-	-	-	-	-
2. Forestry, Fishing, Trapping.....	402	390	379	368	356	345	334	322	311	300
3. Mining, Quarrying...............	2,422	2,323	2,224	2,125	2,026	1,928	1,829	1,730	1,631	1,532
4. Manufacturing...................	17,456	18,719	19,982	21,245	22,508	23,772	25,035	26,298	27,561	28,825
5. Construction....................	3,273	3,321	3,371	3,421	3,471	3,521	3,570	3,620	3,670	3,722
6. Transportation, Storage, Comm...	3,323	3,484	3,645	3,806	3,968	4,129	4,290	4,452	4,613	4,775
7. Electric, Gas, Water............	2,576	2,824	3,070	3,321	3,570	3,819	4,067	4,316	4,564	4,814
8. Trade...........................	1,960	1,942	1,924	1,906	1,888	1,871	1,853	1,835	1,817	1,799
9. Finance.........................	257	278	300	321	343	364	386	407	429	451
10. Community Service...............	283	285	288	290	293	295	298	300	303	306
11. Business Service................	5,870	6,373	6,876	7,379	7,882	8,385	8,888	9,391	9,894	10,397
12. Government Service..............	4,859	5,094	5,329	5,565	5,800	6,036	6,271	6,506	6,742	6,978
13. Recreation Service..............	22	21	20	20	19	19	18	18	17	17
14. Personal Service................	36	38	41	44	47	49	52	55	58	61
Total............................	42,758	45,115	47,473	49,830	52,188	54,546	56,903	59,261	61,618	63,977

[1] Not including Surveyors.

Source: Tables V-A-7 and 8. The years 1962-1969 were calculated by interpolation.

the 1951-61 trend in the proportion of engineers to all occupations by industry in Table V-A-7. These data are compared with those in Table V-A-8 which were based on a study by Meltz for the Department of Manpower and Immigration.[44/]

Since the projections by Meltz were of employment by industry, an adjustment was necessary in order to convert these into estimates of the labour force in order to make them consistent with historical trends which were based on labour force data. This adjustment was done by pro-rating the assumed unemployment of 3 per cent of the labour force by industry sector on the basis of employment distribution for 1970 as estimated by Meltz.[45/] The labour force for the years from 1961 to 1970 was simply interpolated.

The data on the earlier projections of supply are brought together with the projected requirements in Table V-5. An allowance for the 6 per cent vacancy rate which was estimated by employers of engineers for 1962 was added to the estimated requirements for 1970. The net result is an estimated gap between supply and requirements - a shortfall - of 2,350 engineers in 1970.

44/ N.M. Meltz, "Occupational Structure for the Canadian Labour Force, 1931 to 1961, together with Projections to 1970", cf. supra.

45/ Unemployment for the target year 1970 was set at 3 per cent by the Economic Council of Canada, Towards Sustained and Balanced Economic Growth, Second Annual Review, Ottawa, Queen's Printer, 1965, p. 7.

Table V-5

Estimates of Supply and Requirements
for Engineers, 1970

	1961	1970
	No.	No.
Supply[1/]	41,000	62,400
Requirements[2/]	41,000	62,250
Unfilled Vacancies[3/]	2,500	2,500
Total Requirements.......	43,500	64,750
Estimated Shortfall......	2,500	2,350

1/ Based on Table V-3, with an interpolation for 1970.

2/ Based on Table V-4. The 1961 estimate of stock of 42,758 was reduced by 1,750 to match 1961 estimate of supply, and this adjustment was also made in 1970. This means that the 1961 supply and requirements (less vacancies) estimates begin from a common base.

3/ Based on a vacancy rate of 6 per cent in 1962. See Department of Labour, Economics and Research Branch, Employment Outlook for Professional Personnel in Scientific and Technical Fields, 1962-1964, Professional Manpower Report No. 13, December 1962, p. 8.

In evaluating the significance of this projection it is necessary to emphasize that such a difference between supply and requirements will call for some adjustment of supply in relation to requirements. A variety of adjustments are possible, for example, a substitution of another type of manpower for engineers, assuming the supply of such manpower is available. The projected gap is a small one, and in view of the assumptions upon which the analysis rests, represents approximate balance. A small increase in relative salaries of engineers, for example, might reduce the vacancy rate or increase the supply (via inter-occupational mobility) and convert the shortage into a surplus.

The possibility of manpower substitution in the case of engineers will now be examined.

b. Possible Substitutions of Other Types of Manpower for Engineers

It was observed in Chapter III that between 1931 and 1961 about 40 per cent of the increase in the number of engineers arose from an increasingly intensive employment of engineers in various industries. Furthermore, the ratio of engineers to total labour force has risen at different rates in various industries and has been most rapid in those industries where the ratio was already high in 1931. This is similar to experience in the United States.[46/]

46/ For the U.S. between 1930 and 1950, Blank and Stigler found that about 38 per cent of the relative growth of engineers and chemists was explained by the growth in the industries employing many engineers and chemists. For Canada the relative growth for engineers

Blank and Stigler have suggested two possible explanations, one supply-related and the other demand-related for the relative rise in the demand for engineers. On the supply side the relative earnings of engineers have fallen relatively to all occupations including the less skilled. This has undoubtedly encouraged employers to substitute the relatively cheaper labour of engineers for the relatively more expensive labour with less qualifications. On the demand side, changes in the technology of production have increased the relative demand for those with a high-level of technical education.

It is also suggested that the substitution of high-trained for other personnel has occurred by direct and also by indirect substitution. Direct substitution would involve the transfer of tasks requiring a high degree of technical knowledge from supervisors and highly skilled workers to engineers. Indirect substitution, which Blank and Stigler suggest is probably more important, would occur when

46/ (Cont'd.)
between 1931 and 1951 which is explained by the growth of industries employing many engineers (see above, this chapter) amounted to about 70 per cent. This is calculated by taking the percentage of the total growth due to industry distribution of employment - 50 per cent - as a proportion of the growth due to both industry distribution of employment and changes in the occupational composition, within particular industries which total 71 per cent. Changes in the industrial structure were a much more important element in the growth of engineering employment in Canada than in the United States during the 1930's and the 1940's. From 1951-61 the increase in relative growth not explained by changes in industrial structure of employment, increased to 64 per cent in the case of Canada compared with 62 per cent for the United States for the period 1930-50. For the U.S. data see Blank and Stigler, op. cit., p. 55.

capital is substituted for unskilled labour, for example, and engineers or other highly trained personnel are hired to operate and especially to maintain it.[47/]

There is some evidence that both types of substitution have also been occurring in Canada. The long-term trend in the earnings of engineers has been in the same direction as in the United States at least for the 1930's and 1940's. The strong tendency for engineers to move into managerial occupations, i.e., "direct" substitution was observed in Chapter II. Evidence of "indirect" substitution was found in a recent study by the Economic Council of Canada. A survey of 17 large and medium-sized companies employing a total of over 350,000 for representing manufacturing, transportation and communication, distribution and banking, indicated that anticipated requirements between 1965 and 1970 for persons with increasingly higher educational requirements was necessary in order to operate and maintain more sophisticated and expensive equipment.[48/]

The effect of technical and scientific progress upon the demand for persons with scientific and technical training has been widely observed. It is commonplace to say that scientific and technical

47/ David M. Blank and George J. Stigler, op. cit., pp. 62-63.

48/ B.A. Keyes and H.H. Wright, op. cit., p. 17.

knowledge is growing and is making production methods more complex and therefore raising demand for engineers and scientists. One is on much less certain ground in attempting to translate these technological considerations into the requirements for engineers where economic considerations also enter the picture. In assessing the future requirements for engineers it is necessary to consider not only the growth and increasing complexity of technology but also economic considerations which may result in the substitution of engineers for those in other occupations and vice versa. In the study by Keyes and Wright, employers forecasted an increase of about 20 per cent in the requirements for technical and scientific university graduates compared with an increase of 80 per cent in the requirements for graduates from institutions of technology.[49/] To the extent that technical institute graduates are substitutable for some taska done by engineers, the projected requirements suggest that potentially any shortfall of engineering graduates in relation to total requirements in the latter part of the 1960's could be overcome by a greater utilization of technicians providing the supply of the latter is forthcoming. The large recent expansion in the capacity of technical institutes and enrolments suggests that this could very well occur. Consequently in view of this, a relatively small imbalance between projected supply and requirements may be viewed without alarm. The means for a solution to the shortage by means of increasing substitution will exist.

49/ B.A. Keyes and H.H. Wright, op. cit., p. 8.

c. Analysis of Future Supply and Requirements for Engineers with Post-Graduate Degrees

The Keyes and Wright study showed that the anticipated requirements for technical and scientific university graduates with post-graduate degrees were expected to rise by 50 per cent between 1965 and 1970 compared with a 20 per cent rise for technical and scientific university graduates with first degrees only. To the extent that the results of this case study have general validity, in view of the rapidly rising number of graduates with masters and doctors degrees in engineering it augurs well for the ability of Canadian industry to absorb the increased number of post-graduates in engineering. It would be desirable to have a projection of total post-graduate degrees to which projected engineering post-graduate degrees could be related. This projection is not available. In addition, further analysis would be needed to determine the requirements by major economic sectors such as universities, and governments for those with post-graduate degrees in engineering.

A highly tentative projection of future supply and requirements for engineers with post-graduate degrees between 1965 and 1970 is made in Table V-6. This projection is made on the basis of three key assumptions. The first assumption is that the proportion of the stock of engineers with post-graduate degrees is the same in 1965 as

Table V-6

A Tentative Projection of the Supply of and Requirements for Engineers with Post-Graduate Degrees, 1965 to 1970

	1965	1970
Supply........	5,200 1/	8,200 2/
Requirements..	5,200 1/	7,800 3/

1/ Based on 10 per cent of estimated stock of 52,200 engineers in 1965, in Table V-4.

2/ Assuming that engineers who receive post-graduate degrees as a proportion of first-degree engineers will rise from 17 to 24.5 per cent between 1965 and 1970. Based on the proportion of foreign born engineers with post-graduate degrees, 16 per cent, (see Table 11-30) an allowance of 44 per year is made for net migration (see Table V-A-4). Attrition is estimated at 0.8 per cent per annum. (See Table V-A-5.)

3/ Based on an increment of 50 per cent in 1965 stock. See Table V-4 and B.A. Keys and H.H. Wright, op.cit., p. 11.

it was in 1961.[50/] This has the effect of providing a minimum estimate of future requirements, since the numerical change in requirements to 1970 was based on a per cent estimated change in employers' requirements which was applied to the 1965 stock data. The second assumption is that the proportion of engineering graduates who receive post-graduate degrees will continue to increase at the same rate as it has in the recent past.[51/] The third assumption is that the requirements for engineers and scientists with post-graduate degrees as indicated in the Keyes and Wright study is representative of post-graduate engineers in all economic sectors as a group.[52/]

50/ The stock of engineers with post-graduate degrees for 1961 was about 10 per cent of all engineers. See Department of Labour, Economics and Research Branch, Employment and Earnings in the Scientific and Technical Professions 1958-1961, Professional Manpower Report No. 12, p. 10.

51/ Engineers who received master's and doctor's degrees as a proportion of those receiving bachelor's degrees rose from 7.1 per cent in 1958 to 14.0 per cent in 1963. It is estimated that this per cent will rise at a rate of 1.5 per cent per year to about 17 per cent in 1965 and to 24.5 per cent in 1970. See Dominion Bureau of Statistics, Survey of Higher Education, various issues. In the U.S. it is estimated that engineering graduates with master's and doctor's degrees will rise from 22.5 per cent of bachelor degree receivers in 1955 to 37.1 per cent in 1965 and to 43.1 per cent in 1970. See U.S. Department of Health, Education and Welfare, Earned Degrees by Field of Study and Level Projected to 1975, Bulletin OE-54031 No. 31. Washington, D.C., U.S. Government Printing Office, 1964, p. 8.

52/ Employers anticipate an increase in technical and scientific university post-graduates of 50 per cent in 1970 over 1965, and an increase of 23.4 per cent in technical and scientific university graduates without post-graduate degrees. Incidentally, our projected requirement for engineers as outlined above was just under 23 per cent between 1965 and 1970, 64,000 in 1970 compared with 52,000 in 1965. B.A. Keyes and H.H. Wright, op. cit., pp. 8-11.

The trend outlined in Table V-6 suggested that a considerable amount of upgrading of the educational level of the labour force would occur over the next 5 years, provided that post-graduate engineering education at universities continues to expand at a rapid rate. The chief source of the increased supply must be domestic rather than imported if the assumptions made earlier are correct. The outlook for requirements for engineers with post-graduate degrees during the last half of the decade appears to be good. It is also interesting to note that the projected expansion in the anticipated requirements of employers for graduates of technical institutions in 1970 over 1965 is almost 85 per cent.[53/] The anticipated demand for those trained in science and engineering fields appears to be strongest at either end of the post-secondary educational spectrum. The relatively lower projected requirements for engineers with bachelor level degrees may reflect a changing structure of requirements for engineers, with a splitting off of certain traditional engineering tasks to technicians and a more rapid growth in the demand for engineers with highly specialized training. If this is so it could have important implications for the future requirements and training of first degree engineers.

However this analysis is suggestive rather than conclusive and illustrates the need for more specific information on the three key assumptions made as a basis for the projections.

53/ B.A. Keyes and H.H. Wright, *op. cit.*, p. 8.

5. Conclusion

The results of the analysis of supply and requirements projections for all engineers were brought together for 1970. The projections indicate that the supply and requirements will be close to balance in 1970 with a slight overall shortfall of supply in relation to requirements. The gap will be of a size and nature which can probably be filled by a slight adaptation on the supply or requirement side. This might be done for example by a substitution of technicians or scientists for engineers. The match of supply and requirements arises out of the double effect of two factors, first, a moderate increase in requirements for engineers plus a relatively slower increase in supply both from domestically produced engineering graduates and from net migration.

In the case of the more highly qualified engineers the available information suggests that the rapid increase in requirements could well be matched by a rapid rise in the supply of domestically produced graduates. However, the matching of supply and requirements will require a large and continuous expansion of the number of engineers who continue to the post-graduate level of education.

The change in the structure of demand for engineers including those such as technicians who are partly substitutable for engineers is being paralleled by a gradual change in the composition of those trained for scientific and technical occupations. The trends appear to be moving in the same direction. The responsiveness of the educational system to market demand and vice versa suggests that the immediate future problem may be partly one of re-structuring the educational supply side and partly one of ensuring that the linkage mechanisms which connect the manpower requirements to the educational supply side as well as the allocative mechanisms in the market for scientific and technical manpower itself are working flexibly.

However, there is a need for additional longer term information on future supply and requirements, on the future labour force and Gross National Product. In addition more information on future graduates is required. Additional data on the quantitative and qualitative requirements of firms for high-level manpower is needed at a less aggregative level in order to check these projections.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The aim of the study was to examine the short-term and long-term trends in the supply of and demand for engineering and scientific manpower in Canada with a view to designing better projections of supply and requirements and to help formulate more appropriate education, migration and labour market policies.

It was hypothesized that since the most important determinants of supply and requirements are different, a more precise analysis of their components would provide a better understanding of the underlying economic and social factors such as the social demand for education and the changing economic structure.

The approach differs from the Blank and Stigler study of past and current supply and demand by attempting to use the analysis of past and current trends in order to make projections. It differs from the earlier study of the Department of Labour for the Royal Commission of Canada's Economic Prospects by attempting to examine future supply and requirements in a broader framework of the future distribution of industry by occupations.

The long-term trends in both economic and social demand for education appear to suggest the need for broader and deeper foundations in science and engineering education, for example, more science-based courses in engineering, and a greater amount of post-graduate training in engineering as well as in science. In addition, at the sub-professional level of technical education, both supply and requirements are rapidly rising. Educational planning by universities of the balance of engineering and science courses as well as the curriculum content of these courses should take these trends into account.

Moreover in the short-run, the greatest contribution that the educational system can make in facilitating the adjustment of supply and requirements is to provide the type of education that will assist adjustment to different fields and occupations throughout a career.

In the past, international migration has made a net contribution to the pool of scientific and technical manpower in Canada but this source will probably become relatively less important in the future. The reasons are two-fold, first, the expected rapid rise in engineering and science graduates in the future combined with a less rapid growth or even levelling off in the rate of net immigration.

Since a high proportion of those who leave Canada have post-graduate education, attention must be paid to the best balance of the supply of such highly qualified persons especially new graduates and the requirements for them which arise mainly from research, development and teaching in industry, government and universities. It may be that the emigration of Canadian-born with post-graduate education is associated with a lack of suitable employment opportunities in Canada.

The market for engineers appears to interact strongly with the international market, particularly with the United States manpower market.

The long and short-run sensitivity of the supply of engineering manpower to changes in its composition indicates that a careful assessment of inter-occupational and geographic mobility is necessary for accurate estimates of supply to be made.

The long-run requirements for engineers between 1931 and 1961 were related to the growth of industries which employed engineers and to the changing utilization of engineers within particular industries. A rather sharp rise in the utilization of engineers occurred between 1951 and 1961. There appears to be an association between capital investment and the utilization of engineers which suggests that such highly qualified manpower is a joint input along with capital investment in the productive process. This phenomenon appears to have a number of determinants but additional study is needed in order to assess the nature of the complex technical and economic factors that may be involved.

The growing supply of graduates from Canadian universities expected in the future is the main long-run source of future supply. But this source of supply tends to be somewhat inelastic in the short-run. Moreover, although in an aggregative way the market for scientific and technical personnel appears to work quite well, it does reflect a certain lack of homogeneity in the broad supply and requirements categories which is indicated by different earnings trends in various fields of specialization, geographical areas or levels of education. "Demand-side" adjustments, e.g., changes in utilization patterns involving the use of more technicians, have been important in short-run adjustments of supply and requirements.

The operation of the labour market for scientific and technical personnel during the 1950's suggests that an equilibrium of supply and requirements was achieved by means of changes and in utilization patterns. More engineers and scientists with post-graduate degrees and at the other end of the education scale a greater proportion of engineers and technicians without university degrees were employed.

It is important to distinguish between short-run and long-run imbalances between supply and requirements. The inelasticity of supply and the elasticity of requirements in the short run may create a shortage situation as occurred in the mid 1950's. At the same time, long-run trends seem to indicate a greater demand for engineers who possess higher levels of education and also for technical support staff such as technicians. In the early 1960's the market signalled an increasing "shortage" of engineers. But the increased supply of scientists and technicians, who are to some degree suitable substitutes for engineers, helped to ease the shortage. This contrasts with the mid-1950's when no comparable increase in supply accompanied the rising demand and the result was an acute shortage.

The projections indicate that supply and requirements will be approximately in balance in 1970. However, there will be increasing requirements for a larger proportion of engineers with post-graduate education as well as for graduates of technical institutes at the post-secondary level. This re-structuring of requirements as well as supply means that optimum utilization will require a labour market which operates with increasing effectiveness.

A number of education, migration and labour market policy implications emerge from the analysis. These must be stated tentatively, subject to the constraints of the data and assumptions used and to the nature of the partial equilibrium approach used in the study.

The complexity of the supply and the pervasiveness of substitution and mobility of various types indicate that the concept of the supply and utilization of engineers' and scientists' services is more appropriate than any single supply component such as graduates or highly qualified immigrants. The increased utilization of post-graduates and the smaller future proportion of highly qualified immigrants imply that careful attention must be paid to measures which will ensure an adequate supply and best utilization of our scientific and technical manpower over the longer run.

This in turn will provide a basis for a careful articulation with domestic supply of that important proportion of the supply of such manpower which we draw from abroad.

The increased utilization of scientific and technical persons in industry suggests that an increased two-way communication between manpower authorities and business firms would help to link the future manpower needs of the economy with the education and training system.

The inelasticity of supply of scientific and technical persons emphasizes the importance of adjustment on the requirements side, e.g., changes in utilization, in eliminating imbalances in the short-run. Moreover, more broadly-trained people will facilitate inter-field and inter-occupational switching. International migration may also be used to good advantage to help alleviate a short-run shortage of engineers and scientists. Public measures to create a more efficiently operating labour market will require more information on job vacancies and potential applicants as well as measures to facilitate the occupational, geographic and industrial mobility of such manpower.

Since there will be a rising demand for those at the sub-professional and post-graduate level, the needs for the re-training and upgrading of the present stock of engineering manpower will probably be greater in the future.

The study revealed gaps in our information on scientific and technical manpower in Canada and areas where more research is needed. Better information is needed on the stock of scientific and technical manpower. The simple question: Who is an engineer? has several answers depending on the definition used. The Census, provided more information could be obtained on the educational background of persons in managerial and technical occupations, would be a very useful source of information. A follow-up study of the 1971 Census could be made to compare employment and educational data for selected occupations. The new Department of Manpower and Immigration Survey of Professional Scientific and Technical Manpower will be an increasingly useful source of information for studies of career patterns.

More knowledge of the factors which determine career decisions, i.e., choice of university course, occupation, and geographic area of employment would assist education and manpower authorities to match economic needs with educational plans.

In addition to death rates, more accurate information is needed on the working life of those in scientific and technical occupations in order to establish attrition rates more accurately.

The 1971 Census as well as the new Department of Manpower and Immigration survey will also provide reference points for a comparison over time of the industry by occupation data for scientists and technicians, hitherto available only for the engineering portion of the scientific and technical manpower pool.

There are numerous gaps in the price and non-price indicators of the market for scientific and technical manpower. More information on annual salaries of new and experienced engineers, scientists and technicians in relation to other occupations and on job vacancies and unplaced applicants is needed in order to improve the accuracy of labour market analysis.

As a basis for better projections there are several gaps that need to be filled. The factors that have increased the utilization of engineers within industry should be studied in greater detail at the level of the firm and establishment. This could be done by multi-variate analysis which would attempt to correlate the proportion of engineers and scientists as well as patterns of utilization of scientific, technical and other types of manpower with factors such as productivity, capital investment, age and type of capital equipment, research and development, the size and organization of the firm, type of product, price of productive factors and so on.

The analysis revealed that the elasticity of substitution among engineers and other occupations such as managers and within engineering fields of specialization and occupations is quite large. This in turn suggests that at the "macro" level it is essential to make a projection of scientific and technical persons within the broader framework of the labour force by industry which will reflect the fact that an ultimate limit exists to the expansion of scientific and engineering employment, namely, society's requirements for people to perform other types of activities and for other occupations, some of which are growing rapidly such as health services occupations. Engineers in turn must be placed in the framework of other types of scientific and technical personnel.

At the "micro" level, that is, at the level of the business firm and establishment it is necessary to have additional information on utilization practices such as the nature and extent of switching of persons in different occupations and levels of education as requirements and supplies change over time. It would appear therefore that in order to carry a general projection of requirements for scientific and technical persons and in particular of engineers to the level of field of specialization, more information on detailed requirements at the "micro" level of the firm would be needed.

No framework of projections of graduations including post-graduate degrees now exists. This would be a very useful basis for developing consistent projections of the supply of persons from the educational system in relation to other potential sources of supply.

The study attempted to explain the long-term and short-term trends in the supply and requirements for engineering and scientific manpower in Canada. It is hoped that even though many questions remain unanswered, something of value was achieved and that a basis for additional research has been established.

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APPENDIX I-A

An Illustration of the Occupation, Field of Employment Specialization and Course Groupings Used

A number of occupations, fields of employment specialization and university courses in the area of engineering and scientific manpower have been compared in this study. The first part of the Appendix indicates the organization of these occupations and fields in the Department of Manpower and Immigration Register of Scientific and Technical Personnel; the 1961 Census classification of engineering and science occupations; and the Dominion Bureau of Statistics university course classification as compared with the classification of fields suggested by Wolfle.[1]

The fields and occupations used in the Register, the Census and by the Dominion Bureau of Statistics Education Division are outlined. Finally, the composition of the fields in the Register and Dominion Bureau of Statistics lists are compared with the Census occupations for particular time periods in order to show how the fields and occupations had to be re-grouped to achieve a greater measure of comparability.

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[1] Dael Wolfle, Op. cit., pp. 13-14.

0100— ARCHITECTURE

0800— TOWN PLANNING

AGRICULTURE

(See also BIOLOGICAL SCIENCES and FORESTRY)

1000—AGRICULTURE (general)
1010—Agricultural Economics (inc Agricultural finance, marketing, prices and policies, production, rural sociology, and statistics)
1020—Agricultural Engineering
1021— Erosion control — Irrigation
1022— Farm mechanization — power
1024— Processing of farm products
1025— Structures
1030—Animal Science
1031— Anatomy
1032— Biochemistry and physiology
1033— Breeding
1034— Dairy technology
1035— Husbandry
1036— Nutrition
1037— Poultry Science
1045—Bacteriology
1050—Entomology
1051— Apiculture
1052— Ecology
1053— Insect control
1054— Insect physiology
1055— Taxonomy
1058—Extension
1060—Plant Science
1061— Biochemistry and physiology
1062— Breeding
1063— Cereals
1064— Forage
1065— General botany
1066— Horticulture
1067— Pathology
1068— Special crops
1069— Weeds
1090—Soil Science
1091— Bacteriology
1092— Chemistry and fertility
1093— Pedology
1094— Physics
1099—Other — Please describe

BIOLOGICAL SCIENCES (non-agricultural) (See also AGRICULTURE and FORESTRY)

1200—BIOLOGICAL SCIENCES (non-agricultural) (general)
1201—Aerobiology
1202—Anatomy (general)
1203— Embryology
1204— Microscopic, histology
1205— Morphology
1207— Pathological
1208— Systematic
1209— Topographic
1213—Biochemistry (See also CHEMISTRY)
1214—Biological Warfare Agents
1215—Biophysics
1216— Biomechanics, biokinetics
1217— Biospectroscopy spectrometry
1218— Isotope tracer techniques
1219—Blood Banking
1220—Botany (general)
1221— Ecology
1222— Economic
1223— Physiology
1224— Taxonomy
1230—Experimental Psychology
1231— Human engineering
1240—Fish and Wildlife
1241— Biology
1242— Ecology
1243— Pathology
1244— Range and plant ecology
1250—Genetics (general)
1251— Animal
1252— Human
1253— Microorganisms
1254— Plant
1255— Population studies
1259— Other — Please describe
1260—Hydrobiology (general)
1261— Limnology
1262— Marine biology
1263— Biological oceanography
1269— Other — Please describe
1270—Microbiology (general)
1271— Antibiotics
1272— Bacterial metabolism
1273— Bacterial physiology
1274— Bioassay
1275— Biologicals; production and testing
1276— Clinical bacteriology
1277— Epidemiology
1278— Immunology
1279— Fermentation
1280— Food bacteriology
1281— Mycology
1282— Parasitology, Protozoology
1283— Serology
1284— Soil bacteriology
1285— Taxonomy and morphology
1286— Virology
1289— Other — Please describe
1290—Nutrition and Metabolism
1291— Food needs; habits
1292— Food sources; preparation
1293— Nutrient value of foods
1294— Nutritional deficiencies
1300—Pathology
1301— Comparative
1302— Experimental
1303— Technology, methodology
1310—Pharmacology
1311— Chemical
1312— Experimental therapeutics
1313— Toxicology
1320—Physiology
1321— Cellular
1322— Endocrine
1323— Gastro-intestinal
1324— Heart, circulation
1325— Renal, salt, water balance
1326— Respiratory
1327— Work, exercise
1330—Zoology
1331— Ecology
1332— Economic
1333— Herpetology
1334— Ichthyology
1335— Invertebrate
1336— Mammalogy
1337— Ornithology
1338— Parasitology
1339— Taxonomy
1340— Vertebrate
1399—Other — Please describe

CHEMISTRY

(See also CHEMICAL ENGINEERING)

1400—CHEMISTRY (general)
1401—Agricultural and Food Chemistry
1414—Analytical Chemistry
1415— Assaying
1416— Classical methods
1418— Forensic chemistry
1419— Micro-analytical chemistry
1420— Optical and instrumental analysis
1421— Tracer methods
1424—Biochemistry
1425— Clinical
1426— Endocrine
1427— Enzyme, vitamin
1428— Microbiological
1429— Nutrition
1430— Physical
1437—Geochemistry (see also Geosciences)
1443—Inorganic Chemistry
1444— Coordination chemistry
1452— Pure inorganic chemistry
1456—Organic Chemistry
1457— Conformational
1458— Physical-organic
1459— Structural
1460— Synthetic
1476—Pharmaceutical Chemistry
1482—Physical Chemistry
1483— Atomic and nuclear structure and radiochemistry
1484— Catalysts
1485— Colloid chemistry
1486— Corrosion and inhibition
1487— Electrochemistry
1488— Ion exchange
1489— Polymers and macromolecules
1490— Reaction kinetics
1491— Solid state
1492— Spectroscopy
1493— Structure and properties of molecules
1494— Surface chemistry
1495— Theoretical chemistry
1496— Thermodynamics and thermochemistry
1499—Other — Please describe

FORESTRY

1600—FORESTRY (general)
1610— Forest biology
1620— Forest engineering - logging, road and camp construction, road location
1630— Forest management - administration
1640— Forest mensuration - photo interpretation, inventory, scaling, grading, surveys
1650— Forest protection - fire, insects, disease
1660— Forest utilization - forest products, manufacturing, forest economics
1670— Silviculture - natural and artificial regeneration, forest soils, ecology
1699—Other — Please describe

GEOGRAPHY

1800—GEOGRAPHY (general)
1810—Economic Geography
1820—Geographical Techniques
1830—Human Geography
1840—Physical Geography
1850—Regional Geography
1899—Other — Please describe

GEOSCIENCES (GEOLOGY GEOCHEMISTRY, GEOPHYSICS)

2000—GEOLOGY (general)
2010—Economic Geology
2011— Coal
2012— Ground-water
2013— Metalliferous deposits
2014— Non-metallic deposits
2015— Petroleum and natural gas
2020—Engineering Geology
2025—Geomorphology
2030—Mineralogy
2032— Determinative mineralogy
2040—Palaeontology
2041— Invertebrate
2042— Micropalaeontology
2050— Petrology
2052— Metamorphic rocks
2058— Sedimentary rocks
2060—Photogeology
2065—Prospecting and Exploration, Field Geology
2070—Structural Geology
2072— Sedimentary rocks
2080—Stratigraphy
2085—Surficial (Pleistocene and Recent) Geology
2099—Other — Please describe
2200—GEOCHEMISTRY (general)
2210— Biogeochemistry
2240— Rocks and minerals
2249— Other — Please describe
2250—GEOPHYSICS (general)
2260—Geodesy
2270—Geophysical Exploration
2271— Electromagnetic
2272— Gravimetric
2273— Instrumentation
2274— Magnetic
2276— Seismic
2277— Well logging
2280—Hydrology
2285—Oceanography
2290—Seismology
2295—Terrestrial Physics
2299—Other — Please describe

MATHEMATICS

2400—MATHEMATICS (general)
2405—Actuarial Mathematics
2410—Algebra
2415—Analysis (inc. calculus)
2420—Foundations (theory of sets, symbolic logic)
2425—Geometry (inc. algebraic geometry)
2430—Mathematical Applications (biology, chemistry, economics, information theory, physics)
2435—Numerical Analysis (inc. numerical methods, programming, computing instruments)
2440—Probability and Mathematical Statistics
2445—Theory of Numbers (general, analytic, geometric)
2450—Topology (inc. algebraic structures)
2499—Other — Please describe

PHYSICS and ENGINEERING PHYSICS

2600—PHYSICS (general)
2601—ENGINEERING PHYSICS (general)
2602—Acoustics
2607— Ultrasonics
2608— Underwater sound
2610—Astronomy
2611— Astrophysics
2612— Positional astronomy
2613— Radio astronomy
2616—Atomic and Molecular Phenomena
2617— Atomic and molecular spectra
2618— Atomic and molecular structure and properties
2619— Isotopes
2620— X-rays
2622—Biophysics — See also BIOLOGICAL SCIENCES
2623—Electricity and Magnetism
2624— Electrical measurements and instruments
2628—Electronics
2629— Antennae and transmission lines
2630— Conduction through gases
2632— Electron tubes and solid state devices
2633— Physical electronics
2634— Propagation of radio waves
2636—Geophysics (see also GEOSCIENCES)
2637—Health Physics
2639—Heat
2640— Cryogenics
2641— Heat radiation and transmission
2646—Mechanics
2648— Ballistics and missiles
2650— Hydrodynamics
2654—Meteorology
2655— Analysis and forecasting
2656— Climatology
2658— Dynamic and physical research
2659— Instruments
2660— Observations
2663—Nuclear Physics
2664— Cosmic rays
2667— Neutron physics
2668— Nuclear reactions
2669— Nuclear structure, properties
2671— Particle interactions
2672— Radioactivity
2673— Reactors
2675—Optics
2678— Optical instruments
2679— Photography
2684—Servomechanisms
2685—Solid State Physics
2686— Crystals
2689— Instrumentation
2690— Magnetic phenomena
2691— Physics of glasses and high polymers
2692— Physics of metals
2694— Semiconductors
2699—Other — Please describe

VETERINARY MEDICINE

3000—VETERINARY MEDICINE (general practice)
3010—Veterinary Medicine (public health)
3011— Epidemiology
3012— Food and establishments
3013— Livestock
3014— Meat
3015— Milk and dairy products
3016— Poultry
3020—Veterinary Medicine (specialized practice)
3021— Cattle
3022— Horses
3023— Pets
3024— Poultry
3030—Veterinary Science
3032— Anatomy
3034— Bacteriology
3042— Parasitology
3044— Pathology
3052— Virology
3099—Other — Please describe

3100—SCIENCE, GENERAL

3199—OTHER SCIENCE — Please describe

3200— SURVEYING

(Aerial, Geodetic, Hydrographic, Land and Title, Topographic)

AERONAUTICAL ENGINEERING

4000—AERONAUTICAL ENGINEERING (general)
4001—Aerodynamics
4007—Airborne Telecommunications
4010—Aircraft Electrical Equipment and Systems
4013—Aircraft Engines, Jet
4016—Aircraft Engines, Reciprocating
4022—Aircraft Fuel Systems
4025—Aircraft Hydraulic and Pneumatic Systems
4028—Aircraft Instruments and Systems
4031—Aircraft Performance
4034—Aircraft Stability and Control
4037—Automatic Controls
4040—Flight Testing and Instrumentation
4043—Guided Missiles
4046—Heating, Ventilating and Pressurizing
4049—Human Engineering
4052—Maintenance Engineering
4055—Materials and Processes
4064—Personnel Safety Equipment
4073—Quality Control
4076—Rotary Wing Aircraft
4079—Stress Analysis
4082—Weight Analysis
4099—Other — Please describe

CHEMICAL ENGINEERING

(See also CHEMISTRY)

4200—CHEMICAL ENGINEERING (general)
4205—Absorption
4210—Adsorption, ion exchange
4215—Agitation
4220—Automatic control
4225—Computation, analogue and digital
4230—Corrosive mechanisms
4235—Distillation, extraction
4240—Drying, crystallization
4245—Filtration
4250—Fluid mechanics
4255—Fuels
4260—Heat transfer, evaporation, refrigeration
4265—Kinetics, thermodynamics
4270—Materials handling, packaging equipment
4275—Materials of construction
4280—Process control
4285—Separation
4290—Size reduction
4299—Other — Please describe

CIVIL ENGINEERING

4400—CIVIL ENGINEERING (general)
4403—Airports and Landing Fields (drainage, runways and structures)
4409—Dams, Locks and Retaining Walls
4412—Engineering Mechanics
4415—Fire Prevention and Protection
4418—Flood Control
4421—Highways, Streets and Pavements (urban and rural)
4424—Hydraulics (theoretical and applied)
4427—Materials of Construction
4430—Military Engineering
4433—Plant and Methods (construction)
4436—Power Developments (plants, transmission, turbines)
4439—Railroads and Street Railways
4442—Reclamation and Irrigation
4445—Soil Mechanics and Foundations
4448—Structural (bridges, etc.)
4451—Surveying and Mapping
4454—Traffic Control and Transportation
4457—Tunnels and Shafts
4460—Valuations and Appraisals
4463—Waterways (rivers and harbours, ports, terminals, canals)
4466—Sanitary Engineering (general)
4471— Sewage
4472— Waste and garbage (collection and disposal)
4473— Water supply and pollution
4499—Other — Please describe

ELECTRICAL and ELECTRONIC ENGINEERING

4600—ELECTRICAL and ELECTRONIC ENGINEERING (general)
4605—Communications (non-radio)
4606— Telegraph
4607— Telephone
4608— Cable
4610—Electric Power (generation, transmission and distribution)
4611— Central stations
4612— Diesel power plants
4613— Equipment protection
4614— Hydraulic power plants
4615— Nuclear power plants
4616— Overhead systems
4617— Steam power plants
4618— Underground systems
4620—Electrical Apparatus and Machinery
4621— Control equipment (relays, magnets, solenoids)
4622— Feedback control systems
4623— Heating equipment (furnaces and heaters)
4624— Insulated conductors
4625— Measuring equipment
4626— Rotating machines (motors, generators, converters)
4627— Static machines (transformers, rectifiers, capacitors)
4629— Switch gear
4630— Wires and cables
4635—Electricity and Magnetism
4636— Dielectrics
4638— Electrical measurements
4640— Magnetism and magnetic measurements
4642—Electrochemistry (batteries, corrosion, plating)
4645—Electronics
4646— Antennae and transmission lines
4647— Audio and ultrasonics
4648— Circuits
4649— Communications
4650— Components
4651— Computers and data processing
4652— Electrical measurements and instruments
4653— Electron tubes and solid state devices
4654— Microwave techniques
4655— Propagation of radio waves

4656— Telemetering and remote control
4660—Illumination
4661— Industrial, street and flood lighting
4662— Lighting equipment
4663— Light sources
4668—Medical Electronics
4671—Nucleonics and Radiation Control
4674—Radar, Navigational Aids and Aircraft Fire-Control Systems
4677—Radio and Television
4678— Receivers
4679— Techniques, components and circuits
4680— Transmitters and systems
4683—Servomechanisms
4686—Standards
4689—Transportation and Traffic
4690— Aviation electric power
4691— Control systems
4692— Electric railways and equipment
4693— Locomotive power
4694— Signal systems
[illegible]
4699—Other — Please describe

INDUSTRIAL ENGINEERING

4800—INDUSTRIAL ENGINEERING (general)
4810—Engineering Economics
4815—Materials Handling
4820—Methods
4830—Motion Study and Time Study
4840—Plant Layout
4850—Procurement and Materials Accounting
4860—Quality Control
4870—Standardization Engineering
[illegible] Other — Please describe

MECHANICAL ENGINEERING

[illegible] MECHANICAL ENGINEERING (general)
[illegible] Air Frames and Air Structures
[illegible] Applied Mechanics
[illegible] Automotive Engineering and [illegible] Locomotion
[illegible] Boilers and Pressure Vessels
[illegible] Fire Prevention and Protection
[illegible] Fluid Dynamics
[illegible] Forging, Presswork
[illegible] Foundries, Production and Equipment
[illegible] Fuels
[illegible] Furnaces and Combustion Equipment
[illegible] Gas Turbines
[illegible] Heating, Ventilating, Air Conditioning
[illegible] Heat Transfer
[illegible] and Hydraulic Equipment

5032—Instrumentation and Controls
5034—Internal Combustion Engines
5035— Diesel
5036— Gasoline
5040—Lubrication and Bearings
5042—Machinery and Equipment
5044—Machine Tools (including jigs and fixtures)
5046—Materials
5048—Materials handling, packaging equipment
5050—Metallurgy
5052—Nuclear Engineering
5054—Oil and Gas Power
5056—Ordnance and Armament
5058—Piping
5060—Plastics
5062—Power Transmission
5063—Pulp and Paper
5064—Pumps
5066—Refrigeration
5072—Standards
5074—Steam Engines and Turbines
5076—Structures
5078—Textile Engineering
5080—Thermodynamics
5082—Welding
5084—Wires and Cables
5099—Other — Please describe

METALLURGICAL ENGINEERING

5200—METALLURGICAL ENGINEERING (general)
5205—Corrosion
[illegible]—Electrometallurgy
5215—Extraction and Refining, Ferrous
5220—Extraction and Refining, Non-Ferrous
5225—Foundry, Ferrous
5230—Foundry, Non-Ferrous
5235—Heat Treatment
5240—Industrial Minerals Preparation
5245—Mechanical Working of Metals, Primary
5250—Mechanical Working of Metals, Secondary
5255—Metal Physics
5260—Nuclear Metallurgy
[illegible] Ore Preparation
5270 Physical and Mechanical Properties of Metal and Alloys and Test Methods
5275 Powder Metallurgy
5280 Welding
[illegible] Other — Please describe

MINING ENGINEERING

5400 MINING ENGINEERING (general)
[illegible] Coal (also coal preparation)
[illegible] Diamond Drilling
[illegible] Mine Surveying and Layout
[illegible] Non-Metallic or Industrial Minerals
[illegible] Open Pit Mining
[illegible] Ores of Base and Precious Metals

5440—Prospecting and Exploration
5445— Coal
5450— Gas and or petroleum
5455— Metals — base and or precious
5460— Minerals — non-metallic or industrial
5465—Shaft Sinking, Drifting
5480—Underground Mining
5485—Ventilation
5499—Other — Please describe

PETROLEUM ENGINEERING (Including NATURAL GAS)

5800—PETROLEUM ENGINEERING (general)
5810—Development [illegible] of wells
5820—Petroleum and Natural Gas Products
5830—Production [illegible] petroleum and [illegible] natural gas after completion of well
5840—Prospecting and Exploration
[illegible]—Refining
[illegible]—Reservoir [illegible]
[illegible]—Storage
[illegible]—Transportation [illegible] tankers, etc.
[illegible] Other — Please describe

OTHER ENGINEERING and SCIENTIFIC FIELDS

[illegible]—Ceramic Engineering
[illegible]—Instrumentation Engineering
[illegible]—Landscape Architecture
[illegible] Manufacturing Engineering
[illegible] Naval Architecture and Marine Engineering
[illegible] Nuclear Engineering
[illegible] Operations Research
[illegible] Pulp and Paper
[illegible] Process Engineering
[illegible] Product Engineering
[illegible] Safety Engineering
[illegible] Other — Please describe

1964

CLASSIFICATION OF FIELDS OF EMPLOYMENT SPECIALIZATION

NATURAL SCIENCE AND ENGINEERING

ECONOMICS AND RESEARCH BRANCH
DEPARTMENT OF LABOUR CANADA

Professional and Technical Occupations, 1961 Census of Canada*

Division 2--Professional and Technical Occupations

Occ. Code No.	
	Professional engineers
101	Civil engineers
102	Mechanical engineers
104	Industrial engineers
105	Electrical engineers
107	Mining engineers
108	Chemical engineers
109	Professional engineers, n.e.s.
	Physical scientists
111	Chemists
112	Geologists
114	Physicists
119	Physical scientists, n.e.s.
	Biologists and agricultural professionals
121	Biological scientists
124	Veterinarians
129	Agricultural professionals, n.e.s.
	Teachers
131	Professors and college principals
135	School teachers
139	Teachers and instructors, n.e.s.
	Health professionals
140	Physicians and surgeons
141	Dentists
142	Nurses, graduate
143	Nurses-in-training (W)
144	Physical and occupational therapists
145	Optometrists
146	Osteopaths and chiropractors
147	Pharmacists
148	Medical and dental technicians
149	Other health professionals

* Occupational Classification Manual Census of Canada, 1961.

Occ. Code No.	Law professionals
151	Judges and magistrates
153	Lawyers and notaries
	Religion professionals
161	Clergymen and priests, n.o.r. (W)
163	Nuns and brothers, n.o.r. (W)
169	Religious workers, n.o.r. (W)
	Artists, writers and musicians
171	Artists, commercial
172	Artists (except commercial), art teachers
174	Authors, editors and journalists
176	Musicians and music teachers
	Other professionals
181	Architects
182	Draughtsmen
183	Surveyors
184	Actuaries and Statisticians
186	Economists
187	Computer programmers
188	Accountants and auditors
191	Dietitians
192	Social welfare workers
194	Librarians
195	Interior decorators and window dressers
196	Photographers
198	Science and engineering technicians, n.e.s.
199	Professional occupations, n.e.s.

Specializations in Which Bachelor and First Professional Degrees were Granted[*]

Agriculture
Architecture
Arts
Pure Science
Chiropractic
Commerce and Business Administration
Dentistry
Education
Engineering
Fine and Applied Arts
Forestry
Home Economics
Interior Design
Journalism
Law
Library Science
Medicine
Music
Nursing
Occupational Therapy and Physiotherapy
Optometry
Pharmacy
Physical and Health Education
Social Work
Theology
  Catholic
  Protestant
Veterinary Science
Others

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[*] DBS, Education Division, Preliminary Statistics of Education, 1963-64, August 1964, p. 43 (69 pp.)

Fields of Engineering in Which Bachelor Degrees were Granted*

Aeronautical
Agricultural
Ceramic
Chemical
Chemical-Metallurgical
Civil
Electrical
Engineering Physics
Forest
Geological
Geological-Mining
Industrial
Mechanical
Mechanical-Electrical
Metallurgical
Mining
Petroleum
Surveying

Fields of Study in Which Honours Bachelor Degrees in Arts and Science were Granted*

Biological Sciences

Bacteriology
Bacteriology and Immunology
Biochemistry
Biochemistry and Zoology
Biology
Biology and Chemistry
Biology and History
Biophysics
Botany
Conservation Biology
Genetics
Microbiology
Microbiology and Zoology
Physiology
Physiology and Biochemistry
Physiology and Psychology
Zoology

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* DBS, Survey of High Education, Part II: Degrees, Staff and Summary, 1962-63, October 1964, p. 53-56 (59 pp.)

Fields of Study in Which Honours Bachelor Degrees in Arts and Science were Granted* (Cont'd.)

Physical Sciences

Actuarial Mathematics
Chemistry
Chemistry and Biology
Chemistry and Geology
Chemistry and Mathematics
Chemistry and Physics
Chemistry, Physics, English
Food Chemistry
Geology (Including Geological Sciences)
Geology and Chemistry
Geophysics
Household Economics
Mathematical Physics
Mathematics (Including Applied Mathematics)
Mathematics and Chemistry
Mathematics and Economics
Mathematics and Philosophy
Mathematics and Physics
Mathematics and Psychology
Mathematics and Sociology
Metallurgical Sciences
Meteorology
Physics
Physics and Chemistry
Physics and Geology
Physics and Mathematics
Physics and Physiology
Science

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* DBS, Survey of High Education, Part II: Degrees, Staff and Summary, 1962-63, October 1964, p. 53-56 (59 pp.)

Composition of Census Engineering and Science Occupation Classes Used in Comparisons Over Time

Occupation Class	Grouping #1 1931-61	Grouping #2 1931-51	Grouping #3 1951-61	Grouping #3A 1961 Only
Engineering, total		Engineering, total		
Chemical	NA	(Chemical eng.) (Mining eng.)	Chemical eng.	Chemical eng.
Civil	(Civil eng.) (Surveying)	(Civil eng.) (Surveying)	Civil eng.	Civil eng.
Electrical		Electrical eng.		
Mechanical		(Mechanical eng.) (Industrial eng.)		Mechanical eng. Industrial eng.
Other	(Professional eng., (n.e.s.) (Chemical eng.) (Mining eng.)	Nil	(Professional eng., (n.e.s.) (Mining eng.)	Mining eng. Professional eng., n.e.s.
Science				
Biological scientists		NA		Biological scientists
Chemists		NA		Chemists
Geologists		NA		Geologists
Physicists		NA		Physicists
Physical scientists, n.e.s.		NA		Physical scientists, n.e.s.
Other		NA		NA

Composition of Economics and Research Branch Honours Science and DBS Education Division University Courses Used in Comparison with Census Data Over Time Period 1940-1963

University Courses	Grouping #1	Grouping #2	Grouping #3
Engineering, total		Engineering, total	
Chemical	NA	(Chemical, Mining, Petroleum, Geological, Metallurgical)	Chemical
Civil		Civil	
Electrical		Electrical	
Mechanical		(Mechanical) (Industrial)	
Other	(Chemical, Mining, Petroleum, Geological, Metallurgical, Other, Agricultural Engineering, Physics)	(Other Agricultural Engineering, Physics)	(Mining, Petroleum, Geological, Metallurgical, Other, Agricultural)
Science			
Biological		(Bacteriology, Biology, Botany, Zoology, Biochemistry)	
Chemistry		Chemistry	
Geology		Geology	
Mathematics		Mathematics	
Physics		(Physics, Mathematics & Physics)	
Other		Other	

University Course	Grouping #1	Grouping #2	Grouping #3
Engineering, total		Engineering, total	
Chemical	NA	(Chemical, Mining,) (Petroleum, Geological,) (Metallurgical)	Chemical
Civil	(Civil, Forest) (Surveying)		(Civil) (Forest)
Electrical		Electrical	
Mechanical		(Mechanical) (Aeronautical) (Industrial)	
Other	(Chemical, Mining) (Petroleum, Geological) (Nuclear, General,) (Metallurgical, Other,) (Agricultural Engineering) (Physics)	(Nuclear, General) (Other, Agricultural) (Engineering Physics)	(Mining, Petroleum,) (Geological, Surveying,) (Nuclear, General,) (Metallurgical, Other,) (Agricultural Engineering) (Physics)
Science			
Biological		(Bacteriology, Biology) (Botany, Zoology,) (Biochemistry)	
Chemistry		(Chemistry, Chemistry) (& Physics)	
Geology		Geology	
Mathematics		Mathematics	
Physics		(Physics, Mathematics) (& Physics)	
Other		(Geography, General) (Science,) (Metallurgical Science) (Other Science)	

Composition of Register of Scientific and Technical Personnel Fields of
Employment Specialization Used in Comparisons with Census Data Over Time Period 1957-1963

Field of Employment Specialization	Grouping #1	Grouping #2	Grouping #3
Engineering, total		Engineering, total	
Chemical	NA	(Chemical, Mining, Petroleum, Metallurgical)	Chemical
Civil	(Civil Surveying)	(Civil Surveying)	Civil
Electrical	Electrical	Electrical	Electrical
Mechanical	(Mechanical Aeronautical)	(Mechanical Aeronautical)	(Mechanical Aeronautical)
Other	(Chemical Mining Petroleum Metallurgical Other)	Other	Mining Petroleum Metallurgical Other Surveying
Science			
Biological	Biological Science		
Chemistry	Chemistry		
Geology	Geological Science		
Mathematics	Mathematics		
Physics	(Physics & Engineering Physics)		
Other	Geography		

1- Outline Used by Wolfle: General Areas and Specialized Fields used in Analyzing and Reporting Information	1- Outline Used by Wolfle: Subjects of College Study Included in Each Specialized Field	2 - Register of Scientific and Technical Personnel, Fields of Employment Specialization	3 - 1961 Census, Occupation Classes	4 - Adapted from D.B.S., Education Division, University Courses
		Architecture Town Planning	Architects	
	<u>Engineering</u>	<u>Engineering</u>	<u>Professional Engineers</u>	<u>Engineering</u>
Engineering	Engineering Aeronautical Chemical Civil Electrical Mechanical Military or Naval Science Other Engineering	Aeronautical Chemical Civil Electrical and Electronic Industrial Mechanical Metallurgical Mining Petroleum Other Engineering and Scientific Fields	Civil Mechanical Industrial Electrical Mining Chemical Professional Engineers, n.e.s.	Aeronautical Agricultural Ceramic Chemical-Metallurgical Civil Electrical Engineering Physics Forest Geological Geological-Mining Industrial Mechanical Mechanical-Electrical Metallurgical Mining Petroleum Surveying
	<u>Natural Sciences</u>	<u>Natural Sciences</u>	<u>Physical Scientists</u>	<u>Physical Sciences</u>
Chemistry	Chemistry	Chemistry	Chemists	Chemistry Geology Mathematics Mathematics and Physics Other Sciences
Other Physical Sciences	Mathematics Metallurgy Physics	Mathematics Physics & Engineering Physics	Physicists	
Earth Sciences	Astronomy Geography Geology Meteorology	Geography Geoscience (Geology, Geochemistry, Geophysics)	Geologists Physical Scientists, n.e.s.	
Biological Sciences	Anatomy Bacteriology Biochemistry Biology (n.e.c.) Botany Dental Sciences Entomology Medical Sciences Physiology Zoology	Biological Sciences	<u>Biologists & Agricultural Professionals</u> Biological Scientists	<u>Biological Sciences</u> Bacteriology Biochemistry Biology Botany Zoology Biological Science, n.e.c.
Natural Sciences, Unclassified	Natural Sciences (n.e.c.)	Science, General and Other Science		
	<u>Applied Biological Fields</u>			
Agriculture	Agriculture Animal Husbandry Forestry	Agriculture Forestry	Agricultural Professionals, n.e.s.	
Home Economics	Home Economics	Veterinary Medicine	Veterinarians	

Sources: Col. 1: Dael Wolfle, *America's Resources of Specialized Talent*, New York, Harper, 1954.
Col. 2: See Appendix I-A (ii) below.
Col. 3: Dominion Bureau of Statistics, *Occupational Classification Manual, Census of Canada, 1961*.
Col. 4: Dominion Bureau of Statistics, *Survey of Higher Education, Part II, 1962-63*, p. 53; Dominion Bureau of Statistics, *Survey of Higher Education* (earlier issues).

APPENDIX I-B

Comparison of Data from the 1961 Census with the Department of Manpower and Immigration Register of Scientific and Technical Personnel

1. Selected Data from the Census and the Register

Professor D.N. Solomon and Mrs. A. M. Fergusson have discussed the possibility of making a comparison of data from the 1951 census with data from the 1957 cycle survey based on the Register of Scientific and Technical Personnel of the Department of Manpower and Immigration. It was concluded that the differences precluded such a comparison.[1/]

It should be noted at the outset that the difference in concepts used in the Census as opposed to the Register - occupation or work done in the case of the Census compared with scientific and technical education in the case of academic field in the Register - would tend to lead to differences in coverage between these two sources.

1/ David N. Solomon and Agnes M. Fergusson, "The Distribution and Functions of Canadian Engineers and Scientists", Canadian Political Science Association Conference on Statistics, 1960, Papers, E.F. Beach and J.C. Weldon, Editors, Toronto, University of Toronto Press, 1962, pp. 183-216.

When the article by Solomon and Fergusson was written, the 1961 Census data were not available. They pointed out the desirability of making a comparison of Census and Register data when the latter were available. The distribution of engineers by occupation in the Census and by field of employment specialization in the Register indicates in this respect the Census and Register data are fairly similar.[2/] For example, according to the 1961 Census (see Table I-1, Chapter I) civil engineers represented about 28 per cent in both the Census and the Register. In electrical engineering there were 23 per cent according to the Census and 20 per cent according to the Register. In the case of total engineers, the numbers were 43,099 in the 1961 Census and between 38,000 and 45,000 according to the

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2/ In the case of Table I-1 above "field of employment specialization" is used in the case of data from the Scientific and Technical Personnel Register. This is possible because the engineers or scientists with Academic training in these specialties, but who are not currently employed in these specialties, can be removed and those who are employed in these specialties can be shown separately.

register, depending on whether the "field of employment specialization" or "academic specialization" concept, respectively, is used to designate an "engineer".3/

In the Census a substantial group of engineers and scientists who report other occupations, for example, managers and university professors, would not be included in the occupational class of "engineer". In the Register these persons would be included as long as they had an education or association membership background in scientific and technical fields, so the Census would tend to give a downward bias to the numbers of engineers and scientists reported. On the other hand, in contrast to Register

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3/ From the Survey of Scientific and Technical Personnel in 1961, estimates were made of the total engineers in the Register by field of employment specialization and the estimated total is 38,000 in 1961. However, a higher estimate results if the concept of academic course is used to designate an engineer. This total is estimated from a hand count of the Register in 1961. At that time 48,500 engineers were listed. However, this total includes some who were retired, not Canadian citizens, non-technical personnel or persons who were working outside of Canada. It is estimated that about 60 per cent of the retired - 700 - were engineers. In addition, on the basis of the 1961 Survey of Scientific and Technical Personnel about 1,100 engineers probably should have been removed from the Register because they were deceased, non-technical personnel or non-Canadians. An additional 1,300 - based on an estimate of the above survey - were probably Canadians working outside of Canada. If these are removed, it would leave a net total of about 45,400 engineers in Canada in 1961 using the academic specialization as an indication of who is an engineer.

procedures which use graduation or equivalent qualification in scientific or technical fields as criteria for entrance into the Register, the Census would include anyone reporting in an engineering or science occupation regardless of educational background.[4/] This would tend to give an upward bias to the numbers of engineers and scientists as reported in the Census. Although it is not possible to measure precisely the result of these two biases which operate in opposite directions, the net result appears to be a gross number of "engineers"[5/] from the two sources which are not too far apart but whose composition in terms of occupation and level of education may be somewhat different.

A further indication of the composition of Census and Register data can be obtained by looking at the composition by industry and by level of education in 1961.

4/ The inclusion of such persons in the Census is made only after certain checks in the coding procedures. It is not possible to determine the extent to which this is a result of persons being enumerated and coded as "engineer" or "scientist" in the Census who should not have been. There is no evidence to indicate that the coding procedures would give a bias in this case one way or the other.

5/ It was decided to use engineers to illustrate the point since they are reported in both the Census and the Register. In the case of natural scientists, some specializations, for example, mathematics, were not reported separately in the 1961 Census. It would be possible to make selected comparisons of these fields or occupations for the Register and the Census but this was not attempted here.

The industry distribution is discussed more fully in Chapter III. Generally, a comparison by industry of the two sets of data for engineers results in a rather close correspondence. For example, in the 1961 Census 34.4 per cent of the engineers are shown being employed in the manufacturing sector. However, if surveyors are removed the percentage of engineers in manufacturing is around 41 per cent, compared with 38 per cent in the Survey of Scientific and Technical Personnel in 1961. In another case, however, "transportation, storage and communication", the percentage in the Survey of Scientific and Technical Personnel in 1961 was around 7 per cent, whereas the proportion in the 1961 Census not including surveyors was 10 per cent of engineers in this industry. One of the reasons for this difference is suggested by the difference in educational level of engineers in the Census compared with those in the Register of Scientific and Technical Personnel. A comparison of the level of education of those employed as engineers by industry in January, 1962, shows that there were a larger number of engineers without university degrees in the "transportation and communication" industry. For example, the proportion was approximately 13 per cent in all industries, compared with 25 per cent in this industry.[6]

However, in Chapter II, Table II-4, a comparison by level of education indicates that the composition of those in engineering in the Census and the Register by level of education was somewhat different. Those with no university degrees represented 28 per cent in the case of the 1961 Census and only 5 per cent in the case of the Register, based on data from the 1961 Survey of Scientific and Technical Personnel. In civil engineering those with no degrees made up 19 per cent in the Census and only 4 per cent in the case of the Register. In electrical engineering the no-degree proportion was 26 per cent in the Census and 6 per cent in the Register.

6/ See Department of Labour, Economics and Research Branch, Employment Outlook for Professional Personnel in Scientific and Technical Fields, 1962-1964, Professional Manpower Report No. 13, December, 1962, p. 25. The tendency of such persons to be included in the Census but not in the Register would account for at least some of the difference in the proportion of engineers in this particular industry.

2. Match of Information on Engineers Using Data from the 1961 Census and the Department of Labour Survey of Scientific and Technical Personnel, 1961

The purpose of this study was to make a direct comparison between the data on individuals by occupation in the 1961 Census and by field of academic as well as by field of employment specialization in the 1961 Survey of Scientific and Technical Personnel which was based on the Register of the Department of Manpower and Immigration (formerly the Register of Department of Labour). It was felt that a direct comparison of the data on individuals in these two sources of information, the Census using an "occupational" and the Register using a "field of employment" or "field of academic specialization" concept, would reveal differences and similarities which would in turn indicate to what extent the data from these two sources could be used interchangeably. It was decided to compare those individuals whose academic specialization was "engineering" in the 1961 Survey of Scientific and Technical Personnel with their occupational classification in the 1961 Census.

a. Method

Those who reported in the 1961 Survey of Scientific and Technical Personnel as "engineers", i.e., all who had an engineering degree or its equivalent, were divided into two groups, one group who said they were in scientific and technical fields - the "technical" group - and another group who said they were not - "the non-technical". A stratified random sample of 225 out of 9,054 engineers was selected: 108 out of 864 non-technical and 116 out of 8,190 technical, and the results were then matched directly with the individual returns from the 1961 Census.

The actual matching was done internally by the Dominion Bureau of Statistics and the results released statistically in such a way that individuals could not be identified. Of the 225 individuals in the sample, 169 were traced in the 1961 Census records, a success rate of 75 per cent.

b. Limitations

(1) First, the sample was limited of necessity to engineers in the 1961 Survey of Scientific and Technical Personnel since this provided the basis for selection.

The survey was based on the Register, so the vast majority of engineers in the survey had university degrees. It was not possible to examine the occupational status of engineers without university degrees. Since these persons would have been classified as "engineers" on the basis of Census occupation or field of employment in the Register, their inclusion in the sample would have raised the proportion of "technical" engineers.

(2) Some information was available on the 25 per cent in the sample who could not be located. Those who were located and those who were not located were compared to see what bias, if any, those who were not located would have on the results. Those who were not located tended to be a younger and presumably more mobile group. These individuals would have the effect of raising the proportion of engineers who were reported occupationally as "engineer" in the Census by about 1 or 2 percentage points, 1 percentage point in the case of the technical and 2 percentage points in the case of the non-technical group.

These first two limitations suggest that the estimated proportion of engineers who were reported occupationally in the Census as "engineers" - 70 per cent of the technical and 16 per cent of the non-technical - which is based upon this sample is probably a minimum estimate.

(3) The timing of the data collected, June, 1961, in the case of the Census, and early 1962 in the case of the Survey of Scientific and Technical Personnel, meant that the information was over six months apart in time. The information requested in the Survey of Scientific and Technical Personnel covered the calendar year 1961, so this would tend to bring it more in line with the Census. In the case of occupational comparisons, it is believed that this difference in time would probably have very little influence. It might possibly exert a slight upward bias on the proportion who would have been reported occupationally as engineers in the Census since there is a tendency for those trained as engineers to move out of this occupation as the level of experience increases.

c. Conclusion

The results in the following table show that about seven out of ten individuals in the Survey of Scientific and Technical Personnel who reported that they were in "technical" fields were also reported occupationally as "engineers" in the Census. On the other hand, less than two out of ten who reported in the Survey of Scientific and Technical Personnel that they were "non-technical" were reported as being in engineering occupations in the 1961 Census. This suggests that "field of employment" in the case of the Register data is best for comparisons with Census data since seven times out of ten an engineer in the Register is also reported as an engineer in the Census.

The degree of confidence attached to these estimates can be estimated by applying the formula for the variance of a proportion p,

$S_p^2 = \frac{Pq}{N-1}(1-f)$, where P=0.70, q=0.30, N=116 and f= 0.0143

$$Sp = \sqrt{\frac{Pq}{N-1} \times (1-f)} = \sqrt{\frac{0.70 \times 0.30}{116-1} \times (1-0.0143)} = 0.042$$

The 0.95 confidence interval is P $\pm$ 1.96 sp, that is, 0.70 $\pm$ 0.082. Thus, the probability is 19 chances out of 20 that the proportion of engineers in the Register of Scientific and Technical Personnel who were also reported as "engineers" in the Census is between 62 and 78 per cent.

In the case of "technical" engineers who graduated after 1950, 80 per cent were found to be in "engineering" occupations in the Census. A recent U.S. Study found that 80 per cent of the engineers who took undergraduate work were in engineering occupations two years later.7/

7/ U.S. National Science Foundation, Two Years After the College Degree, Washington, D. C., U.S. Government Printing Office, 1963, p. 199.

Occupations Reported in the 1961 Census by
Engineering Graduates in the Survey of
Scientific and Technical Professions, 1961

Engineering Graduates, Survey of Scientific and Technical Professions, 1961	Total		Occupations Reported in 1961 Census: Managerial		Engineering		Other Professional		All Other Occupations	
	No.	%	No.	%	No.	%	No.	%	No.	%
Employed in a Scientific or Technical Field	87	100	14	16	61	70	4	5	8	9
Not Employed in a Scientific or Technical Field	81	100	55	68	13	16	5	6	8	10

Source: Department of Labour, Economics and Research Branch, Survey of Scientific and Technical Professions, 1961 and Special Comparison by Dominion Bureau of Statistics of Register and Census information.

Sample Counts of Engineers by Year of Graduation and Occupation, Match of Returns from the 1961 Census with Survey of Scientific and Technical Personnel Respondents, 1961

Graduating Year	Total	Managerial Occupations	Professional Engineers	Other Professionals	All Other Occupations
	Engineers—Non-Technical				
1930 and Before	14	7	2	2	3
1931-1940	14	12	2	0	0
1941-1950	34	24	6	2	2
After 1950	19	12	3	1	3
Total	81	55	13	5	8
	Per Cent				
1930 and Before	100	50.0	14.3	14.3	21.4
1931-1940	100	85.7	14.3	0.0	0.0
1941-1950	100	70.6	17.6	5.9	5.9
After 1950	100	63.1	15.8	5.3	15.8
Total	100	67.9	16.0	6.2	9.9
	Engineers—Technical				
1930 and Before	6	1	4	1	0
1931-1940	10	1	5	1	3
1941-1950	36	9	24	1	2
After 1950	35	3	28	1	3
Total	87	14	61	4	8
	Per Cent				
1930 and Before	100	16.6	66.7	16.7	0.0
1931-1940	100	10.0	50.0	10.0	30.0
1941-1950	100	25.0	66.7	2.8	5.5
After 1950	100	8.6	80.0	2.8	8.6
Total	100	16.1	70.1	4.6	9.2

APPENDIX 2

A Basis for Estimating Engineering Graduations

In an attempt to develop a basis for the projection of engineering enrolments and graduations, a number of variables were examined to determine their possible use as predictors of engineering enrolments and degrees. These included: total male and female enrolments, total male undergraduate and post-graduate enrolments; total male undergraduate enrolments; total bachelor and first professional degrees; total male bachelor and first professional degrees. These variables were also examined over a variety of time periods. The closest association historically was found to be between engineering degrees and total male bachelor degrees. The regression equation based upon the 1953-63 period, however, was characterized by considerable plus and minus deviations and the results for the three-year projection period 1966-68 were too high when examined in relation to the more reliable estimates based on first-year engineering enrolments in the 1963-64 to 1965-66 period.

It was therefore decided to rely instead upon first-year engineering enrolments as the basis for estimating engineering graduations for 1966 to 1968 and to assume that the 1969-76 trend in engineering graduations as a percentage of total male bachelor graduations would fall somewhere between the experience of the immediate and more distant past. In Table V-A-2, a comparison is made of the results of the 1953-63 projections, the estimates in the present study and the projection made by Mitchener for the years 1971 and 1976. It is apparent that the projection in this study falls between the average of Mitchener's projection and that based upon the 1953-63 trend. It is felt that Projection B, while more conservative than that based on the historical trend, will be the most likely possibility if the cyclical pattern of engineering enrolments repeats itself and if engineering enrolments and degrees consequently increase as a proportion of total male enrolments and bachelor's degrees.

APPENDIX 3

Method of Calculating the Estimated Supply of Engineers to 1976

The stock of engineers at some future date is equal to the stock at some initial date plus gross additions minus gross withdrawals occurring between the initial and terminal dates.[1/]

1. Initial Stock

The initial stock comprises the estimated 41,000 engineers who were employed in Canada in 1961.

2. Gross Additions

Gross additions to engineering manpower come from graduation of engineers from Canadian universities, Canadian graduates of engineering faculties abroad and graduates of other than engineering faculties who enter engineering occupations, immigrant engineers and upgradings to professional status of those who have no university degree. Only three of these flows are considered here, graduates of Canadian universities, immigration and upgradings.

1/ The terminal date for graduations is 1976 and for immigration, emigration and net migration, 1975.

a. Graduations

It is assumed that Canadians who graduate abroad in engineering are approximately matched by foreigners who receive engineering degrees here. However, on the basis of an examination of Canadian data,[2/] and of data in United States,[3/] it is assumed that only 85 per cent of the engineering graduates enter engineering occupations. It is also assumed that graduates in other faculties who enter engineering are matched approximately by those who enter engineering occupations and later move to other occupations after a period of time.

b. Gross Immigration

The estimate by Kasahara of gross immigration of 125,000 per annum up to 1970 was accepted and assumed to continue to 1976.[4/] It was assumed that engineers would continue to constitute the same percentage of total annual

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2/ See Table II-32 above

3/ See U.S., National Science Foundation, Scientists, Engineers and Technicians in the 1960's, Requirements and Supply, cited above, p. 23.

4/ F.T. Denton, Yoshiko Kasahara and Sylvia Ostry, Population and Labour Force Projections to 1970, Staff Study No. 1 prepared for the Economic Council of Canada, Ottawa, December 1964, p. 5.

immigration as in the 1961-65 period, 1.3 per cent. This proportion was applied to estimated gross immigration in order to derive the estimates of gross immigration of engineers.

c. Upgradings

It was estimated that upgradings would represent 15 per cent of university graduates in engineering from 1962-66.[5/] In view of the long-term trend towards fewer engineers without university degrees it was decided to reduce assumed upgradings to 10 per cent of university graduates for the period 1967 to 1976. The net effect is to reduce upgradings from 10 per cent of engineering entrants (including graduates and net migrants in engineering) in 1962-66 to 8 per cent from 1967-76.

3. Withdrawals

The withdrawals considered here are deaths and retirements, emigration and transfers out of engineering to other occupations.

5/ Department of Labour, Economics and Research Branch, Professional Manpower Report No. 13, Employment Outlook for Professional Personnel in Scientific and Technical Fields, 1962-64, Ottawa, December 1962, p. 25.

a. Deaths and Retirements

Deaths and retirements have been calculated for the initial stock, for engineering graduates who enter engineering occupations in the projection period, for net migrant engineers and for those upgraded to professional status who enter engineering during this period of time.

(i) Losses from Initial Stock

The stock of engineers in the 1961 Survey of Scientific and Technical Personnel was distributed by single years of age. To those aged 46 or less the Canadian Life Tables 1960-62 (males) were applied to determine the number of survivors by 1966, 1971 and 1976. Next, Life Tables were used to determine how many of those 47 years of age and older would survive to the retirement age of 65 years thereby comprising withdrawals due to retirement. The remainder comprised withdrawals due to deaths and these were added to deaths among the group 46 years and younger in 1961 to yield total deaths occurring within each of the terminal periods. Appendix V-A-5 summarizes the results of these operations. Withdrawal rates represent the average annual withdrawals during a period as a percentage of the average stock during that period of time. These rates were then applied to the estimated stock of 41,000 engineers in 1961.

(ii) Losses from Graduations

The average age of graduate engineers is assumed constant at 24 years. Canadian Life Tables were used to determine how many of the graduates added to the stock would survive by 1966, 1971 and 1976. Since average age of graduation is 24 years even the 1965 graduates would be under retirement age by 1976, no calculation for retirement is necessary for this group.

(iii) Losses from Net Immigration and Upgradings

The average age of net migrant engineers is assumed constant at 27 years and the same technique is applied as was used for graduate engineers in calculating withdrawals.

b. Emigration

The estimate by Kasahara of a gross emigration of 75,000 per annum was used and assumed to continue to 1976.[6/] It was assumed that engineers would continue to constitute the same percentage of total annual emigration as in 1961-65, 1.8 per cent. This proportion was applied to the assumed gross emigration in order to derive the estimate of gross emigration of engineers.

[6/] See F.T. Denton, et. al, op. cit., p. 5.

c. Transfers

It was noted above that an estimated 15 per cent of engineering graduates do not enter engineering occupations and these were deducted from projected engineering graduations in estimating this source of supply.[7/]

In addition, in estimating the withdrawals from initial stock during the projection period, it was assumed that 0.5 per cent per annum would transfer from engineering to other occupations.[8/] No allowance was made for subsequent transfers of engineering graduates who entered engineering occupations nor of net migrant engineers nor of those upgraded to professional status. Any upward bias that this would have on the supply from these sources would probably be at least partially offset by transfers into engineering from other occupations.

4. Projected Stock of Engineers

The results of these calculations are given in Table V-A-5.

7/ See Appendix Table V-A-5.

8/ See Table II-38 above and U.S., National Science Foundation, Scientists, Engineers and Technicians in the 1960's, cited above, pp. 14 and 15, for a similar estimate.

Table II-A-1 - Numerical and Percentage Distribution of Males and Females in the Labour Force[1] by Selected Professional Occupations, Canada,[2] 1931-1961

Occupation	Total Number				Per Cent of All Occupations				Per Cent of Professional Occupations			
	1931	1941	1951	1961	1931	1941	1951	1961	1931	1941	1951	1961
All occupations	3,917,612	4,195,951	5,214,913	6,342,289	100.0	100.0	100.0	100.0	-	-	-	-
All professional occupations	238,366	282,766	387,797	634,284	6.1	6.7	7.4	10.0	100.0	100.0	100.0	100.0
Architects	1,298	1,202	1,740	2,940	*	*	*	0.1	0.5	0.4	0.4	0.5
Engineers (including surveyors)	16,587	19,791	34,385	51,370	0.4	0.5	0.7	0.8	7.0	7.0	8.9	8.1
Engineers (excluding surveyors)	..	..	29,960	42,990	..	..	0.6	0.7	..	..	7.7	6.8
Chemical engineers	..	..	2,572	2,995	..	..	0.1	0.1	..	..	0.7	0.5
Civil engineers (including surveyors)	7,524	6,721	12,168	20,257	0.2	0.2	0.2	0.3	3.2	2.4	3.1	3.2
Civil engineers (excluding surveyors)	..	..	7,743	11,877	..	..	0.2	0.2	..	..	2.0	1.9
Surveyors	..	..	4,425	8,380	..	..	0.1	0.1	..	..	1.1	1.3
Electrical engineers	3,937	4,557	6,349	8,758	0.1	0.1	0.1	0.1	1.7	1.6	1.6	1.4
Mechanical engineers (including industrial)	2,859	4,518	8,328	12,091	0.1	0.1	0.2	0.2	1.2	1.6	2.1	1.9
Mechanical engineers (excluding industrial)	..	..	..	8,130	..	..	..	0.1	..	..	..	1.3
Industrial engineers	..	..	..	3,961	..	..	..	0.1	..	..	..	0.6
Mining engineers	2,267	3,995	4,968	2,336	0.1	0.1	0.1	*	0.9	1.4	1.3	0.2
Other engineers				4,933				0.1				0.8
Veterinarians	1,046	1,050	1,205	1,524	*	*	..	*	0.4	0.4	0.3	0.2
Other professionals	219,435	260,723	350,467	578,450	5.6	6.2	6.7	9.1	92.1	92.2	90.4	91.2
Dentists	4,039	3,740	4,608	5,463	0.1	0.1	0.1	0.1	1.7	1.3	1.2	0.9
Law	8,602	8,398	9,635	12,899	0.2	0.2	0.2	0.2	3.6	3.0	2.5	2.0
Nurses	31,898	38,509	50,761	84,546	0.8	0.9	0.9	1.3	13.4	13.6	13.1	13.3
Physicians and surgeons	10,020	10,723	14,325	21,266	0.3	0.3	0.3	0.3	4.2	3.8	3.7	3.4
Professors and college principals	3,200	4,135	5,422	11,145	0.1	0.1	0.1	0.2	1.3	1.5	1.4	1.8
Teachers	82,983	86,453	105,118	167,694	2.1	2.0	2.0	2.6	34.9	30.6	27.1	26.4
Others[3]	78,693	108,765	160,598	275,437	2.0	2.6	3.1	4.4	33.0	38.5	41.4	43.4

* Less than 0.05 per cent - nil or zero .. not available or not appropriate or applicable.

1/ 14 years of age and over for 1931, 1941 and 1951; 15 years of age and over for 1961.
2/ Not including Yukon and Northwest Territories. Includes Newfoundland in 1951 and 1961. Persons on active service excluded from 1931, 1941, 1951 and 1961.
3/ Persons in occupations which were not comparable over time are included here.

N.B.: The "gainfully occupied" rather than the "labour force" concept was used prior to 1951 for determining labour force status. The labour force includes a few persons seeking work who have never been employed. Occupations for 1931, 1941 and 1961 were arranged on the 1951 classification basis.

Sources: Canada, Dominion Bureau of Statistics, Ninth Census of Canada, 1951, Vol. X, Table 63.
Dominion Bureau of Statistics, Occupation and Industry Trend in Canada, 1954, SP-8; Labour Force, Occupations by Sex, 1961 Census of Canada, 1963.

Occupation	1931	1941	1951	1961	1931-1941	1941-1951	1951-1961	1931-1961
All occupations	3,917,612	4,195,951	5,214,913	6,342,289	7.1	24.3	21.6	61.9
All professional occupations	238,366	282,766	387,797	634,284	18.6	37.1	63.6	166.1
Architects	1,298	1,202	1,740	2,940	-7.4	44.8	69.0	126.5
Engineers (including surveyors)	16,587	19,791	34,385	51,370	19.3	73.7	49.4	209.7
Engineers (excluding surveyors)	..	..	29,960	42,990	..	..	43.5	..
Chemical engineers	..	..	2,572	2,995	..	..	16.4	..
Civil engineers (including surveyors)	7,524	6,721	12,168	20,257	-10.7	81.0	66.5	169.2
Civil engineers (excluding surveyors)	..	..	7,743	11,877	..	..	53.4	..
Surveyors	..	..	4,425	8,380	..	..	89.4	..
Electrical engineers	3,937	4,557	6,349	8,758	15.7	39.3	37.9	122.5
Mechanical engineers (including industrial)	2,859	4,518	8,328	12,091	58.0	84.3	45.2	322.9
Mechanical engineers (excluding industrial)	..	..	..	8,130	..	..	..	..
Industrial engineers	..	..	..	3,961	..	..	..	..
Mining engineers Other engineers	2,267	3,995	4,968	2,336 4,933	76.2	24.4	46.3	220.6
Veterinarians	1,046	1,050	1,205	1,524	0.4	14.8	26.5	45.7
Other professionals	219,435	260,723	350,467	578,450	18.8	34.4	65.1	163.6
Dentists	4,039	3,740	4,608	5,463	7.4	23.2	18.6	35.3
Law	8,602	8,398	9,635	12,899	-2.4	14.7	33.9	50.0
Nurses	31,898	38,509	50,761	84,546	20.7	31.8	66.6	165.1
Physicians and surgeons	10,020	10,723	14,325	21,266	7.0	33.6	48.5	112.2
Professors and college principals	3,200	4,135	5,422	11,145	29.2	31.1	105.6	248.3
Teachers	82,983	86,453	105,118	167,694	4.2	21.6	59.5	102.1
Others 3/	78,693	108,765	160,598	275,437	38.2	47.7	71.5	250.0

☆ Less than 0.05 per cent - nil or zero .. not available or not appropriate or applicable.

1/ 14 years of age and over for 1931, 1941 and 1951; 15 years of age and over for 1961.
2/ Not including Yukon and Northwest Territories. Includes Newfoundland in 1951 and 1961. Persons on active service excluded from 1931, 1941, 1951 and 1961.
3/ Persons in occupations which were not comparable over time are included here.

N.B.: The "gainfully occupied" rather than the "labour force" concept was used prior to 1951 for determining labour force status. The labour force includes a few persons seeking work who have never been employed. Occupations for 1931, 1941 and 1961 were arranged on the 1951 classification basis.

Sources: Canada, Dominion Bureau of Statistics, Ninth Census of Canada, 1951, Vol. X, Table 63.
Dominion Bureau of Statistics, Occupation and Industry Trend in Canada, 1954, SP-8; Labour Force, Occupations by Sex, 1961 Census of Canada, 1963.

Table 11-A-3 - Numerical and Percentage Distribution of the Male Labour Force[1] by Selected Professional Occupations, Canada,[2] 1931-1961

Occupation	Total Number				Per Cent of All Occupations				Per Cent of Professional Occupations			
	1931	1941	1951	1961	1931	1941	1951	1961	1931	1941	1951	1961
All occupations	3,252,310	3,363,111	4,051,020	4,581,839	100.0	100.0	100.0	100.0	-	-	-	-
All professional occupations	120,582	152,690	220,023	360,488	3.7	4.5	5.4	7.9	100.0	100.0	100.0	100.0
Architects	1,296	1,186	1,697	2,874	☆	☆	☆	0.1	1.1	0.8	0.8	0.8
Engineers (including surveyors)	16,587	19,791	34,341	51,196	0.5	0.6	0.9	1.1	13.8	13.0	15.6	14.2
Engineers (excluding surveyors)	..	..	29,937	42,874	..	..	0.7	0.9	..	..	13.6	11.9
Chemical engineers	..	..	2,569	2,981	..	..	0.1	0.1	..	..	1.2	0.8
Civil engineers (including surveyors)	7,524	6,721	12,147	20,170	0.2	0.2	0.3	0.4	6.2	4.4	5.5	5.6
Civil engineers (excluding surveyors)	..	..	7,743	11,848	..	..	0.2	0.3	..	..	3.5	3.3
Surveyors	..	..	4,404	8,322	..	..	0.1	0.2	..	..	2.0	2.3
Electrical engineers	3,937	4,557	6,338	8,718	0.1	0.1	0.2	0.2	3.3	3.0	2.9	2.4
Mechanical engineers (including industrial)	2,859	4,518	8,319	12,074	0.1	0.1	0.2	0.3	2.4	3.0	3.8	3.4
Mechanical engineers (excluding industrial)	..	..	..	8,115	..	..	..	0.2	..	..	..	2.3
Industrial engineers	..	..	..	3,959	..	..	..	0.1	..	..	..	1.1
Mining engineers) Other engineers)	2,267	3,995	4,968	2,334	0.1	0.1	0.1	0.1	1.9	2.6	2.2	0.6
Other engineers				4,919				0.1				1.4
Veterinarians	1,046	1,050	1,178	1,498	☆	☆	☆	☆	0.9	0.7	0.5	0.4
Other professionals	101,653	130,663	182,807	304,920	3.2	3.9	4.5	6.7	84.3	85.6	83.1	84.6
Dentists	4,007	3,695	4,540	5,228	0.1	0.1	0.1	0.1	3.3	2.4	2.1	1.5
Law	8,543	8,268	9,433	12,573	0.3	0.2	0.2	0.3	7.1	5.4	4.3	3.5
Nurses	-	226	910	2,678	-	☆	☆	0.1	-	0.1	0.4	0.7
Physicians and surgeons	9,817	10,339	13,665	19,814	0.3	0.3	0.3	0.4	8.1	6.8	6.2	5.5
Professors and college principals	2,941	3,858	4,610	8,779	0.1	0.1	0.1	0.2	2.4	2.5	2.1	2.4
Teachers	18,274	21,988	29,322	54,281	0.6	0.7	0.7	1.2	15.2	14.4	13.3	15.1
Others[3]	58,071	82,289	120,327	201,567	1.8	2.5	3.0	4.4	48.2	53.9	54.7	55.9

☆ Less than 0.05 per cent - nil or zero .. not available or not appropriate or applicable.

1/ 14 years of age and over for 1931, 1941 and 1951; 15 years of age and over for 1961.
2/ Not including Yukon and Northwest Territories. Includes Newfoundland in 1951 and 1961. Persons on active service excluded from 1931, 1941, 1951 and 1961.
3/ Persons in occupations which were not comparable over time are included here.

N.B.: The "gainfully occupied" rather than the "labour force" concept was used prior to 1951 for determining labour force status. The labour force includes a few persons seeking work who have never been employed. Occupations for 1931, 1941 and 1961 were arranged on the 1951 classification basis.

Sources: Canada, Dominion Bureau of Statistics, Ninth Census of Canada, 1951, Vol. X, Table 63.
Dominion Bureau of Statistics, Occupation and Industry Trend in Canada, 1954, SP-8; Labour Force, Occupations by Sex, 1961 Census of Canada, 1963.

Occupation	1931	1941	1951	1961	1931-1941	1941-1951	1951-1961	1931-1961
All occupations	3,252,310	3,363,311	4,051,020	4,581,839	3.4	20.5	13.1	40.[illegible]
All professional occupations	120,582	152,690	220,023	360,488	26.6	44.1	63.8	199.0
Architects	1,296	1,186	1,697	2,874	-[illegible].5	43.1	69.4	121.8
Engineers (including surveyors)	16,587	19,791	34,341	51,196	19.3	73.5	49.[illegible]	20[illegible]
Engineers (excluding surveyors)	..	..	29,937	42,874	..	..	43.2	..
Chemical engineers	..	..	2,569	2,981	..	..	16.0	..
Civil engineers (including surveyors)	7,524	6,721	12,147	20,170	-10.7	80.7	66.0	168.[illegible]
Civil engineers (excluding surveyors)	..	..	7,743	11,848	..	..	53.0	..
Surveyors	..	..	4,404	8,322	..	..	89.0	..
Electrical engineers	3,937	4,557	6,336	8,716	15.7	39.1	37.6	[illegible].4
Mechanical engineers (including industrial)	2,859	4,516	8,319	12,074	58.0	84.1	45.1	3[illegible]
Mechanical engineers (excluding industrial)	..	..	..	8,115	..	..	..	..
Industrial engineers	..	..	..	3,959	..	..	..	..
Mining engineers	2,267	3,995	4,968	2,334	76.2	24.4	46.0	219.9
Other engineers				4,919				
Veterinarians	1,046	1,050	1,178	1,498	0.4	12.2	27.2	43.2
Other professionals	101,053	130,663	182,807	304,920	28.5	40.0	66.8	200.0
Dentists	4,007	3,695	4,540	5,228	-7.8	22.9	15.2	[illegible]5
La[illegible]	8,543	8,268	9,433	12,573	-3.2	14.1	33.3	47.[illegible]
Nurses	-	226	910	2,678	-	302.7	194.3	
Physicians and surgeons	9,817	10,339	13,665	19,814	5.3	32.2	45.0	10[illegible]
Professors and college principals	2,941	3,858	4,610	8,779	31.2	19.5	90.4	198.[illegible]
Teachers	18,274	21,988	29,322	54,281	20.3	33.4	85.1	197.0
Others[3]	58,071	82,289	120,327	201,567	41.7	46.2	67.5	247.[illegible]

* Less than 0.05 per cent - nil or zero .. not available or not appropriate or applicable.

1 14 years of age and over for 1931, 1941 and 1951; 15 years of age and over for 1961.
2 Not including Yukon and Northwest Territories. Includes Newfoundland in 1951 and 1961. Persons on active service excluded from 1931, 1941, 1951 and 1961.
3 Persons in occupations which were not comparable over time are included here.

NOTE The "gainfully occupied" rather than the "labour force" concept was used prior to 1951 for determining labour force status. The labour force includes a few persons seeking work who have never been employed. Occupations for 1931, 1941 and 1961 were arranged on the 1951 classification basis.

Sources: Canada, Dominion Bureau of Statistics, Ninth Census of Canada, 1951, Vol. X, Table 63.
Dominion Bureau of Statistics, Occupation and Industry Trend in Canada, 1954, SP-8; Labour Force, Occupations by Sex, 1961 Census of Canada, 1963.

Breakdown of Year-to-Year Changes in Engineering Bachelor Graduations by Associated Factors:
Changes in Total Male Undergraduate Enrolment, Per Cent Enrolled in First Year
Engineering Courses and Drop-Out Rates in Engineering Courses, 1950-54 to 1960-64

Year	(1) Total Male Undergraduate Enrolment	(2) Actual First Year Engineering Enrolment	(3) Change In Actual First Year Engineering Enrolment	(4) First Year Engineering Enrolment as a Per Cent of Total Male Enrolment	(5) Estimated First Year Engineering Enrolment Assuming Per Cent Unchanged From Previous Year = (1) X (4) of Previous Year	(6) Change in First Year Engineering Enrolment Attributable to Change in Total Enrolment = (5) minus (2)	(7) Change in First Year Engineering Enrolment Attributable to Change in Per Cent (2) - (5)	(8) Subsequent Actual Graduation (Bachelor)	(9) Drop-Out Rates in Engineering Courses %	(10) Change in Actual Graduation	(11) Change in Graduations Attributable to Change in Total Enrolment (6) X (100 - (8))	(12) Change in Graduations Attributable to Change in Per Cent (7) X (100 - (8))	(13) Change in Graduations Attributable to Change in Drop-Out Rate (10) - (11) - (12)	(14) Net Change Attributable to Changes in Per Cent and Drop-Out Rate (12) + (13)
1950-54	55,028	1,815		3.30				1,252	31.0					
1951-55	50,170	2,062	+247	4.11	1,656	-159	+406	1,337	35.2	+85	-103	+263	-75	+188
1952-56	46,602	2,676	+614	5.74	1,915	-147	+761	1,597	40.3	+260	-88	+454	-106	+348
1953-57	46,821	3,001	+325	6.41	2,688	+ 12	+313	1,741	42.0	+144	+ 7	+182	-45	+137
1954-58	47,798	3,432	+431	7.18	3,064	+ 63	+368	1,930	43.8	+189	+ 35	+207	-53	+154
1955-59	51,083	3,589	+157	7.01	3,668	+236	- 79	2,057	43.0	+117	+135	- 45	+27	- 18
1956-60	54,545	4,150	+561	7.61	3,824	+235	+326	2,171	47.7	+124	+123	+171	-170	+ 1
1957-61	58,713	4,682	+532	7.97	4,468	+318	+214	2,412	48.5	+241	+164	+110	-33	+ 77
1958-62	64,303	4,625	- 57	7.19	5,125	+443	-500	2,437	46.8	+ 50	+236	-266	+80	-186
1959-63	69,771	4,156	-469	5.96	5,017	+392	-861	2,246	45.9	-212	+212	-466	+42	-424
1960-64	73,909	4,176	+ 20	5.65	4,405	+249	-229	2,367	43.3	+117	+141	-130	+106	- 24

Sources. 1. Col. (1) - D.B.S., Survey of Higher Education 1954-1961, Ottawa, August, 1963, Table 15, p. 34.
2. Col. (2) - Engineering Institute of Canada, The Engineering Journal, Vol. 25, Nos. 1 and 12, Vol. 26-43, No. 12, Vol. 45, No. 12, Vol. 47, No. 1, January, 1942, December, 1942-1960, January, 1962.
3. Col. (8) D.B.S., Survey of Higher Education, Ibid., 1952-54, 1950-52.
4. Col. (9) = Col. (2) - Col. (8) ÷ Col. (2).

Table II-A-6

Total, Professional, and Engineering Immigration to Canada, 1946-1963

Total Immigration(1) to Labour Force	Professional Immigration(2)	Engineering Immigration(2)	Professional / Total	Engineering / Total	Engineering / Professional
No.	No.	No.	%	%	%
14,375	1,423	269	9.9	1.9	18.9
39,771	2,040	383	5.1	1.0	18.8
75,204	2,426	448	3.2	0.6	18.5
52,934	1,937	367	3.7	0.7	18.9
40,123	1,686	318	4.2	0.8	18.9
113,386	4,200	784	3.7	0.7	18.7
85,029	7,203	1,382	8.5	1.6	19.2
91,133	8,585	2,057	9.4	2.3	24.0
84,376	8,350	1,687	9.9	2.0	20.2
57,987	7,159	1,315	12.3	2.3	18.4
91,039	9,343	1,685	10.3	1.9	18.0
151,511	16,040	3,103	10.6	2.0	19.3
63,078	7,553	1,010	12.0	1.6	13.4
53,551	6,947	783	13.0	1.5	11.3
53,573	7,436	725	13.9	1.4	9.7
34,809	6,696	547	19.2	1.6	8.2
36,748	8,218	967	22.4	2.6	11.8
45,866	9,640	1,198	21.0	2.6	12.4
431,911	35,497	7,225	8.2	1.7	20.4
412,752	47,319	7,306	11.5	1.8	9.8
844,663	82,816	14,531	9.8	1.7	17.5

Louis, Immigration and Emigration of Professional and Skilled Manpower During the
Period, Special Study No. 1 prepared for the Economic Council of Canada, June
able A-14, p. 142.

ouis, ibid., p. 172.

Table II-A-7

Total, Professional and Engineering Emigration from Canada to the United States, 1950-1963

Total Emigration to Labour Force(1)	Professional Emigration(2)	Engineering Emigration(2)	Professional / Total	Engineering / Total	Engineering / Professional
No.	No.	No.	%	%	%
11,912	2,814	223	23.6	1.9	7.9
13,185	2,931	347	22.2	2.6	11.8
17,688	3,797	538	21.5	3.0	14.2
18,141	3,525	529	19.4	2.9	15.0
17,378	3,352	494	19.3	2.8	14.7
19,412	4,166	615	21.5	3.2	14.8
22,512	5,277	953	23.4	4.2	18.1
26,143	6,251	1,264	23.9	4.8	20.2
19,463	4,784	720	24.6	3.7	15.1
21,623	5,593	1,310	25.9	6.1	23.4
25,338	5,587	881	22.0	3.5	15.8
23,508	5,285	811	22.5	3.4	15.3
24,723	5,833	880	23.6	3.6	15.1
26,220	6,344	834	24.2	3.2	13.1
85,804	17,771	2,523	20.7	2.9	14.2
115,079	27,492	5,128	23.9	4.5	18.7
200,883	45,263	7,651	22.5	3.8	16.9

(1) Parai, Louis, Immigration and Emigration of Professional and Skilled Manpower During the Post-War Period, Special Study No. 1 prepared for the Economic Council of Canada June 1965, Table A-41, p. 202.

(2) Parai, Louis, ibid., Table A-44, p. 208.

Table II-A-8

Total, Professional and Engineering Net Migration(1), 1950-1963

Total Net Migration to Labour Force	Professional Net Migration	Engineering Net Migration	Professional / Total	Engineering / Total	Engineering / Professional
No.	No.	No.	%	%	%
28,211	- 1,128	95	- 4.0	0.3	
100,201	1,269	437	1.3	0.4	34.4
67,341	3,406	844	5.1	1.3	24.8
72,992	5,060	1,528	6.9	2.1	30.2
66,998	4,998	1,193	7.5	1.8	23.9
38,575	2,993	700	7.8	1.8	23.4
68,527	4,066	732	5.9	1.1	18.0
125,368	9,789	1,839	7.8	1.5	18.8
43,615	2,769	290	6.3	0.7	10.5
31,928	1,354	- 527	4.2	- 1.7	-38.9
28,235	1,849	- 156	6.5	- 0.6	- 8.4
11,301	1,411	- 264	12.5	- 2.3	-18.7
12,025	2,385	87	19.8	0.7	3.6
19,646	3,296	364	16.8	1.8	11.0
346,107	17,726	4,702	5.1	1.4	26.5
297,673	19,827	2,178	6.7	0.7	11.0
643,780	37,553	6,880	5.8	1.1	18.3

(1) Total immigration to Canada minus emigration to the United States.

See Tables II-A-6 and 7.

Comparison of Bachelor Graduations, Immigration, Emigration and Net Migration,(1) for Professional and Engineering Occupations, 1951-1960

Occupation and Year	(1) Graduations	(2) Immigration	(3) Emigration	(4) Net Migration	(5) Total (Graduation Plus Net Migration)	(6) Per Cent Graduations of Total	(7) Per Cent Immigration of Total	(8) Per Cent Emigration of Total	(9) Per Cent Net Migration of Total	(10) Total (Graduation Plus Net Migration)
Professional and Technical										
1951..........	15,754	4,200	2,917	1,283	17,037	92.5	24.6	17.1	7.5	100.0
1952..........	13,288	7,203	3,797	3,406	16,694	79.6	43.1	22.7	20.4	100.0
1953..........	12,575	8,585	3,525	5,060	17,635	71.3	48.7	20.0	28.7	100.0
1954..........	12,083	8,350	3,352	4,998	17,081	70.7	48.9	19.6	29.3	100.0
1955..........	12,967	7,159	4,166	2,993	15,960	81.2	44.9	26.1	18.8	100.0
1956..........	13,770	9,343	5,277	4,066	17,836	77.2	52.4	29.6	22.8	100.0
1957..........	14,783	16,040	6,251	9,789	24,572	60.2	65.3	25.4	39.9	100.0
1958..........	16,062	7,553	4,784	2,769	18,831	85.3	40.1	25.4	14.7	100.0
1959..........	17,080	6,947	5,593	1,354	18,434	92.7	37.7	30.3	7.4	100.0
1960	18,720	7,436	5,587	1,849	20,569	91.0	36.2	27.2	9.0	100.0
Engineers										
1951..........	2,425	784	347	437	2,862	84.7	27.4	12.1	15.3	100.0
1952..........	1,770	1,382	538	844	2,614	67.7	52.9	20.6	32.3	100.0
1953..........	1,337	2,057	529	1,528	2,865	46.7	71.8	18.5	53.3	100.0
1954..........	1,252	1,687	494	1,193	2,445	51.2	69.0	20.2	48.8	100.0
1955..........	1,337	1,315	615	700	2,037	65.6	64.6	30.2	34.4	100.0
1956..........	1,597	1,685	953	732	2,329	68.6	72.3	40.9	31.4	100.0
1957..........	1,741	3,102	1,264	1,838	3,579	48.6	86.7	35.3	51.4	100.0
1958..........	1,930	1,010	720	290	2,220	86.9	45.5	32.4	13.1	100.0
1959..........	2,047	783	1,310	-527	1,520	134.7	51.5	86.2	-34.7	100.0
1960..........	2,171	725	881	-156	2,015	107.7	36.0	43.7	-7.7	100.0

(1) Total immigration less emigration to the United States.

Sources: 1. See Table II-13.
2. See Tables II-A 6 to 8.

Table II-A-10

Males and Females in Selected Occupations with University Level Education, Total and Foreign Born, 1961

Occupation	All Grades of Education		Some University		University Degree		All Grades of Education		Some University		University Degree	
	Total in Occupation	Foreign Born	Total in Occupation	Foreign Born	Total in Occupation	Foreign Born	Total in Occupation	Foreign Born	Total in Occupation	Foreign Born	Total in Occupation	Foreign Born
	No.	No.	No.	No.	No.	No.	%	%	%	%	%	%
Professional Engineers...............	43,066	14,216	4,595	1,834	31,122	9,489	100.0	100.0	10.7	12.9	72.2	66.7
Civil Engineers....................	11,917	3,736	1,169	401	9,656	2,883	100.0	100.0	9.8	10.7	81.0	77.[illegible]
Mechanical Engineers...............	8,137	3,406	908	487	5,370	2,055	100.0	100.0	11.2	14.3	66.0	60.3
Industrial Engineers...............	3,962	1,313	549	225	1,772	549	100.0	100.0	13.9	17.1	44.7	41.8
Electrical Engineers...............	8,763	2,850	938	376	6,473	1,926	100.0	100.0	10.7	13.2	73.9	67.6
Mining Engineers...................	2,349	592	225	52	1,889	476	100.0	100.0	9.6	8.8	80.4	80.4
Chemical Engineers.................	2,996	816	230	69	2,608	686	100.0	100.0	7.7	8.5	87.0	84.0
Professional Engineers n.e.s.......	4,942	1,503	576	224	3,354	914	100.0	100.0	11.6	14.9	67.9	60.8
Physical Scientists................	11,062	3,588	1,367	441	8,087	2,754	100.0	100.0	12.4	12.3	73.1	70.[illegible]
Chemists...........................	6,144	2,081	916	318	4,071	1,468	100.0	100.0	14.9	15.3	66.3	70.5
Geologists.........................	2,770	878	279	74	2,366	769	100.0	100.0	10.1	8.4	85.4	87.[illegible]
Physicists.........................	699	242	30	8	635	227	100.0	100.0	4.3	3.3	90.8	93.8
Physical Scientists n.e.s..........	1,449	387	142	41	1,015	290	100.0	100.0	9.8	10.6	70.0	74.9
Biologists and Agricultural Professionals........................	5,936	1,182	730	116	4,276	883	100.0	100.0	12.3	9.8	72.0	74.7
Biological Scientists..............	1,666	458	187	45	1,355	376	100.0	100.0	11.2	9.8	81.3	82.1
Veterinarians......................	1,524	328	110	14	1,301	287	100.0	100.0	7.2	4.3	85.[illegible]	87.5
Agricultural Professionals n.e.s...	2,746	396	433	57	1,620	220	100.0	100.0	15.8	14.4	59.0	55.5
Architects.........................	2,940	1,249	268	118	2,315	945	100.0	100.0	9.1	9.4	78.7	75.7
Total - Professional and Technical...	628,911	119,610	110,071	20,964	195,245	42,619	100.0	100.0	17.5	17.5	31.0	35.6

Sources. 1. Dominion Bureau of Statistics, 1961 Census of Canada, Labour Force Bulletin 3.1-9, Table 17.
2. Dominion Bureau of Statistics, Unpublished tabulation of Foreign Born in Professional Occupations by Level of Schooling.

Table III-A-1

Distribution of Total Labour Force and Engineers by Industry, 1931, 1951 and 1961

Industry	Total Labour Force			Engineers, Including Surveyors		
	1931	1951	1961	1931	1951	1961
tal All Industries1/	3,921,833	5,214,913	6,342,289	16,587	34,385	51,370
riculture	1,123,988	827,030	639,619	7	108	35
restry, Fishing, Trapping	97,503	180,512	143,073	204	642	653
ning, Quarrying, Oil Wells	71,836	103,848	118,788	1,143	2,365	3,204
nufacturing	723,627	1,360,701	1,466,840	4,157	13,325	17,721
Foods and Beverages	84,155	153,170	196,887	143	390	473
Tobacco	7,511	8,474	8,833	12	23	24
Rubber	13,904	21,627	18,844	81	289	234
Leather	32,578	38,338	37,069	11	26	35
Textile	44,819	78,688	62,252	72	318	365
Knit Goods	9,832	23,018	19,746	7	34	13
Clothing	66,241	97,987	96,503	5	32	25
Wood	55,643	116,948	100,084	106	231	231
Furniture	19,678	29,462	34,682	13	36	58
Paper	41,556	89,700	101,640	445	1,141	1,371
Printing, Publishing	39,634	62,963	84,239	28	49	77
Iron and Steel2/	144,743	320,630	352,271	2,220	6,513	8,386
Transportation Equipment	106,772	186,782	175,623	452	1,771	2,679
Non-metallic Minerals) 3/	27,318	35,708	44,970	95	358	475
Petroleum and Coal)		14,001	16,891	132	583	913
Chemical	15,837	51,143	70,075	249	1,212	1,817
Miscellaneous	13,406	32,062	46,231	86	319	545
nstruction	249,789	350,762	465,976	2,370	3,502	5,302
ansportation, Storage, Communication	277,169	402,707	456,633	1,865	2,289	3,619
blic Utilities	25,370	61,814	70,317	1,542	2,484	2,980
ade	387,692 4/	710,095	949,312	382	1,994	1,990
Wholesale	60,767	195,468	292,730	151	1,544	1,859
Retail	326,766	514,627	656,582	231	450	131
nance, Insurance, Real Estate	92,320	143,985	228,811	51	180	283
rvice	703,298	1,005,902	1,644,747	4,694	7,416	15,296
Community) 5/	249,454	371,736	639,892	180	197	304
Business)		58,878	119,119	2,365	3,463	7,31[illegible]
Government	113,772	232,859	404,479	2,093	3,662	7,109
Recreation	17,670	28,703	39,810	15	25	28
Personal	322,402	313,726	441,447	41	69	41
specified	169,241	67,557	158,173	172	60	207

31 and 1961 adjusted to 1951 industrial classification.
cludes non-ferrous metal products and electrical apparatus and supplies.
n-metallic mineral products and products of petroleum and coal cannot be separated for 1931.
cludes 137 males and 22 females that could not be assigned for either wholesale or retail trade.
mmunity and business services cannot be reported for 1931.

es: Dominion Bureau of Statistics: Seventh Census of Canada, Vol. VI, Table 58;
Ninth Census of Canada, Vol. IV, Table 23;
Tenth Census of Canada, Vol. III, Part 2, Table 15.
Unpublished data obtained from the D.B.S. were used to supplement the above sources.

Table III-A-2

Sources of Changes in the Number of Engineers, Sum of Main and Detailed Industry Sectors, 1931-1951, 1951-1961 and 1931-1961

Total of Aggregations Industry	Total Change	Labour Force	Distribution of Labour Force by Industry	Occupational Structure of Each Industry	Total Change	Labour Force	Distribution of Labour Force by Industry	Occupational Structure of Each Industry
	No.	No.	No.	No.	Per Cent	Per Cent	Per Cent	Per Cent
1931-1951								
Engineers, Including Surveyors								
Total....................	17,798	5,469	-153	12,482	100.0	30.7	-0.8	70.1
Sum of Main Groups.......	17,798	5,469	5,122	7,207	100.0	30.7	28.8	40.5
Sum of Detailed Sectors..	17,798	5,469	8,649	3,660	100.0	30.7	48.6	20.7
1951-1961								
Total....................	16,985	7,434	40	9,511	100.0	43.8	0.2	56.0
Sum of Main Groups.......	16,985	7,434	1,225	8,326	100.0	43.8	7.2	49.0
Sum of Detailed Sectors..	16,985	7,435	3,516	6,034	100.0	43.8	20.7	35.0
1951-1961								
Engineers, Excluding Surveyors								
Total....................	13,030	6,477	-286	6,839	100.0	49.7	-2.2	52.5
Sum of Main Groups.......	13,030	6,477	511	6,042	100.0	49.7	3.9	46.4
Sum of Detailed Sectors..	13,030	6,478	2,484	4,068	100.0	49.7	19.1	31.2
1931-1961								
Engineers, Including Surveyors								
Total....................	34,783	10,237	-186	24,732	100.0	29.4	-0.5	71.1
Sum of Main Groups.......	34,783	10,238	7,750	16,795	100.0	29.4	22.3	48.3
Sum of Detailed Sectors..	34,783	10,236	10,270	14,277	100.0	29.5	29.5	41.0

Source: See Table III-A-1.

Table IV-A-1

Indicators of Demand for Engineers and of Business Activity, 1946-1965

ar	1 Annual Starting Salaries of Engineers[1/]	2 Starting Salaries, Engineers	3 Average of Job Vacancies to Unplaced Applicants, Engineers	4 Employees, Manufacturing	5 Index of Real Domestic Products at Factor Cost	6 Business Gross Fixed Capital Formation	7 Annual % Change G.N.P.
	$	Annual % Change		(Millions)	(1949 = 100)	(Billions)	
6...	2,124	-	-	1.06	89.8	1.4	-
7...	2,148	1.1	-	1.13	93.8	2.1	1.3
8...	2,460	14.5	-	1.16	97.1	2.6	1.9
9...	2,580	4.9	-	1.17	100.0	3.0	3.9
0...	2,640	2.3	0.4	1.18	106.4	3.3	6.9
1...	2,700	2.3	0.8	1.26	114.6	4.0	6.2
2...	3,420	26.7	0.7	1.29	122.7	4.5	8.0
3...	3,420	0.0	1.0	1.33	126.7	5.0	3.8
4...	3,600[2/] (3,804)[3/]	5.3[2/] (11.2)[3/]	0.8	1.27	123.9	4.8	2.9
5...	3,804	5.7	2.2	1.30	136.3	5.2	8.6
6...	4,140	8.8	5.8	1.35	147.7	6.8	8.6
7...	4,524	9.3	1.8	1.36	147.0	7.3	1.3
8...	4,704	4.0	0.5	1.29	148.9	7.0	1.2
9...	4,740	0.8	0.8	1.30(1.29)	156.5	6.9	3.5
0...	4,812	1.5	1.1	1.28	158.5	6.7	2.4
1...	5,082	5.6	0.7	1.27	161.4	6.6	[illegible]
2...	5,148	1.3	1.2	-	171.4	7.0	6.7
3...	5,292	2.8	1.2	-	180.3	7.5	5.1
4...	5,520	4.3	2.0	-	-		[illegible]
5...	5,820	5.4	4.0	-	-		[illegible]

Median, 1946-1954, Average, 1954-1965.
Median.
Average.

rces:

Col. 1: 1946-1954, Department of Labour, Technical Personnel Bulletin, First Quarter, 19[illegible] (Mimeographed). 1954-1965, National Employment Service, "Supply and Demand, University Graduate", various issues, 1954 to 1965.

Col. 2: Based on Col. 1.

Col. 3: D.B.S., Labour Demand and Supply, various issues, 1946 to 1965. (Mimeographed).

Col. 4: 1946-1963, D.B.S., Canada Year Book, 1965, p. 659, 1964 and 1965.

Col. 5: D.B.S., Ibid, p. 1017.

Col. 6: D.B.S., National Accounts, Income and Expenditure, 1926-1956, Table 54; Ibid, 1962, Table 25; Canada Year Book, 1965, p. 1010.

Col. 7: 1946-1963, Basic data taken from D.B.S., Canada Year Book, 1965, p. 1009; 1964 and 1965, National Accounts, Income and Expenditure, 1964, p. 18; Ibid, p. 13.

Table IV-A-2

Unfilled Vacancies and Unplaced Applicants, Engineers,
Week Ending Nearest June 1, 1947-1966

Year	Unfilled Vacancies		Unplaced Applicants	
	Number	Index: 1947 = 100	Number	Index: 1947 = 100
1947....	432	100.0	505	100.0
1948....	210	48.6	467	92.5
1949....	193	44.7	638	126.3
1950....	178	41.2	1,269	251.3
1951....	385	89.1	578	114.4
1952....	408	94.4	637	126.1
1953....	548	126.9	424	84.0
1954....	563	130.3	932	184.5
1955....	1,283	297.0	449	88.9
1956....	1,948	450.9	282	55.8
1957....	1,608	418.5	604	119.6
1958....	628	145.4	907	179.6
1959....	1,235	286.3	943	186.7
1960....	1,208	280.1	746	147.7
1961....	1,009	233.6	936	185.3
1962....	508	117.6	435	86.1
1963....	650	150.5	749	148.3
1964....	795	184.0	493	97.6
1965....	1,305	302.1	318	63.0
1966....	942	218.1	265	52.5

Source: D.B.S., Labour Demand and Supply, various issues, 1947 to 1966 (Mimeographed).

Table IV-A-3

Indicators of Long-Run Supply of Engineers, 1920-1960

Year	1 Total Estimated Population of Canada	2 Immigrant Arrivals in Canada	3 New and Repair Construction Expenditures Millions of Constant 1949 Dollars	4 1935-39 = 100	5 Immigration As % of Total Population	6 Engineering % of Total Enrolment[1]
	(000's)					
1920...	8,336	138,824	-	-	1.62	12.5-P
1921...	8,788	91,728	-	-	1.04	12.5-T
1922...	8,919	64,224	-	-	0.72	11.1
1923...	9,010	133,729	-	-	1.49	10.2-P
1924...	9,143	124,164	-	-	1.36	8.9-T
1925...	9,294	84,907	-	-	0.91	8.5
1926...	9,451	135,982	1,430	111.1	1.44	8.2
1927...	9,637	158,886	1,633	126.9	1.65	8.6
1928...	9,835	166,783	1,892	147.0	1.70	9.0
1929...	10,029	164,993	2,034	158.0	1.65	9.6-P
1930...	10,208	104,806	1,878	145.9	1.03	10.3
1931...	10,376	27,530	1,624	126.2	0.27	11.3
1932...	10,510	20,591	1,107	86.0	0.20	11.4
1933...	10,633	14,382	899	69.9	0.14	11.2-T
1934...	10,741	12,476	1,022	79.4	0.12	10.6
1935...	10,845	11,277	1,114	86.6	0.10	10.0
1936...	10,930	11,643	1,210	94.0	0.11	10.1
1937...	11,045	15,101	1,395	108.4	0.14	10.7-P
1938...	11,152	17,244	1,343	104.4	0.15	11.6-T
1939...	11,267	16,994	1,379	107.1	0.15	[illegible]
1940...	11,381	11,324	1,510	117.3	0.10	12.4
1941...	11,507	9,329	1,870	145.3	0.07	12.6
1942...	11,654	7,576	2,009	156.1	0.07	[illegible]
1943...	11,795	8,504	2,073	161.1	0.07	15.2
1944...	11,946	12,801	1,732	134.6	0.11	14.1
1945...	12,072	22,722	1,772	137.7	0.19	[illegible]
1946...	12,292	71,719	2,124	165.0	0.58	17.6-T
1947...	12,551	64,127	2,399	186.4	0.51	17.3
1948...	12,823	125,414	2,652	206.1	0.98	18.1-P
1949...	13,447[2]	95,217	2,931	227.7	0.71	17.0-T
1950...	13,712	73,912	3,110	241.6	0.54	[illegible]
1951...	14,009	194,391	3,235	251.4	1.39	13.1
1952...	14,459	164,498	3,527	274.0	1.14	12.5
1953...	14,845	168,868	3,704	287.8	1.14	13.5-P
1954...	15,287	154,227	3,707	288.0	1.01	14.9-T
1955...	15,698	109,946	3,967	308.2	0.70	15.8

Table IV-A-3 (Continued)

Year	1 Total Estimated Population of Canada	2 Immigrant Arrivals in Canada	3 New and Repair Construction Expenditures Millions of Constant 1949 Dollars	4 1935-39 = 100	5 Immigration As % of Total Population	6 Engineering % of Total Enrolment
	(000's)					
1956...	16,081	164,857	4,596	357.1	1.03	16.2
1957...	16,610	282,164	4,823	374.7	1.70	16.9-P
1958...	17,080	124,851	-	-	0.73	17.0-T
1959...	17,483	106,928	-	-	0.61	15.8
1960...	17,870	104,111	-	-	0.58	14.6-P
1961...	-	-	-	-	-	13.6
1962...	-	-	-	-	-	12.0
1963....	-	-	-	-	-	10.8
1964...	-	-	-	-	-	10.1
1965...	-	-	-	-	-	9.3

/ Col. 6: P and T = business cycle peaks and troughs.
/ The population of Newfoundland is included beginning in 1949.

Sources:

Cols. 1-5: Buckley, K.A.H. and M.C. Urquhart, (Eds.), Historical Statistics of Canada, Toronto; Macmillan, 1965, pp. 1423 and 503.

Col. 6 : D.B.S., Survey of Higher Education, 1962-63, Part 11, p. 36. Ibid. 1936-38, p. 79; 1938-40, p. 38; 1940-42, p. 38; 1942-44, p. 39; 1944-46, p. 76; 1946-48, p. 50; 1948-50, p. 63; 1950-52, p. 55; 1952-54, p. 57; 1954-61, p. 29; 1962-63, p. 31; unpublished data from Higher Education Section, Education Division, D.B.S. In some cases, revised figures from unpublished documents of the Higher Education Section were used in place of published figures.

	1	2	3	4	5	6	7	8	9	10	11
				Average Salaries, Engineers (Census)							
Year	Average Earnings, Supervisory and Office Employees in Manufacturing	Engineers Starting Salaries (N.E.S. Series)[1]	Engineers and Scientists Average Salaries (N.R.C. Series)	Total Engineers	Electrical Engineers	Mechanical and Industrial Engineers	Engineers, Survey of Scientific and Technical Professions	University Teachers	Dentists	Lawyers	Medical Doctors and Surgeons
	$	$									
1946...	2,305	[illegible],124	-	-	-	-	-	3,482	[illegible]	5,637	6,[illegible]
1951...	3,296	2,70[illegible]	3,86[illegible]	3,636	3,816	3,774	-	4,797	[illegible],752	6,360	[illegible]
1952...	3,513	3,42[illegible]	4,90[illegible]	-	-	-	-	4,860	6,377	7,[illegible]04	[illegible],494
1953...	3,707	3,4[illegible]	5,1	-	-	-	-	5,24[illegible]	6,596	[illegible],933	9,979
1954	3,854	3,600[2] 3,604[3]	5,74[illegible]	-	-	-	-	5,423	6,941	9,6[illegible]	10,6[illegible]1
1955...	3,990	3,604	5,900	-	-	-	-	N.A.	7,610	10,167	10,54[illegible]
1956 .	4,22[illegible]	4,140	6,540	-	-	-	-	5,892	8,530	10,560	11,7[illegible]
1957 ..	4,471	4,524	7,120	-	-	-	-	6,713	9,256	11,164	12,657
1958...	4,773	4,7[illegible]	7,390	-	-	-	8,000	7,445	[illegible],876	11,[illegible]37	14,[illegible]
1959 ..	4,9[illegible]	4,740	7,6[illegible]	-	-	-	8,300	7,979	10,796	12,030	14,5[illegible]
1960 ...	5,217	[illegible],61	7,960	-	-	-	8,600	8,404	11,[illegible]	12,514	15,191
1961 ..	5,[illegible]	5,026	8,240	8,623	7,316	7,001	8,800	8,646	11,481	13,[illegible]3	15,642
1962 . .	-	5,1[illegible]	8,550	-	-	-	9,200	8,894	12,743	12,957	16,712
1963 .	-	5,[illegible]	8,820	-	-	-	9,600	9,103	12,735	14,186	18,131
1964 .	-	5,[illegible]	-	-	-	-	-	9,668	-	-	-
1965 .	-	5,820	-	-	-	-	-	-	-	-	-

- Not available.

1 Mean, 1946-1954, Average, 1954-1965.
2 Median.
3 Average.

Sources:

Col. 1 : 1946-59, D.B.S., General Review of the Manufacturing Industries of Canada, 1960, p. 84; 1960 and 1961, Ibid. 1961, p. 9[illegible].

Col. 2 : See Table IV-A-1.

Col. 3 : National Research Council, Survey of Professional Salaries, Engineers and Scientists, various issues, 1946-1963.

Cols. 4-6 : See Table IV-1.

Col. 7 : Department of Labour, Economics and Research Branch, Employment and Earnings in the Scientific and Technical Professions, 1959-1962, Professional Manpower Report No. 14, June 1963, Table 1; Annual Earnings in the Scientific and Technical Professions, 1963, P.M./6, July 1964, Table 1.

Col. 8 : D.B.S., Salaries and Qualifications of Teachers in Universities and Colleges, 1963-64, p. 33.

Cols. 9-11: Department of National Revenue, Taxation Division, Taxation Statistics, various issues, 1948 to 1965.

Table IV-A-5

Graduations and Net Migration, Engineering, Graduations in Pure Science and Technology as a Proportion of Labour Force, 1946-1965

	1	2	3	4	5
		Graduations			
Year	Total Labour Force	Engineering	Pure Science	Technical Institute Diplomas	Net Migration, Engineering
	No.	No.	No.	No.	No.
1946....	4,829	1,006	887	205	-
1947....	4,942	1,096	1,099	280	-
1948....	4,988	1,690	1,562	292	-
1949....	5,055	2,999	1,935	315	-
1950....	5,163	3,589	1,812	418	95
1951....	5,223	2,425	1,571	489	437
1952....	5,324	1,770	1,220	535	644
1953....	5,397	1,337	1,116	587	1,528
1954....	5,493	1,252	1,061	577	1,193
1955....	5,610	1,337	1,106	694	700
1956....	5,782	1,597	1,105	865	732
1957....	6,003	1,741	1,180	929	1,838
1958....	6,127	1,930	1,270	1,082	290
1959....	6,228	2,057	1,584	1,191	-527
1960....	6,403	2,171	1,701	1,535	-156
1961....	6,518	2,412	1,889	1,646	-264
1962....	6,608	2,437	2,227	2,088	87
1963....	6,737	2,246	2,591	2,123	364
1964....	6,933	2,422	3,076	2,135	655
1965....	7,141	2,256	3,530	2,887	1,298

Sources:

Col. 1 : Department of Labour, Annual National Data from the Labour Force Survey, Canada, 1949-1965.

Cols. 2 and 3: D.B.S., Survey of Higher Education, v.r.

Col. 4 : D.T. Wright, "Survey of Enrolments in Technical Institutes" diplomas awarded in engineering - related courses, unpublished data obtained by the author and used with the permission of Dr. Wright.

Col. 5 : See Table V-A-4 below.

Table IV-A-6

Indicators of Demand and Supply, Engineers, and of Business Activity, 1946-1965

Year	1 Ratios of Unfilled Vacancies to Unplaced Applicants	2 Annual Per Cent Changes Starting Salaries (N.E.S. Series)	3 Ratios of Engineering Degrees to Labour Force	4 Ratios of Engineering and Net Migration to Labour Force	5 Ratios of Engineering, Net Migration, Science and Technical Diplomas to Labour Force	6 Business Gross Fixed Capital Formation
1946...	N.A.	-	2.08	-	4.34	1.4
1947...	N.A.	1.1	2.22	-	5.01	2.1
1948...	N.A.	14.5	3.39	-	7.11	2.6
1949...	N.A.	4.9	5.93	-	10.38	3.0
1950...	0.4	2.3	6.95	7.14	11.45	3.3
1951...	0.8	2.3	4.64	5.48	9.42	4.0
1952...	0.7	26.7	3.32	4.91	8.21	4.5
1953...	1.0	0.0	2.48	5.31	8.46	5.0
1954...	0.8	5.3	2.28	4.45	7.43	4.8
1955...	2.2	5.7	2.38	3.63	6.84	5.2
1956...	5.8	8.8	2.76	4.03	7.44	6.8
1957...	1.8	9.3	2.90	5.96	9.48	7.3
1958...	0.5	4.0	3.15	3.62	7.46	7.0
1959...	0.8	0.8	3.30	2.46	6.91	6.9
1960...	1.1	1.5	3.39	3.15	8.20	6.7
1961...	0.7	5.6	3.70	3.30	8.72	6.6
1962...	1.2	1.3	3.69	3.82	10.35	7.0
1963...	1.2	2.8	3.33	3.87	10.87	7.5
1964...	2.0	4.3	3.49	4.44	11.95	N.A.
1965...	4.0	5.4	3.16	4.98	13.96	N.A.

N.A. = Not Available

Sources:

Cols. 1 and 2: See Table IV-A-1.

Cols. 3 - 5 : Calculated from Table IV-A-5.

Col. 6 : See Table IV-A-1.

Table V-A-1

Estimates of the Stock of Engineering and Scientific Manpower in Canada, 1961

Source	Engineers Number	Scientists[1] Number	Engineers and Scientists Number
1. Employment Outlook Survey, 1962	29,196	13,052	42,248
2. 1961 Census (incl. only those with university degrees)	31,122	(11,062 ((12,363)[2]	(42,184 ((43,485)[2]
3. 1961 Census	43,066	(15,474 ((16,998)[2]	(58,540 ((60,004)[2]
4. Survey of Scientific and Technical Personnel, 1961 (incl. those employed in engineering and science fields)	37,857	18,376	56,233
5. Survey of Scientific and Technical Personnel, 1961 (incl. those who have university degrees or other professional recognition)	41,544	23,994	65,538
6. Special Hand Count of the Register of Scientific and Technical Personnel, 1961	48,476	29,284	77,760

(1) Incl. agriculture, forestry and veterinary medicine.
(2) Incl. veterinarians.

Sources:

No. 1 - Department of Labour, Economics and Research Branch, Professional Manpower Report No. 13, Employment Outlook for Professional Personnel in Scientific and Technical Fields, 1962-64, December 1962, pages 5 and 6.

No. 2 - Census of Canada 1961, Vol. III, Part 1, Table 17.

No. 3 - Ibid.

No. 4 - Department of Labour, Economics and Research Branch, Professional Manpower Report No. 12, Employment and Earnings in the Scientific and Technical Professions, 1958-61, September 1962 and special tabulations.

No. 5 - Ibid.

No. 6 - Department of Labour, Economics and Research Branch, Professional Manpower Report No. 10, Engineering in Scientific Manpower Resources in Canada, Their Employment, Earnings and Salary Rates 1960-61, June 1951, page 63.

Table V-A-2

Alternative Estimates of Annual Engineering Graduations, 1971 and 1976

Academic Year	Mitchener[1] Number[a]	This Study[2] Number	Historical Trend,[3] 1953-63 Number
1960-61 (Actual)	2,496	2,412	2,412
1970-71 (Projected)	3,487-4,263	3,744-4,659	5,758
1975-76 (Projected)	4,567-5,581	5,058-6,294	7,725

(a) Includes engineering and architecture, Architecture accounts for about 4 per cent of the total.

Sources: (1) R.D. Mitchener, First Degrees Awarded by Canadian Universities and Colleges Projected to 1976/77, Ottawa, Canadian Universities Foundation, 1964.

(2) Table V-1.

(3) Based on a regression of bachelor engineering degrees (Y) and total male bachelor degrees (X), 1953-63. The equation is: $Y = 152 + 0.13475 X$.

Table V-A-3

Projections of Pure Science Degrees to 1976

Academic Year Ended	(1) Total Male Bachelor and First Professional Degrees	(2) Pure Science Degrees			(3) Pure Science Degrees		
	Number	Number			Per Cent		
1946	5,992	887			14.8		
47	7,250	1,099			15.2		
48	10,574	1,562			14.8		
49	14,468	1,935			13.4		
1950	14,836	1,812			12.2		
51	12,554	1,571			12.5		
52	10,258	1,220			11.9		
53	9,637	1,116			11.6		
54	9,190	1,061			11.5		
55	9,886	1,106			11.2		
56	10,619	1,105			10.4		
57	11,324	1,180			10.4		
58	12,249	1,270			10.4		
59	12,992	1,584			12.2		
1960	13,963	1,701			12.2		
61	15,029	1,889			12.6		
62	16,782	2,227			13.3		
63	18,168	2,591			14.3		
64	20,716	3,076			14.8		
65	23,840	3,530			14.8		
		(A)	(B)	(C)	(A)	(B)	(C)
66	24,600	3,600	4,400	4,000			
67	27,700	4,100	5,000	4,600			
68	31,000	4,600	5,600	5,100			
69	34,500	5,100	6,200	5,700			
1970	38,200	5,700	6,900	6,300			
71	41,600	6,200	7,500	6,900	14.8	18.0	16.4
72	45,200	6,700	8,100	7,400			
73	48,500	7,200	8,700	8,000			
74	51,400	7,600	9,300	8,500			
75	54,000	8,000	9,700	8,900			
76	56,200	8,300	10,100	9,200			
Total, 1966-76	452,900	67,100	81,500	74,600			
Percentage Change, 1965 to 1976	135.7	135.1	186.1	160.6			
Average Annual Percentage Change, 1965 to 1976	12.3	12.3	16.9	14.6			

Sources: Col. 1: (same as Col. 1, Table V-1).
Col. 2: Col. (1) x Col. (3).
Col. 3: Variant A based on pure science graduates as a per cent of total male bachelor and first professional degrees, 1964 and 1965.
Variant B is based on an extension for 1971 of the average annual increa in pure science as a per cent of total male bachelor and first professional degrees between 1960 and 1965, 0.5 per cent per year.
Variant C is an average of A and B.

Net Migration, by Intended Occupation 1950-65, Projected to 1976

Immigrants to Canada[1]

Year	Total Immigrants	Destined to Labour Force	Professional and Technical Workers		Engineering		Professional / Total		Engineering / Total		Professional / Total L.F.	Engineering / Total L.F.	Engineering / Professional	
	No.	No.	No.		No.		%		%		%	%	%	
1950	73,912	40,123		1,686		318		2.28		0.43	4.20	0.79		18.86
51	194,391	113,386		4,200		784		2.16		0.40	3.70	0.69		18.67
52	164,498	85,029		7,203		1,382		4.38		0.84	8.47	1.63		19.19
53	168,868	91,133		8,585		2,057		5.08		1.22	9.42	2.26		23.96
54	154,227	84,376		8,350		1,687		5.41		1.09	9.90	2.00		20.20
55	109,946	57,987		7,159		1,315		6.51		1.20	12.35	2.27		18.37
56	164,857	91,039		9,343		1,685		5.67		1.02	10.26	1.85		18.03
57	282,164	151,511		16,040		3,102		5.68		1.10	10.59	2.05		19.34
58	124,851	63,078		7,553		1,010		6.05		0.81	11.97	1.60		13.37
59	106,928	53,551		6,947		783		6.50		0.73	12.97	1.46		11.27
1960	104,111	53,573		7,436		725		7.14		0.70	13.88	1.35		9.75
61	71,689	34,809		6,696		547		9.34		0.76	19.24	1.57		8.17
62	74,586	36,748		8,218		967		11.02		1.30	22.36	2.63		11.77
63	93,151	45,866		9,640		1,198		10.35		1.29	21.02	2.61		12.43
64	112,606	56,190		11,965		1,476		10.63		1.31	21.29	2.63		12.34
65	146,758	74,195		16,654		2,254		11.35		1.54	22.45	3.04		13.53
Projections			(A)	(B)	(A)	(B)	(A)	(B)	(A)	(B)			(A)	(B)
1966	125,000	62,500[2]	9,125	13,375	1,375	1,625	7.3	10.7	1.1	1.3			15.1	12.1
67	125,000		9,125	13,375	1,375	1,625	7.3	10.7	1.1	1.3			15.1	12.1
68	125,000		9,125	13,375	1,375	1,625	7.3	10.7	1.1	1.3			15.1	12.1
69	125,000		9,125	13,375	1,375	1,625	7.3	10.7	1.1	1.3			15.1	12.1
1970	125,000		9,125	13,375	1,375	1,625	7.3	10.7	1.1	1.3			15.1	12.1
71	125,000		9,125	13,375	1,375	1,625	7.3	10.7	1.1	1.3			15.1	12.1
72	125,000		9,125	13,375	1,375	1,625	7.3	10.7	1.1	1.3			15.1	12.1
73	125,000		9,125	13,375	1,375	1,625	7.3	10.7	1.1	1.3			15.1	12.1
74	125,000		9,125	13,375	1,375	1,625	7.3	10.7	1.1	1.3			15.1	12.1
75	125,000		9,125	13,375	1,375	1,625	7.3	10.7	1.1	1.3			15.1	12.1
1976	125,000		9,125	13,375	1,375	1,625	7.3	10.7	1.1	1.3			15.1	12.1
1967-71	625,000		45,625	66,875	6,875	8,125	7.3	10.7	1.1	1.3			15.1	12.1
1972-76	625,000		45,625	66,875	6,875	8,125	7.3	10.7	1.1	1.3			15.1	12.1
1967-76	1,250,000		91,250	133,750	13,750	16,250	7.3	10.7	1.1	1.3			15.1	12.1

Emigrants from Canada to the United States[3/]

Year	Total Emigrants	Destined to Labour Force	Professional and Technical Workers	Engineering		Professional / Total	Engineering / Total		Professional / Total L.F.	Engineering / Total L.F.	Engineering / Professional	
	No.	No.	No.	No.		%	%		%	%	%	
1950	23,251	11,912	2,814		223	12.10		0.96	23.62	1.87		7.92
51	27,277	13,185	2,931		347	10.75		1.27	22.23	2.63		11.84
52	37,848	17,688	3,797		538	10.03		1.42	21.47	3.04		14.17
53	35,842	18,141	3,525		529	9.83		1.48	19.43	2.92		15.01
54	32,941	17,378	3,352		494	10.18		1.50	19.29	2.84		14.74
55	37,206	19,412	4,166		615	11.20		1.65	21.46	3.17		14.76
56	44,061	22,512	5,277		953	11.98		2.16	23.44	4.23		18.06
57	50,057	26,143	6,251		1,264	12.49		2.53	23.91	4.83		20.22
58	35,687	19,463	4,784		720	13.41		2.02	24.58	3.70		15.05
59	41,395	21,623	5,593		1,310	13.51		3.16	25.87	6.06		23.42
1960	48,682	25,338	5,587		881	11.48		1.81	22.05	3.48		15.77
61	45,209	23,508	5,285		811	11.69		1.79	22.48	3.45		15.35
62	47,597	24,723	5,833		880	12.25		1.85	23.59	3.56		15.09
63	51,511	26,220	6,344		834	12.32		1.62	24.20	3.18		13.15
64	49,998	25,307	6,171		821	12.34		1.64	24.38	3.24		13.30
65	50,029	25,169	5,764		956	11.52		1.91	22.90	3.80		16.59
Projections				(A)	(B)		(A)	(B)			(A)	(B)
1966	75,000	38,250[2/]	9,000	1,425	1,350	12.0	1.9	1.8			15.8	15.0
67	75,000		9,000	1,425	1,350	12.0	1.9	1.8			15.8	15.0
68	75,000		9,000	1,425	1,350	12.0	1.9	1.8			15.8	15.0
69	75,000		9,000	1,425	1,350	12.0	1.9	1.8			15.8	15.0
1970	75,000		9,000	1,425	1,350	12.0	1.9	1.8			15.8	15.0
71	75,000		9,000	1,425	1,350	12.0	1.9	1.8			15.8	15.0
72	75,000		9,000	1,425	1,350	12.0	1.9	1.8			15.8	15.0
73	75,000		9,000	1,425	1,350	12.0	1.9	1.8			15.8	15.0
74	75,000		9,000	1,425	1,350	12.0	1.9	1.8			15.8	15.0
75	75,000		9,000	1,425	1,350	12.0	1.9	1.8			15.8	15.0
1976	75,000		9,000	1,425	1,350	12.0	1.9	1.8			15.8	15.0
1967-71	375,000		45,000	7,125	6,750	12.0	1.9	1.8			15.8	15.0
1972-76	375,000		45,000	7,125	6,750	12.0	1.9	1.8			15.8	15.0
1967-76	750,000		90,000	14,250	13,500	12.0	1.9	1.8			15.8	15.0

Net Migration[4]

Year	Total Net Migration	Destined to Labour Force	Professional and Technical Workers		Engineering		Professional / Total		Engineering / Total		Professional / Total L.F.	Engineering / Total L.F.	Engineering / Professional	
	No.	No.	No.		No.		%		%		%	%	%	
1950	50,661	28,211		-1,128		95		-2.23		0.19	-4.00	0.34		
51	167,114	100,201		1,269		437		0.76		0.26	1.27	0.44		34.44
52	126,650	67,341		3,406		844		2.69		0.67	5.06	1.25		24.78
53	133,026	72,992		5,060		1,528		3.80		1.15	6.93	2.09		30.20
54	121,286	66,998		4,998		1,193		4.12		0.98	7.46	1.78		23.87
55	72,740	38,575		2,993		700		4.11		0.96	7.76	1.81		23.39
56	120,796	68,527		4,066		732		3.37		0.61	5.93	1.07		18.00
57	232,107	125,368		9,789		1,838		4.22		0.79	7.81	1.47		18.78
58	89,164	43,615		2,769		290		3.11		0.33	6.35	0.66		10.47
59	65,533	31,928		1,354		-527		2.07		-0.80	4.24	-1.65		-38.92
1960	55,429	28,235		1,849		-156		3.34		-0.28	6.55	-0.55		- 8.44
61	26,480	11,301		1,411		-264		5.33		-1.00	12.49	-2.34		-18.71
62	26,989	12,025		2,385		87		8.84		0.32	19.83	0.72		3.65
63	41,640	19,646		13,296		364		7.92		0.87	16.78	1.85		11.04
64	62,608	30,883		5,794		655		9.25		1.05	18.76	2.12		11.30
65	96,729	49,026		10,890		1,298		11.26		1.34	22.21	2.65		11.92
Projections			(A)	(B)	(A)	(B)	(A)	(B)	(A)	(B)			(A)	(B)
1966	50,000	24,250	125	4,375	- 50	275	0.25	8.75	-0.1	0.55			-40.0	6.29
67	50,000	24,250	125	4,375	- 50	275	0.25	8.75	-0.1	0.55			-40.0	6.29
68	50,000	24,250	125	4,375	- 50	275	0.25	8.75	-0.1	0.55			-40.0	6.29
69	50,000	24,250	125	4,375	- 50	275	0.25	8.75	-0.1	0.55			-40.0	6.29
1970	50,000	24,250	125	4,375	- 50	275	0.25	8.75	-0.1	0.55			-40.0	6.29
71	50,000	24,250	125	4,375	- 50	275	0.25	8.75	-0.1	0.55			-40.0	6.29
72	50,000	24,250	125	4,375	- 50	275	0.25	8.75	-0.1	0.55			-40.0	6.29
73	50,000	24,250	125	4,375	- 50	275	0.25	8.75	-0.1	0.55			-40.0	6.29
74	50,000	24,250	125	4,375	- 50	275	0.25	8.75	-0.1	0.55			-40.0	6.29
75	50,000	24,250	125	4,375	- 50	275	0.25	8.75	-0.1	0.55			-40.0	6.29
1976	50,000	24,250	125	4,375	- 50	275	0.25	8.75	-0.1	0.55			-40.0	6.29
1967-71	250,000	121,250	625	21,875	-250	1,375	0.25	8.75	-0.1	0.55			-40.0	6.29
1972-76	250,000	121,250	625	21,875	-250	1,375	0.25	8.75	-0.1	0.55			-40.0	6.29
1967-76	500,000	242,500	1,250	43,750	-500	2,750	0.25	8.75	-0.1	0.55			-40.0	6.29

Sources: 1/ 1950-65 - Department of Labour, Economics and Research Branch, Professional Manpower Report No. 11, The Migration of Professional Workers Into and Out of Canada, 1946-60, page 9; Immigration to Canada by Intended Occupation and Province of Intended Destination, calendar years 1940-55, inclusive, Department of Citizenship and Immigration, Immigration 1961, 1962, 1963, 1964 and 1965.

1966-76 - Projection A is based on engineers as a per cent of total immigrants during 1953-65. Projection B is based on the 1961-65 period.

2/ Number destined to labour force for 1966 was estimated as 50 per cent of immigrants and 51 per cent of emigrants, based on the average from 1961-65.

3/ 1950-65 - Emigration compiled from special tabulations prepared by the Immigration and Naturalization Service, U.S. Department of Justice. The last six months of 1965 were based on an estimate by the author.

1966-76 - Projection A is based on the 1953-65 period and Projection B on the 1961-65 period. Only one variant is shown for professionals because both base periods gave nearly identical results.

4/ Immigration minus emigration.

Source of Supply of Engineers	Survivors				Withdrawals					
					1962-66		1962-71		1962-76	
	1961	1966	1971	1976	No.	% Rate	No.	% Rate	No.	% Rate
1. Stock, 1961	41,000	37,720	33,620	28,085						
Initial Stock					41,000		41,000		41,000	
Withdrawals[(a)]					3,280	1.6	7,380	1.8	12,915	2.3
Survivors					37,720		33,620		28,085	
2. Graduate Engineers	-	9,972	24,410	46,198						
Total					9,997		24,532		46,547	
Withdrawals[(b)]					25	0.1	122	0.1	349	0.1
Survivors					9,972		24,410		46,198	
3. Net Immigrants	-	2,666	4,054	5,429						
Total					2,679		4,054		5,429	
Withdrawals[(b)]					13	0.2	41	0.2	81	0.2
Survivors					2,666		4,013		5,348	
4. Upgradings	-	1,492	2,907	5,038						
Total					1,500		2,936		5,115	
Withdrawals[(b)]					8	0.2	29	0.2	77	0.2
Survivors					1,492		2,907		5,038	
5. Total Supply	41,000	51,850	64,991	84,750						
Total										
Withdrawals										
Survivors										

[(a)] Deaths, retirements and transfers to other occupations.
[(b)] Deaths and retirements.

Sources: Line 1, 1961 table is based on estimate in Table V-A-1.
Line 2, Based on data in Table V-1, Projection "C", minus an allowance of 15 per cent for graduates who do not enter engineering occupations.
Line 3, Based on data in Table V-A-5.
Line 4, Based on data in Table II-36, in which upgradings were estimated to equal 15 per cent of engineering graduations from 1961-66 and 10 per cent thereafter.

Table V-A-6

Royal Commission on Canada's Economic Prospects
Comparison of Proportion of Graduations, Immigration, Emigration and Net Immigration of Engineers, 1956-65, with Actual Results

Year	Graduations	Net Immigration	Total
Projection:(1)			
1956-60	10,200	4,700	14,900
1961-65	15,300	3,400	18,700
Actual:(2)			
1956-60	9,486	2,177	11,663
1961-65	11,773	2,140(3)	13,913(3)

Year	Immigration	Emigration to the U.S.	Net Immigration
Projection:(1)			
1956-60	7,820	3,150	4,670
1961-65	6,800	3,450	3,350
Actual:(2)			
1956-60	7,305	5,128	2,177
1961-65	6,442	4,302	2,140

Sources: (1) Royal Commission on Canada's Economic Prospects, Skilled and Professional Manpower in Canada, 1945-1965, Ottawa, Economics and Research Branch, Department of Labour, July 1957, pp. 88 and 89.
(2) Tables V-1 and V-A-4.
(3) The last six months of 1965 have been estimated by the author.

Table V-A-7

Projection to 1970 of Engineers as a Per Cent of Occupations, by Industry

Industries	Engineers Less Surveyors		
	1951	1961	1970
	Percentages		
1. Agriculture	.01	.002	-
2. Forestry, Fishing, Trapping	.24	.28	.32
3. Mining, Quarrying	1.60	2.04	2.44
4. Manufacturing	.96	1.19	1.40
5. Foods and Beverages	.25	.24	.23
6. Tobacco	.27	.27	.27
7. Rubber	1.33	1.24	1.15
8. Leather	.07	.09	.11
9. Textile	.40	.58	.74
10. Knit Goods	.15	.07	-
11. Clothing	.03	.03	.03
12. Wood	.12	.17	.22
13. Furniture	.12	.17	.22
14. Paper	1.22	1.30	.3[illegible]
15. Printing	.08	.09	.10
16. Iron and Steel, etc.1/	2.02	2.35	2.67
17. Transportation	.94	1.52	2.04
18. Non-metallic Minerals	.99	1.05	1.11
19. Petroleum, Coal	3.92	5.08	6.13
20. Chemical	2.35	2.58	2.78
21. Miscellaneous Minerals	.99	1.17	1.33
22. Construction	.78	.70	.62
23. Transportation, Storage, Community	.52	.73	.92
24. Electric, Gas, Water	3.54	3.66	3.77
25. Trade	.28	.21	.14
26. Wholesale	.78	.63	.49
27. Retail	.09	.02	-
28. Finance	.10	.11	.12
29. Service	.55	.67	.78
30. Community	.05	.04	.03
31. Business	4.44	4.93	5.37
32. Government	1.15	1.20	1.25
33. Recreation	.08	.06	.04
34. Personal	.01	.01	.01
35. Unspecified	.08	.15	.22
Total	.57	.68	.7[illegible]

1/ Includes Iron and Steel, Non-Ferrous Metals, and Electrical Apparatus.

Sources: Dominion Bureau of Statistics: Ninth Census of Canada, 1951, Vol. IV, Table 23. Tenth Census of Canada, 1961, Vol. III, PM 2, Table 15. Unpublished data obtained from the D.B.S., was used to supplement the above sources.

Table V-A-8

Total Employment and Estimated Labour Force, 1970

	1 Employment, 1970	2 Labour Force, 1970
	Thousands	
1. Agriculture......................	543	559
2. Forestry, Fishing, Trapping......	94	96
3. Mining, Quarrying................	61	62
4. Manufacturing....................	1,999	2,058
5. Construction.....................	583	600
6. Transportation, Storage, Comm....	504	519
7. Public Utilities.................	124	127
8. Trade............................	1,248	1,285
9. Finance..........................	365	375
10. Community Service................	993	1,022
11. Business Service.................	188	193
12. Government Service...............	542	558
13. Recreation Service...............	42	43
14. Personal Service.................	596	615
Total............................	7,883	8,119

Sources:

Col. 1: N.M. Meltz, "Occupational Statistics for the Canadian Labour Force, 1931 to 1961 Together with Projections to 1970", a study prepared for the Department of Manpower and Immigration, 1966, to be published soon.

Col. 2: Employment, 1970 plus estimate of 3 per cent unemployment.