TECHNOLOGICAL CAPABILITY IN THE FOREST PRODUCT SECTOR OF BRITISH COLUMBIA: AN EXPLORATORY INQUIRY

Roger Hayter

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DISCUSSION PAPER NO. 13

Acknowledgements and Preface

This research was made possible by a President's Research Grant (Simon Fraser University) worth about $2300 and I gratefully acknowledge this support. As was the case here President Research Grant Awards often provide "seed money" for research in its early stages. Accordingly the emphasis in this discussion paper is on providing relevant background material and on revealing issues and relationships rather than testing precise and preconceived ideas. It was felt that the subject matter is of sufficient interest to warrent presenting an interim report. Needless to say any comments would be most welcome.

Bill Thompson conducted all the interviews with the capital goods manufacturers and his efforts are most gratefully appreciated. Sincere thanks are also due to the many respondents who gave of their time in answering my questions including Mr. Tony French, Mr. David Gaschoin, Mr. J. Gorlick, Mr. G.F. Hoerber, Irene, Mr. R. Lewis, Mr. D. Loader, Mr. H. Maxwell, Mr. Parasin, Mr. D.K. Payne, Mr. L.H. Powell, Mr. B. Reid, Mr. I.B. Robertson, Dr. P. Thomas, Mr. Whightman, Mr. Wilson, Mr. G. Worum and all the individuals employed by the capital goods manufacturers who completed my questionnaire. Thanks also to Rosemarie, Nancy and Moyna for typing perseverance.

Technological Capability in the Forest Product Sector of British Columbia: An Exploratory Inquiry

Roger Hayter

This paper seeks to define and explain the level of technological capability in British Columbia's forest product sector. For its point of departure the discussion accepts the Science Council of Canada's interpretation of technological capability as "the ability to solve scientific and technological problems and to follow, assess and exploit scientific and technological developments" (Britton and Gilmour, 1978, p. 130). The notion of technological capability therefore refers to complex processes comprising research and development activities involved in the discovery of inventions, acts of innovation and the subsequent adaptations made to innovations when introduced into new organizational, sector and regional environments.

It is widely accepted that in comparison with the United States and other capitalist countries Canadian industry's performance in research and development (R & D) is poor in absolute and relative terms. In 1978 R & D employment in manufacturing industries, for example, accounted for only one per cent of total employment (Stats. Can., 1979, cat. 13-203) while total funds for intra-mural R & D were less than $1b (Table 1).

Table 1

Sources of Funds for Intramural R & D 1963-1978

	Federal Government	Provincial Governments $M	Business	Foreign	Total
1963	28.9	0.1	144.2	7.2	180.4
1970	62.4	0.8	330.8	19.1	413.0
1975	86.0	4.0	565.4	41.1	696.5
1978e	115.0	30.0	732.5	50.0	927.5

Source: Statistics Canada, 1979, cat. no. 13-203.

According to Statistics Canada (1979, cat. no. 13-203) Canada's intramural expenditures in 1975 were 0.60 per cent of industrial domestic product compared to 1.58% for West Germany, 1.19% for Japan, 1.71% for Sweden, 1.74% for the U.K. and 1.92% for the U.S.

While there is little doubt that Canada's R & D effort is small in scale there is controversy as to why this is so and the nature of the associated economic and social implications. Explanations for the relatively low level of R & D activity in Canada, for example, have variously stressed protectionism, small market size, inadequate labour skills, lack of effective government action, risk-averse entrepreneurship, high levels of corporate concentration and high levels of foreign ownership. These and other determinants of the level of R & D activity which have been suggested in the literature, however, can be conveniently polarized into conventional explanations which stress the role of cost-revenue conditions and institutional interpretations which stress the role of corporate (and government) policies and structures.

According to conventional wisdom industrial research and development functions actually (and should) locate as costs and revenues dictate so that the relative poverty of Canada's technological effort simply reflects a lack of comparative advantage. In this regard, limited and high cost supplies of appropriately skilled labour and (especially) limited market potentials are frequently cited comparative disadvantages (e.g. Palda, 1979). It is also worth noting that according to this view the lack of R & D does not by itself constitute "a problem". Rather what is emphasized is industry's willingness and ability to innovate. In this regard, economists such as Daly (1979), Safarian (1979) and Palda (1979) argue that protectionism militates against innovation and underlies Canada's productivi problems, particularly in the secondary manufacturing sector. Free trade, they argue, would encourage industry to become more efficient since the pressures of international competition would force firms to specialize more (thereby achieving economies of scale) and to more quickly adopt the latest technologies.

In contrast to the free trade or internationalist position, over the past decade or so the Science Council of Canada has explained Canada's technological weaknesses primarily as a result of the policies and structures of foreign controlled corporations. Britton and Gilmour (1978), for example, argue that branch plants inhibit exports (of secondary manufacturers) and by substituting corporate for local linkages, directly and indirectly increase import dependency on a variety of goods and services including research and development. Furthermore, given these linkages, they suggest free trade would simply provide cheaper imports rather than stimulate domestic innovation and production. Consequently they urge that increased investment in R & D is essential to ensure innovation in the early stages of product life cycles when Canada as a high wage country can be internationally competitive while at the same time providing for more high status employment opportunities. In other words the Science Council considers R & D as an essential input to sustained industrial growth and as an appropriate target for development for its own sake.

The extent to which the Science Council's explanation of technological weakness has been accepted by policy makers across the country is not clear. At the provincial level, however, the strategy of promoting R & D based manufacturing has been accepted with growing enthusiasm and commitment. In British Columbia, for example, Discovery Parks Inc. was established in 1979 in order to "attract capital intensive, high technology industry and investment to the Province of British Columbia by developing campus style research and development parks adjacent to major educational institutions" (Discovery Parks Inc. n.d. p. 1). Whether or not the emphasis which has so far been placed on physical site planning and on physical proximity to education institutions will indeed provide the necessary catalyst for the stimulation of "high technology" industry is a moot point. There is also a question of product, industry or sectoral priorities, that is the kinds of activities that a science and technology policy in British Columbia should try to encourage - or the kinds of activities in which science and technology should be boosted. So far there seems to have been little discussion of these priorities.

Just how a range of priorities to be emphasized in a science and technology policy should be determined is clearly problematical. There are obvious difficulties in precisely predicting the pace and direction of inventive and innovative activity while the implications of recent innovations are not necessarily limited by traditional industry boundaries. An essentially shot gun approach to research policy, however, has real dangers. As Mensch (1979, p. 215) states "A strategy of try anything but quickly produces too many flops, and in the hurry, it suppresses the often superior alternatives at the expensive of 'anything.' " Assuming that there are benefits to be gained from specializing in the R & D effort it would surely seem logical for British Columbia to aspire to high levels of technological capability in at least the established resource based sectors. Indeed in a report submitted to the provincial government in 1976 recommending policies mobilizing the province's capabilities in applied research, consistent with economic development goals, Gaudry (1976) urged just such an emphasis. Further, as Gilmour (1978, p. 20) has noted on behalf of the Science Council, the case for developing indigenous technological capability "is not exclusive to the so-called high technology industries: it underlies production and other technical change in <u>all</u>

goods producing industries." Britton (1980) has also expressed the view that an important priority for technological policy in Canada should be the resource based industries.

In essence the most appealing case for emphasizing technological capability in the resource industries is that it is consistent with the principle of comparative advantage. Such a policy would draw upon and contribute towards accumulated investments in physical and human resources, it may lead to the exploitation of hitherto untapped resources and would help maintain competitiveness in key sectors of the economy. As Gaudry (1976) points out, however, the formulation of effective science policies for industry first requires an inventory and evaluation of existing capabilities. To contribute towards such an inventory and evaluation this paper examines the evolution and level of technological capability in the forest product sector of British Columbia. Methodologically, the study focusses on performance and characteristics at the level of the individual firm (and establishment) and conceptually it leans heavily on a framework initially proposed by Freeman (1974) and adapted by the Science Council of Canada (Britton and Gilmour, 1978). This framework is now outlined.

The Technological Strategies of Firms (and Economies)

As Freeman (1974, p. 256) notes firms operate within environments which offer them a range of technological as well as market possibilities. It is certainly true that firms can "accept the supply of inventions and innovations as given, and attempt to maximize ... access to available inventions and innovations " (Thomas and LeHeron, 1975, p. 236). While such access may be accomplished by intelligence networks (including illegal ones) and roving technical scouts such "counterpunching skills" are only permissable in certain situations such as industries characterized by a relatively free flow of information or in regions where firms enjoy distinct processing or marketing advantages. Firms can of course supplement monitoring of technological change by investing in their own R & D. It is important to recognize, however, that in societies characterized by more or less continuous technological change surviving firms must employ at least an implicit technological strategy. In this regard, and to provide a basis for understanding the wide spectrum of technological choices available to firms, Freeman (1974) has classified technological innovation as "traditional", "dependent", "imitative", "defensive", and "offensive".

According to Freeman in the traditional firm technology is based on craft skills and is essentially "non-innovative". The dependent firm also makes no attempt to initiate technical or product change except at the specific request of its customers, or parent, who will also provide the expertise to implement the requested changes. According to Britton and Gilmour (1978, p. 135) "A very large number of Canadian firms both foreign and domestically controlled fall into this category". An imitative strategy involves the firm in adaptive R & D in order to copy the technological leaders and combined with other advantages this can provide the basis for corporate market growth. Finally there are the offensive and defensive firms both of which rely heavily on intramural R & D especially in the areas of applied research and design engineering. The differences between the two strategies are in the timing and nature of innovation. In particular, offensive firms strive successfully for technical and market leadership in the introduction of new products and processes while the defensive firm is content to be somewhat later and to try to take advantage of any errors made by the early innovators without being left behind.

While Freeman articulated this classification as a contribution to a more realistic theory of the firm his concepts have been used to interpret the technological strategies and technological needs of societies in different stages of industrialization. In particular, Britton and Gilmour (1978) have adopted such a perspective by which to better understand the level of technological capability throughout the Canadian economy (see Table 2).

Thus Britton and Gilmour classify societies in terms of traditional, dependent, imitative, defensive and offensive technological strategies which are respectively related to non-industrialized, industrializing, semi-industrialized, industrialized and post-industrial stages of development. In turn, these strategies-and-stages imply a different bundle of technical skills and changes in the relative importance of technology imports and exports. Thus with industrial development this framework suggests increased technological sophistication and in particular the emergence of specialized R & D functions, growing interdependencies or liasions among R & D and related activities and the export of technology.

With reference to the relationships between industrialization and technological capability so outlined (in Table 2) several additional comments are pertinent. First technology evolves along qualitative as well as quantitative dimensions. Thus while all societies have a technological base 'modern' technology and the relationships between science and society in the 20th Century are fundamentally different from those of previous periods. In particular, Freeman (1974, pp. 29-31) notes that R & D has become more professionalized, that is a larger proportion of R & D is now carried out within industry and has increasingly involved the application of formally learned scientific principles to whole systems.

Table 2

Relationship Between Technology Development Strategies, Technology Resources and Industrial Development

Strategy	Emphasis	Major Characteristics	Technical Skills	Technology Development Capability
Traditional (Non-industrialized)	Local Technology	No contacts with foreign technology Technology based on traditional skills No product changes (no demand for it)	Lower management training Technician training Vocational training General education	None - Gradual creation of an industrial mentality and climate
Dependent (Industrializing)	Tertiary Technology (diffusion of existing Technology)	Satellite role to technology stronger countries; long technology gap; importing know-how Copying (little product change)	Production engineering Project evaluation Industrial eng. and management Basic general eng. capability	Investment projects formation and evaluation (including evaluation and selection of technology)
Imitative (Semi-industrialized)	Tertiary Technology (diffusion of existing Technology)	Following the leader country with a short T gap; importing proprietary technology (patents, licences) Process improvements Foreign technology adaptation	Adaptive development Consultant services Design engineering (adaptive design)	Adaptation of foreign technology
Defensive (Industrialized)	Secondary Innovation	Following the leader country as closely as possible "Catch-up and over take" objective. Product differentiation	Strong R & D capability Design engineering Production eng.	Generation of new technology packages Adaptation and improvement of foreign technology
Offensive (Post-industrial)	Original Innovation	First in the world in products and process innovation "Maintain the leadership objective" Frontier research	Frontier R & D	Generation of new original technology

Source: Britton and Gilmour, 1978, p. 136. (adapted from Carrére).

Second, for any given society (or firm for that matter) the technological strategies identified are not mutually exclusive. In other words, a society can exhibit dependent, imitative and offensive characteristics simultaneously. In this regard it might be noted that the existence of branch plants affiliated to offensive firms does not provide the host environment with the technological capability of the parent firm.

Third, while it is appropriate to think of societies evolving along a continuum of technological capability the process is not automatic. The previously noted view that it is cheaper for Canada to purchase imported technology rather than develop a greater indigeneous capability, for example, is essentially the equivalent of freezing technological evolution in the dependent and imititative stages. Indeed, there are good reasons for believing active government policies are needed to promote R & D especially, but not only, in the high technology industries (see McFetridge, 1978).

Fourth, technological evolution is not necessarily dependent upon 'major breakthroughs':

> "it must always be remembered that after the introduction of a new process or the construction of a new plant, many minor technical improvements will be made. These will not necessarily be recorded in patent statistics, both for reasons of secrecy and for patentability. ... in the case of Du Pont's rayon plants, many of the minor technical improvements were not patented but were together more important in their contribution to productivity than the major changes" (Freeman, 1974, p. 94).

Indeed, in the "mature" industries, such as the forest product sector the cumulative impacts of minor or incremental technical improvements are likely to dominate contributions to productivity change.

Finally, and on a more methodological note, it is important to recognize that Freeman's classification of technological strategies, and the modification adopted by Britton and Gilmour, is exploratory and relationships are expressed only in broad qualitative terms. Conventional, more quantitative 'diffusion of innovation' studies, however, tend to adopt a too restricted a perspective in which wider social, political and technological conditions are held constant. The approach reviewed here, on the other hand, at least attempts to make explicit the interrelationships between technology and industrialization in a more comprehensive way.

Objective and Scope

This study seeks to determine and explain the contemporary level of technological capability in the forest product sector of British Columbia. The guiding thesis is that given its size, rate of growth and relative importance within B.C., a high level of technological capability in the sector can be expected. While technological capability is difficult to define succinctly, since it is an umbrella concept incorporating complex scientific, engineering and entrepreneurial processes, R & D activities are clearly central to any such assessment. In this regard it is useful to interpret, as industry does, R & D in terms of a basic research - applied research - development - technology transfer continuum (see Furnas, 1958, pp.1-15).

Simply and conventionally stated basic research involves the search for fundamental laws and is the study of the phenomenon of nature and society for its ow sake. Applied research, on the other hand, focusses the results of basic research to a specific process, material or device, that it is to an industrial scale, to meet a defined commercial objective. As Furness points out applied research emphasizes identification of new products and processes and "usually carries an investigation up to the point of the first successful working model of a mechanical or electrical device, or through the usual glassware stage in a chemical synthesis" (Furness, 1958, p. 7). In the development stage scientists, such as chemists, physicists and metallurgists, are increasingly replaced by engineers and is defined by Furness (p. 8) as "the application of technology to the improvement, testing, and evaluation of a process, material or device resulting from applied research." It might be noted that development includes the design, building and running of pilot plants, as well as an evaluation of their products. Subsequent application of research at an industrial site with actual or potential customers, as well as related market research and evaluation, is here considered to represent the "technological transfer" stage of R & D. In this stage engineering is involved in, first, process design (product specifications, process flow, scale of operations) and with mechanical design (facility layout, foundation design, supply of plant infrastructure etc.).

Bearing in mind these definitions it is argued that technological capability in the forest product sector can be usefully indicated by the number, size and scope of specialized R & D activities, by the nature and extent of R & D liaisons and by the level of exports of technological expertise whether in the form of information, direct investment or the sale of equipment. More specifically this study examines, first, specialized R & D laboratories notably thosed operated or sponsored by the forest product manufacturing firms in terms of evolution, employment, activity, product or process orientation and relative emphasis on the basic research - applied - development - technology transfer continuum. Second, capital goods manufacturers to the forest product sector are examined in terms of industrial and organizational characteristics, the nature of R & D work and levels of export activity. Finally, the size and scope of the engineering consulting community is assessed to determine their contribution to the technological capability of B.C.'s forest product sector.

Information was drawn from two main sources: open ended interviews with executives or managers responsible for (private sector funded) R & D programmes and with senior personnel in consulting engineering firms; and a questionnaire survey of capital goods manufacturers. In addition several Statistics Canada publications and Patent Statistics were surveyed. Because of limitations of time and resources this study was limited to activities operating in, or supported by, the private sector, and located within the Vancouver metropolitan area. Thus academic institutions, notably the forestry faculty at U.B.C., and exclusively government agencies such as the Pacific Forest Research Centre at Victoria were excluded. The level of government and academic research related to the forest resource throughout Canada, however, is comprehensively discussed by Smith and Lessard (1971). Within these constraints there is no reason to believe the study contains any methodological biases.

To introduce the analysis R & D activity in the Canadian forest product sector as a whole is briefly outlined.

Research and Development in the Canadian Forest Product Sector

Useful aggregate indexes of the search for innovation in the Canadian forest product sector viz or viz other industries are provided by dollar expenditures on R & D (Table 3) and by patent statistics (Table 4).

Table 3

Total Intramural Expenditures, by Industry

	1972	1976	1978
		$M	
Mines & Wells	27.3	40.9	50.3
Chemical Based	95.4	162.3	204.1
Wood Based	19.6	34.0	40.5
(Wood)	(1.1)	(2.0)	(2.3)
(Pulp & Paper)	(18.5)	(32.0)	(38.2)
Metals	48.0	76.9	94.7
Machinery & Transportation	100.0	146.7	220.0
Electrical	114.1	166.0	195.8
Other Manufacturing	7.6	9.1	11.6
Other Industries	47.4	90.9	107.0
	459.3	729.9	927.5

Source: Statistics Canada, 1979, cat 13-203.

As indicated in Table 3 intramural R & D expenditures by the wood based industries in 1978 amounted to only $40 m or 4.4% of the total. These industries of course are not noted for being research intensive compared to say chemicals and electrical products. Nevertheless, the forest product industries are Canada's most important economically and in view of the fact pulp and paper activities annually account for around $7 b in revenues R & D amounting to $38 m is to say the least modest - about 0.5% of gross sales.

While patent statistics may appear more useful than expenditure figures, since they represent a count of actual inventions, not all inventions are patented, some inventions are never used, the number of patents give no indication of importance and the ownership characteristics of patents can be misleading (see Schmookler, 1966). Nevertheless patent statistics are at least useful for broad comparative purposes regarding the level of inventive activity. In the context of 24 manufacturing activities, for example, the paper and allied industry ranked eight in terms of (potential) use of patented inventions in 1976 and fourteenth in terms of (probable) manufacture

Table 4

Probable Industry of Potential Use and of Probable Manufacture of Canadian Patented Inventions, by Year of Patent Grant

	Industry of Potential Use		Industry of Probable Manufac	
	1972	1976 %	1972	1976
Food & Beverages, Tobacco	3.2	3.2	0.9	1.0
Rubber and Plastics	3.1	2.6	3.2	3.2
Leather, Textiles, Clothing	2.7	2.1	2.8	2.1
Wood	1.2	1.2	0.9	0.7
Furniture & Fixtures	0.6	1.2	2.2	2.1
Paper & Allied	3.3	2.7	2.6	1.6
Printing, Publishing	0.5	0.2	0.2	0.1
Primary Metals (Ferrous)	1.3	1.6	0.3	0.5
Primary Metals (Non-Ferrous)	1.4	1.9	0.9	0.4
Metal Fabricating	3.8	4.3	12.1	16.4
Agricultural Implements	1.0	0.6	3.1	1.3
Industrial Machinery	5.5	5.1	25.2	24.4
Office Machinery	0.9	1.2	1.1	1.0
Aircraft	1.0	0.3	0.6	0.1
Motor Vehicles & Parts	4.0	3.8	4.6	4.4
Other Transportation	2.9	1.7	3.5	1.9
Communications Equipment	4.6	5.0	8.4	8.4
Electrical Industrial Equipment	2.1	1.7	3.6	2.5
Other Electrical Equipment	1.3	2.0	3.3	3.8
Synthetic Resins	1.2	1.0	1.1	1.2
Pharmacenticals	1.1	2.1	0.4	1.2
Other Chemicals	4.2	3.4	4.6	5.4
Scientific/Professional Equip.	1.4	2.5	5.7	8.4
Other	5.0	3.7	8.6	7.8
Total Manufacturing	57.3	52.8	-	-

Source: Statistics Canada, 1979, cat. no. 13-203.

Table 5

Inventors and Owners of Patents Issued in the Canadian Forest Product Sector 1950 - 1975'

	Patent Inventors (%)	Patent Owners (%)
Individual(s)	679 (70%)	11 (1.4%)
Organizations	288	791 (98.6%)

Table 6

Location of Inventors and Owners of Patents Issued in the Canadian Forest Product Sector 1950 - 1975'

Location	Inventor(%)	Owner(%)
British Columbia	37 (3.8)	20 (2.5)
Rest of Canada	111 (12.0)	95 (12.0)
United States	621 (64.0)	550 (68.0)
Europe	179 (19.0)	124 (16.0)
Elsewhere	19 (2.0)	15 (2.0)

Table 7

Location of Country with Printy Date on Patents Issued in the Canadian Forest Product Sector 1950 - 1975'

Location	Number (%)
Canada	1
United States	499 (74.4)
Europe	158 (20.5)
Elsewhere	13 (1.9)

' Approximately a 10% sample.

Source: Patents, Bureau of Intellectual Property, Consumer and Corporate Affairs.

of such patents (Table 4). Wood products was near the bottom in both cases. It might also be noted that in terms of industry of probable manufacture the industrial machinery industry is easily the most important source of patents.

To obtain further insights regarding patents taken out for use in the Canadian forest product sector a 10% sample of the monthly patent statistics published by Statistics Canada was surveyed between 1950-1975. Selected characteristics of the individual patents were then coded and computed. Several observations are worth making. First in the majority of cases (70%) inventors were individuals while in virtually all cases (98.6%) patent owners were organizations (Table 5). It is not known, however, the extent to which individuals were employed by the patent owners. Second, with respect to place of residence inventors and patent owners were largely located outside B.C. and outside Canada (Table 6). Third, the priority date for 95% of the patents was before 1950 and in virtually 75% of the cases the country with the priority date was the United States (Table 7). Fourth, 77.5% of the patents sampled were process oriented which is contrary to the general trend for all industries. Between 1972 and 1978, for example, about 90% of the patents taken out by Canada inventors were for products (Statistic Canada, Cat. No. B203 1979, p. 47) while an earlier study showed 68% of patents granted were for products (op.cit., 1979, p. 43). Fifth, the intra-sectoral distribution of patents indicates that 72.9% were in pulp and paper with 29.3% in paper converting activities (Table 8). This is to be expected since pulp and paper mills are generally more capital intensive and technologically more sophisticated compared to wood processing units. However, with respect to inventors based in B.C. almost half of the patents issued were in wood processing activities (Table 9). In other words, B.C.'s inventive activity as measured by patents appears to be not only relatively small in scale in total but also relatively concentrated in the low technology activities of the

Table 8

Intra-sectoral Distribution of Patents Issued in the Canadian Forest Product Sector 1950 - 1975'

Sector	Number (%)
Logging operations	85 (8.8)
Sawmills	58 (6.0)
Plywood mills	31 (3.2)
Other Wood mills	89 (9.2)
Pulp mills	167 (17.3)
Primary paper mills	254 (26.3)
Paper converting mills	283 (29.3)

Table 9

The Location of Inventors and the Intra-sectoral Distribution of Patents Issued in the Canadian Forest Product Sector 1950 - 1975'

	Location of Inventor (%)				
Sector	British Columbia	Rest of Canada	United States	Europe	Elsewhere
Logging	7	10	50	16	1
Wood	16	20	94	47	1
Pulp	5	23	100	35	4
Primary paper	1	21	175	48	8
Paper converting	8	36	201	33	5

'Approximately a 10% Sample.
Source: Patents, Bureau of Intellectual Property, Consumer and Corporate Affairs.

forest product sector.

Research and Development Laboratories in B.C.'s Forest Product Sector

Selected characteristics of research and development laboratories located in the Vancouver metropolitan area and owned or sponsored by forest product manufacturers firms have been tabulated (Table 10). While there are only six of them these facilities may be readily disaggregated into company owned or operated R & D, Industry Association R & D and joint government-industry R & D.

Company R & D: Among the forest product manufacturing firms MacMillan Bloedel's (MB's) R & D effort, based at its East Vancouver laboratory, is easily the most significant in British Columbia in quantitative and qualitative terms. The facility is well equipped and includes, for example, printing presses, digesters, a scanning electronic microscope, numerous testing devices (such as a prufbau tester, lint roughness tester etc.) and various scientific instruments. The laboratory also has a machine shop and it has manufactured its own equipment and instruments which are used in MB's mills. MB's R & D budget and employment is typically the largest or second largest among Canadian forest product firms. In 1977 MB was the 11th ranked R & D spender in all Canadian industry (Skeklasa, 1978, p. 35). In 1978 MB spent $6.8 m on R & D which amounted to 16.8% of all intra-mural R & D in the forest product sector in Canada. In terms of employment the laboratory's 65 professionals include chemists, chemical engineers, physicists, mechanical engineers, wood technologists, mathematicians and computing scientists. In addition to these R & D professionals a further 10 are employed in logging research and another 21 in forestry research (mainly genetics) at Nanaimo.

Table 10

Specialized R & D Facilities Located in the Vancouver Metropolitan Area and Serving the Forest Product Industries

Affiliation/Location	Origins	Size 1978[1]	Scope
A. Company R & D			
MacMillan Bloedel Research, E. Vancouver	1966/7. Relocation and expansion of pulping technical groups recently concentrated at Harmac.	\$6.8 65(135)	Applied Developmental Product and Process Wood and Paper.
Canadian Forest Products, New Westminster	1958/9 following award of 3 NRC Grants.	4(10)	Developmental Plywood Products.
Crown Zellerbach Canada, Richmond	1969/70 in an old speciality plywood plant	3(9)	Trouble-shooting Processing
B. Association R & D			
Council of Forest Industries, North Vancouver	1972/3 but first set up by PMBC in early 1950's	2(10)	Developmental Wood Products
C. Government-Industry R & D			
Forest Engineering Research Institute, Vancouver	1975, an offshoot of PPRIC in Montreal and a Fed. Govt. lab. in Ottawa	\$2-3m 12	Developmental Process Log harvesting and transportation
Forintec, Vancouver (UBC)	1979. Privatization of former Western Forest Product Lab est. in 1918	\$3m (110)	Formerly basic and applied. Product and Process. Wood.

Source: Fieldwork

1: Size is indicated by 1978 budget and professional (and total) employment.

The roots of MB Research lie in two small technical groups established in the early 1950's at the Harmac and Powell River pulp and paper mills and a few scattered technical personnel within the Building Materials Division. In 1966/7 these groups were first consolidated at Harmac and then re-located to Vancouver. At that time the Department had 12 professionals and scientists. The specific rationale underlying the creation of the Department is not known although MB was in the midst of a major consolidation of its B.C. facilities and had recently expanded into other Provinces and overseas. Once established in Vancouver the initial emphasis on chemical pulping was methodologically built up to include technical support for first plywood, then waferboard (following acquisition of a waferboard mill in Saskatchewan which required considerable technological adaptation to make profitable), next newsprint and finally packaging. The firm itself has described in some detail its activities in these five areas so it is not necessary to repeat that discussion here (MB, 1978). It might be noted, however, that the Department at one time also had a forest chemicals group comprising 8/9 people and concerned with extracting chemicals from wood residues. While some patents were taken out the firm considered this research tangential to its main interests and so it was discontinued.

With respect to the scope of MB's R & D activities the firm estimates about 80% of professional time involves applied, developmental and technological transfer work. The R & D group do no basic research and the remaining time is spent on service work ("trouble shooting") particularly for the Building Materials Division which has only limited technical expertize (in contrast to the Pulp and Paper Group) and where the problem is "to solve problems in a manner in which local individuals can help" (pers. comm.). The R & D Group, however, clearly prefers not to become embroiled in such troubleshooting. In this regard, the R & D laboratory's location away from manufacturing facilities (and head-office) is thought important to provide the "breathing space" necessary to concentrate on longer term problems.

MB's R & D effort emphasizes process and to a lesser but growing extent product innovations in all the major branches of forest products. The group estimates the allocation of its resources in one and five year "running" plans and attempts to "think in terms of 10 years". Ideas are submitted to the Product Groups before projects are determined and scientists assigned. In practice R & D priorities seem to be essentially determined by long run operational problems facing the company. These priorities may be set by a rather specific stimulus as, for example, occurred when the R & D group had to respond to the problems of the Saskatchewan waferboard mill acquired by the firm. The priorities may also be set as a resulting of evolving appreciation and even anticipation of changing trends. This is particularly well demonstrated by MB's recent innovations of several speciality papers which reflect the firm's foresight in recognizing technological changes in printing processes including a growing demand for stronger but lighter paper.

An inherent characteristic of R & D is its uncertainty. Projects fail for one reason and another, it is difficult to calculate rates of return on investment in R & D while the R & D process itself is often extremely lengthy. It took over a decade, for example, for MB, after experimenting with alternative pulping processes to improve yields, to achieve commercial success with respect to thermomechanical pulping (TMP). During the R & D process MB identifies various "milestones" or thresholds which may involve, for example, reports, seminars or the construction of pilot plants. This latter can occur within the R & D department itself, elsewhere in company space (e.g. an operating mill) which is "rented" by the R & D group while pilot plants have even been connected to mainstream operations. In fact at the pilot plant stage technological responsibility for a project may shift from the R & D department. In any case throughout the life of a project the R & D department will maintain frequent and "open" communication with MB's main business groups. Contact is also frequently required with capital goods manufacturers and these are apparently mostly initiated by MB; local wood processing equipment suppliers are regarded as "good" while for pulp and paper mill suppliers the firm must necessarily look outside B.C. Relationships with local engineering consultants, however, are strong enough for MB to retain specialists to hire them. MB's R & D group also makes some use of professionals and specialized facilities at Forintec's Vancouver laboratory (notably its veneer peeling test machine) and Forintec's Ottawa laboratory. For fundamental research MB largely relies on the Universities, especially in the United States, and the Pulp and Paper Research Institute of Canada's (PPRIC) Montreal laboratory. When utilizing Association R & D, such as PPRIC, MB insists the results of their own projects are kept confidential.

Notwithstanding its own significant investments in R & D MB does recognize the widely prevalent view among forest product firms in B.C. that

R & D

is not necessary because of the industry's "openness" to new technological information. Certainly technological information is readily diffused through exchange visits, trade journals, annual technical conferences and by the equipment supplied by capital goods manufacturers. In addition MB

cited an example of a patent taken out on the chlorine dioxide bleaching process by two companies in Central Canada which had given them a return of $20-30 m in royalties alone as the exception which proved the rule that patents are of little value in the forest product sector. In response the obvious question as to the value of intramural R & D MB claimed several corporate advantages. First it was noted that R & D personnel help screen requests (and offers) for mill visits and in conducting visits to other companies. (The very fact that visits are requested of course does suggest forest product firms do have technologically distinct information which has value). Second, it was noted that there are now areas of rapid change, for example, with respect to newsprint furbish and specialities where formal R & D inputs are crucial to cost-reductions and product developments. Third, and most important, the respondents claimed R & D provides MB with an important marketing edge in two main ways. First, it was claimed R & D provided a "head-start" over competitors during which MB enjoyed an exclusive advantage. The length of the head-start, or competitor's learning curve was estimated at 12-24 months (in contrast to the previously noted pre-innovation R & D process which might last 10-12 years). The second marketing advantage claimed for R & D was that it instills confidence in customers that problems can be solved if and when they arise.

What evidence there is available suggests that MB has been, and is, an important innovator and that the benefits claimed by MB for its R & D have likely been realized. Richard Schwindt (n.d. p. 142) for example, obtained lists of "major and less significant inventions and innovations" in various branches of forest products for between approximately 1950 and 1975, and (qualitatively) reviewed MB's performance as an inventor, innovator and adopter in comparison with other North American firms. Schwindt found MB's record to be "extremely good" in various wood products and the firm to be at least "active" in pulping and papermaking. MB's record in pioneering forest product transportation systems, including most notably the self propelled, self loading, self dumping log barge, is also well known. Examples of recent important technological developments by MB include the pioneering of waferboard technology (thus helping to establish a viable wood processing industry in aspen covered areas), innovation of plywood and waferboard panels, the innovation of several speciality papers, the innovation of new inking methods for corrugated containers while MB was the first to introduce TMP in North America. Schwindt's (n.d. p. 146) conclusion is worth noting:

"In summary, MacMillan Bloedel's progressiveness score seems high. The evidence indicates that it is an active inventor, innovator and adopter of new products and processes. Its research efforts seem to be directed toward those areas which are in need of emphasis".

To use Freeman's (1974) terms, and bearing in mind the dimensions of technological change in the forest product sector, MB's technological strategy may be described as at least "defensive" and possibly as "offensive". In its R & D programme MB has taken the initiative in process and product developments and there is evidence that in some respects at least MB has emerged as an international leader or is among the international leaders. MB's R & D effort has also been designed to resolve technological problems in environments other than British Columbia - including, for example, the development of waferboard technology in Central Canada and specialized logging equipment for Southern States.

In contrast to MB, other forest product manufacturing firms have limited technological capability within B.C. and apparently no particular aspiration to do otherwise. Canadian Forest Products has a small 'planning and development' group located as part of its New Westminster plywood operations. Essentially the group is concerned with improving groving, printing, up-grading and embellishing methods in order to "differentiate" Canfor's plywood and hardboard products. Much of this work, it was admitted, involves imitation although this is apparently often costly. The group does not do pilot plant work, has limited liaison with other technical people, and its "developmental" work is clearly focussed on the technology transfer end of the R & D continuum.

The only other forest product firm with a Vancouver based R & D group is Crown Zellerbach Canada. However, its Richmond plant has no laboratory facilities and it essentially provides a centre for a small technical staff which provide "trouble-shooting" services to operating divisions, especially Building Materials. In recent years much of its work has been directed towards resolving pollution problems. It might also be noted that while most pulp and paper mills throughout the province have technical groups attached these groups are principally involved in quality control, trouble shooting and technical adaptation within the mills. MB apart then, the technological strategy adopted by the major Vancouver based forest product firms can be summarized as "dependent".

Association R & D: The principal forest product association R & D is performed by the Council of Forest Industries (COFI). COFI's R & D laboratory was originally designed in the early 1950's as a structural testing facility for plywood and financed by the Plywood Manufactures of British Columbia (PMBC). The scope of COFI's R & D has since been enlarged to include first lumber and then shingles and shakes although plywood remains the dominant focus receiving 80% of the funding.

COFI's revenues derive from member company contributions which are based on volume of production (so as a result MB is the largest single contributor). The annual budget and priorities are first determined by an R & D sub-committee made up of representatives from member companies. This committee then advises each of the Plywood, Lumber, and Shingle and Shake Committees which are themselves comprised mainly senior executives of the member companies - and who have the ultimate decision-making authority. COFI's R & D is overwhelmingly product and marketing oriented and focusses on laboratory examination of the strength, physical and sectional properties of construction products; help in overseas marketing, structural testing of component systems utilizing wood, the development of technical literature, and representing the industry on national and international committees.

COFI provides information which nobody else does, including the setting of commonly accepted standards, and performs services beyond the reach of smaller companies. COFI has taken out patents to protect member companies and has contributed towards the innovation of new panel products (e.g. COFI FORM). As of 1979, however, COFI employed just two professionals and 5 technicians, which is its lowest ever level. COFI's activities were in fact reduced after a review of its operations by the industry in 1978 and this demonstrates the most significant problem facing Association R & D such as that provided by COFI - vunerability to short term thinking by 'sponsors'. However, the potential scope of COFI's activities is also necessarily influenced by virtue of the fact that <u>all</u> member companies have access to COFI's services, information and patented products. (Thus member companies with novel ideas must, like MB, demand secrecy). In this regard a sensitive issue among Canadian firms, including MB, is that foreign owned member companies of COFI provide a "pipeline" of information for parent companies without cost and without a reciprocal arrangement. At the same time, the <u>extent</u> to which subsidiary companies are willing to support Association R & D is presumably circumscribed by access to parent company R & D services which also have to be paid for. These same issues, in fact, confront joint industry-government sponsored R & D.

<u>Industry-Government Sponsored R & D</u>: The two main industry-government sponsored agencies in B.C. are the Forest Engineering Research Institute (FERIC) and FORINTEC (formerly the Western Forest Products Laboratory). Both FERIC and FORINTEC originated from Government administered R & D programmes and, in fact, the latter only started to become "privatized" in early 1979. Both organizations have eastern counterparts.

FERIC began operations in 1975 in Vancouver with 5 professionals to conduct logging research. Logging research in Canada can be traced to the 1930's when the Federal Government and Industry, as part of the Pulp and Paper Research Institute of Canada (PPRIC), established laboratories in Ottawa and Montreal respectively. PPRIC maintained a Woodland Section, comprising both a silvicultural group and a logging group, until 1971 when it was disbanded. The idea was to start up a new organization - FERIC - to conduct R & D in logging only by hiring professionals from the Federal Government's Ottawa laboratory and PPRIC although in the event government people did not transfer.

By 1979 FERIC's Vancouver office employed 12 professionals, foresters and engineers and the budget reached $2.3 M while a similar sized operation is based in Montreal. FERIC's broad policy is set (or santioned) by a Board of Directors comprising members from various Federal Government Departments (including Industry, Trade and Commerce and Supply and Services) and the forest product companies. FERIC scientists and engineers generate five year plans while the actual programme is vetted by eastern and western advisory committees who meet annually to direct research emphasis. Generally, FERIC's R & D involves wood harvesting, log transportation, and the environmental impacts of logging.

The main objective of FERIC's research and development is to minimize the costs of logging by improving present practices, developing new systems and machines and <u>applying</u> research results. This latter responsibility requires FERIC to closely cooperate with both forest product and equipment manufacturers including with respect to concept evaluation, field testing and developing pre-production models. So far (not surprisingly given its short history) the stimulus to such cooperation has come from industry. An example is provided by Northwood which wanted to develop a felling head which resulted in less wastage. In this case the company provided the financing and the location for testing while a FERIC engineer designed the new Felling Head. The tool was built by a small manufacturer in Prince George and this firm will have marketing autonomy. The tool is being patented and in this respect the policy is to charge only cost to member companies and market price to non-member companies. FERIC's R & D therfore is also strongly oriented towards the technological transfer end of the R & D continuum.

FERIC's specialized functions have no doubt helped its credibility especially since logging research is being given greater priority by the compan themselves. FERIC has demonstrated willingness and ability to cooperate with individual companies in the specifics of technological transfer. It is true that FERIC, like COFI, faces the problems resulting from members on the one hand having equal access to information and, on the other, having limited willingness to sustain R & D over the long run. Indeed even federal government participation and support can no longer be regarded as a source of stability in view of the government's sudden and somewhat irrational withdrawal of support for the Western Forest Products Laboratory (WFPL).

The WFPL was first established by the Federal Government in 1918 and by 1978 it employed over 100 professionals and enjoyed a budget in excess of $3M. It focussed mainly on basic and applied research particularly with respect to wood processing activities and it undertook research on its own initiative and in response to company requests including from consulting firms who lacked their own laboratory or library facilities. However, following the reports of a joint industry-federal task force (1978 and 1979) the Federal Government decided to "privatize" the WFPL (and EFPL) in 1979 to create Forintec. While the existing (capital) facilities were in effect offered for nothing privatization also meant withdrawal of federal back-up services. To replace these monies the provincial government has stepped in with financial aid while an industry committee struck to obtain financing for

Forintec has so far (mid-1981) been unsuccessful. The ostensible rationale for "privatization" is apparently that private sector R & D, in contrast to public sector R & D, is more likely to be channelled into profitable and useful opportunities. In fact, considerable concern has been expressed, including by the Science Council (Cordell and Gilmour, 1976), regarding technological transfer for commercial use from government R & D laboratories in all sectors of the Canadian economy. In this respect the former WFPL also certainly had its critics including among the respondents contacted during this study. On the other hand industry itself is frequently skeptical (and short-sighted) about basic research since its immediately practical application(s) is usually unclear. Yet the applied research of to-day is often made possible by the basic research of years and even decades ago. Whether or not the Federal Government assumed that the R & D performed by WFPL was of little value and would be replaced/replicated by the private business is not clear. However, it seems entirely unrealistic to believe that firms who themselves have consistently failed to support internal R & D programmes would subsidize a joint industry effort, especially at short notice and at a time when the same firms were reducing the level of support for COFI. There is certainly a feeling that the manner in which privatization was implemented was irrational (see Whitnay, 1978; Digeldein, 1978). There was virtually no forewarning to the staff and no firm or even tentative commitment of support from the private sector was obtained. So far Forintec has experienced significant losses of senior personal and has yet to define clearly its goals and priorities. Notwithstanding these uncertainties its sheer size and scope means that it is a potentially formidable competitor to existing (or potential) specialized R & D firms.

Specialized R & D Firms

As an alternative to intramural and especially to Association R & D specialized firms can potentially provide R & D to manufacturing companies on a contract basis. While Econotech was the only such company in the Vancouver area and serving the forest sector that could be found this type of firm can offer important benefits to the sector. Consequently, the history and functions of Econotech are of interest.

Econotech was originally the R & D Division of Columbia Cellulose (Cocel) which was first set up at Prince Rupert and then relocated to Vancouver in the mid-1960's because of recruiting difficulties. At its peak Cocel's R & D Division employed 80-90 people and was largely concerned with pulping processes especially dissolving pulps which are used in a variety of end products including cellophane, plastic handles, cigarette filters and so on. Cocel, in fact, was closely integrated with its parent company, the Celenese Co. of New York. In particular, Cocel supplied Celenese with its only internal source of dissolving pulps and while Cocel's R & D focussed on pulping the rather larger scale effort of Celenese in New York focussed on the pulp converting stages.

As Cocel began to lose money in the late 1960's the R & D staff became more embroiled in operational problems, especially with respect to the kraft and sulphite mills, rather than with large term research regarding dissolving pulps. When it became clear Cocel would finally close down its R & D Division two employees in 1972 collaborated to purchase the laboratory and create Econotech. At that time the company had 9 employees although by 1978 it was back to 20. Econotech has contined to specialized in pulping R & D and it is particularly concerned with developmental work and technological transfer. Virtually all work is by contract, including by sub-contract, and their major customers are forest product firms, capital goods manufacturers and consulting engineers. While Econotech does provide "consulting services" regarding operational matters it emphasizes independent evaluations of pulping processes utilizing its own equipment which includes complete pilot plant facilities for pulping and bleaching.

Their work is split equally between large and small companies while approximately 50-70% of their revenue is generated within B.C. Econotech's growth, and its ability to export its services reflect various competitive advantages most notably because it has a high level of expertize in an area (dissolving pulps) where there are few competitors. Econotech also claims a reputation for maintaining confidentiality. In this respect it might be noted that all its employees sign secrecy agreements while sometimes technologists are themselves not informed about the underlying nature of the problem they are investigating. At the same time Econotech has accumulated considerable experience in a variety of mill environments throughout North America thus widening its problem solving abilities. Finally, it should be noted that Econotech's R & D is essentially complementary rather than competitive viz a viz the major companies. In this regard firms such as Econotech provide a buffer against rapid hiring and firing by the major manufacturing companies. That is, Econotech can not only provide R & D for firms lacking the appropriate expertize it can conduct 'overload' R & D for the majors.

The small specialized R & D supplier can therefore offer a potentially important role in the sector. Ironically, while the government has urged "privatization" so far Econotech has yet to win a single contract from either the federal or provincial governments. On the other hand, the creation of Forintec in effect represents subsidization of a competitor to Econotech. It may also be argued that the lack of more companies like Econotech results from a general lack of corporate R & D since in many ways such small firms represent spin-off and complementary developments to large scale industry R & D.

The Capital Goods Manufacturers

The ultimate goal of research and development is the commercial innovation of a new product and/or process. Since this invariably involves investment in new plant or at least equipment, the capital goods manufacturing industries perform functions critical to an assessment of technology capability. Indeed, in the case of the forest product sector where process oriented innovation has dominated it is established opinion that capital goods firms have themselves been in the forefront of the research and development process. In the specific case of British Columbia it is well known that a forest product based capital goods sector does exist. Indeed, according to a recent provincial government publication,

"Economics and the basic characteristics of the rough terrain have forced provincial manufacturers to be particularly innovative in design. The result is a highly sophisticated industry with a large degree of automation where necessary, advanced technological features and a good capacity to export" (Provincial Government of B.C., n.d.p.) (my emphasis). The following sections seek to determine the veracity of this statement regarding capital goods suppliers to the forest product sector.

General Characteristics of Capital Goods Firms: Equipment manufacturers to the forest product industries were established in the earliest phases of industrialization in British Columbia. One of the sampled firms, for example, could trace its roots to a New Westminster plant built in 1876. Since then of course the capital goods industry has undergone much growth and change and in this respect the early emphasis on sawmilling equipment has been enlarged to incorporate logging equipment, forest product transportation products and plywood machinery manufacturers. None of the sampled plants, however, provided inputs of significance to the pulp and paper industry.

Of the 34 plants interviewed 25 were (Table 11) privately owned all with their head-offices in British Columbia. Of the remaining nine, seven were foreign controlled and two controlled elsewhere in Canada. Of the privately owned plants all but four were managed by an owner. Most of the companies had been established prior to 1970 and in almost half the cases acquisition was the favoured method of entry into the industry (Table 12). As would be expected the plants were typically small in terms of employment and sales although a quarter of the sample did belong to parent companies who controlled more than three plants (Table 13). The branch plants were also typically larger than the privately owned ones with respect to employment and sales (Tables 14 & 15). Most of the firms with more than one plant integrated their operations through material flows to some degree. All the branch plants, for example, purchased some inputs from affiliated destinations (Table 16). Generally speaking affiliated inputs and outputs comprised less than 25% of the value of linkages (Table 17). As would be anticipated affiliated input-output linkages were significantly associated with the larger plants (Table 18). With respect to material linkage characteristics several observations are worth noting. First, most plants obtained at least one quarter of their material inputs from within British Columbia so that these firms are closely backwardly integrated within the local economy (Table 19). Outside of British Columbia imports are more important than purchases from the rest of Canada. On the demand side all the sampled plants obtained some revenue from sales within British Columbia while most receive at least half their revenue from intra-provincial sales. Correspondingly sales to other parts of Canada and exports were not as significant although half the plants did derive <u>some</u> revenue from these sources (Table 20).

<u>Research and Development by Capital Goods Manufacturers:</u> Surprisingly, half the sample claimed some internal R & D capability while most indicated they had design capability (Table 21). Moreover, half the sample noted at least three-quarters of their sales derived from products which were locally

Table 11

Organizational Characteristics of Sampled Capital Goods Manufacturers

Central Status		Head-Office Location	
Private Canadian	25 (74%)	B.C.	25 (74%)
Branch Plant	2 (5%)	Rest of Canada	2 (5%)
Foreign Branch Plant	7 (21%)	Elsewhere	7 (21%)

Organizational Structure	
Entrepreneurial	21 (64%)
Managerial	4 (12%)
Managerial/Decentralized	8 (24%)

Table 12

Date of Origin of Sampled Capital Goods Manufacturers

Time of Entry		Method of Entry	
Pre-1950	7 (27%)	Acquisition	15 (47%)
1950-69	14 (52%)	New Plant	13 (41%)
1970	6 (21%)	Empty Plant	4 (12%)

Source: Field Work

Table 13

Size Characteristics of Sampled Capital Goods Manufacturers

No. of Employees

Employee Class	Sampled Plants
1 - 24	18 (53%)
25 - 100	9 (28%)
100 - 500	7 (19%)

Plants Controlled by Parent Company

Plant Class	Sampled Plants
1	17 (50%)
1 - 3	9 (27%)
3	8 (24%)

Annual Sales

Sales	Sampled Plants
<$1.0 M	12 (34%)
$1-4.9 M	10 (29%)
$5-9.9 M	10 (29%)
$10-19.9 M	2 (6%)

Table 14

Sampled Capital Goods Manufacturers: Organizational Status and Size of Plant (Employment)

	Employment	
Organizational Status	<25	25 - 499
Privately owned	16	9
Branch plant	2	7

χ^2_{cal} = 4.34 (Significant at .05 level) Cramer's V =.13

Table 15

Sampled Capital Goods Manufacturers: Organizational Status And Size Of Plant (Sales)

Organizational Status	<999	Sales ('000) 1 - 4999	5 - 20,000
Privately owned	10	8	5
Branch plant	1	1	7

Collapsing the first two columns χ^2_{cal} = 8.53 (Significant at .05 level)
Cramer's V = .27.

Table 16

Sampled Capital Goods Manufacturers: Affiliated Input-Output Material Linkages, 1978

Organizational Status	Affiliated Inputs None	Some
Privately owned	21	4
Branch plants	0	9

χ^2_{cal} = 20.09 (Significant at .05 level)
Cramer's V = .59

	Affiliated Outputs None	Some
Privately owned	20	4
Branch plants	3	6

χ^2_{cal} = 7.9 (Significant at .05 level) Cramer's V = .24

Table 17

Affiliated Input - Output Linkages, 1978

Linkage	Percentage Distribution By Value		
	0	1 - 25	25 +
Inputs	21	11	2
Outputs	23	9	1

Source: Fieldwork, 1979.

Table 18

Sampled Capital Goods Manufacturers: Employment Size and Affiliated Input - Output Linkages, 1978

	Affiliated Inputs	
Employment Size	None	Some
<25	14	4
25 - 499	7	9

χ^2_{cal} = 4.17 (Significant at .05 level) Cramer's V = .12.

	Affiliated Output	
	None	Some
<25	18	3
25 - 499	8	7

χ^2_{cal} = 3.63 (Not Significant).

Source: Fieldwork.

Table 19

Geographical Distribution of Material Inputs of Sampled Capital Goods Manufactuers

	Percentage Distribution By Value				
Source	0	1 - 24	24 - 49	49 - 74	75+
British Columbia	6	1	6	6	14
Rest of Canada	12	16	4	0	1
Imports	5	17	6	4	1

Table 20

Geographical Distribution of Outputs of Sampled Capital Goods Manufacturers,

	Percentage Distribution By Value				
Destination	0	1 - 24	24 - 49	49 - 74	75+
British Columbia	-	2	3	10	18
Rest of Canada	13	19	1	2	1
Exports	14	15	2	3	-

Source: Fieldwork, 1979.

researched, developed and designed. In addition, only three plants relied more or less exclusively on foreign designs while products modified from 'foreign' designs were not of any importance to the respondent firms (Table 22). Caution needs to be exercised in interpreting statistics regarding the characteristics of product technology especially since some respondents did not regard the various categories offered (see Table 22) as mutually exclusive. Nevertheless the general trend is clear and consistent with prevailing opinion: the products manufacturered by equipment suppliers to the forest product sector are distinctive and reflect strong local input of technology.

In other respects the dimensions of technological capability are less impressive. Employment statistics, in particular, indicate that the formal committment to R & D is minimal. Thus only one of the sampled firms employed any scientists at all and only one employed more than five engineers (Table 23).

In total of the 32 sampled firms which provided information 2 scientists, 41 engineers and 77 technicians were employed. Of these the 9 externally controlled plants employed both scientists, 26 of the engineers and 42 of the technicians. Admittedly CanCar, which is reputedly the most innovative equipment manufacturer in B.C. and which employed 1 scientist, 7 engineers and 69 technicians in 1977 (Canada, Supply and Services, 1978), is not included. CanCar, it might be added, is also foreign controlled. A minimum size for an "efficient" R & D effort in the capital goods industry is not known to the author - but only 8 of the sampled firms employed 5 or more professional employees (including technicians). With respect to R & D budgets systematic data is not available but with few exceptions the firms did not allocate funds to R & D on a planned basis. Similarly, just a handful of the sampled firms have specialized laboratory facilities and/or design offices. Only eight of the sampled firms indicated they had taken out patents.

Some further observations regarding the characteristics of product technology are worth noting. Neither branch plants nor privately

Table 21

Capital Goods Manufacturers: R & D and Design Capability

	R & D Capability	Design Capability
Yes	16	30
No	16	4

Table 22

Characteristics of Product Technology of Sampled Capital Goods Manufacturers,

	Percentage Distribution of Sales By Value			
Product Development	0	1 - 24	25 - 74	75+
Local	3	4	7	17
Foreign	22	5	2	3
Foreign Adaptation	15	10	3	1

Source: Fieldwork, 1979

Table 23

Employment of Scientists, Engineers and Technicians By Sampled Capital Goods Manufacturers, 1978

Number	Scientists	Engineers	Technicians
None		16	12
1	-	8	11
2-5	1	8	7
6-10	-	1	2
11+	-		1

Table 24

Sampled Capital Goods Manufacturers: Organizational Status and Characteristics of Product Technology, 1978

(a)

Organizational Status	Product Development - Local: None	Product Development - Local: S me
Privately owned	2	19
Branch plant	0	9

These variables are statistically independent.

(b)

	Sales of Foreign Designed Products: None	Sales of Foreign Designed Products: S me
Privately owned	13	7
Branch plants	5	2

Obviously these variables are statistically independent.

(c)

	Sales of Products Adapated from Foreign Designs: None	Sales of Products Adapated from Foreign Designs: S me
Privately owned	10	10
Branch plants	3	5

These variables are statistically independent.

owned plants are more or less likely to research, develop and design products locally or to sell foreign designs (Tables 24a and 24b). There is some indication that branch plants are more likely to modify foreign designs than privately owned plants but the relationship is not statistically significant (Table 24c). With respect to claims concerning R & D and design capability organizational status is not important (Tables 25a and 25b) although branch plants are likely to hire more engineers (Table 25c). This latter relationship is significant although the association is not a strong one. Surprisingly none of these relationships including various characteristics of product technology, appear strongly influenced by size of plant, (Table 26). Larger firms do claim to have greater R & D capability (Table 27a) but in terms of employment of professionals (Table 27b) or of engineers (Table 27c) these claims are weak and cannot be statistically supported.

Export Characteristics of Capital Goods Firms: The point of view offered by Bedford (p. 7) in the mid-1970's that "while some of the best sawmilling and logging equipment in the world is built in British Columbia, export markets are not pursued with sufficient aggressiveness" is at least given indirect support by the behaviour of sampled firms. As noted (Table 20) only five plants exported 25% or more of their sales while 14 had no exports at all. In attempting to explain B.C.'s poor export performance Bedford (p. 7) argued that firms "do not have the resources, both financial and human, to pursue offshore markets. In fact, a considerable amount of their scarce financial resources are spent on research and development".

It is of course more usual and intuitively appealing to reverse Bedford's arguement - that is hypothesize that investment in R & D would encourage exporting. Indeed, it is interesting that the null hypothesis that there is no relationship between various indexes of technological capability and

Table 25

Sampled Capital Goods Manufacturers: Organizational Status and Technological Capability

Organizational Status	Research and Development Capability: Yes	Research and Development Capability: No
Privately owned	12	12
Branch plants	6	3

χ^2_{cal} = .67 (Not Significant)

	Design Capability: Yes	Design Capability: No
Privately owned	21	4
Branch plants	9	0

χ^2_{cal} = 1.68 (Not Significant)

	Number of Engineers: None	Number of Engineers: 1 or More
Privately owned	14	10
Branch plants	2	8

χ^2_{cal} = 4.15 (Significant at .05 level) Cramer's V= .12

Table 26

Sampled Capital Goods Manufacturers: Employment Size and Product Technology Characteristics

(a)

Employment Size	Product Development Done Locally	
	None	Some
<25	2	13
25 - 499	1	15

Obviously these variables are statistically independent.

(b)

	Products Based on Foreign Designs	
	None	Some
<25	12	5
25 - 499	10	5

Obviously these variables are statistically independent.

(c)

	Product Adaptations of Foreign Designs	
	None	Some
<25	8	6
25 - 499	7	8

Obviously these variables are statistically independent.

Table 27

Sampled Capital Goods Manufacturers: Employment Size and Technological Capability

(a)

Employment Size	Research and Development Capability: Yes	No
<25	6	10
25 - 499	10	6

χ^2_{cal} = 2.0 (Not Significant).

(b)

	Design Capability: Yes	No
<25	15	2
25 - 499	15	0

These variables are statistically independent.

(c)

	Professional Employees: None	Some
<25	4	12
25 - 499	2	14

χ^2_{cal} = .82 (Not Significant)

(d)

	Engineers: None	Some
<25	8	8
25 - 499	5	11

χ^2_{cal} = 1.18 (Not Significant).

Table 28

Sampled Capital Goods Manufacturers: Exports and Product Technology Characteristics

(a)

Engineers	Exports: None	Exports: Some
None	5	6
Some	3	15

χ^2_{cal} = 2.94 (Not Significant)

(b)

Monitor R & D	Exports: None	Exports: Some
Yes	4	15
No	8	6

χ^2_{cal} = 4.15 (Significant at .05 level). Cramer's V = .14.

(c)

(c) R & D Capability	Exports: None	Exports: Some
None	9	7
Some	3	13

χ^2_{cal} = 4.8 (Significant at the .05 level) Cramer's V = .15.

exports can be rejected in the case of the sampled plants (Tables 28a, 28b, 28c, and 28d). Given the complexity of factors likely to influence export performance and bearing in mind only one of the sampled firms employed more than 5 engineers, the strength of the associations, as indicated by Cramer's V, are in fact surprisingly good. The variables have, of course, been measured in a very crude way and reduced to a binary format. Nevertheless these results can be used to reject Bedford's point of view.

It might be expected that larger plants would be more prone to export. However, this hypothesis cannot be statistically supported at the 5% level of confidence (Table 29a). The relationships between size of plant and sales to the Vancouver metropolitan area and to the rest of Canada are also not significant (Tables 29b and 29c). Similarly, there is no relationship between organizational status and export levels, and sales to the rest of Canada (Table 30b and 30c). However, privately owned plants are much more likely to have markets within the Vancouver area than branch plants (Table 30a).

In an open-ended qualitative way the sampled firms were asked to comment about the problems they faced in achieving greater sales to the rest of Canada and higher export levels. The pattern of responses revealed some general characteristics worthy of note. As would be expected, several of the smaller firms indicated they were simply not interested in expanding their sales beyond British Columbia! Others referred to the costs of transportation to Eastern Canada as well as to competitors located there. However, there were observations offered by several respondents that are of particular interest to this paper. The first concerns marketing. Thus many comments referred to "limited sales personnel", the "preferences given to local firms", the "hassle" of dealing overseas banks, the inability to provide a "local service back'up", the "lack of sales outlets", only "one part-time salesman in Ontario" etc. The peculiar difficulties in exporting overseas were more formally recognized a few years

Table 29

Sampled Capital Goods Manufacturers: Employment Size and the Geographical Distribution of Input - Output Material Linkages

(a)

Employment Size	Exports	
	None	Some
<25	9	9
25 - 499	3	12

χ^2_{cal} = 3.3 (Not Significant)

(b)

	Sales Within the Vancouver Metropolitan	
	None	Some
<25	3	15
25 - 499	5	10

χ^2_{cal} = 1.3 (Not Significant)

(c)

	Sales to the Rest of Canada	
	None	Some
<25	5	13
25-499	6	9

χ^2_{cal} = 1.0 (Not Significant)

Sampled Capital Goods Manufacturers: Organizational Status and the Geographical Distribution of Outputs, 1978

(a)

Organizational Status	Sales within Vancouver Metropolitan Area (% Value) None	Some
Privately owned	1	23
Branch plant	7	2

X^2_{cal} = 19.1 (Significant at the .05 level) Cramer's V = .58

(b)

	Sales to the Rest of Canada None	Some
Privately owned	8	16
Branch plant	3	6

These variables are statistically independent

(c)

	Export None	Some
Privately owned	10	14
Branch plants	2	7

These variables are statistically independent ago when several equipment manufacturers created Canmillex, a cooperative sales agency. The success of Canmillex in promoting exports, however has not been determined.

The second set of comments that are worth underlining referred to the distinctive nature of the industry in B.C. Thus the respondents variously noted "In Eastern Canada there is a different market need, that is light machinery there, heavy here". Or, "Types of market in the East not the same technology needs or scale as in B.C.". Or B.C. offers "A unique technological market" etc. In attempting an assessment of technological progressiveness of capital goods firms these comments provide useful insights.

The Technological Progressiveness of Capital Goods Firms: It is not easy to summarily interpret the technological progressiveness of capital goods firms in Freeman's (1974) classes of technological strategies. The evidence is partial, subjective and to some extent at least apparently contradictory. Thus on the one hand the capital goods sector is distinctive and innovative while at the same time its formal commitment to R & D is meagre and its export activity is less than what might have been expected. In addition, although the questionnaire data collected on this issue is very limited it does indicate a relatively low level of technological liaison between the sampled capital goods manufacturers and consultants, governments and customers (Table 31). In particular there is virtually no contact with government laboratories, only four firms indicated 'frequent' contact with engineering consultants while more than one-quarter of the sample did not have any technological liaisons with their customers.

Clearly part of the explanation for the apparent paradox concerning the technological progressiveness of capital goods firms lies in the distinctive nature of B.C.'s forest resource and the industry's concentration on logging and wood processing technology - historically a so-called "low-technology" industry. Thus many of the firms in the industry have pursued a "traditional

Table 31

Technological Liasons Between Sampled Capital Goods Manufacturers and Consultants, Governments and Customers, 1978

Extent of Liason	Consultants	Governments'	Customers
None	13	25	9
Some	13	5	8
Frequent	4	-	12

Source: Fieldwork, 1979.

technological strategy" in the sense of emphasis on the ideas of owner-entrepreneurs, local experience and industrial craft skills. At the same time those firms have been innovative in responding to the peculiar technological needs of the local environment. The sampled capital goods firms, however, have been unwilling and/or unable to transfer their technological expertize to other environments beyond a relatively low level. Indeed, it appears that greater levels of exports and interprovincial sales are strongly limited by a lack of investment in R & D, including the design capability to modify products for alternative environments and a failure to build up extra-provincial marketing networks. While the reasons for this situation cannot be stated with certainty it is clear that the spatial planning horizons (and ambitions) of capital goods firms in Vancouver remain essentially provincial in scope.

In contrast to B.C. based firms some capital equipment manufacturers based elsewhere have been more aggressive in expanding their corporate spheres of influence including into B.C. Indeed, over the past decade or so several important international firms have established production bases in B.C. - usually by acquisition of a local firm. As a result international firms have gained access to the B.C. market as well as to local managerial and technological know-how. As would be expected such externally controlled firms have not been motivated to build up large R & D facilities and to expand exports from B.C. The fact that these branch plants tend to have somewhat more professional employees than the local traditional firms reflects at least in part their affiliation to parent companies who are typically more committed to "professionalized" R & D so that to ensure proper integration of the corporate system all branches require a certain level of technological sophistication. One possible implication of these trends is that as the logging and wood processing industry become more automated the R & D input will necessarily become more professionalized and increasingly dependent on foreign technology. In other words, given present trends, the future will likely witness an even more circumscribed level of technological capability and one which is defined for the most part by externally controlled firms. Ironically, outside of the capital goods industry Vancouver based engineering consultants exhibit aggressive marketing and a high level of design capability and in so doing create access to world markets for forest product equipment.

The Consulting Engineers

Even in the "mature" industry such as forest products investment in new equipment and plant requires considerable design engineering skills in selecting and intergrating a wide array of components each of them being continually improved and involving varying degress of adaptation to local circumstances. Experience is clearly critical in this work and so it should not be surprising to note that Vancouver based firms have achieved a world-wide reputation for engineering resource developments particularly in the forest product sector. What is perhaps unexpected is the size and scope of consulting engineering in B.C.

With respect to all types of engineering B.C., with 10% of Canada's population, has 15% of its consulting engineering capability. Precise estimates of size and importance of the engineering industry are difficult to make because the industry is largely privately owned and statistics are not collected on a regular basis. However, in 1974 there were at least 280 consulting engineering firms in B.C. employing more than 6,000 people and which obtained total billings of $180 M. Of this amount $30 M represented export income and $40 M was derived from other provinces. While a detailed sectoral breakdown is not available it is likely that forest product

Table 32

Selected Characteristics of Sampled Engineering Consultants

Company[1]	Origins of Vancouver Office	Other Office Locations and Affiliated Companies[2]	Initial Export Business Year	Place	Scope
Beak Consultants, Acquired by Sandwell in 1968 (60/208)	1960 by Tom Beak, a chemist from U.K.	Montreal (1958), Toronto (1959) Calgary (1972), Portland (1979) Saskatoon, St. John's	-	-	Environmental some energy related work.
Environcon Ltd., 1/3 owned by Simons since ? (120/160)	1971 by three former Beak employees	Toronto, Montreal 1971/2 became part owner of Chemex Labs, Calgary, 1978	1974	U.S.	Environmental some fishery and energy related work.
Forestal Intl. Ltd., Acquired by Sandwell in 1974. (20)	1952 by H. Swantje	1970's acquired Agrisearch of Calgary (now closed)	1956	Pakistan	Forestry. Agro-forestry.
S.G. Gardiner Eng., Acquired by SNC of Montreal in 1980. (15)	1961/2 by S.G. Gardiner, then Chief engineer of Tahsis	-	1964	Peru	Wood Products.
Hallmark Eng. Ltd., sold to employees 1970-1980 (85)	1964 by Mr. Hall then part of management at MacMillan Bloedel	-	1965	Finland	Wood Products.
Reid, Collins & Ass., affiliated with Simons since 1978. (90)	1961, by 2 former Forestal employees	1971/2, acquired a tree seed extracting plant, Richmond (Now at Aldergrove) Also nursery at Aldergrove (1972/3) landscaping business, Edmonton (1978), Seattle (1980), Anchorage.		Ecuador	Forestry including seed production and mapping.

cont'd.

Company[1]	Origins of Vancouver Office	Other Office Locations and Affiliated Companies[2]	Initial Export Business Year	Place	Scope
Sandwell and Co. Ltd., public company since 1969. (250/1200)	1949 by P.R. Sandwell	See Text	1953	New Zealand	All aspects of forest sector plus extensive work in other areas.
H.A. Simons (International) Ltd., (1200/2200)	1944 by H.A. Simons who since 1912 had been associated with the B.C. forest sector	Decatur, G.A., Seattle, Montreal. Affiliated with Crippen Consultants, Reid Collins, (1978), Envirocon ( ) all of Vancouver, Simons Pacquer of Seattle, Hurterfiber Cons. of Montreal and H.A. Simons Ltd. of Santiago	1954 1962	U.S. Sweden	All aspects of forest sector plus extensive activities in other areas.
Norman Springate & Ass. (50/53)	1968 by N. Springate then V.P. of Cargate Industries, a plywood equipment mfger.	Portland	1969 1969	U.S. Columbia	Wood Products, Pulp and Paper.
Stothert Eng. Ltd. (200/250)	1966 by W.D. Stothert then a plant manager for Cocel, a forest product firm	Winnipeg, Montreal, Seattle, Calgary, Nelson and Lagos. In 1977 acquired C.D. Schultz and their offices in Vancouver, Edmonton, Quebec and Seattle.	1974	Nigeria	All aspects of forest sector and transportation facilities.

Source: Company brochures and interviews.

[1] Figures in brackets indicate employment size of Vancouver head-office/rest of company.

[2] Where available year office established is given in brackets.

related work accounted for at least 10% of the intra-provincial work and considerably more of the extra-provincial work (Consulting Engineers, 1977).

As would be expected most consulting engineering firms in B.C. are small and in 1974, for example, 56% had less than four employees. However 2% of consulting engineering firms in 1974 did have over 126 employees. Indeed, one of the unusual characteristics of the business in B.C. is the existance of a few very large firms, the two largest being H.A. Simons and Sandwell and Co. Both of these firms were set up to serve the forest industry and this industry remains their most significant sectoral market. In total there are probably about 50-75 consulting engineering firms engaged in forestry related work and of these approximately 15 are of significance at least in terms of number of employees. Ten of these firms were contacted and a senior member interviewed regarding the evolution, size and scope of their activities (see Table 32). Several generalizations are worth noting.

1. The emergence of consulting engineering in support of the forest product sector has largely been a post-war phenomenon. The sector's growth has been extremely rapid since 1950 and this has clearly been an important stimulus to the business. Engineering consultants provide various services including the process and mechanical design engineering services necessary to erect new plants or introduce new equipment. They do virtually no laboratory, especially pilot plant work. However, while the engineers typically do not regard their work as "R & D" much of their activities clearly fall within the "technological transfer" stage of R & D.

2. The consulting engineers of Vancouver are to a large extent organized around two "core" companies, H.A. Simons and Sandwell & Co. These firms are extremely large by world standards and in 1978 they employed over 1000 people each. Sandwell is also exceptional for a consulting firm in that it is a public company - with billings in 1977 which totalled

\$39 M (Financial Post Card Corporation Service). The principal competitors to these firms which are of a similar size are SNC of Montreal, Jacco Pourri, an organization heavily subsidized by the Finnish Government, and a few Swedish and Japanese capital goods manufacturers who also provide consulting engineering services.

3. The sampled consulting engineering firms, most notably Simon's and Sandwell's, have pursued strategies of vertical and horizontal integration. Sandwell, for example, began as an engineering consultant to the pulp and paper industry and subsequently expanded to obtain expertize in forest surveying (by acquiring a controlling interest in Forestal in 1974 and Alberni consult of London, UK), sawmill engineering (by acquiring a 20% interest in Carroll Hatch & Ass. in 1979) and in environmental impact analysis (by acquiring Beak in 1968). In addition, Sandwell has expanded horizontally or geographically through the establishment of business offices in other cities, notably Atlanta, Portland and London (U.K.), and by negotiating various joint venture arrangements with companies in other countries, especially in Europe. Some of Sandwell's affiliates, such as Beak, have multiple offices and in addition Sandwell controls companies whose activities often relate to forest product developments such as Agrisearch Investment Analysis of Calgary which is involved in agriculture and food activities. Similar strategies have been pursued by H.A. Simons and to a lesser degree by Stothert. These three firms are therefore able to provide <u>integrated</u> engineering services to the forest product sector.

4. Within the framework of Simons and Sandwell, subsidiary companies and affiliates still typically maintain their identity and enjoy considerable autonomy in seeking out and completing projects. Indeed it is appropriate to suggest that the organizational structure of consulting engineering in

Vancouver imparts the advantage of large organizational size without excessively restricting entrepreneurial initiative.

5. All the sampled firms have obtained business outside the province including the U.S. which is regarded by the firms themselves as part of the "domestic" market. The relative importance of 'export' income naturally varies by year and by company. Thus two of the sampled firms have hitherto restricted themselves primarily to North America. However, the activities of several others have been literally global in scope. H.A. Simon's, for example, between 1954 and 1978, has provided engineering to new manufacturing plants in over 30 different countries across six continents. The geographical scope of its 'feasibility studies' for wood based industries has been even more extensive. Furthermore it is not just the largest companies who are engaged in overseas work. Forestal, for example, has completed approximately 1000 projects in about 60 countries in six continents.

According to the firms large size and integrated services is particularly important as regards international marketing. Many third world countries in fact are requiring the consultants to make some financial commitment and to operate the projects they design at least for a while. Indeed, to reduce financial risks, Simons has set up a legally distinct corporate entity to administer international business.

6. Beak and Environcon were the only two sampled consultants to own laboratory facilities - in both cases to help in environmental impact analyses. In addition Reid Collins has its own nursey and has recently installed a computer mapping facility. All the firms have office space and 'design offices'. Essentially, however, the competitiveness of the consulting engineering firms rests on their experience in transferring

the technology of large industrial systems within the resource sector, especially forest products.

7. In contrast to Japanese and Scandinavian competitors, the sampled consultants are not affiliated with capital goods manufacturers. This difference in business organization is of some significance especially in the competition to supply technology to the Third World. Thus the sampled firms all argued consulting should remain independent from manufacturing in order to maintain the integrity of their evaluations and advice. On the other hand, they are faced with competitors willing to provide a complete technological package to clients in the Third World and in so doing are able to charge nominal consultants fees.

As noted business transactions and technological liasons between engineering consultants and local capital goods manufacturers do exist (see Table 31). The sampled consultant frequently cited examples of how their design work on export projects, to the extent that their terms of reference required specifications of equipment suppliers, had led to business for local manufacturers. Indeed several respondents indicated a preference for directing purchases of equipment to local sources. The ability of the consultants to generate such export business for local manufacturers, however, is limited at least by (a) the lack of local equipment manufacturers in the pulp and paper industry (b) constraints imposed by non-Canadian financial backers of overseas projects who apparently usually 'tie' financing to purchases of machinery from their own country and (c) the extent to which the clients themselves retain discretion to select equipment from alternatives suggested by the consultants.

It is therefore unlikely that the ties between capital goods manufacturers and consulting engineers are as strong as they might be. Whether or not closer ties should be encouraged is a matter for conjecture, however. It is possible that closer integration of consulting engineering and equipment manufacturers would generate economic benefits within the province and might alleviate the marketing and technological constraints facing the manufacturers in increasing their exports. However, there are also the questions pertaining to the political realities of 'tied aid' and of the business ethics - or at least preferences - to which the consultants subscribe. Nevertheless it is to such questions of technological linkage that a science policy for industry must ultimately address.

Technological Linkages in B.C.'s Forest Product Sector

At the present time the B.C. forest product sector exhibits both strengths and weaknesses in terms of its technological capability. Within the sector there are business and business sponsored enterprises which are involved in various aspects of R & D which are innovative and which do export technology. In the critical area of design engineering, Vancouver's consulting engineering community provides a combination of entrepreneurship, contacts, expertize and experience in the transfer of forest product technology which makes it a world leader.

The sector is technologically weak, however, because critical functions and linkages are missing or limited in scope. Among the forest product enterprises in the province, for example, there is only one important intramural R & D laboratory; there is only one specialized R & D firm serving the forest product sector; and among Vancouver based capital goods manufacturers only one of the sampled firms employed scientists at all and more than 5 engineers. In view of the relatively low level of R & D activity pursued by the firms themselves it is not surprising to find that Association R & D is relatively poorly supported also and that it remains vunerable to short term changes in industry attitudes. Furthermore the Federal Government's privatization policy of its aim long established forest product based R & D seems to have 'accomplished' only a reduction in Federal expenditures rather than an increase in R & D activity.

As for the nature of 'technological liaisons' among institutions within the forest product sector it needs to be emphasized that in this report they were investigated only in a rather superficial way. Consequently any generalizations must be speculative. With this caveat in mind the overriding observation offered is that while there are important transactions between forest product firms, R & D laboratories, equipment manufacturers and engineering consultants "the system" is by no means as integrated as it could be. There simply does not exist a concentration and clustering of R & D facilities taking advantage of, and contributing towards, a network of inter-establishment linkages pertaining to material inputs, labour and information etc. Yet such agglomerations of R & D activity are widespread elsewhere (see Malecki, 1978). In addition, it has already been pointed out that transactions between engineering consultants and capital goods suppliers remain at 'arms length' and as a result important spin-off benefits to B.C. are probably lost. Indeed in a general sense the capital goods manufacturers appeared locally technologically isolated and certainly not part of any discernible <u>systematic</u> set of R & D interrelationships among themselves or with other institutions. Similarly the strong <u>impression</u> gained from the interviews was that there was little ongoing interaction between private sector R & D and government and academic institutions in B.C. This was again especially true of the capital goods firms who perhaps naturally enough, generally 'blamed' the latter for being irrelevant to the needs of business. It is possible, however, that the failure of these manufacturers to take advantage of public sector research facilities in part results from their own failure to fully invest in R & D.

In providing an admittedly controversial explanation for the lack of technological capability throughout Canadian industry the Science Council has emphasized the role of foreign ownership. With respect to levels of technological capability in the forest product sector of British Columbia, especially as reflected in R & D laboratories operated by forest product manufacturing firms and by capital goods manufacturers, there is little doubt that foreign ownership exerts an important - and negative - influence. Indeed, all the parent companies which control subsidiary companies or branch plants in forest product manufacturing in B.C. and which operate R & D laboratories have centralized them entirely outside Vancouver and the province (Table 32). In the case of Rayonier this actually involved gradually running down a laboratory which in the early 1950's, when owned by Alaska Pine, employed 30-40 professionals. Certainly there are reasons to believe that in this sector R & D is under-invested in B.C. In Washington State, for example which has a smaller timber harvest than B.C. (1970 data) one firm employs more R & D employees than are found in all of B.C..

Furthermore, it is important to recognize that centralized R & D laboratories are an important mechanism by which parent companies integrate their global operations - subsidiaries are not 'free to choose' where they purchase their R & D. Witness, for example, the Chairman of Scott Paper (of Vancouver) statement:

"A new agreement is being completed with Scott Paper Company of Philadelphia, Pennsylvania, calling for both management and financial participation in research and development programs to be carried out by

Table 32

Research and Development Facilities of Foreign Owned Forest Product Companies Operating in British Columbia, 1977

Company	Location	Emphasis	Employment
Boise Cascade	Vancouver, WA	Pulp and Paper	22
	Chamblee, GA	Building Materials	18
	Boise, IDAHO	Wood & wast utilization	7
	InH. Falls, MI	Fibreboard, hardboard	12
Chamption InH.	Brewster, NY	Cellulose fibres	17
	Minneopolis, MI	Folding cartons	
	Hamilton, OH	Pulp	27
	St. Paul, MI	Containers	
Crown Zellerbach	Camas, WA	Pulp, paper & forest biology	169
	Kirkwood, MD	Fibreboard	22
	Antioch, CA	Paper	17
	SanLeandro, CA	Packaging materials	34
	West Lynn, OR	Publication papers	8
Evans Products	Corvallis, OR	Wood	49
International Paper	Tuxedo Park, NY	Pulp & Paper	267
	Mobile, AL	Pulp	96
	Georgetown, SC	Corrugated Containers	10
	Philadelphia, PA	Milk containers etc.	11
	Longview, WA	Plywood, panelboard	5
	Bainbridge, GA	Forest genetics	15
Mead	Chillicothe, OH	Pulp, paper, converted papers	110
ITT Rayonier	Whippany, NJ		
	Shelton, WA		
Scott Paper	Philadelphia, PA	Pulp & paper	387
	Holyoke, MD		50
	Westbrook, ME	Pulp & paper	159

cont'd.

Company	Location	Emphasis	Employment
Simpson Timber	Redmond, WA	Wood	22
	Vicksburg, MI	Printing papers	11
Weyerhaeuser	Tacoma, WA	Technical Support	216
	"	Administrative support	102
	"	Pulp & Paper	163
	"	Logging	62
	"	Wood	102
	Centralia, WA	Forestry	103
	Hot Springs, ARK	Forestry	69

Source: Jacques Cattell Press.

Scott in their U.S. facilities and elsewhere. The agreement is part of a long-term arrangement which joins together all of Scott's international affiliates in a way that will significantly increase financial, marketing and technical resources avaialble for development of new products and processes. It will take effect in 1979". (Scott Paper Limited, 1978, p. 1).

There are several economic implications which arise from such formal, and less formal, links between parent company R & D facilities and subsidiary operations. First, payments for R & D services constitute an income leakage. For B.C. between 1969-71, for example, this may have amounted to $100 M (Hayter, 1981, p. 111). Second, payments for R & D represent a direct loss of employment opportunities in managerial and scientific occupations. Third, there is a loss of spin-off benefits not only in terms of multiplier impacts but also in terms of reduced demand for complementary suppliers such as Econotech and possibly even for academic and public sector services. Finally, it is possible that priorities and goals set for parent company R & D as a whole may not overlap with local needs. To the extent that B.C.'s comparative advantage in forest products is becoming more dependent on improved utilization, conversion and marketing of existing timber supply region this latter concern is likely to become more significant.

Foreign ownership can certainly not be regarded as the only constraint on greater levels of R & D in B.C.'s forest product sector. After all Cocel once had the largest R & D facility in Vancouver (although it is worth noting Cocel was its parent's only forest product subsidiary). The truncating effects imposed by foreign ownership however, have clearly been reinforced by inward looking entrepreneurial attitudes especially among equipment manufacturers and inadequate government policy which has neither provided carrots (e.g. tax incentives) nor sticks (e.g. "No R & D no trees") of an appropriate nature. Industry, itself has often urged for greater government incentives for R & D. Yet, any government attempt to so stimulate R & D cannot practically ignore the fact that most of the large firms operating in B.C. already have access to the R & D supplied by their parents. Certainly general appeals to invest in R & D are unlikely to be successful - as the lack of enthusiasm to support Forintec would seem to testify. Indeed, if policies to promote R & D in the forest product sector are to be effective the total set of functions and inter-relationships among relevant actors including capital goods suppliers, consulting engineers, small specialized firms, government and academic departments as well as forest product manufacturing firms must be considered. In this respect future research might usefully focus more explicitly on the nature of technological liasons or knowledge transfers within B.C. and between B.C. and the rest of the world.

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