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The Labor Market Experience of Engineers in North America
Les ingénieurs sur le marché du travail en Amérique du Nord

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Article abstract

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The authors have undertaken a major project which they envision ultimately as an on-going analysis of the labor market behavior of technical and scientific manpower in highly developed economies. Their paper represents a first step in this direction.

The advantage of the comparative method in labor, as in other fields, is that it permits the testing of hypotheses among countries and that it allows distinguishing purely national phenomena from those which transcend boundary lines. We have undertaken a major project which we envision ultimately as an on-going analysis of the labor market behavior of technical and scientific manpower in highly developed economies. The present paper represents a first step in this direction.

In recent years, there has been a strong preoccupation in the relevant literature with size, role, and utilization of technical manpower. [1] Most of the studies, however, have been confined to specific groups, relatively few demographic variables, or narrow geographic areas. The current essay broadens the scope of investigation by examining several aspects of the labor market experience of engineers in Canada *and* the United States. The topics are : (1) social and educational background, (2) supply and demand analysis, (3) distribution and deployment, (4) earnings, (5) mobility and migration, and (6) utilization.

BOYD, A.D., Science Council of Canada ; GROSS, A.C., Cleveland State University and Science Council of Canada ; McKAY, R.R., West Virginia University.

[1] See, for example, *Toward Better Utilization of Scientific and Engineering Talent,* Washington, National Academy of Sciences, 1964 ; and *Engineering and Scientific Manpower Resources in Canada,* Ottawa, Department of Labour, 1961.

Environment and education

Holding that the socio-economic background of workers in general and that of professional workers in particular provides useful clues to their subsequent employment patterns, led us to investigate first the question of occupational choice. Why do men elect to study engineering and to pursue it as a career ? Surveys which probed this question directly, including our own, found that engineering students and graduates were generally unable or unwilling to formulate the reasons for or the factors in their choice of college education or occupation. Some said that they wanted to do technical work at a more practical level than pure science ; some chose the field to be more employable in an increasingly technological economy ; and still others viewed engineering as suitable preparation for a variety of occupations [2]. In terms of personal guidance, our and others' investigations showed that family and experience played a larger role than did friends or counsellors. Finally, we could identify three characteristics which appear common to most engineering graduates and which yield definite clues about their choice of training and profession.

First, consistent with earlier studies, we found that engineering students in the 1960's were still considerably more likely than most other college males to have fathers employed in the skilled trades in both Canada and the United States. Men who are factory or craft workers encounter engineers, but seldom other professionals, in their daily routines ; they then pass on this symbol of upward mobility to their sons. Engineering was perceived by the young men as a quicker way to a profession than medicine, law or even science. Engineering students were found to be highly ambitious and much concerned with success and status. In Canada about two-thirds and in the U.S. slightly over one-half of recent engineering graduates preferred to be successful as against being independent or well-liked [3].

Second, North American engineering graduates proved to be of high intelligence and possessing a wide variety of interests. On various intel-

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[2] H. A. ESTRIN (ed.), *Higher Education in Engineering and Sciences,* New York, McGraw-Hill Book Co., 1963, pp. 398-99 and pp. 406-408 ; numerous articles in the *Engineering Journal,* Montréal, published by the Engineering Institute of Canada ; Eli GINZBERG, *Occupational Choice,* New York, Columbia University Press, 1963.

[3] The initial work is G. K. KRULEE and E. B. NADLER, « Studies of Education for Science and Engineering : Student Values and Curriculum Choice, » *Institute of Radio Engineers Transactions on Engineering Management,* New York, December, 1960, p. 157.

ligence scales, those from engineering faculties ranked ahead of most other disciplines, with the exception of physical scientists [4]. A survey of relevant articles in the psychological literature between 1930 and 1965 also convinced us that the old stereotype of an engineering student, which pictured him as being interested chiefly in equations and mechanisms, must be discarded. In fact, engineers have broad interests and like to work with people as much as with products and processes. The combination of the above traits usually lead to strong self-confidence.

Third, engineering education is regarded by students, graduates and employers as a rigourous and systematic preparation and as such, suitable for a wide range of occupations. Analysis of curricula at Canadian and American universities confirms the exacting nature of preparation required. At the same time, (1) the trend toward more elective and optional courses in engineering faculties, (2) the ease with which engineering graduates handle advanced courses outside their discipline, and (3) the variety of tasks which employers assign the graduates, give credence to the view that such men have a solid foundation for a variety of careers.

His social background, ambition, talent, range of interest, and assessment of his undergraduate training lead the engineering graduate to a lack of strong commitment as he enters the labor force. He does not feel bound to a specific career, profession, or organization. Furthermore, the characteristics cited are carried well beyond graduation. Thus, if the desire for success is not fulfilled in a technical career, such a man will consider viable alternatives to engineering. The most frequent choice is a managerial occupation which usually offers higher remuneration, added status, and escape from some technical obsolescence.

Supply-demand analysis

The number of persons employed in the engineering profession in Canada and the United States has increased in each decade since 1900 and generally has grown at a more rapid rate than the respective population, labor force, or professional workers as a group. The sources of such manpower have been traditionally classified into three, non-mutually exclusive categories : immigrants, college graduates, and non-degree engineers. In the past, immigration has been a more important source of engineering manpower in Canada than in the U.S. : nearly one-third of

[4] Dael WOLFLE, *America's Resources of Specialized Talent,* New York, Harper & Bros., 1954, p. 209, based on several previous nationwide studies and reconfirmed in more recent reports. Wolfle's book was also the first one to pinpoint the socio-economic background of college graduates.

Canadian, but only seven per cent of U.S. engineers were foreign-born at the start of the 1960's. At the same time, emigration of engineers as a percentage of the labor force was much higher for Canada than for the U.S., thereby contributing further to the lower proportion of native-born engineers in the former country.

The output of institutions of higher learning is the most important source of engineering manpower in both countries, but on this basis the two nations show an interesting contrast. In 1961, about 72 per cent of Canadian engineers held a college degree compared to only 55 per cent for the United States. Differing definitions account partly for this, with the Census of Canada employing the stricter term, « professional engineer », against the U.S. Census designation, « engineer, technical ». The key factor, however, was the more rapid rate and acceptance of technological change in the U.S., which forced employers to supplement the flow of college graduates by intensive up-grading of non-degree personnel. Another factor accounting for the lower proportion of degree-holding engineers in the U.S. was the more restrictive immigration policy of that country.

The determinants of demand for engineers can be traced to general economic conditions, specific industrial characteristics, the state of technology, and government policies. Blank and Stigler reported that shifts in industrial structure statistically explained 40 per cent of the total change in demand for engineers in the U.S., between 1930 and 1950 [5]. Business activity and government expenditures on research contributed little toward explaining the secular rise in demand. They also found that a relative decline in engineering salaries was a factor in explaining the increased demand for such manpower. But Hansen reported a clearcut reversal of this trend in the U.S. during the 1950's, which clearly suggested a growing shortage of engineers [6].

J. P. Francis analysed the demand for engineering manpower in Canada by seeking to explain why the number of engineers increased almost 100 per cent, while the labor force grew only 33 per cent during the 1931-1961 period [7]. He found that in the first two decades, the differ-

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[5] D. M. BLANK and G. J. STIGLER, *The Demand for and Supply of Scientific Personnel*; New York, National Bureau of Economic Research, 1957, p. 60.

[6] W. L. HANSEN, « The 'Shortage' of Engineers, » *Review of Economics and Statistics,* Cambridge, August, 1961, pp. 251-56.

[7] J. P. FRANCIS, « Engineers and the Canadian Economy, » *Engineering Journal,* Montréal, September, 1962. pp, 47-50.

ent growth rates could be attributed almost exclusively to the changing structure of the economy, meaning — as did Blank and Stigler — that industries which were major users of engineering talent were the fastest growing ones. According to him, changes in occupational structure within industries played a negligible role until 1951, but such factors statiscally explained over two-thirds of the differential increase in requirements for engineers during the 1950's [8]. In that decade, technical developments and the subsequent need for engineers were generated by a relatively few key industries, such as chemical and electrical machinery manufacturing, the federal government, universities, and consulting organizations.

A comparative study of the market conditions for engineers in both countries is made possible by using available census and relate data for the decades between 1930 and 1960. Our simplified supply-demand analysis will follow the procedure outlined by Meltz for major occupational categories [9]. It is assumed that (1) the market for engineers is national in scope, (2) price (i.e. relative earnings) and quantity (i.e. the proportion of the labor force employed as engineers) are determined simultaneously in the market, and (3) the demand and supply curves have their typical shapes. The movement from one equilibrium point to another depends on the direction and magnitude of shifts as well as on the slopes of the curves. While a given movement can be consistent with various combinations, it is possible to state which shift was dominant and the direction of the shift.

Figure 1 shows that in both Canada and the U.S., supply was dominant during the 1930's and 1940's. But during the 1950's, the economies of the two countries — both expanding and both technically-oriented now — were able to generate more than sufficient demand to absorb the growing supply. These conclusions are in agreement with results reported by Meltz for Canadian professionals and the findings of Hansen for U.S. engineers, during all or portions of the same time span. (When refinements are made in this analysis in terms of age and educational levels, the reduction in engineers' relative earnings over the decades is not quite as steep ; but the results just reported remain unchanged.) Indeed, the

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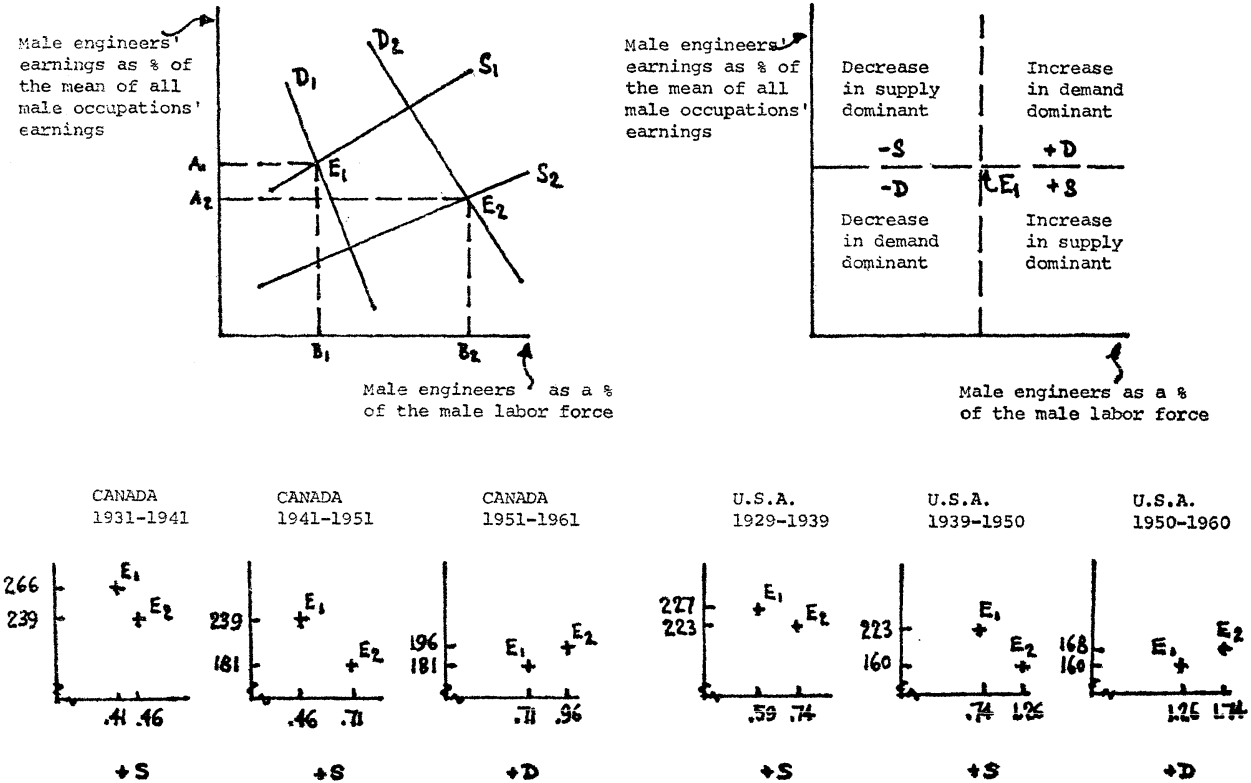
[8] Our own analysis shows that more importance should have been assigned to occupational structure changes in the 1930's and 1940's and less in the 1950's than Francis indicated.

[9] N. M. MELTZ, *Chances in the Occupational Composition of the Canadian Labor Force, 1931-1961,* Ottawa, Department of Labour, 1965, pp. 81-89. Assumptions stated are those of Meltz ; they apply to engineers and other professionals even more so than to other occupations.

Figure 1

GRAPHICAL SUPPLY-DEMAND ANALYSIS, ENGINEERING MANPOWER, CANADA, 1931-1961 AND U.S.A., 1929-1960



Source: *Census of Canada, 1931-1961; U.S. Census, 1930-1960; Historical Statistics of the U.S.;* D. BLANK and G. STIGLER, *The Demand for and the Supply of* Scientific Personnel (N.Y.: NBER, 1957).

patterns observed seem so strong and consistent that it can be claimed that a shortage of engineers did exist in both nations during the 1950's, after an oversupply of two decades. For various reasons we estimate that when census figures become available in the next few years, they will show an approximate balance between the supply of and the demand for engineers during the 1960's in both countries.

Distribution and deployment

Tables 1, 2, and 3 illustrate, respectively, the distribution of engineers in Canada and the United States among branches, industries, and primary activities. The first of these tables provides not only an interesting contrast between the two groups of engineers, but also an insight into technical development in the two countries. The « all other engineers » category has clearly become more important in both economies, at the expense of civil, electrical, and mechanical engineers, but the trend has been much more pronounced in the United States. Diversification and specialization have been carried further in the U.S. than in Canada, due in part to relatively larger defense, space, and research expenditures. The figures in Table 1 reflect the resultant heavy demand for aeronautical, biomedical, industrial, nuclear, and petroleum engineers. The decline in the relative importance of the older branches is also a result of the rise of rival or neighboring disciplines (e.g. engineering physics vs. electrical engineering).

Table 1

DISTRIBUTION OF CANADIAN AND AMERICAN ENGINEERS BY MAJOR BRANCHES OF THE PROFESSION, 1930-31 AND 1960-61

Branch	*Canada*		*U.S.A.*	
	1931	1961	1930	1960
Civil engineers	38%	28%	40%	19%
Electrical engineers	29	20	27	21
Mechanical engineers	21	28	27	18
All other engineers	11	24	6	42
TOTAL - per cent	100%	100%	100%	100%
- number (000's)	13	43	217	860

Source: *Census of Canada, 1931 and 1961*
U.S. Census, 1930 and 1960
Historical Statistics of the U.S.

Table 2

DISTRIBUTION OF LABOR FORCE AND ENGINEERS, BY INDUSTRY, CANADA 1961 AND U.S.A. 1960

Industry	*CANADA*		*U.S.A.*	
	Labor force	*Engineers*	*Labor force*	*Engineers*
Agriculture, forestry, fishing	12.1%	1.0%	6.7%	0.2%
Mining, quarries, oil wells	1.9	5.7	1.0	1.7
Manufacturing	21.7	40.5	27.1	55.0
Construction	6.7	5.6	5.9	10.7
Transportation, communication, utilities	9.3	15.8	6.9	8.6
Trade: wholesale and retail	15.3	4.6	18.2	3.2
Finance, insurance, real estate	3.5	0.6	4.2	0.9
Commercial, business, and personal services	19.5	14.4	21.0	11.4
Public administration and defense	7.5	11.3	4.9	8.2
Unspecified/unidentified	2.5	0.5	4.0	0.2
TOTAL - per cent	100%	100%	100%	100%
- number (000's)	6,472	43	64,646	860

Source: *Census of Canada, 1961*
U.S. Census, 1960

It is clear from the data of Table 2 that engineers are highly concentrated in selected major and minor industry groups. In both countries, about 70 to 75 per cent of engineers worked in mining, manufacturing, utilities, and government, compared to about 35 to 40 per cent for the labor force. There is further concentration of engineers within the manufacturing and service sectors. The data reflect the similar needs of key industries in both nations for technical manpower, but within a given sector, the differences reflect each nation's underlying industrial structure. Thus, Canada has a higher proportion of her engineers in the « TUC sector » (transportation, utilities, and communication), because of the utilization of major natural resources and the subsequent transport of same over vast distances. What is really notable is the similarity among the two nations ; by 1961, Canada became a major processor of goods as well as an economy of professional and business services, where engineers are utilized in increasing numbers.

While the designation of a principal activity by an engineer is often an arbitrary decision, especially when his time is divided equally among several functions, the data of Table 3 provide a rough indication and comparison of engineers' work activities in the two countries. Engineers in the U.S. are much more heavily concentrated in research-development than are their Canadian counterparts. By contrast, Canadian engineers show a heavier concentration in the managerial-executive activity. On the basis of available information, it appears that the difference in functional profiles is due to both a relatively lower demand for specialized technical skills and a relatively higher demand for managerial skills in Canadian industries. The functional diversity of engineering manpower in Canada is underscored by looking at the occupational distribution of this group. Thus, while only about one-fourth of recent U.S. engineering graduates are employed in « non-engineering occupations », the corresponding percentage for their Canadian counterparts is between 40 and 50 per cent [10].

Some observers have noted with alarm the low percentage of Canadian engineers who designate research-development as their primary activity ; in fact, qualitative difference were inferred from the statistics. It has been argued that both Canadian-owned companies and Canadian subsidiaries of foreing-owned corporations should undertake more research programs. Patterns in one country, however, are not really appropriate guidelines for another economy in view of different national goals, industrial structure and education programs. Furthermore, economic growth and a competitive position can be maintained by using research findings originating in another nation. In addition, much of the research and development effort in the U.S. has been defense-oriented and Canada had no need for the performance or the utilization of this type of work. Available evidence does suggest that R & D activity appealed to more Canadian engineers than the number of opportunities available so far for doing such work. A variety of public and private organizations in Canada have recently dedicated themselves to expanding development and innovative work in order to retain « native talent ».

Geographic concentration of engineers — not illustrated in tabular form — is typical for both countries. Thus, as of 1961, the Province of

[10] Data here are based on primary research, statistics from various government and private sources, and the volume, *Two Years After the College Degree,* Washington, Bureau of Social Science Research for the National Science Foundation, 1963. In constructing tables 1 through 3 we chose to disregard more recent data, e.g. the preliminary results now available from the 1967 survey of the Canada Department of Manpower and Immigration, due to lack of comparability and also some demonstrable bias as compared to decennial censuses.

Table 3

DISTRIBUTION OF SELECTED ENGINEERS, BY PRIMARY WORK FUNCTION, CANADA AND U.S.A., 1960-1964

Primary work function or Principal activity	CANADA [a]			U.S.A. [b]		
	1960	1961	1962	1963	1964	1964
Construction, installation	10.9%	9.7%	10.5%		4.0%	6.0%
Design, drafting	16.6	16.8	17.5			16.0
Executive, administrative	28.6	29.4	26.3	10.0%	21.0	18.0
Production, maintenance	15.8	15.7	14.7	34.0	7.0	10.0
Research, development	7.1	6.8	7.2	30.0	27.0	35.0
Sales, service, marketing	9.4	10.0	10.4		6.0	4.0
Teaching, instruction	2.7	2.8	3.4	1.0	4.0	n.a.
Testing, inspection	2.9	2.4	3.1			2.0
Field exploration	1.4	1.4	1.4			
All other functions [c]	4.3	4.7	5.1	24.0	25.0	8.0
Function not stated	0.6	0.3	0.4		6.0	
TOTAL – per cent [f]	100 %	100 %	100 %	100 %	100 %	100 %
– number (000's)	9	9	10	840	58 [d]	4 [e]

Source: For Canada (columns 1 to 3) : *Employment and Earnings in the Scientific and Technical Professions, 1959-1962, Professional Manpower Report #14,* Ottawa, Department of Labour, 1963.
For U.S.A. : column 4 : *Profiles of Manpower in Science and Technology,* Washington, National Science Foundation, 1963 ; column 5 : *Engineering Manpower in Profile,* New York, Engineers Joint Council, 1964 : column 6 : R. Perrucci, et al., « The Engineer in Industry and Government, » *Journal of Engineering Education,* March, 1966.

Notes:
a. A one-third nationwide sample of those with engineering degrees or equivalent qualifications.
b. Those employed in engineering with whatever degree or no degree.
c. Includes all non-technical functions.
d. Membership survey of professional societies ; R & D includes 21% in design, all other includes 9% in consulting and 6% in technical supervision.
e. Includes engineers in industry and government, but not those in educational institutions.
f. May not add to 100 due to rounding.

Ontario has attracted 37 per cent of the Canadian labor force and 45 per cent of all engineers, with even higher percentages for selected branches of engineering. The location of corporate headquarters, research and manufacturing facilities, and several new universities account for much of the concentration. Similarly, the states of California, New York, Ohio, and Pennsylvania command about one-fourth of the U.S. labor force and 37 per cent of all American engineers. With the current public commitment in both nations to decentralization, aiding lagging regions, and developing various centers of excellence, it is unlikely that the geographic concentration of engineers would be intensified in the near future. Of course, residence of engineers is heavily influenced by corporate policies as well, but these too are now often directed away from heavily congested, older urban areas.

Earnings

The simplified supply-demand analysis previously presented indicates that while relative earnings of North American engineers deteriorated in the 1930-1950 period, the years since mid-century brought a reversal in this trend. In the 1950-1965 period, engineering salaries kept pace with or exceeded improvements experienced by all wage-earners. Engineers' remuneration in Canada increased by 85 per cent during 1951-1961, while the corresponding figure for all wage earners' income was 77 per cent. In the U.S., earnings of engineers rose 62 per cent between 1953 and 1964, while production workers' remuneration increased 44 per cent. Annual percentage increases in engineering salaries during the 1950's and early 1960's were about 4 to 9 per cent in both nations, with starting salaries rising on the average at a much faster rate than the earnings of experienced men. But since « salary compression » was prevalent among non-technical professions, we hold that the operation of market forces contributed more to the salary compression than did the obsolescence of older engineers.

Data on engineering salaries come not only from government sources, but also from professional associations, such as the Canadian Council of Professional Engineers and the Engineers Joint Council. These sources indicate that in 1966, engineers with one-year experience earned $6,700 in Canada and $8,600 in the U.S., in their respective currencies. At the 10-year experience level, the figure were $9,500 and $12,000 and at the 20-year mark the average salary was $15,000 in both countries [11]. The

[11] Report on Salaries, Ottawa, Canadian Council of Professional Engineers, 1966 and *Professional Income of Engineers,* New York, Engineers Joint Council, 1967.

earnings of young engineers in the two countries reflect a pervasive difference of about 20 per cent in favor of U.S. wages and salaries. The lack of difference in earnings of senior men mirrors the fact that significantly more Canadian than American engineers pursue administrative functions. In view of the above and the fact that technical specialization is most marked among recently trained men, it is not surprising to see an influx of young Canadian engineers to the U.S. At the same time, a decade after graduation, half of these Canadians return to their native land.

An investigation has been made into the causes of salary variations for Canadian engineers only, by one of the authors, with the results reported in detail elsewhere [12]. Holding years since graduation constant, it was found that top earners received about twice as much as those at the lower end of the salary range. The explanation for such wide dispersion was found in the nature of the work, industrial settings, and quality of performance. Aside from residency in the U.S., some of the significant, positively associated variables were self-employed status, managerial occupation, academic grade average, hours worked, professional license, type of industry, and number of job offers recently received.

Mobility and migration patterns

In our primary surveys, we found generally close agreement on the extent of mobility by engineering graduates in Canada and those in the U.S. as well as between the two sets of data and figures previously reported [13]. On the average, engineers in both countries made two job shifts for every ten years in the labor force. This extent of mobility was significantly lower than that reported for blue-collar workers and slightly less than that for the labor force, but the figures were comparable to previous results reported for professionals [14]. As is the case for most

12 A. C. GROSS, « Patterns and Determinants of Income of Canadian Engineering Graduates, » *Industrial and Labor Relations Review,* Ithaca, October, 1969, pp. 52-64.

13 The discussion in this section is based on primary research conducted in 1965-66, among Canadian and American electrical engineering graduates, with sample sizes of about 800 and 500, respectively.

14 Some previous reports dealing with engineers' mobility include : A. J. JAFFE, *Characteristics of Men Employed in Engineering Jobs in the U.S. in 1958,* Washington, National Science Foundation and Bureau of Census, 1963 ; Robert PERRUCI *et al.,* « The Engineer in Industry and Government, » *Journal of Engineering Education,* Washington, March, 1966, pp. 259 ff. ; *The Early Post-Graduate Years in the* PARKER, Labor Market Behavior of Engineers and Scientists ; An Analysis in the Aerospace Industry, unpublished Ph.D. thesis, University of Wisconsin, 1963.

occupations, a small, highly mobile group accounted for a large proportion of total job changes ; in this case, about one-fifth of all persons changing jobs accounted for 55 per cent of all job shifts. At the other extreme, 35 per cent of the respondents made no job changes in the last ten years. Mobility of engineers declined with age, though the rate of decrease was certainly less pronounced than that for blue-collar workers of the labor force as a whole. About one-fifth of those we surveyed made intrafirm occupational shifts, indicating the importance of « internal labor markets ».

For Canadian engineering graduates, the most frequent type of job shift was a simultaneous change in employer, industry, and occupation. This kind of move accounted for almost one-half of all job shifts and was especially popular during the five years following graduation. There was a strong tendency beyond this period to move from technical to managerial occupations, with the motives being the desire for higher earnings, better status, fear of obsolescence, and the limited number of high-level technical openings. The movement into management, accomplished with relative ease, implies much flexibility in the labor market and transferability of skills on the part of individuals.

Engineering graduates in the U.S. showed a stronger tendency than the Canadians for remaining in engineering occupations and technical activities. About 70 per cent of the Americans' job shifts involved changes in employer and industry, with only 30 per cent involving a change in occupation. There were relatively few « complex job shifts », with only 12 per cent of the job changes involving a simultaneous change in employer, industry, and occupation. The U.S. economy and American corporations, because of their sheer sizes and variety, offer a wider choice of functions within a given employing unit, occupation or industry, thereby decreasing the likelihood of a complex job change. But, on the whole, the pattern of mobility among U.S. engineering graduates was comparable to that exhibited by the Canadians who held advanced degrees.

Theoretical considerations and empirical evidence suggest a positive correlation between voluntary mobility and the level of economic activity. Some previous surveys and the results of our own verify this type of association for engineers too, though the impact of an economic downturn was found to be much less severe on the mobility of engineering or scientific groups than on the movement of those in clerical or manual occupations. Furthermore, the mobility data for U.S. engineers show that the impact of the recessions of 1958 and 1961 was offset for them by the fact that this was the period immediately following the launching of the first Soviet satellite.

Having examined the extent and the nature of mobility, we now turn to its traditional role as a process of allocating workers and inducing them to move in the direction of jobs yielding the highest net economic advantage. Based on both theoretical and empirical evidence, an argument can be made for *or* against the hypothesis that mobile college graduates would have higher salaries than immobile ones [15]. In our studies, mobile engineers in the U.S. exhibited a higher annual increase in earnings over the years than did their immobile colleagues. At the same time, immobile men received higher annual increases in their present jobs than did the mobile ones. In the analysis of the annual earnings of Canadian graduates, both the number of job shifts and the number of months spent with the present employer showed positive correlation with current income. These results suggest that while mobility is in the direction of higher paying jobs, stability is also rewarded. It is also apparent that the most highly valued worker may be the individual who « has been around », but who has now « settled down » with his present employer.

Considerations which affect the movement of engineering graduates among employers also enter into the decision about job changes across international boundaries. Some of the motivating factors in moving from Canada to the U.S. include superior economic opportunities, better or more specialized research facilities, a more moderate climate, nearness of metropolitan labor markets (e.g. Vancouver to Seattle, rather than to Toronto), and the transfer of professionals and managers by multi-national corporations. As noted in the section on earnings, young Canadian engineers have especially strong financial incentives to move south. Between 1953 and 1963, a total of nearly 10,000 engineers left Canada for the United States, but the flow slackened in the late 1960's. General social, economic, and political factors are cited to explain the decreased mobility. Recently passed U.S. immigration laws also had a dampening effect on the southward movement, but attempts are being made to have the earlier conditions restored [16].

Movement of engineers from the United States to Canada has also occurred, with close to 2,000 engineers entering Canada from the U.S. between 1953 and 1963. The rate has increased recently from about 200 to 300 per year. Responsible for this flow in the past were the existence

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15 *Wages and Labour Mobility*, Paris, Organization for Economic Cooperation and Development, 1965, p. 17.

16 « Immigration Snarl : New Law's Quotas Balk Entries from Canada, Latin American Lands, » *Wall Street Journal*, New York, January 14, 1970, p. 1 and p. 20.

of selected attractive opportunities, e.g. the exploitation of ore deposits in Quebec, oil in Alberta, and lumber in British Columbia, and — once again — the transfer of personnel by multi-national companies. More recently, the turmoils in the U.S. — involving urban congestion, the racial crisis, crime, and lack of frontiertype opportunities — and the desire for a more open, less troubled environment have been cited as the reasons for moving to Canada [17]. And, of course, since the more experienced engineers earn similar salaries on both sides of the border, it is not surprising that as they get older, Canadian engineers residing in the U.S. will consider returning to their homeland.

Studies dealing with international migration in general and with movement of people between Canada and the U.S. in particular, concluded that the North American continent can be regarded as a single labor market for professionals [18]. Our data on engineers lend further evidence to this hypothesis. Social and political considerations appear to favor the Canadian economy at the moment, and undoubtedly these influence intercountry movement. But our study of the characteristics of engineers leads us to believe that, in the long run, mobility across the border is likely to reflect economic considerations. With good relations between the two nations continuing, we expect « free flows » and « freely chosen flows » in either direction.

Utilization

Numerous reports have dealt in the past 10 to 15 years with the utilization of manpower in general and that of engineers in particular. In the U.S. there has been much concern with the « shortage » of engineers and its real or imagined impact on national security and economic growth. In Canada, concern has been expressed, as noted, with the movement of engineers out of engineering and also across international boundaries. But relatively few of the many papers offer meaningful empirical evidence on the topic. At one extreme, some reports resort to so-called objective

17 « Americans Move to Canada in Record Numbers, » *The New York Times,* New York, January 1, 1970, p. 25 and p. 31.

18 See L. PARAI ; *Immigration and Emigration of Professional and Skilled Manpower During the Post-War Period,* Ottawa, Economic Council of Canada, 1965 ; D. DYCK, *The Geographic Mobility of the 1955 Class of Graduates in Science and Engineering,* Ottawa, Department of Manpower and Immigration, 1967: *The Migration of Professional Workers into and out of Canada,* Ottawa, Department of Labour, 1961.

criteria, e.g. unemployment rates, earnings, or deployment patterns [19]. Using such yardsticks, one finds little support for the view that there has been misutilization of engineers in the 1960's in North America. At the other end, several papers apply subjective criteria, and conclude, for example, that engineers in large organizations desire to do little or no sub-professional work [20].

At the broadest level, it is clear that « manpower utilization relates to all those policies and practices which are designed to achieve the fullest and most efficient use of the total potential labor resources ... » [21] Some of the material presented in this essay and evidence based on the same data, not shown here, are relevant to an assessment of utilization in this, its broadest sense. For example, we found that the undergraduate engineering curricula in both Canada and the U.S. have undergone changes, with the result that more flexible, yet still rigorous, programs emerged. This appeared to be in line with the desire of graduates, educators, and employers [22]. Canadian engineering curricula have not become as science-oriented as their counterparts in the U.S. ; thus, the industrial needs of the two economies are reflected in their educational programs. (Admittedly, one could argue that curricula should « lead » or anticipate industrial

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19 See, for example, F. T. DENTON, *An Analysis of Interregional Differences in Manpower and Utilization and Earnings, Staff Study no. 15,* Ottawa, Economic Council of Canada, 1966 ; and *Studies in Scientific and Engineering Manpower, Staff Report no. 63-1,* Washington, U.S. Department of Commerce, Office of Science and Technology, 1963.

20 Three unpublished dissertations make this point : R. V. KIRK, A Study of the Utilization of Scientific and Engineering Manpower, Purdue University, 1962 ; Stephen PARKOFF, The Career Development and Utilization of Engineering and Science Graduates. Columbia University, 1964 ; W. C. REYNOLDS, Jr., A Model for Engineering Manpower Utilization, University of Alabama, 1964. See also *A New Look at Engineer Attitudes,* New York, Deutsch and Shea, Inc., 1961. At the same time, others argue some sub-professional work by engineers (say 20 per cent of total working hours) is highly beneficial from a corporate or national viewpoint ; see, e.g. Donald PELZ and Frank ANDREWS, *Scientists in Organizations,* New York, J. Wiley and Sons, 1966.

21 Herbert S. PARNES, *Effective Utilization of Engineering Manpower,* Washington, The President's Committee on Scientists and Engineers, 1959, p. 3. This is a survey of the literature which also includes several references to utilization of technicians.

22 See *Toward Better Utilization ... ;* Myron TRIBUS, « The Trouble with Engineering, » *International Science and Technology,* New York, March, 1963, pp. 44-49 ; S.N. KALRA and J.G. PARR, « Engineering Curricula : A Reappraisal », *Engineering Journal,* Montréal, July 1965, pp. 16-18. Several additional sources could be cited from the economic, educational and engineering literature.

patterns.) At the graduate level, we found apparent freedom and financial ability on the part of the graduates to choose among a variety of programs and universities. The educational aspects of most training programs and « in-house » course offerings were not highly regarded by the graduates we surveyed, because most of them preferred the status of courses leading to an advanced degree.

Turning from education to employment, we found much flexibility in the market for engineers. First, while there was frictional unemployment in a few cases, involuntary, long-term unemployment was absent in the work histories of all graduates. Second, the graduates enjoyed a high level of salaries and, recently, a rise in relative earnings as well. Third, mobility of engineering graduates was characterized by a significant amount of movement, presence of complex job shifts, responsiveness to general economic conditions, and frequent achievement of immediate wage gains upon changing jobs. Last, there was an apparent matching of job requirements and qualifications ; for example, advanced degree holders were seldom found in sales positions, where advanced technical training would seem superfluous.

In the remaining discussion, we adopt a narrower definition of effective utilization, one which was made by Wolfle in 1954 :

> It means employment in an occupation for which the worker is well adapted by virtue of his ability and experience, in which he is able to make a useful contribution to society and in which he is satisfied and adequately rewarded for his work. [23]

The emphasis in our case is on the first and second aspects, partly because data are more readily available in both countries and partly because we already commented on the earnings of engineers. The relationship between academic training and current position was probed by two, multiple-choice type questions ; the first related to the specific undergraduate training as a prerequisite for the job and the second dealt with the usefulness of such education in the performance of the work. The matter of useful contribution was also probed, but only indirectly ; it was assumed that the ease or difficulty by which a man could be replaced on the job with a person of different educational background would give an indication of this aspect. The specific questions and the various results obtained in Canada and the U.S., in surveys by us and by others, are shown in Table 4. The following interpretation can be made of the statistics.

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[23] WOLFLE, *America's Resources* . . . , p. 212.

Table 4

SELECTED ASPECTS OF UTILIZING UNDERGRADUATE COLLEGE MAJOR ON THE JOB, CANADA, 1965 AND U.S.A. 1960 AND 1965

	CANADA 1965				U.S.A. 1960		U.S.A. 1965	
	Class of 1959		Class of 1964		Class of 1958		Classes 1957-1961 (Selected members)	
	All EEG(a)	EE(a)	All EEG(a)	EE(a)	Varied Background EE(a)	EEG(a) EE(a)	All EEG(a)	EE(a)
"HOW IMPORTANT IS YOUR EDUCATIONAL BACKGROUND AS A PREREQUISITE FOR YOUR JOB?" (b)								
1. A degree in my field is required	48.2%	64.1%	43.6%	61.5%	56.4%	62.3%		
2. A degree in at least a related field is required	23.5	23.9	22.4	18.4	30.0	27.0		
3. A college degree is a prerequisite for the job	18.8	6.8	16.8	7.5	6.4	4.7	n.a.(c)	n.a.(c)
4. A college degree is not required for the job	9.4	5.1	17.8	12.6	7.2	6.0		
	100. %	100. %	100. %	100. %	100. %	100. %		
"HOW USEFUL IS YOUR EDUCATIONAL BACKGROUND IN THE PERFORMANCE OF THE WORK YOU DO?" (b)								
1. Making considerable use of my undergraduate major	33.1%	44.0%	23.6%	33.3%	68.2%			
2. Courses in major field were not the right preparation	15.4	21.6	13.4	13.8	8.3			
3. Making only occasional use of my undergraduate major	18.9	17.2	23.9	21.3	16.4			
4. Making practically no use of my undergraduate major	5.9	2.6	11.5	8.6	1.8	n.a.(c)	n.a.(c)	n.a.(c)
5. Making use of college education in general	23.2	12.9	20.5	19.5	3.8			
6. College training I had is not related to my job	3.5	1.7	7.1	3.5	1.5			
	100. %	100. %	100. %	100. %	100. %			
"DO YOU FEEL THAT YOUR JOB COULD BE DONE AS WELL OR BETTER BY SOMEONE WITH AN EDUCATIONAL BACKGROUND DIFFERENT FROM YOURS?" (b)								
1. No	40.4%	55.6%	30.8%	40.6%	71.9%	77.3%	56.5%	58.4%
2. Yes, with college training in another field	28.2	16.2	18.7	12.6	6.3	4.0	17.4	18.5
3. Yes, someone with less formal training could do it	19.6	18.0	35.2	30.9	17.0	15.4	17.1	18.1
4. Yes, someone with vocational training could do it	2.0	0.9	9.0	9.7	0.9	0.7	3.4	2.9
5. None of the above fits my situation	9.0	9.4	6.2	6.3	3.9	2.6	5.6	2.1
	100. %	100. %	100. %	100. %	100. %	100. %	100. %	100. %
TOTAL — no.	255	117	321	174	889	727	322	243

NOTE: (a) EE = current occupation is electrical engineer; EEG = electrical enginnering graduate.
(b) For detailed listing of multiple choice answers, see source no. 2.
(c) Not available.

Source: 1. Primary research by the writers for Canada and for U.S.A. 1965.
2. *Two Years After the College Degree No. 63-23* (Washington: National Science Foundation, 1963), pp. 231-38, for U.S.A., 1960.

The formal or informal requirements imposed by employers appear to be equally high in both countries ; about one-half of the respondents in each case think that the specific degree they hold is a prerequisite for the job. The presence of apparently high barriers for entering or holding a job seems more justified in the U.S., where about two-thirds of the respondents made considerable use of their undergraduate major on the job against one-third reported by the Canadian graduates. The difference can be attributed to a wider variety of technical job openings and greater emphasis on research and development in the U.S. than in Canada (cf. Table 3 and the earlier discussion on occupations). As a result, the U.S. electrical engineering graduate can match more closely his individual abilities and preferences with specialized job openings and job requirements. This is not the case in Canada, where such graduates are more likely to be called upon to perform a variety of technical tasks. However, this may well contribute to broader experience for the Canadians and lead to an earlier undertaking of administrative activities and managerial occupations — a fact, which was demonstrated already, and one with which the Canadian graduates appear to be pleased.

The data of Table 4 show, as might be expected, that a substantially higher share of electrical engineering graduates who now practice as electrical engineers make considerable use of their undergraduate majors than do those graduates who are now in different occupations. This view also extends to the question dealing with the matter of substitutability ; for example, in the U.S. from 60 to 80 per cent of such men hold that a person with a different educational background could not do their jobs as well or better. The Canadians are more « charitable » in this respect, especially the recent graduates. The reason for this has been alluded to above, but it is also due to the fact that first-year assignments (the Canadian class of 1964 in 1965) often revolve around training programs and assignments not directly related to the specific educational background.

The key conclusion which emerges is that requirements for a specific degree are relatively high and are somewhat unrealistic (at least in the graduates' view) when compared to the proportion of graduates reporting considerable use of their undergraduate training and when the matter of substitutability by individuals of different training is considered. At the same time, there is no question that college training and technical training can be utilized widely and well in a variety of job assignments, including those which are not an equivalent match for the undergraduate training. A large economy, with wide diversity, can naturally accommodate better

those men who seek a specialized work environment corresponding to their specific university training.

Since Canadian graduates showed lower levels of utilization on the scales used above, it may be in order to report some additional, encouraging evidence from our survey in that country. First, those men who left electrical engineering or even engineering itself generally were pleased with the rigourous nature of their education — which, they felt, prepared them for a wide variety of positions. Second, there was a definite increase over time in the utilization of college training (specific and general combined). Third, on the question of choosing the same undergraduate major again, 70 per cent answered affirmatively and over 80 per cent would recommend engineering as a worthwhile career to a young high school graduate. Finally, an item analysis indicated average or above average levels of satisfaction with varied aspects relating to the work environment.

Conclusion

There has been a dramatic increase in the number of engineers and in their proportion in the labor force of North America during the past forty years. Supply was dominant for decades in Canada and the United States, but demand has dominated since mid-century in both economies. Engineers, for long enjoying a high level of absolute remuneration, have now found improvements in their relative earnings as well. Salaries of engineers are higher in the U.S. than in Canada, but the difference is much less pronounced or even non-existent for older men. The pattern of engineers' movement between the two nations underscores the dominance of economic considerations and the existence of a common labor market.

The social environment and the academic training of engineering graduates strongly influence their careers. As a result of their background and education, engineers tend to be ambitious and self-confident, to have wide interests, and to regard themselves as well prepared for a variety of occupations. If the desire for higher earnings and status cannot be fulfilled in technical positions, these men will seek feasible alternatives and will often enter managerial ranks. On the whole, there are more similarities than differences in the distribution of engineers in the two countries, especially by branches of the profession, industrial sectors, and geographic areas. The differences in regard to primary activities are more pronounced,

but this is a reflection of industrial and corporate requirements of the two economies rather than supply or individual considerations. In both countries, the extent of mobility by engineering graduates resembles that of the respective labor force. The direction of movement is usually toward higher paying jobs and greater utilization. There is much flexibility in the labor market of both countries and individuals are able to move with apparent ease among diverse positions. Young engineering graduates are generally well utilized in their current jobs ; the Canadians use their general university training, while the Americans are utilizing their specific undergraduate major.

LES INGÉNIEURS SUR LE MARCHÉ DU TRAVAIL EN AMÉRIQUE DU NORD

Bien des motifs, qui vont des valeurs qu'ils incarnent au rôle qui leur est dévolu dans la croissance économique, ont incité les spécialistes des relations professionnelles à s'intéresser aux catégories de salariés de haute qualification, ingénieurs et hommes de science principalement. Aussi les études sur cette question se sont-elles multipliées au cours des derniers dix ans. Mais, toutefois, on les a presque toujours présentées dans une optique étroite qui ne faisait guère de place à la perspective historique et à l'évolution d'ensemble. Les travaux destinés à éclairer les changements survenus dans le temps et les variations d'un pays à l'autre sont peu nombreux. De plus, l'analyse s'avère parfois contradictoire. Les uns parlent de pénurie de main-d'oeuvre ; d'autres, d'excédent.

À la lumière de ce qui précède, nous avons fait une étude comparative des expériences vécues par les ingénieurs du Canada et des États-Unis sur les divers marchés du travail. Nous espérons pouvoir en faire bientôt autant pour les scientifiques. Nous avons considéré les sujets suivants : (1) l'arrière-plan de la scolarité ; (2) l'état de l'offre et de la demande ; (3) la répartition et l'étalement ; (4) les traitements ; (5) la mobilité et les migrations ; et (6) l'utilisation. Les résultats se fondent à la fois sur la recherche de première et de seconde main, y compris les thèses de doctorat des auteurs.

Trois caractéristiques communes fondamentales se retrouvent chez les ingénieurs diplômés tant canadiens qu'américains. Celles-ci donnent des indices très nets en ce qui concerne le choix de cette discipline. D'abord, plus que pour les autres diplômés d'université, il y a de bonnes chances que ces hommes — il y a peu de femmes parmi les diplômés en génie — soient fils d'ouvriers qualifiés ou d'apparentés. De plus, les diplômés en génie donnent l'impression d'être ambitieux et intelligents, d'avoir des centres d'intérêt variés. Enfin, ils voient dans leur formation d'ingénieur une préparation appropriée et rigoureuse menant à une grande diversité d'emplois. L'interaction des facteurs précédents débouche sur une insuffi-

sance de forte motivation dans le choix d'une carrière ou d'une vocation vraiment marquée. Si la satisfaction laisse à désirer au plan technique, le diplômé en génie n'hésitera pas à chercher ailleurs, souvent du côté des carrières administratives.

Depuis 1900, tant au Canada qu'aux États-Unis, le nombre des ingénieurs s'est accru plus rapidement que la population, que la main-d'oeuvre et que les autres travailleurs professionnels en général. Pendant cette période, l'immigration a joué un rôle plus marqué au Canada qu'aux États-Unis quand il s'est agi de répondre à la demande. De même, il y a beaucoup plus d'ingénieurs canadiens que d'ingénieurs américains qui détiennent un diplôme collégial. Ces divergences peuvent s'expliquer par des politiques d'immigration et des concepts statistiques différents, la rapidité des changements techniques et l'accession des sans-diplôme à la profession.

Les éléments déterminants de la demande d'ingénieurs se ressemblent d'un pays à l'autre. Les changements dans la structure économique ont joué un rôle prédominant ici comme là-bas. Les industries qui avaient et ont toujours le plus recours au savoir de l'ingénieur se trouvent être celles qui se développent le plus vite, du moins jusqu'à maintenant. En réalité, la demande ne provient que d'un nombre de sources relativement restreintes : les industries chimiques et électriques, certaines entreprises d'utilité publique, le gouvernement fédéral et quelques institutions appartenant au secteur tertiaire.

Une analyse sommaire de la demande d'ingénieurs entre 1930 et 1960 indique que l'offre l'emportait dans les deux économies durant les années '30 et '40. Au cours des années '50 et au début des années '60, grâce à l'expansion de l'une et de l'autre dans le domaine technique, la situation s'est inversée. L'écart paraît assez tranché pour parler d'excédent dans les deux premières décennies et de pénurie par après. Les rapports provisoires des recensements laissent voir que l'équilibre s'établit à peu près entre l'offre et la demande dans les deux pays vers la fin des années '60.

D'une façon générale, il y a beaucoup plus de ressemblance que de différence dans la répartition des ingénieurs dans l'un et l'autre pays, qu'il s'agisse de la concentration territoriale ou industrielle ou de la spécialité (génie civil, génie électrique, etc). À cause des besoins de l'industrie et des sociétés, les divergences sont beaucoup plus accusées quand il s'agit du premier emploi. Il ne fait pas de doute que la spécialisation des ingénieurs américains et le rôle relativement important qu'ils jouent dans les travaux de recherches et de développement constituent un double avantage. Par ailleurs, pour les ingénieurs canadiens diplômés, la recherche et le développement reste une activité de départ attrayante, mais elle est insaisissable.

Comparés à l'ensemble, les traitements des ingénieurs ont baissé aux États-Unis et au Canada entre 1930 et 1950, mais, depuis la demie du siècle, ils ont pris une courbe ascendante et même dépassé le taux de croissance de rémunération de toutes les autres catégories de salariés. Depuis 1950, le pourcentage annuel du taux d'accroissement des salaires parmi les ingénieurs s'établit entre 4 et 9 pour cent par année tant au Canada qu'aux États-Unis, ceux des débutants dans la carrière s'élevant beaucoup plus rapidement que ceux des ingénieurs d'expérience. Reflet de

la demande et d'un éventail plus grand de choix, c'est chez les débutants que la disparité dans les salaires est la plus prononcée entre les deux pays. Résultat jusqu'ici : un nombre important de jeunes ingénieurs canadiens émigrent aux États-Unis pour revenir plus tard quand ils ont pris de l'âge.

Dans l'un et dans l'autre pays, les ingénieurs diplômés ont tendance à s'orienter vers les carrières administratives. Cette tendance est plus forte au Canada où la spécialisation offre moins de choix et où les ingénieurs subissent moins la concurrence des diplômés en sciences de l'administration. Les ingénieurs diplômés canadiens sont tout aussi mobiles que leurs collègues américains. Les jeunes ingénieurs changent en moyenne deux fois d'emploi tous les dix ans sur le marché du travail. Le taux de mobilité décroît avec l'âge, mais plus lentement que parmi les cols bleus. Les occasions de changer de travail ou de fonction à l'intérieur même des sociétés deviennent plus nombreuses et, souvent, elles freinent les déplacements d'un employeur à l'autre. Le chômage ne fait pas problème et, en dépit des coupures dans les contrats de la Défense aux États-Unis, vues en longue période, les perspectives d'emploi pour les ingénieurs sont bonnes. La tendance à l'immigration d'un côté à l'autre de la frontière se continuera. Jusqu'ici, des considérations d'ordre économique sont principalement à la source des mutations d'emploi et de l'immigration, mais on décèle également d'autres facteurs.

L'éventail des postes occupés par les ingénieurs reflète les caractères de leur personnalité, leur formation scolaire et leurs expériences professionnelles. Si l'on considère l'élasticité du marché du travail comme critère d'une saine utilisation, il y a plusieurs indices encourageants : liberté de déplacement, grande amplitude de déplacement, présence d'une grande diversité d'emploi, adaptation aux conditions économiques et fréquemment, augmentation de salaire dès la mutation. D'une façon générale, les exigences de la fonction et les qualifications individuelles s'équilibrent bien. Mais que les employeurs réclament la possession d'un diplôme dans une spécialité, c'est quelque peu manquer de réalisme et se montrer faussement exigeant, surtout si l'on considère la proportion des ingénieurs diplômés qui déclarent n'utiliser que leurs connaissances de base dans leur travail.

Les États-Unis, dont l'industrie est diverisfiée et avancée, peuvent offrir un meilleur choix aux ingénieurs qui recherchent un milieu de travail spécialisé et une activité professionnelle déterminée. Mais cette situation comporte comme conséquences le danger d'une spécialisation trop poussée et la possibilité de chômage. Les ingénieurs diplômés canadiens ont moins d'occasions de travailler toujours dans la branche de leur spécialité, mais ils trouvent à utiliser fort bien leur formation universitaire de base. On remarque que, dans les deux pays, à mesure que le temps passe, il y a progrès en ce qui concerne l'utilisation des connaissances en génie. Aussi, la majorité des ingénieurs diplômés estiment leur profession et ne se font pas faute de la recommander à qui veut poursuivre une carrière intéressante.