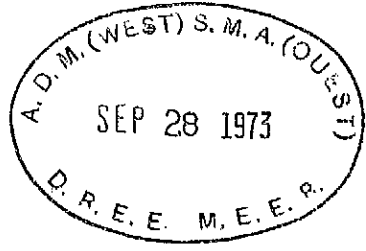
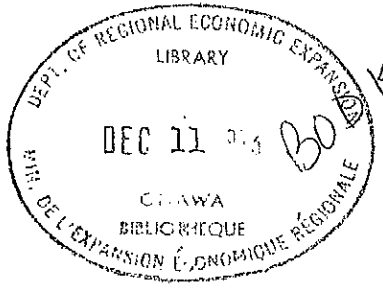


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RESEARCH AND DEVELOPMENT ACTIVITIES
IN SASKATCHEWAN



Department of Regional
Economic Expansion

September, 1973
Alvin Lampert

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I INTRODUCTION

This study examines scientific and technological research and development (R&D) activities in the province of Saskatchewan. Its objective is to ascertain the amount and character of such activities at the present time, and to assess the significance of the R&D industry within the provincial economy. This description and analysis is required to provide the basis for future DREE policies in relation to R&D in Saskatchewan.

The study is based upon discussions with officials involved in the process of technological innovation and in the formulation of science policy at both the federal and provincial levels, and upon various written sources. In Ottawa, conversations were held with representatives of the Science Council of Canada, the Ministry of State for Science and Technology, the Department of Industry, Trade and Commerce, the Department of Agriculture, the Department of Communications and the Department of Energy, Mines and Resources. In Saskatchewan discussions were held with representatives of the Saskatchewan Research Council and the University of Saskatchewan. Several meetings with Dr. T.P. Pepper, Director of SRC, and his leading management personnel were particularly helpful and rewarding. A wide range of written sources was consulted including, in particular, various reports and studies of the Science Council, reviews of national science policy, and the Humphreys report on university research and industrial development in Saskatchewan, obtained from the National Research Council.

The study is basically divided into two parts. Part One presents an outline of the current state of research and development activities in Saskatchewan. A general overview of the provincial R&D effort is followed by a detailed sectoral breakdown. This breakdown yields information on the location, extent and nature of the various R&D program activities presently being pursued in Saskatchewan.

This profile provides the necessary basis for Part Two of the study, which evaluates the potential for expanded research and development activities in Saskatchewan on the basis of the research function's contribution to the province's economic growth. A theoretical discussion of the impact of scientific and technological activities on economic development is followed by an examination of possible future R&D initiatives of direct relevance and benefit to the Saskatchewan economy. The study concludes with recommendations as to appropriate DREE policies in the area of research and development in Saskatchewan.

In this study, R&D is defined according to the usage of Statistics Canada.^{1/} Scientific R&D is investigative work carried out to a) acquire new knowledge; b) devise and develop new products or processes; and c) apply newly acquired knowledge in making technically significant improvements to existing products or processes. When necessary to test a new or improved product or process, the design, construction and evaluation of a pilot plant or prototype are included in scientific R&D.

^{1/}Statistics Canada: "Industrial R&D Expenditures in Canada", 1969, Cat. #13-203

P A R T O N E

II AN OVERVIEW OF R&D ACTIVITY IN SASKATCHEWAN

(i) Level of R&D Expenditures

Table 1 presents the most recent data available on the general level of the R&D effort in Canada on a regional basis. These figures refer to expenditures in the natural sciences and engineering and, thus, do not include research expenditures in the medical and health sciences, the social sciences, and the humanities. To permit a consistent approach and to allow for comparability of data, these latter fields have been excluded, so far as possible, from the statistical compilations used in this study.

Both the absolute and the relative figures in Table 1 indicate the low level of R&D activity in Saskatchewan, as compared with the rest of Canada. In 1971, expenditures on scientific and technological research and development activities in Saskatchewan amounted to approximately \$23 million, or less than three per cent of the national total. Saskatchewan expenditures on R&D were the lowest of any region in Canada in absolute terms.

Saskatchewan's performance is not significantly better when related to population size and to the proportion of its resources devoted to R&D (i.e. as a percentage of gross provincial product). In both of these relative terms, the province's expenditures on R&D are the second smallest in Canada. With regard to R&D expenditures per capita, Saskatchewan (at \$23.8) lags behind all other regions except the Maritimes (at \$19.5),

TABLE 1

INDICATORS OF PROVINCIAL R&D ACTIVITIES, 1971

	<u>R&D Expenditures</u>			<u>R&D Expenditures Per Capita</u>		<u>R&D Expenditures Related to GPP</u>	
	<u>\$000,000</u>	<u>% of Total</u>	<u>Rank</u>	<u>\$</u>	<u>Rank</u>	<u>% of GPP</u>	<u>Rank</u>
Atlantic Provinces	41.4	4.5	6	19.5	7	.67	5
Quebec	192.9	20.8	2	33.5 ¹	3	.88	3
Ontario	341.4	36.8	1	66.2 ¹	1	1.32	1
National Capital	179.3	19.4	3				
Manitoba	37.2	4.0	7	37.6	2	.92	2
Saskatchewan	22.6	2.4	8	23.8	6	.66	6
Alberta	54.1	5.8	5	32.1	4	.73	4
B.C.	57.2	6.2	4	25.9	5	.54	7
CANADA	926.8	100.0		42.7		.99	

¹Expenditures of the national capital region distributed 5 per cent Quebec; 95 per cent Ontario.

Source: Statistics Canada; Regional Research and Development Expenditures, 1971; April 1973

as well as the overall regional average (at \$42.7). With regard to R&D expenditures as a percentage of gross provincial product, a type of measure commonly utilized to gauge a region's research intensity, Saskatchewan (at .66 per cent) devotes less resources proportionately to R&D activities than all other regions except British Columbia (at .54 per cent). This latter relative measure suggests that the Saskatchewan R&D effort is a full fifty per cent below the overall regional average (at .99 per cent).

The data in Table 1, taken together, makes clear the generally poor performance of the province of Saskatchewan in the field of scientific and technological research and development activities. Saskatchewan contributes a relatively insignificant share to the national R&D effort. Saskatchewan's own R&D effort is, generally, the weakest of any region in Canada.

Of course, a wide variety of factors account for this comparatively poor performance, such as the lack of a strong industrial base in the province, the concentration of manufacturing industry in the central provinces of Ontario and Quebec, the consequent emphasis of federal programs supportive of research, development and innovation on Central Canada, and a host of environmental factors relating to problems of markets, entrepreneurship, venture capital, and technology transfer. However, the fact remains that Saskatchewan finds itself on the bottom rung of the ladder in Canada so far as regional R&D efforts are concerned. The province's position in regard to an

activity of important significance for economic development,^{1/} must be a cause for serious concern to those interested in fostering growth within the province and in reducing regional economic disparities. As a preliminary observation, it is evident that, although a large increase in Saskatchewan's share of the national R&D effort is neither likely nor necessary, steps should be taken by all parties concerned to stimulate innovative activities, and to augment the R&D effort within the province.

(ii) Structure of R&D Expenditures

A breakdown of the total R&D effort by sectors of the economy may be undertaken on the basis of source of funds or sector of performance. Table 2 presents the most recent data available on the general structure of R&D activities in Saskatchewan in terms of performance sectors, and compares this with the national sectoral breakdown.

The data illustrate two outstanding characteristics of research and development in Saskatchewan. Firstly, compared with national and international distributions, the university sector (\$10.2 million in expenditures) performs an usually high proportion of the R&D done in the province, amounting to almost one-half the overall effort, as opposed to only one-quarter at

^{1/}The importance of R&D activities to economic development will be more fully explored in section IV of this study.

TABLE 2

SASKATCHEWAN & CANADA--CURRENT INTRAMURAL EXPENDITURES ON R&D, 1971
BY SECTOR OF PERFORMANCE

<u>Sector of Performance</u>	S A S K A T C H E W A N		C A N A D A	
	<u>(\$000,000)</u> <u>Expenditures</u>	<u>% of</u> <u>Total</u>	<u>(\$000,000)</u> <u>Expenditures</u>	<u>% of</u> <u>Total</u>
Industry	1.2	5.3	371.0	40.3
Federal Government	8.4	37.2	282.7	31.4
Provincial Non-profit Industrial Research Institutes ¹	1.7	7.5	14.5	1.6
Provincial Government	1.1	4.9	16.7	1.8
Universities ²	10.2	45.1	236.0	25.6
TOTAL		100.0	920.4 ³	100.0

¹In Saskatchewan, the Saskatchewan Research Council (SRC)

²In Saskatchewan, the University of Saskatchewan

³Canada total includes any expenditures in the Yukon and the Northwest Territories.

the national level. Secondly, the private industry sector in Saskatchewan performs an almost negligible amount of R&D, lagging far behind all other sectors. The abysmally small research effort of provincial industry, in absolute terms, appears all the more meagre when compared with the important role of the private sector at the national level. At that level, private industry accounts for as much as forty per cent of total R&D expenditures, while Saskatchewan industry performs only one-twentieth of provincial R&D. Because of the poor performance of Saskatchewan industry in this area, the provincial government has necessarily stepped in to augment the provincial R&D effort through its own departments and through its research agency, the Saskatchewan Research Council. This accounts for the fact that the provincial government and the S.R.C. together perform a much higher proportion (12.4 per cent) of R&D than these sectors perform (3.4 per cent) at the national level.

The rather unusual distribution of R&D in Saskatchewan by sector of performance outlined in Table 2 possesses important implications for technological innovation and economic development within the province. The relative importance of the university sector reduces, to some extent, the potential impact of R&D upon the provincial economy, because much of the research carried out by universities is necessarily of a basic character, without strong direct linkages to the local economy and often unrelated to that economy's problems and prospects. However,

of even greater significance from the viewpoint of innovation and development, is the extreme weakness of the private industrial R&D sector. It is a commonly accepted tenet of science policy around the world that the closer the performer of R&D to actual economic conditions, to the real problems and potentialities of the business world, to nuts and bolts considerations of markets, capital financing, investment decisions and so on, the more likely and greater the influence of such R&D upon the local economy. The private sector is thus universally viewed as having a crucial role to play in translating R&D into profitable economic growth. Moreover, statistics indicate that the highest proportion of development work, that aspect of the process of technological innovation that takes the results of basic and applied research and translates them into new and useful products and processes, occurs in the private industrial sector. In the case of Saskatchewan, therefore, it is clear that a serious gap exists in the provincial R&D effort in the form of an almost total absence of private industrial R&D. If the current maldistribution of R&D in Saskatchewan is to be rectified, and if, thereby, the R&D function is to contribute fully to the province's economic growth, then the gap must be at least partially closed, even though its complete elimination is impossible because of the general weakness of the industrial base within the province.

A successful strategy to cut down the R&D gap must necessarily be two-pronged. Firstly, steps should be taken to ensure a maximum R&D effort within the private sector itself, these steps to cover such matters as patents, management assistance, mechanisms for technology transfer, and full utilization of government-sponsored research, development and innovation programs. Secondly, since the resources and capacities of the private sector in Saskatchewan are strictly limited in terms of R&D potential, steps should be taken to increase the industrially-oriented R&D activities of the province's principal research organizations--the University of Saskatchewan and the Saskatchewan Research Council. More effective utilization of these institutions, their capital and manpower resources and their know-how, in terms of economically relevant research activities, is urgently required. What is called for is a redirection of university research towards more work of an applied character, as has been suggested in the Humphrys' Report,^{1/} together with a general expansion of the activities of the S.R.C., characterized by less R&D of a basically "pre-industrial" nature and a fuller development of its technical services program for industry. Allied to this would be continued encouragement of the research programs of provincial government departments, agencies and crown corporations, such as the Saskatchewan Power Corporation.

^{1/}J.M. Humphrys, "University Research and Industrial Development in Saskatchewan", University of Saskatchewan, Regina, August 1972.

Table 3 presents the most recent data available (1968-69) on the general structure of R&D activities in Saskatchewan in terms of source of funds, and compares this with the national breakdown.

TABLE 3

DISTRIBUTION OF R&D EXPENDITURES BY SOURCE OF FUNDS, 1968-69

<u>Source of Funds</u>	<u>Saskatchewan</u>	<u>Canada</u>
	%	%
industry	3.4	31.0
federal government	78.5	53.4
provincial government	17.4	
universities	-	12.0
other	<u>0.7</u>	<u>3.6</u>
TOTAL	100.0	100.0

all gov't

Source: Humphrys' Report

The domination of the federal government in the area of funding R&D activities in Saskatchewan is starkly apparent from the table. The federal government alone is responsible for funding approximately four-fifths of all R&D performed in Saskatchewan. The Saskatchewan government provides less than one-fifth of the funds for R&D, approximately the same proportion as the amount of research its agencies and the S.R.C. perform. The private industry sector provides a paltry three per cent of R&D funding in the province, which again underlines that sector's insignificant role in the Saskatchewan R&D effort.

The pre-eminent role of the federal government in the financing of research and development work in Saskatchewan has important implications for the type of R&D activity carried on in the province. The supplier of funds for R&D work necessarily determines the general orientation of such work. In the case of Saskatchewan, the federal government devotes the bulk of its funds to its own intramural research, predominantly in the field of agriculture, and to grants to the University of Saskatchewan, where much basic research is performed. The provision of funding for industrial R&D necessarily suffers because of the federal government's domination in this area. By and large, the provision of money for industrial R&D is restricted to the Saskatchewan government, much of the money being used to support research at the S.R.C. The unusual position of Saskatchewan in regard to the funding of R&D is apparent from the skewness of the provincial distribution of R&D funding as compared with the more normal distribution at the national level. Because of its influence upon the type of R&D work carried out, this skewness represents another problem affecting the R&D sector within Saskatchewan.

The three tables presented above and the discussion based upon them depict a bleak picture for scientific and technological research and development in Saskatchewan. In regard to the three aspects of R&D outlined above, the position of Saskatchewan is unique and unenviable, all three aspects represent areas of serious concern. Saskatchewan is lagging

behind other regions of Canada in terms of its R&D effort, no matter by what measures this effort is examined. Given that "industrial R&D is a vital part of innovation and innovation is essential for economic growth",^{1/} then, if Saskatchewan does not want to fall further behind the other regions of Canada, it must augment and restructure its R&D effort.

(iii) R&D Manpower

Table 4 presents summary data on the number of qualified scientists and engineers (Q.S.E.) performing R&D in Saskatchewan in 1968-69. More complete information on the total employment generated by the R&D sector (i.e. including support personnel) is unavailable. The table yields similar conclusions to those suggested by the data on expenditures. The employment figures emphasize the pre-eminent role of the University of Saskatchewan in the provincial research effort; the University employs over one-half of R&D personnel in Saskatchewan. The figures also underline the poverty of the private R&D effort, which accounts for only about one per cent of R&D employment in the province.

Qualified manpower in the R&D sector in Saskatchewan make up approximately 0.12 per cent of the provincial labour force. On the national level, Q.S.E.'s account for 0.26 per cent of the labour force, so that, in regard to this variable, the Saskatchewan R&D effort lags far behind the national one.

^{1/} Humphrys' Report, p. 63

TABLE 4

NO. OF Q.S.E.* PERFORMING R&D IN SASKATCHEWAN, 1968-69

<u>Sector</u>	<u>No. of Q.S.E.</u>	<u>%</u>
Federal Government	166	28.8
Provincial Government	45	7.8
S.R.C.	38	6.6
University of Sask.	321	55.7
Industry	<u>7</u>	<u>1.2</u>
TOTAL	577	100.0

Source: Humphrys' Report, p. 58

* Qualified Scientists and Engineers

III THE CURRENT SITUATION

(i) Federal Research and Development in Saskatchewan

The federal government pursues an extensive program of intramural research and development in Saskatchewan, accounting for about two-fifths of all R&D performed in the province. However, in comparison with the total federal R&D effort across Canada, the program in Saskatchewan is relatively insignificant. Only three federal agencies--the Department of Agriculture, Environment Canada, and the National Research Council--have research laboratories established in Saskatchewan and are actively engaged in intramural research activities. Moreover, almost the entire federal research effort in the province is devoted to agriculture. Because of the overwhelming importance of the agricultural industry in the provincial economy, the federal government has, historically, located part of its agricultural research effort in Saskatchewan. Presently, one experimental farm and four research stations of the federal Department of Agriculture, as well as the Prairie Regional Laboratory of the NRC, are situated in the province. The only other federal research installations in Saskatchewan are relatively minor operations of Environment Canada. The federal government does not pursue any intramural R&D activities in the province in primary or manufacturing industries.

Tables 5 and 6 present a profile of federal R&D in Saskatchewan in terms of expenditures and manpower. The tables make clear the pre-eminent position of agriculture in the overall federal R&D program in Saskatchewan. Ninety per cent of federal expenditures and ninety-two per cent of federal manpower are devoted to agricultural research at the four research stations and one experimental farm of the Department of Agriculture and at NRC's Prairie Regional Laboratory.

Prairie Regional Laboratory (PRL)--located on the University of Saskatchewan campus at Saskatoon (1970-71 employment: 88, expenditures: \$1,710,000). The general objective of this facility is to study the influence of genetics, environment and physiological age on the growth and reproduction of micro-organisms, yeasts, algae, plant cells and higher plants, and the control of these variables to develop new products and to improve the quality and yield of present products.^{1/} Research work covers the fields of microbiology, the chemistry of natural products, plant biochemistry, enzymology and physiology. There is extensive collaboration on various projects between PRL scientists and those at the University of Saskatchewan and in the Canadian Department of Agriculture.

PRL is doing substantial work to promote the production of rapeseed in Canada as an alternative crop, and the utilization of rapeseed oil as a domestic product to replace imported vegetable oils used for shortenings, margarines, salad and cooking oils. This activity has been continuing since 1948, and

^{1/}National Research Council, "Activities of the Laboratories, 1971".

TABLE 5

FEDERAL GOVERNMENT R&D IN SASKATCHEWAN--EXPENDITURES, 1970-71

<u>Department or Agency</u>	<u>Expenditures</u> <u>(\$'000)</u>	<u>% of</u> <u>Total</u>
Canada Department of Agriculture:		
experimental farm: Indian Head	296	4.1
research station : Melfort	636	8.8
research station : Swift Current	1588	21.9
research station : Regina	557	7.7
research station : Saskatoon	1771	24.4
TOTAL CDA	4848	66.9
Environment Canada:		
Regina	313	4.3
Saskatoon	379	5.2
TOTAL ENVIRONMENT CANADA	692	9.5
National Research Council:		
Prairie Regional Laboratory: Saskatoon	1710	23.6
TOTAL FEDERAL R&D IN SASKATCHEWAN	7250	100.0
TOTAL FEDERAL R&D IN CANADA	288700	
% OF TOTAL FEDERAL R&D PERFORMED IN SASK.		2.5

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Source: Scientific Activities: Federal Government Costs and Expenditures, Ministry of Science and Technology, September 1972, pp. 18-20.

TABLE 6

FEDERAL GOVERNMENT R&D IN SASKATCHEWAN--PERSONNEL, 1970-71

<u>Department or Agency</u>	<u>Scientific & Professional</u>	<u>Executive & Administrative</u>	<u>Support</u>	<u>Total</u>	<u>% of Total</u>
Canada Department of Agriculture:					
experimental farm: Indian Head	5	-	26	31	6.5
research station : Melfort	9	-	33	42	8.9
research station : Swift Current	30	1	92	123	25.9
research station : Regina	12	-	20	32	6.8
research station : Saskatoon	46	1	75	122	25.7
TOTAL CDA	102	2	246	350	73.8
Environment Canada:					
Regina	4	-	6	10	2.1
Saskatoon	9	1	16	26	5.5
TOTAL ENVIRONMENT CANADA	13	1	22	36	7.6
National Research Council:					
Prairie Regional Laboratory: Saskatoon	31	2	55	88	18.6
TOTAL FEDERAL R&D PERSONNEL IN SASK.	146	5	323	474	100.0
TOTAL FEDERAL R&D PERSONNEL IN CANADA				24278	
% OF TOTAL FEDERAL R&D PERSONNEL IN SASK.					2.0

Source: Scientific Activities: Federal Government Costs and Expenditures, Ministry of Science and Technology, September 1972, pp. 18-20.

entails collaborative research with the Canadian Department of Agriculture, the Universities of Saskatchewan and Manitoba, and Canadian industries involved in oil extraction and processing. PRL's links with the agricultural industry are further maintained through consultation on processing problems and product analysis services.

PRL is currently involved in a research program on the production and utilization of field peas as a high protein crop for use as a feed supplement. Research into this area was initiated because the replacement of soybean by rapeseed created a problem in the supply of protein supplements for livestock production. At the same time, PRL is looking into the potential for the utilization of field peas in protein-rich foods for human consumption. Research programs are investigating new methods for measuring the protein content of peas in order to facilitate plant breeding programs to increase protein content, the separation of the starch and protein fractions of the peas, use of the protein for the creation of milk and meat substitutes, and use of the starch fraction in the brewing industry.

Related to the development of high protein crops is research into the nitrogen fixation properties of field peas. The possibility of transferring such a capability to cereal grains (self-fertilizing wheat!) is also being explored. There is considerable interest in increasing the nitrogen fixation capabilities of crops from the viewpoint of reducing fertilizer costs.

PRL is also involved in fermentation technology, of potential value to industry, sewage treatment research and river purification studies. A research program into the biosynthesis of antibiotics, toxins and pharmaceuticals could have industrial applications. Several modest PRL programs are devoted to the forest products industry, such as work related to the improved utilization of several varieties of conifers in Saskatchewan that are currently considered to have only marginal economic value for the pulping industry and studies on the use of wood fibre for fibreboard and hardboard.

Canadian Department of Agriculture (CDA)--operating four research stations, two experimental farms (one affiliated with the Saskatoon research station), and an animal pathology laboratory in Saskatchewan (1970-71 employment: 350, expenditures: \$4,848,000). All CDA facilities in Saskatchewan engage in inter-disciplinary, mission-oriented research. However, the activities of a research station may cover the whole gamut from basic research through development, with each focussing its attention on a limited number of specific roles.

The Melfort Research Station conducts a program of research into forage production and utilization but also studies crop and soil management, and animal nutrition.

The Regina Research Station is the main centre for research into weed control in Western Canada. It also is responsible, in co-operation with the Indian Head experimental farm, for the production and distribution of seed of new varieties of cereal, oilseed and forage crops.

The Saskatoon Research Station, the largest CDA facility in Saskatchewan, located in close proximity to PRL on the university campus, is engaged in an extensive research program into crop and animal production, in collaboration with the Scott experimental farm. Investigations are being pursued into the breeding of rapeseed, mustard, wheat, barley, alfalfa, sweet clover, brome grass, seed canarygrass, slender wheatgrass, and crested wheatgrass, the physiology of drought tolerance in cereals, the ecology and control of plant diseases and weeds, the histophysiology and nutrition of insects, the characterization and fertility of soils, and pesticide residues in soils and crops.

The Swift Current Research Station devotes the bulk of its effort to the peculiar problems of the production of cereal and forage crops in southwestern Saskatchewan. A small engineering group is engaged in designing and testing farm machinery equipment for uses at all CDA facilities in Saskatchewan.

From the viewpoint of an equitable distribution of federal R&D expenditures across Canada, the present federal R&D effort in Saskatchewan is grossly inadequate. As the following breakdown indicates, on the basis that Saskatchewan possesses four per cent of Canada's population, the province ought to be receiving approximately \$35 million in federal expenditures on scientific activities

Total expenditures on scientific activities by federal departments, 1972-73 (\$million)

Equitable Saskatchewan Share at 4 per cent

Environment	204.58	8.18
NRC	143.32	5.73
IT&C	100.42	4.02
DND	87.45	3.50
CDA	69.87	2.79
AECL	68.09	2.72
EMR	59.79	2.39
other	<u>147.02</u>	<u>5.88</u>
	880.54	35.21

In actual fact, however, as the breakdown below indicates, the federal government is spending only slightly more than \$7 million on scientific activities in Saskatchewan.

Actual expenditures by federal departments on activities in Saskatchewan, 1970-71 (\$million)

Environment	0.69
CDA	4.86
NRC	<u>1.70</u>
	7.25

Thus, in general terms, the federal scientific and technological effort in Saskatchewan is approximately \$28 million below the equitable level, or as much as four times the present effort. Federal government expenditures on scientific activities in Saskatchewan account for only .8 per cent of total federal expenditures in Canada, rather than the 4 per cent demanded by considerations of equity. Steps should be taken to rectify this situation. One response would involve the transfer of some federal labs from other parts of the country, particularly central Canada, to Saskatchewan. This matter deserves further

study. The Ministry of State for Science and Technology is currently examining a proposed policy of decentralizing federal research laboratories, breaking up the present concentration of such facilities in central Canada.

(ii) Provincial Research and Development in Saskatchewan

a) The Saskatchewan Research Council (SRC)

The Saskatchewan Research Council was established in 1947 by legislative act to perform "research and investigation into the fields of the physical sciences, pure and applied, as they affect the economy of the Province of Saskatchewan, and such particular matters as may be brought to its attention by the Lieutenant-Governor in Council." The duties of the Council include the following:^{1/}

- 1) to operate as a centre of knowledge concerning the technical aspects of provincial resources and industrial activities.
- 2) to provide the government with information to be used in formulating development and conservation policies.
- 3) to act, when required, in the capacity of a research and branch of provincial government departments and crown corporations.

^{1/} Andrew H. Wilson; "Research Councils in the Provinces: A Canadian Resource", Science Council of Canada Background Study #19, June 1971, p. 88

- 4) to participate with other agencies in the search for new natural resources.
- 5) to investigate methods for industrial utilization of natural resources.
- 6) to assist industry in technical matters.

The main research laboratory of the SRC is located on the university campus in Saskatoon. This makes for excellent interrelationships and a valuable flow of ideas between the SRC's research personnel and the faculty of the University of Saskatchewan. Although other installations, such as the important slurry pipeline laboratory are also located in Saskatoon, the SRC possesses facilities and performs its work throughout the province.

The SRC is organized into five main operating divisions: chemistry, engineering, geology, physics and industrial services.

Table 7 through table 10 present an outline of the research effort of SRC. The data in Table 7 relates to the sum total of SRC expenditures, the growth of SRC expenditures over the period 1968-1972, and the breakdown of these expenditures between laboratory divisions. In 1972, SRC expenditures amounted to \$1,840,047, representing a 41 per cent increase since 1968. This increase puts the SRC in the mid-rank of the rates of expenditure growth of research councils in other provinces. SRC expenditures are fairly evenly distributed between

TABLE 7

SASKATCHEWAN RESEARCH COUNCIL--EXPENDITURES, 1968-1972

<u>Year</u>	<u>Chemistry</u>	<u>%</u>	<u>Engineering</u>	<u>%</u>	<u>Geology</u>	<u>%</u>	<u>Industrial Services</u>	<u>%</u>	<u>Physics</u>	<u>%</u>	<u>Adminis- tration</u>	<u>%</u>	<u>Total</u>	<u>%</u>
1968	153149	11.7	414146	31.7	261857	20.1	94929	7.3	200313	15.3	181018	13.9	1305412	100.0
1969	174425	12.3	378685	26.7	318190	22.4	105683	7.4	191324	13.5	250402	17.6	1418709	100.0
1970	175957	12.1	334042	23.0	320833	22.0	122217	8.4	229348	15.8	273051	18.8	1455448	100.0
1971	178979	10.7	460635	27.4	442548	26.3	130058	7.7	207953	12.4	260198	15.5	1680371	100.0
1972	<u>226251</u>	<u>12.3</u>	<u>461784</u>	<u>25.1</u>	<u>458676</u>	<u>24.9</u>	<u>134828</u>	<u>7.3</u>	<u>272675</u>	<u>14.8</u>	<u>285833</u>	<u>15.5</u>	<u>1840047</u>	<u>100.0</u>
TOTAL	908761	11.8	2049292	26.6	1802104	23.4	587715	7.6	1101613	14.3	1250502	16.2	7699987	100.0
% Change 1968-72		47.7		11.5		75.2		42.0		36.1		57.9		41.0

Source: Annual Reports.

laboratory divisions, with engineering accounting for the highest proportion, approximately one-quarter. However, the industrial services division accounts for both the lowest amount and proportion of SRC spending. Over the period 1968-1972, the geology division was responsible for the largest increase in lab expenditures (75.2 per cent), while the spending of the engineering relatively stagnated, increasing only 11.5 per cent.

The main source of income for the SRC is a provincial government grant as is characteristic of provincial research councils across Canada. In 1971, the government of Saskatchewan provided the SRC with a grant of \$1,085,000, accounting for almost three-fifths of the Council's budget. The size of the provincial grant has been steadily increasing over time. The federal government provided the SRC with about a quarter of its funds in the form of grants and contract. Most of the remainder of the Council's budget was covered by private industry through contracts. Industrial contract support of the SRC has increased modestly in recent years. Table 8 also demonstrates that grants represent the main method of support, with contracts from government and industry accounting for less than 40 per cent of Council income.

Table 9 indicates that the SRC employs 86 personnel, of whom 32 are highly qualified scientists and engineers. This staff complement has remained relatively stable over the last few years. The general competence of the scientific staff

TABLE 8

SASKATCHEWAN RESEARCH COUNCIL--SOURCE OF FUNDS, 1971
(\$'000)

<u>Source</u>	<u>Subsidy</u>	<u>Grant</u>	<u>Contract</u>	<u>Royalty</u>	<u>Other</u>	<u>Total</u>	<u>% of Total</u>
This institution							
Federal Government		62	434			496	26.3
Provincial Government		1085				1085	57.5
Canadian Industry			292			292	15.5
Other Canadian					15	15	0.8
Foreign Industry							
Other Foreign							
TOTAL		1147	726		15	1888	100.0
% OF TOTAL		60.8	38.5		0.8		100.0

Source: Statistics Canada: Provincial Non-Profit Industrial Research Institutes; 1971 Survey.

TABLE 9

SASKATCHEWAN RESEARCH COUNCIL--PERSONNEL, 1971

<u>Type of Personnel</u>	<u>Bachelor</u>	<u>Master</u>	<u>Doctor</u>	<u>Total</u>
Scientists and Engineers	10	10	12	32
Technologists and Technicians				38
Workers (maintenance, shops)				5
Administrative and Clerical Staff				10
Management				<u>1</u>
TOTAL				86

Source: Statistics Canada: Provincial Non-Profit Industrial
Research Institutes; 1971 Survey

extends to biology, chemistry, geology, physics and agricultural, chemical, civil, electrical, industrial and mechanical engineering. The Council possesses particularly strong expertise in a number of specific areas of direct relevance to the economic and social problems of Saskatchewan^{1/} including:

- chemistry of effluent treatment and purification
- environmental monitoring
- water problems (e.g. snow and ice, surface water, water quality)
- chemical engineering in resource industries
- coal
- industrial minerals (exploration, processing, inventoring, uses, etc.)
- chemical engineering in manufacturing industries
- industrial engineering (company planning, plant and process selection and development, production engineering, etc.)
- slurry pipeline investigations
- pilot plant design and operation
- radioactive tracer techniques

Over one-third of the scientific staff have had managerial or technical experience in industry.

^{1/}T.P. Pepper: "Technical Competence of Saskatchewan Research Council Staff", April 1973

Table 10 suggests the nature of the research activity currently being pursued at the Saskatchewan Research Council. In terms of expenditures, approximately half the effort is devoted to studying the problems and potential of Saskatchewan's natural resources. Of the remaining research activity approximately ten per cent applies to each of four other fields (in order of spending): primary industries, utilities (the major portion of which involves transportation research in the area of pipelining), secondary industries and environment. This distribution of expenditure between fields of application suggests that a significant portion of the SRC's work is concerned with indirect or "pre-industrial" research, providing the basic data required before industrial activity can begin at all.

The following is a more detailed summary of current R&D programs at the Saskatchewan Research Council, by laboratory division:^{1/}

1. Chemistry Division--field of interest: the development of processes for secondary industry in Saskatchewan; the formulation of chemical procedures related to natural resources that can be made the basis for industry, concentrating on two resources which Saskatchewan possesses

^{1/}Humphrys' Report p. 65; Andrew Wilson "Research Councils in the Provinces", p. 90; The Saskatchewan Research Council, Annual Reports, 1965-1972.

TABLE 10

SASKATCHEWAN RESEARCH COUNCIL--
EXPENDITURES BY FIELD OF APPLICATION, 1971

	<u>1971</u>	<u>1972</u> (forecast)
	--%--	--%--
Natural Resources ¹	59	49
Primary Industries ²	9	13
Secondary Industries ³	6	9
Construction Industry	-	-
Service Industries ⁴	-	-
Utilities ⁵	13	10
Environment ⁶	4	8
Developing Countries	-	-
Other	9	11
	<u>100</u>	<u>100</u>

¹ Exploration, conservation, mensuration of resources.

² Production, harvesting, concentration.

³ Products, processes of manufacturing industries (including food and beverages, tobacco, rubber, textiles, clothing, wood products, furniture, paper, primary metals, metal fabricating, machinery, transportation equipment, electrical products, non-metallic mineral products, petroleum and coal products, chemical products, scientific instruments).

⁴ Finance, trade, tourism.

⁵ Transport, communication, power.

⁶ Pollution abatement, wastes recovery and disposal.

Source: Statistics Canada: Provincial Non-Profit Industrial Research Institutes; 1971 Survey.

in abundance: the salts (sodium chloride, potassium chloride and sodium sulphate), and the organic materials (petroleum, natural gas, lignite, animal products, vegetable oils and forest products).

--current research activities: .

- development of processes for the utilization of potash
- investigation of caking problems in the potash industry
- assessment of the quality of the province's lignite resources
- potential non-energy uses of lignite and of products associated with lignite e.g. leonardite (A portion of this project was funded by a contract from the Mines Branch, Department of Energy, Mines and Resources to determine the size of leonardite resources in Saskatchewan)
- the assessment of high-protein crops which are adaptable to the province's semi-arid regions, e.g. kochia, quinoa
- assistance to native people in the formulation of time and labour reducing methods for the Indian leather (i.e. the design of an appropriate tanning technology)
- water studies utilizing tritium measurement techniques

- partial or major utilization of bark by simple chemical treatments
- carbon-14 dating
- analyses of contaminants in water and in waste effluents

2. Engineering Division--field of interest: the solution of problems of Saskatchewan industries, the development of new technology for utilizing the natural resources of the province, the provision of technically qualified personnel to advise all economic sectors in Saskatchewan. This work includes technical and economic feasibility studies and pilot plant investigations.

--current research activities:

- technical studies related to new uses, and methods of more efficient recovery, of Saskatchewan raw materials
- basic engineering research to provide data for the development or improvement of specific parts of a process or equipment
- specialized technical assistance to industry on request
- ceramic materials studies. The SRC performs a high volume of contract research on behalf of manufacturers of brick, tile, sewer pipe and cement
- studies on the development of products suitable as cat litter and garage floor cleaners

- investigation of the drying properties of Saskatchewan clays
- the utilization of lignite flyash for the purification of industrial and domestic sewage
- study of the hydrological balance of Big Quill Lake as part of the Canadian program for the International Hydrological Decade
- Idylwyld underpass storm drainage study
- small drainage basin studies
- desalination of water by natural freezing, oriented toward the development of appropriate small-scale processes
- studies of the water balance of sloughs and potholes
- study of mass transfer fundamentals of solution mining to aid in the development of techniques applicable to Saskatchewan potash
- investigation of the rock mechanics in potash mining to determine design parameters for safe mines
- research into the pipeline transportation of solid materials, such as iron concentrates, metallurgical coal, sulphur, thermal coal, limestone and potash in slurry form. This major program of studies into the performance of various slurries flowing in large diameter pipes

is funded by the Transportation Development Agency (TDA). The SRC is mandated to develop accurate engineering design data from large-scale slurry pipeline facilities and to continue basic studies in the interests of the advancement of solids, pipelining in general. The original TDA program, begun in 1970, terminates in September 1973, after a total cost of \$495,000. Because the pipeline research facility and team at the SRC "have the most versatile capability of any institution in the world that is dedicated to large-scale slurry pipeline research"^{1/}, active consideration is being given to further programs in this field. TDA is currently considering maintaining the research program with a contract totalling \$240,000, while EMR is negotiating with the SRC on an \$85,000 contract for research specifically into coal-oil pipelining.

3. Geology Division--field of interest: surveying of Pleistocene geology in Saskatchewan in relation to the search for groundwater; investigation of preCambrian geology in northern Saskatchewan in relation to the search for metal ores.

^{1/}Canadian Transport Commission, Systems Analysis Branch,
"Future Research on Slurry Pipelining at the SRC", December 1972

--current research activities:

-groundwater geology and hydrology studies.

These studies are a continuing joint federal-provincial project under the Agricultural and Rural Development Act (ARDA). ARDA support of this research program terminates in March 1974, after eleven years at a funding level of approximately \$200,000 per year

-groundwater information services

-study of the stratigraphy of the Qu'Appelle Valley, funded by the National Research Council

-study of the urban geology of Saskatoon

-evaluation of Saskatchewan's coal resources.

Begun in 1972, this three-year federal-provincial program involves joint participation by the SRC, the Saskatchewan Department of Mineral Resources and the Geological Survey of Canada.

-pre-Cambrian geology and geochemistry, including research into special aspects of base metal ore deposits

4. Physics Division--field of interest: atmospheric physics, particularly precipitation mechanisms; the application of geophysics to groundwater investigations.

--current research activities:

- studies of precipitation development
- investigation of pesticide drift. This project is partly funded by CDA and involves some co-operative work with the CDA research station at Regina. Further research into the problem of aircraft spray drift is being undertaken on a \$9,000 grant from NRC
- research in groundwater geophysics under the ARDA groundwater program, in co-operation with other divisions of SRC
- lignite and leonardite logging study involving co-operation between the Saskatchewan Department of Mineral Resources, MER and SRC's Physics, Geology and Chemistry divisions

5. Industrial Services--field of interest: increasing the technical, industrial and entrepreneurial capabilities of industry in Saskatchewan by communicating scientific and technological information to industry, fostering the use of such information, providing technical assistance, and promoting the use of industrial engineering and management science by industry.

--current research activities:

- the Technical Information Service. The work of the Industrial Inquiries section of TIS involves responding to specific requests from firms for information and advice on technical matters, visits to plants, and monthly publication and distribution of "Catalyst", a general information sheet on the process of technological innovation. The Industrial Engineering section makes the services of SRC engineers available to industry. They provide assistance in overcoming production problems and in designing improved methods of production, with the objective of significant cost reductions. The section also publishes "Industrial Business Management"
- the Technical Assistance Program. This program aids industry in applying the information and advice it receives. Assistance is also given industry in taking advantage of the research, development and innovation programs of the federal government. In 1972, the SRC support was instrumental in the establishment of the North Eastern Alfalfa Dhydrators Research Association.

Attempts have been made to assess the contribution that the research activities of the SRC make to the economy of Saskatchewan. The Science Council concluded that "the Councils in Alberta and Saskatchewan can be rated as well established and effective".^{1/} In an assessment of the value of the work of the SRC over the period 1947-1968, Dr. T.E. Warren, former SRC Director, concluded that "the contribution of the Council to the cumulative gain in net value of commodity production from 1947 to 1968 is not less than one-tenth of one per cent of the total".^{2/} Given that this cumulative gain totalled about eight billion dollars, the contribution of the research effort of the SRC to the growth of the Saskatchewan economy over that period amounted to at least eight million dollars. Furthermore, as Dr. Warren points out, "This is not a complete measure of the value of the Council's work. The future benefit of the work that has been done up to the present should be included. This may be about an order of magnitude greater than the past benefit because of the accumulation of results from extended studies, the growth of the Council's effort and the normal delay between discovery and application".

It is clear that the Saskatchewan Research Council has had some impact on economic growth in Saskatchewan. Because of the weakness of the industrial sector, the SRC remains

^{1/}Andrew Wilson, "Research Councils in the Provinces", p. 62

^{2/}T.E. Warren, "Value of the Work of the Saskatchewan Research Council, August 1969, p. 15

"the principal local resource active in industrial R&D".^{1/}
The Council thus occupies a key position in the Saskatchewan economy from the viewpoint of fostering technological innovation essential to economic growth. The question is how best to maximize the impact of the SRC's work on the local economy.

The SRC possesses all those advantages of provincial research councils which make them particularly responsive to the needs and potentials of regional economies. The Council consciously attempts to maintain an industrial orientation. It has available to it a broad range of scientific and technical expertise, intimately familiar with the unique problems and opportunities of the Saskatchewan economy. A high proportion of the Council's industrial and regional orientation--the type of research work it performs--is applied research, although some basic research is carried out. The Council generally operates much closer to the actual application of technology to industry than other organizations, such as the University of Saskatchewan. The SRC thus possesses important strengths, which make it a tool of considerable value to the economy.

However, it appears that the full potential of this tool, in relation to its impact on the provincial economy, has yet to be realized. The Science Council has pointed out^{2/} that much of the research work done by the SRC is of a "pre-industrial" character, i.e. involving the provision of background information

^{1/}Humphrys' Report, p. 63

^{2/}Andrew Wilson, "Research Councils in the Provinces", p. 36

essential before the initiation of any industrial activity of all. This orientation is understandable and obviously required given the undeveloped or underdeveloped state of many of Saskatchewan's resources. If the SRC is to play a role commensurate with its mandate and its expertise in the presently envisaged economic expansion in Saskatchewan, it is clear that the thrust of the Council's effort should be more squarely directed to research work directly related to current industrial activities and future economic opportunities in the province. As an example, research related to the development of Saskatchewan's rich resources of industrial minerals, such as lignite coal and clays, is called for. The SRC, in co-operation with private industry, is ideally situated to perform such research.

Although several such large-scale research programs could be of significant benefit to the Saskatchewan economy, the SRC could make its greatest contribution via an expansion of its industrial services operations. At present, the Council supports a relatively modest program of direct technical assistance to private industry in Saskatchewan in the form of information and industrial engineering services. It is clear that the Council recognizes the value of this small portion of its effort. I.S. Evans, head of the Council's Industrial Services Division, affirms that "the innovative process depends almost equally on technology, capital and entrepreneurship. Since new technology is the product of scientific research, it is the Division's duty to increase

the amount of new technology available to industry".^{1/} Andrew Wilson of the Science Council has commented^{2/} that the SRC has an extremely important role to play as a source of information for Saskatchewan industries in relation to upgrading their technical competence. It is precisely more of this type of service or trouble-shooting R&D that is required in Saskatchewan due to the province's peculiar industrial structure. Much of the industrial sector in Saskatchewan is composed of small industries which are not interested in expansion, but have been established and built up by local entrepreneurs to a size with which they are satisfied. These firms do not need and do not want major R&D programs. However, they are afflicted with diverse technical problems which can be taken to the SRC for solution. In order to provide more of this assistance to private industry, the SRC should considerably expand and upgrade this particular function, with its immediate involvement in actual industrial problems and direct economic payoffs. Such an expansion of industrial services activity represents the optimal route to a general expansion and improvement in the technology base of the Saskatchewan economy.

^{1/}Saskatchewan Research Council, 26th Annual Report, 1972, p. 27

^{2/}Private conversation, June 28, 1973

b) Government Departments and Agencies

Several agencies and departments of the Saskatchewan government pursue intramural research programs of their own, although the overall provincial government R&D effort is a limited one. In 1971, total expenditures by government departments and agencies on R&D amounted to about \$1.1 million; R&D programs gave employment to sixty-six qualified scientists and engineers.

The Department of Natural Resources maintains research activities in two areas. The Fisheries Branch operates the Saskatchewan Fisheries Laboratory, which is located at the SRC facilities in Saskatoon. Its professional staff includes six scientists; the Lab engages in basic and applied research in the fields of fish ecology, limnology, pollution assessment and fish culture in lakes.

The Wildlife Branch operates the Wildlife Research Division, which is located in Saskatoon. Its professional staff includes seven scientists; the Division engages in basic and applied research in the fields related to wildlife, mainly on big game and game birds, largely of an ecological nature.

The Department of Mineral Resources maintains a large and active program of research in the earth sciences through the Geological Sciences Branch. The Branch possesses a professional R&D staff of thirty-two scientists; it engages in applied research and development related to the economic geology of Saskatchewan as applied to petroleum and natural gas, metallic minerals and industrial minerals.

Saskatchewan Minerals, a crown corporation, located in Chaplin, engages in applied research and development for its own internal uses. With a professional staff of only one scientist, the corporation's research program covers new production methods, product improvement and improved methods of obtaining raw materials.

Saskatchewan Power, a crown corporation, possesses a particularly active, forward-looking and economically relevant research program. The corporation's R&D centre, located in Regina, with a professional staff of twenty scientists, is presently doing practical research work, much of which having wide application to the energy problems of northern Saskatchewan. In this regard, Saskatchewan Power is currently looking for funding for a research project on small hydro development in northern Saskatchewan, to be located at Stanley Mission. The objective of this project is to investigate the possible use of small hydro-electric units in the north as reliable, simple and low-cost sources of energy suited to the needs of small communities, in lieu of diesel generators or other sources of electricity. The project involves the planning, design, construction, installation, operation, instrumentation and evaluation of a small (150-225 KW) hydro plant at Stanley Mission on Rapid River for experimental purposes in order to consider further developments in northern Saskatchewan. The project is closely related to northern development in Saskatchewan. Begun on a limited basis in 1973-74, the project is planned to run until 1976 at a total cost of \$345,000.

(iii) The University of Saskatchewan^{1/}

In terms of expenditures and employment, the university sector in Saskatchewan is the largest single performer of research work in the province. In 1971, total expenditures on R&D at the Saskatoon and Regina campuses of the University of Saskatchewan amounted to over \$10 million, or over 45 per cent of all R&D expenditures in the province; in 1968-69, the number of qualified scientists and engineers on the university faculty performing R&D totalled 321, or almost 56 per cent of all such qualified manpower in the province. It is clear that the University of Saskatchewan plays a very significant role in the overall provincial R&D effort.

Tables 11 and 12 present summary data on sources of funds and areas of research at the University of Saskatchewan. It is clear, firstly, that the bulk of the university's research is performed on the Saskatoon campus. With regard to the funding of university research, federal government departments and agencies provide as much as four-fifths of total financial support. Federal funding of university research has levelled off in recent years, after having experienced a ten-fold increase during the decade of the sixties. Provincial government sources of support provide funding at a relatively modest level; over three-quarters of such support goes towards

^{1/}This section has relied heavily on the Humphrys' Report and on the Annual Reports of the University.

TABLE 11

AMOUNT AND SOURCE OF FUNDS BY AREAS OF RESEARCH, UNIVERSITY OF SASKATCHEWAN, 1971-72
SASKATOON CAMPUS

<u>Area of Research</u>	<u>Federal Government</u>	<u>Provincial Government</u>	<u>Industry</u>	<u>Prof. Assocs. & Trusts</u>	<u>Others</u>	<u>Total</u>
Agriculture	949510	333765	41000	124375	8000	1456290
Natural Sciences:						
Biology	117350	-	-	10280	-	127630
Chemistry & Chemical Engineering	148095	13000	5300	500	-	166895
Geological Sciences	206365	17180	9300	37300	3000	273145
Mathematics	50460	-	4000	-	-	54460
Physics	733110	-	-	-	-	733110
TOTAL Natural Sciences	1255380	30180	18600	48080	3000	1355240
Humanities	6245	-	-	-	-	6245
Social Sciences	127365	-	-	-	4170	131535
Education	39570	13200	-	6875	-	59645
Commerce	-	-	2000	1000	-	3000
Engineering	873035	34920	25650	-	3535	937140
Home Economics	5000	4000	-	-	-	9000
Medical Health Sciences	1430485	4000	85780	300735	32765	1853765
Principals' Fund	86000	-	-	-	-	86000
TOTALS: Saskatoon	4772590	420065	173030	481065	51470	5898220

Source: University of Saskatchewan, Annual Report, 1971-72.

TABLE 12

AMOUNT AND SOURCE OF FUNDS BY AREAS OF RESEARCH,
UNIVERSITY OF SASKATCHEWAN, 1971-72
REGINA CAMPUS

<u>Area of Research</u>	<u>Federal Government</u>	<u>Provincial Government</u>	<u>Industry</u>	<u>Prof. Assoc. & Trusts</u>	<u>Others</u>	<u>Total</u>
Natural Sciences, Mathematics and Engineering	346051	21365	6000	35000	-	408426
Social Sciences, Humanities & Education	30459	-	-	-	-	30459
Principal's Fund	25000	-	-	-	-	25000
Totals: Regina	401510	21365	6000	35000	-	463385
GRAND TOTAL	5174100	441430	179030	516065	51470	6361605
Percentage	81.3%	6.9%	2.8%	8.1%	0.8%	100.0%

Source: University of Saskatchewan, Annual Report, 1971-72

agricultural research, in line with the province's original mandate to the University to carry out agricultural R&D and extension services related to Saskatchewan's economic requirements. In gauging the weakness of private industry's R&D effort in Saskatchewan, it is noteworthy that this sector provides less funds to the University for research than do professional associations and trusts. The ties linking the University of Saskatchewan to private industry in the province thus remain tenuous, with baleful consequences for the extent to which the University performs research of direct relevance to the Saskatchewan economy.

Tables 11 and 12 indicate the most important areas of research at the University of Saskatchewan in terms of overall funding. In 1971-72 expenditures in the medical and health sciences accounted for the highest proportion of research spending (31.4 per cent). The next most important areas of research were agriculture (24.7 per cent) and natural sciences (23.0 per cent), followed by engineering (15.9 per cent). These four areas alone accounted for 95.0 per cent of all research expenditures at the University. It is in just these areas that the University of Saskatchewan is considered to possess nationally-renowned centres of excellence. As J.W.T. Spinks, President of the University of Saskatchewan, noted in his brief to the Senate Committee on Science Policy,^{1/} the University

^{1/} p. 6178

has developed areas of excellence in agricultural research, including soils research, research in the natural sciences, particularly nuclear research and upper atmosphere research, and certain aspects of medical research.

Most of the research at the University of Saskatchewan is performed by research institutes or research groups. J.M. Humphrys' has compiled a complete summary of the work presently being done by these institutes and groups: the following is a slightly abridged version of his tabulation.^{1/}

Saskatoon Campus

1. Saskatchewan Institute of Pedology (no. of research staff: 29 professionals)--soil surveying, soil testing lab, evaluation of sensing of soil and vegetal characteristics by remote optical photography.
2. Crop Development Centre (14 professionals, 15 technicians)-- development of new crops, plant breeding, seed lab. The centre was established in 1971, with initial financing for three years of one million dollars from the National Research Council and the Saskatchewan Department of Agriculture. Current research projects include the production of new wheat varieties, new varieties of feed barley, high protein field peas and special crops adapted to Saskatchewan. Certain aspects of the Centre's work are clearly related to research being performed at PRL and at the SRC.

^{1/} Research in the humanities, social sciences and medical and health sciences is not included.

3. Dairy and Food Science (6 professionals)--recovery of whey solids, conversion of waste carbohydrate to protein.
4. Animal Science (4-8 professionals)--quality of feed grains, assessment of the economic significance and nutrient content of ration formulas for broilers, swine and dairy cattle, development of erucic acid, free variety of rapeseed, utilization of high-protein rapeseed residue for livestock feed and as supplement to human food, interdisciplinary studies of field peas and sunflower seeds with regard to more efficient methods of extracting the proteins, their utilization and nutritive value and the use of the carbohydrate portions of the seeds.
5. Soil Science--studies of contaminants in Saskatchewan agricultural soils and in lake and river bottom sediments, the nutrient and water requirements of economic plants in Saskatchewan, data bank on soil fertility.
6. Biology (19 professionals)--investigation of the saline lakes of Saskatchewan and their biological productivity, inventory of the vascular flora and vegetation of northern Saskatchewan, embryo transplantation in cattle of similar and different breeds, population changes, breeding rates, growth rates, food habits, etc. of prairie birds, investigation of seed dormancy and germination, partly related to finding a better means of controlling wild oats, growth regulation in plants.

7. International Biological Program (Matador Project)--(50-80 professionals)--study of potential productivity of semi-arid grassland. The Program is presently in its concluding phases and should be completed by January, 1974.
8. Chemistry and Chemical Engineering (26 professionals)-- investigation of processes for reducing sodium sulfate to sodium sulfide, pollution studies, conversion of the waste bark from pulp mills into useful products, the utilization of aspen for animal feed, collaborative research with the SRC on slurry pipelining.
9. Geological Sciences (15 professionals)--Precambrian rocks in northern Saskatchewan, Devonian sediments of plains region, Cretaceous and Tertiary rocks of southern Saskatchewan, exploration geophysics.
10. Linear Accelerator Laboratory (10 professionals, 12 technicians)--electron scattering, electron disintegration.
11. Plasma Physics (5-6 professionals)--basic research on plasma heating, radiation and wave phenomena, effect of test probes on plasmas.
12. Institute of Space and Atmospheric Studies (9 professionals)--auroral and ionospheric phenomena, observation of atmosphere at altitudes of 20-60 miles using balloons and rockets.
13. Hydrology Division--watershed studies (precipitation and runoff), infiltration to frozen soils, plastic canal liners, reclamation of saline soils.

14. Civil Engineering (18 professionals)--sanitary engineering (waste ponds, industrial waste treatment, assimilative capacity of northern rivers, ice cover), study of traffic accidents in the Saskatoon district, investigation of foundation conditions in Saskatoon, transportation (planning and design of systems, structural capability under variable terrain conditions).
15. Electrical Engineering (19 professionals)--high technology biomedical engineering, studies on power system reliability, development of a system for telephone transmission of electrocardiograms and other physiological recordings, development of a photodensitometric system for quantitative determination of substances separated by chromatography and electrophoresis, work on remote equipment with meteorological uses, automatic map making.
16. Mechanical Engineering (22 professionals)--applied and theoretical mechanics (elastomer tool design, power line vibration, automation and control engineering, project, sponsored by Atomic Energy of Canada, on a fluidically controlled system for shutting down a nuclear reactor and detections of fuel failures (two patents have been applied for), development of a temperature-controlled unit for housing unattended instruments in remote northern areas, studies on fatigue induced failures of steel and the detection of incipient failures in various types of machines, collaborative R&D on systems required for automation of agricultural machinery.

17. Agricultural Engineering (13 professionals)--hydrology, farm structures, including optimum designs for the safe storage of grains, cold weather heat exchangers for livestock buildings and the use of treated lumber posts as economical and stable foundations for farm buildings, control devices for farm equipment. The Control Engineering Division in 1972 received a five-year, \$540,000 development grant from the NRC to improve the operation of farm equipment by applying automatic sensing and control to a machine's operation. Planned projects include automatic control of combine feed rate to provide maximum capacity with minimum grain loss, automatic depth control of tillage and seeding equipment, livestock feedlot automation, automatic guidance of farm tractors for field work.
18. Institute of Northern Studies (20 part-time investigators)--service and support for studies of Northern Saskatchewan and the Canadian North, arctic training centre at Rankin Inlet three-year study on contract with the Canadian Wildlife Service of the economic and social benefits of Canada's migratory birds.
19. Geography--Canada Land Inventory (Physical capability of land for outdoor recreation) land use in Saskatchewan's agricultural areas.
20. Horticultural Science--hardy fruits, irrigation and fertilization of vegetables, potato breeding, study of moisture stress.

21. Pharmacy--isolation and identification of alkaloids occurring in some Saskatchewan plants to determine their possibilities for medicinal use, investigation of the possibilities of Saskatchewan grown plants, such as peppermint, spearmint and dill as economic sources for volatile oils used by the pharmaceutical industry, studies of film coatings on compressed tablets, diffusion of drugs through skin.

Regina Campus

1. Canadian Plains Area Centre--resource centre for interdisciplinary research in humanities, fine arts, social and natural sciences pertaining to Canadian Plains Area.
2. Water Quality Research (2-3 professionals, 10-15 technicians)--- studies on the biological and chemical characteristics of waters in the Qu'Appelle Basin, the algae in Saskatchewan lakes, microbial degradation of crude oil in water and soil, the harvesting of algae from lakes, the detection and determination through neutron activation methods of the concentrations of trace elements in lakes and rivers, operation of analytical lab and two microbiological labs, analysis of water samples. Consideration is being given to the establishment of a water studies institute.
3. Biology Department (15 professionals)--the ecology and behaviour of Saskatchewan animals and birds, the bioenergetics of the grassland ecosystem, studies on the physiology and morphology of various Saskatchewan plants, investigation of the interaction between herbicides and soil microorganisms.

4. Chemistry Department (11 professionals)--studies on the degradation and properties of herbicides, high temperature batteries, selenium metabolism in plants, high temperature co-ordination chemistry of transition metals, preparation of pure inorganic salts, oxidation of organic compounds, basicity of organic compounds, synthesis, structure and conformation of diphenyl compounds, bio-synthesis, inter-molecular forces in solids and solutions, NMR spectroscopy, nuclear chemistry.
5. Gravity Waves Project (6 professionals)--detection of possible existence of gravitational radiation from space. Purchase of special equipment funded by a special NRC grant.
6. Physics Department--experimental and theoretical studies of the structure of various chemical compounds, nuclear physics research.
7. Geology Department (4 professionals)--development of techniques for the determination of small quantities of uranium, the possible prediction of the shape and structure of permeable rock bodies which affect groundwater and petroleum movement, the occurrence of selenium and tellurium in rocks and soils of southern Saskatchewan, gravity survey of the Regina area to map bedrock structure.
8. Faculty of Engineering--studies on corrosion and erosion in slurry pipelines, corrosion in high temperature pressure systems, a systems analysis of plant location economics of manufacture and distribution of a wheat

product, building science, geo-technical and foundation engineering, plastic panels for building construction, transportation in the North, acoustics, operations research.

It is clear, from this compendium of current research activities, that the University of Saskatchewan, in keeping with its history and traditions, continues to perform a great deal of research of direct interest to the province. The solution of regional economic and ecological problems remains an integral element of the University's overall research effort. In the past, this orientation has produced important economic benefits for Saskatchewan and has contributed, via industrial spinoffs, to the fostering of new local industries. However, it is also clear that the University's potential for performing economically beneficial research has not yet been fully tapped. The University itself has indicated that it wishes closer ties with industry, that it would like to perform more industrially related research, and that it is particularly interested in doing more development work.^{1/} Whatever the future direction of research at the University of Saskatchewan, it possesses important strengths and expertise in a number of areas, all of which should be taken advantage of in the formulation and performance of possible new R&D initiatives in Saskatchewan. Eventually, the research effort of the University of Saskatchewan must be co-ordinated with the

^{1/}Private conversation with Dr. B.W. Currie, Vice-President (Research), University of Saskatchewan, July 12, 1973

activities of other research agencies in the province so that the overall provincial R&D effort might form a logical, coherent whole, so that duplication of research might be avoided, and so that the maximum economic benefits of R&D might be realized.

(iv) The Private Industry R&D Effort in Saskatchewan

Table 13 presents summary data on the research activities of private industry in Saskatchewan. The data make clear the sad state of industrial R&D in the province. In 1971, Saskatchewan possessed only seven private industrial R&D establishments (there are now eight, following the establishment of the North Eastern Alfalfa Dehydrators Research Association in October 1972); a total of fourteen firms were engaged in R&D work. Intramural R&D is restricted in a limited number of industry groups, particularly mines and machinery and transportation equipment. Total R&D expenditures on R&D by private industry amounted to slightly over \$1 million i.e. one-tenth of research expenditures of the University of Saskatchewan. The private R&D effort in Saskatchewan gave F.T.E. employment to only thirty qualified scientists and engineers. Clearly, industrial R&D in Saskatchewan is insubstantial compared with the other research sectors, is insignificant in relation to the overall national private R&D effort, and is unimportant as an income--and employment--creating economic activity within the context of the Saskatchewan economy as a whole. As has been indicated, this situation seriously hinders the process of technological innovation which is an essential aspect and determinant of economic growth.

TABLE 13

INDUSTRIAL R&D IN SASKATCHEWAN, 1971

<u>Industry Group</u>	<u>R&D Establishments</u> ¹		<u>Current Intramural R&D Expenditures (\$000)</u>		<u>Scientists & Engineers (Full-time Equivalents)</u>	
	<u>Sask.</u>	<u>Canada</u>	<u>Sask.</u>	<u>Canada</u>	<u>Sask.</u>	<u>Canada</u>
Mines and Wells	2	32	143	17386	5	268
Chemical Based	1	271	x	79743	x	2021
Wood Based	-	55	-	19887	-	436
Metals	-	70	x	35467	x	788
Machinery and Transportation Equipment	2	109	334	66243	4	1105
Electrical	-	142	-	120418	-	2428
Other Manufacturing	1	48	x	8267	x	178
Other Industries	<u>1</u>	<u>44</u>	<u>331</u>	<u>23533</u>	<u>10</u>	<u>487</u>
TOTAL	7	771	1161	370944	30	7711

¹R&D establishments refers to units where R&D is organized as such. Expenditures and personnel figures include both R&D done inside and outside R&D establishment. Of the 7 R&D establishments in Saskatchewan, one was founded in 1971, one in 1970, two were founded in 1969, one between 1966 and 1968, one between 1960 and 1965 and one between 1950 and 1959. Seven companies were doing R&D but had no R&D establishment.

x--confidential

- zero

Source: Statistics Canada, Science Statistics Section, unpublished table.

The following summary presents information on private industrial R&D facilities in Saskatchewan.

1. North Eastern Alfalfa Dehydrators Research Association-- established in October 1972 with the assistance of the Saskatchewan Research Council. The Association operates a laboratory in Tisdale and is engaged in research.
2. Crawford's Foods Ltd.--research lab in Wynyard opened in 1971. The lab engages in research related to poultry production, poultry processing and better utilization of byproducts.
3. Newfield Seeds Ltd. (Nipawin)--has a research program related to pea and bean starch and protein.
4. Kalium Chemicals Ltd. (Regina)--operates a research laboratory which has a staff of four scientists (3 chemists, 1 physicist) and one chemical engineer. The lab is engaged in applied research and development work related to potash in the fields of chemistry, chemical engineering, physics, geology and metallurgy.
5. Ormiston Mining and Smelting Co. Ltd. (Moose Jaw)-- has a development program in the mining field involving one mechanical engineer.
6. Fabco Machinery Ltd. (Saskatoon)--engaged in the development of machinery and equipment for use in potash mines.

7. Industrial Machine (Regina)--engaged in the development of a tunnelling machine.
8. SED Systems Ltd. (Saskatoon)--evolved from the University of Saskatchewan's Space Engineering Division. The division was established in 1965 and in 1972 was incorporated as a wholly-owned subsidiary of the University. SED is a particularly dynamic-organization with an established international reputation for excellence in the field of high-technology electronics and communications. It is very market-oriented and since demand in the provincial market for its products and services is strictly limited, it relies on Canadian (particularly federal government) and international sales.

SED designs and manufactures a wide range of advanced electronic instrumentation and monitoring systems. It has been actively involved in the Canadian Satellite Program, particularly the ERTS and CTS satellites. SED designed, constructed and now operates the ERTS ground station at Prince Albert, and now offers for sale a design for a low cost ERTS station to countries interested in utilizing ERTS satellites. SED is currently producing a telemetry and command station for Telesat Canada for installation in Allan Park, Ontario to be used with the Anik II communications satellite. Among its leading product lines are sounding rocket payloads, specialized instruments for the unattended monitoring and recording of natural features (e.g. snow

depth in remote locations), the High Line Data Acquisition (HILDA) System for measuring performance of high voltage power transmission lines, a digital voice modulation system, aerospace systems and automatic telephone dialing equipment.

SED has an active R&D program, which has been responsible for the development of the products noted above. Its R&D staff includes a recently formed research group of one scientist and one technologist who work full-time on research, and three to five personnel working solely on development. Some current projects include R&D on the measurement of wind velocities and temperature by unattended instruments in remote areas (funded by the Saskatchewan Department of the Environment), rocket released spin probes (funded by a research grant from NRC), and R.F. radiometry (funded by a contract from the Department of Transport). All R&D activities are oriented towards coming up with a marketable product.

SED is interested in expanding its R&D program, believing more work could be done of economic value to Saskatchewan and Canada.^{1/} It presently has a proposal before NRC for IRAP assistance for a research program on agricultural instrumentation. SED has generally not taken advantage of the

^{1/}Private conversation with Mr. Dennis Johnson, Vice-President SED Systems, July 20, 1973.

innovation assistance programs of the federal government such as PAIT, but has relied for funds for R&D on its own resources and on grants from various agencies.

SED Systems Ltd. is a centre of expertise in the field of high-technology electronics and communications in Western Canada. Its R&D activities in this regard could profitably be expanded, to the benefit of Saskatchewan and Canada. The corporation's aims include continuing heavy involvement in satellite and other space technologies, the establishment of a commercial electronics production facility and the further development of advanced technology in Saskatchewan.

Due to the paucity of information, this summary of industrial R&D activities in Saskatchewan must necessarily remain incomplete.

The federal government supports R&D in industry through a number of research development and innovation assistance programs. The rationale underlying these programs is that, if Canada is to maximize the economic benefits to be derived from technological innovation, research work must be more directly related to actual business opportunities and more R&D should in fact be done by private industry itself. The major federal incentive schemes for industrial R&D and their administrative agencies are:

- | | | |
|----|--|---|
| 1. | Industrial Research and
Development Incentives Act (IRDIA) | Department of
Industry, Trade and
Commerce (IT&C) |
| 2. | Program for the Advancement of
Industrial Technology (PAIT) | IT&C |
| 3. | Industrial Research Assistance
Program (IRAP) | National Research
Council |

The manner of assistance for R&D activities differs between the programmes. IRDIA involves tax credits, while PAIT and IRAP involve grants.

In general, Saskatchewan industry has been either unwilling or unable to take advantage of these assistance programs. On a regional basis, the distribution of the application of these programs across Canada has followed the pattern of distribution of value-added manufacturing activity. Table 14 indicates this pattern for the case of the PAIT program. It is clear that use of the program depends on the regional industrial base. With Saskatchewan, in 1970, accounting for only 1.0 per cent of value-added manufacturing activity in Canada (a percentage only greater than that of Newfoundland and P.E.I.), it is not surprising that the R&D incentive schemes of the federal government have had little applicability to Saskatchewan industry. Table 15, giving data on the provincial distribution of funding by all federal government innovation related assistance programs for the most recent single period available, further details and confirms the neglect of Saskatchewan by these schemes. In the period under review, Saskatchewan did not receive a single grant under PAIT, the federal government's leading R&D incentive scheme,

TABLE 14,

REGIONAL DISTRIBUTION OF PAIT FUNDS

	<u>Maritimes</u>	<u>Quebec</u>	<u>Ontario</u>	<u>Prairies</u>	<u>B.C.</u>
PAIT Funds (to Feb./73 \$000)	662.9	34,106.5	76,780.5	5,428.5	18,180.6
% PAIT Funds	0.49	25.23	56.8	4.01	13.45
Manufacturing Activity--1969 Value Added (\$000,000)	700	5,673	10,636	1,376	1,745
% Value Added	3.47	28.18	52.83	6.83	8.67

Source: Department of Industry, Trade and Commerce, Office of Science and Technology, "Possible Initiatives for Consideration at W.E.O.C." May, 1973.

TABLE 15

PROVINCIAL DISTRIBUTION OF INCENTIVES GRANTS
(\$000)

<u>Program</u>	<u>Period</u>	<u>Alberta</u>	<u>British Columbia</u>	<u>Manitoba</u>	<u>New Brunswick</u>	<u>Nova Scotia</u>	<u>Newfoundland</u>	<u>Ontario</u>	<u>P.E.I.</u>	<u>Quebec</u>	<u>Saskatchewan</u>
IRAP	1971/72	301	851	95	-	162	24	5223	21	2990	28
PEP	1970/71 to 1971/72	-	116	114	12	-	-	336	-	263	-
DIP	1971/72	-	123	530	1297	-	-	24550	-	22146	-
PAIT	1971/72	700	4100	700	100	200	-	22000	-	9000	-
IRDIA	1970/71	585	1216	98	133	85	-	13147	-	14848	44
IDAP	1971/72	-	65	71	-	48	-	588	-	256	-
DIR	1971/72	158	7	113	-	30	-	2596	-	1578	-

IRAP--Industrial Research Assistant Program (NRC)
 PEP--Program to Enhance Productivity (IT&C)
 DIP--Defence Industrial Productivity Program (IT&C)
 PAIT--Program for the Advancement of Industrial Technology (IT&C)
 IRDIA--Industrial Research and Development Incentives Act (IT&C)
 IDAP--Industrial Design Assistance Program (IT&C)
 DIR--Defence Industrial Research Program (Defence Research Board)

Source: Report, Interdepartmental Committee on Innovation, January 1, 1971--May 31, 1972.

which accounts for almost one-third of all expenditures under such programs.

Since the inception of the IRAP program, three applications for assistance have been received from Saskatchewan and all three have been approved. Nineteen seventy-two support involved a grant of \$28,900 to Crawford Foods Ltd. in Wynyard and a grant of \$40,900 to the North Eastern Alfalfa Dehydrators Research Association in Tisdale.

Since the inception of the PAIT program, five applications from Saskatchewan have been approved. To date, program expenditures in the province have amounted to \$250,000, or .27 per cent of total expenditures. The following firms have received PAIT support:

Interprovincial Steel and Pipe Co.	Regina
Western Roto-Thresh	Saskatoon
Fabco Machinery Ltd.	Saskatoon
Crawford Foods Ltd.	Wynyard
Newfield Seeds	Nipawin

Detailed data on IRDIA support in Saskatchewan is unavailable.

In keeping with federal policy or promoting more industrially-oriented R&D, other instruments have been devised in recent years and administered by the Department of Industry, Trade and Commerce. Programs have been instituted involving the establishment of Industrial Research Institutes (IRI), Centres

for Advanced Technology (CAT) and Industrial Research Associations (IRA). At present, there are no such institutions, with their emphatic industrial R&D orientation and dependence upon private support, located in Saskatchewan. Western representation in these programs is limited, but now covers the other three provinces. B.C. possesses a Centre for Advanced Technology, the Centre for Ocean Engineering in Vancouver operated under the auspices of B.C. Research. An Industrial Research Institute affiliated with the University of Manitoba is currently being set up. Similarly, a sulphur development institute, a collaborative effort between private industry, IT&C and the government of Alberta, is being established with a high level of industrial financing (25 per cent). Although IT&C insists that Western Canada will eventually be adequately represented under these programs, and that special efforts should be made to develop centres of excellence of particular interest to the West, there are no definite plans at present to have any of these schemes operative in Saskatchewan. There is currently one proposal before the department from Saskatchewan concerning the establishment of a CAT--an industrial minerals centre of technology--under the auspices of the Saskatchewan Research Council. The proposal is currently under negotiation.^{1/}

^{1/} The negotiation involves Dr. T.P. Pepper, Director of the SRC and Dr. Ed Sanderson, Director, Science Advisors Branch, IT&C.

It is apparent that federal government research, development and innovation assistance programs have, up to the present, time experienced almost total failure in Saskatchewan. Clearly, this lack of success is due to the fact that these programs are manifestly not suited to the industrial structure characteristic of the Saskatchewan economy. This structure militates against the performance of intramural R&D in the private sector and of extramural R&D supported by the private sector.

The Saskatchewan economy is characterized by a small number of small firms, which are often dependent for their growth upon the technical and entrepreneurial skills of a single individual, which growth is therefore strictly limited. Generally, such firms are either unaware of the possibilities of utilizing science and technology for profitable, commercial ends, or uninterested in the possibilities or unable to financially support the technology which might benefit their businesses. Thus, they are not "very systematic or even very competent in their use of technology", nor do they "appreciate the role of R&D in their businesses."^{1/} It is not surprising that, of the province's 750 manufacturing companies, it has been estimated that only 1 per cent perform research or support it extramurally and only 2 per cent have sufficient technical competence to ask for and use technical information relevant

^{1/}Humphrys' Report, p. 67

to their businesses. It is precisely the level of technical competence of manufacturing companies in Saskatchewan that must be raised, through improved and expanded technical assistance programs, if the R&D function is to increasingly benefit the Saskatchewan economy in the future. And this must necessarily be linked to an improvement in the general economic environment in which Saskatchewan firms operate.

PART TWO

IV R&D AND REGIONAL ECONOMIC DEVELOPMENT

It is generally believed that the R&D function is significantly productive in terms of economic development only insofar as it is an integral and essential element in the process of technological innovation. Technological innovation is a complex, variegated process, composed of a number of steps, the absence of any one of which defeats the entire process. The steps involved and the average range of costs (as a per cent of total costs) of each may be summarized as follows:^{1/}

1. the idea or innovation
2. research (R) 5-10%
3. development (D)
4. estimation of the potential market
5. design 10-20%
6. tooling-up or construction of plant 40-60%
7. manufacturing start-up 5-15%
8. marketing start-up 10-25%
9. reaping the profits

Thus, R&D, the science and technology end of the innovation spectrum, represents only one element in the entire process, and, from the viewpoint of expenditures, not necessarily the most significant. Only when joined with the

^{1/}A Vanterpool "The Potential for Science-Based Industry in the Halifax-Dartmouth Area", Department of Regional Economic Expansion, January 1971, Appendix 5, p. 64

other elements of the innovative process does science and technology lead to economic development. Clearly, it is not simply the case that more or less money spent on R&D is necessarily going to result in more or less innovation.^{1/} In allocating funds for R&D, it is essential that the R&D be related to regional economic opportunities and comparative advantages, so that the other steps in the process of technological innovation might take place and that concrete economic benefits might be realized. In sum, as Humphrys points out,^{2/} the relationship between R&D and economic development may be stated most simply as follows: "industrial R&D is a vital part of innovation and innovation is essential for economic growth".

As an integral element in the process of technological innovation; R&D may contribute to industrial growth via several avenues. It may lead to improved productivity performance by a firm or an industry through new and more efficient methods of production. It may expand or create markets through the introduction of new products. It may foster the creation of new businesses or even entirely new industries through the generation of industrial spinoffs and entrepreneurial talent. In this regard questions of entrepreneurship, venture capital and so on

^{1/}Vanterpool, p. 65

^{2/}Humphrys' Report, p. 63

have yet to be fully studied. The need for them, if R&D is to have an economic payoff, is clearly apparent; their absence militates against the potential growth effects of a region's R&D effort. In sum, research and development may act as a catalyst of regional industrial growth through improvements to the competitive position and economic viability of indigenous primary and secondary industries.

In addition to such indirect and diffuse effects, R&D may directly contribute to economic development through its own expenditure and employment patterns. As an industry like any other, R&D institutions located in a particular region create income and employment through their own activities and through their effects on the regional economy. R&D institutions may contribute to regional economic development in the following ways:^{1/}

- 1) the creation of effective demand--direct employment of laboratory personnel and the purchases that are made locally by the R&D installation and their employees.
- 2) the effects of the R&D installation on the ability of a region to attract or generate new industry--an environmental asset that, like good water or transportation, enlarges the potential of a region for further development.

^{1/}National Academy of Sciences--"The Impact of Science and Technology on Regional Economic Development", Washington, D.C. 1969, p. 25.

- 3) giving rise to new enterprises--as a result of the R&D performed by the installation.

This direct impact of scientific and technological activities upon the regional economy is most pronounced at the local level. If there exists a concentration of R&D facilities in a particular city, then R&D may play an important role as a generator of economic activity and as a support of the urban economy. Within Saskatchewan, the city of Saskatoon presents an example of such concentration of R&D facilities. Within the city are located:

- the University of Saskatchewan
- CDA research station
- NRC Prairie Regional Lab
- Saskatchewan Research Council
- Wildlife Research Division
- Research facilities of Fabco Machinery Ltd.
- SED Systems Ltd.

Many of these facilities are located on the university campus, so that the potential exists for valuable cross-fertilization of ideas and for collaborative research work. All these R&D installations have over the years dependably pumped money into the economy of Saskatoon and have provided employment opportunities for the educated and skilled elements of the Saskatchewan population. With a wide range and number of R&D facilities already in place, with an attractive physical, social and cultural environment, with a central location, Saskatoon has the potential to develop further as a major research centre in Western Canada. This potential has recently been recognized with the announcement of the establishment there of an oilseeds' research centre.

V FUTURE INITIATIVES IN R&D IN SASKATCHEWAN

From the overview of the Saskatchewan R&D effort, it is apparent that R&D activities in the province should be expanded if equity in the regional distribution of R&D in Canada is to be realized, and if the potential economic payoffs of such activities might be plumbed. From the above theoretical discussion of R&D and regional economic development, it is also apparent that a region's R&D effort must be related to the regional economic environment if that effort is to have growth effects. It remains pointless to establish R&D in a region which will have no economic payoff, or will not be picked up by indigenous industry.

In the case of Saskatchewan, these considerations suggest that future R&D initiatives should be related to the province's current economic development strategy and general growth prospects. This, in turn, suggests that the general approach to expansion of R&D activities in the province should necessarily be two-sided. The approach should comprise:

- 1) fitting an R&D program into the general DREE-Saskatchewan development program--i.e. integrating R&D activities into the steel, wood products and agribusiness sectors.
- 2) investigating and pursuing new initiatives in R&D for which Saskatchewan has unique advantages and which might give important economic payoffs.

Possible future R&D activities in these areas, as well as the status of several proposed or upcoming R&D projects in Saskatchewan, are discussed below.

DRPE has identified, and is presently working on, several major development opportunities in the province. These involve expansion and rationalization of the steel, wood products and agriculture-oriented industries. Each of these sectors is faced with technological problems or technological opportunities which could form the basis of R&D programs.

In the case of the major development opportunities in steel and forestry, most of the requisite technologies can be bought from outside the province either from the United States or from central Canada. However, given an expansion of these industries in Saskatchewan, some R&D into the peculiar local circumstances and problems facing them in the province is clearly required. Such research would be major within the region; but minor within Canada as a whole.

Steel

With respect to steel, possible regionally-oriented R&D programs include:

--determination of a process for the reduction of iron oxide most appropriate to a Saskatchewan steel facility (Present processes range from the conventional blast furnace to low shaft furnaces to kiln reduction).

- determination of the appropriate reductant--either lignite or natural gas, as well as the location of the reduction plant.
- investigation of upgrading of lignite for utilization as a reductant.
- alternative cheap formula for, and cheap sources of, molybdenum.

Wood Products

With respect to wood products, possible regionally-oriented R&D programs include:

- utilization of the province's aspen resources.
- study of pulped, steam-treated aspen for use as livestock fodder.
- utilization of twigs and buds with a higher protein content for livestock fodder, giving 100 per cent utilization of all materials taken from the forest.
- improvements in, and new uses for, fibreboard, particle boards, blockboards and wood wool boards, particularly in the field of building construction.
- bark composting or mixing with peat, the products of which may be pelletized to supply food and growth stimulants.

--investigation of alternative modes of transportation for the gathering, hauling and shipping of forest products over difficult terrain in northern Saskatchewan.

Agriculture

In the case of agriculture-oriented activities, Saskatchewan is the ideal place for expanded R&D efforts, given the over-riding importance of the agricultural industry in the provincial economy and the considerable expertise and numerous facilities already available there. There are a large number of areas which require research and investigation if Saskatchewan agriculture is to expand and to diversify. Some research needs are related to agricultural inputs, such as farm machinery and livestock fodder, others are related to agricultural outputs, such as new and improved crops and products, while others are related to increasing the value-added activity of the agricultural sector. With regard to agriculture-oriented activities, possible future R&D programs, which might have direct economic payoffs and which appear scientifically and technologically sound, include:

1. oilseeds--expanded investigation of concentrated seed protein and starch, including processing methods and extraction technologies, and new crops and products.

A major initiative in this direction is the impending establishment in Saskatoon on the university campus of

an oilseed and grain product development facility; announced by the federal government in July, 1973. The facility, a collaborative effort of the federal Department of Industry, Trade and Commerce, the Saskatchewan Department of Agriculture and the Rapeseed Association of Canada, will comprise a pilot plant which will be available to industry for development work on a contract basis besides carrying out general development projects on Canadian raw materials. The work of this installation will be of a development rather than research character and will be oriented towards the development of techniques for converting such crops as rapeseed into food and feed protein ingredients of sufficiently high quality to compete with soybean and other products which must now be imported. It will also be concerned with the development of products from new or undeveloped crops such as sunflower and faba beans. The federal government will cover 90 per cent of the estimated capital cost (\$3-4 million) of the facility, and will cover first year operating costs of \$1 million with this support decreasing by \$200,000 annually. At the end of five years, consideration will be given to an annual grant of \$200,000. However, it is hoped that the facility will be self-supporting from industrial contract work within the five-year period.

2. farm machinery--development of specialized short line farm equipment. This work would be oriented towards the development of farm machinery specifically suited to the needs of Western Canada and the northern prairie states. It would involve the investigation of appropriate technologies in the agricultural implements field--i.e. capital-saving technologies appropriate to the available labour pool, visiting industrial structure and potential markets.

3. livestock--feed sources--study of the effect of different ensilaging methods of alfalfa protein and saponin and relationship to bloat.

--study of new products for dehydrated alfalfa producers: mechanical and chemical methods for separating leaves and leaf protein and colouring pigments (carotene and xanthophyll).
--examination of other high yielding leaf protein sources as raw material for the dehydrated alfalfa producers.

These research initiatives stem from the planned major expansion of livestock production in the province, with the consequent need for more pasture, forage crops and feed grains.

--hide processing--investigation of different hide processing and leather production methods suited to Saskatchewan conditions. At present, no hide processing industry exists in the province. The establishment of such an industry could conceivably result from such research.

--improving the feeding performance of livestock--
comparison of deer and cattle rumen digestion, and
attempt to improve cattle rumen digestion.

--feasibility study of deer as a new domestic animal.

Improvements in livestock feeding performance might result
in increased productivity in the livestock industry, as
well as cheaper costs. Deer as a domestic animal might
especially benefit the economically depressed areas of
the northern part of the province.

4. new and improved crops--study of fish protein from
freshwater fish, including the determination of the
extent of provincial resources of suitable non-game fish,
possible sustained yields and appropriate methods of
collecting and processing such fish into protein.

--study of brine shrimp eggs collection and processing.

This research might foster an increase in the Saskatchewan
production of brine shrimp eggs (a high-priced source of
fish feed) which is presently much below the maximum
possible sustainable yield.

--investigation of dual purpose crops--i.e. crops
providing food plus fibre or food plus biomass.

Examples of such research include the pelletizing of straw and other agricultural residues and examination of such materials as new fuel sources for power generating systems; inventoring and research on fibre (paper and pulp) possibilities of various agricultural residues.

5. farm structures--study of more efficient hog barns of improved design.

--investigation of feasibility of methane generation from hog manure to heat hog barns, dispose of wastes and provide a supplemental source of portable fuel for farm equipment.

--investigation of cheaper and more reliable grain drying systems.

6. general agricultural technology--formation of a study group to investigate the application of appropriate technologies to the Saskatchewan agricultural industry. This group would look at the design of small scale best economically viable agricultural product processing methods to enable local or Saskatchewan processing.

The other side of the suggested approach to the expansion of the R&D effort in Saskatchewan involves initiatives related to activities for which Saskatchewan possesses a comparative advantage, or which would yield demonstrable economic benefits to the province. Such R&D would be based on the province's unique resource base, or would be addressed to the solution of particular problems facing the province, such as the provision of energy and suitable modes of transportation for the northern part of the province. Based on such an orientation, possible future R&D programs include:

--the establishment, under the auspices of the Saskatchewan Research Council, of an industrial minerals centre of technology. Such a proposal is presently before the federal Department of Industry, Trade and Commerce. IT&C has expressed reservations concerning the likelihood and extent of private industrial participation in funding the centre's proposed research program. Under the CAT program, IT&C requires some guarantee that the centre will be relatively self-supporting from industrial contract work over most of the life of the centre's work. The SRC is presently preparing a reply to some of IT&C's reservations. The original SRC submission envisions a seven-year research program, with a net cost of \$660,000. It is anticipated that local industry would contribute a total of about \$220,000 in contract work to the maintenance of the centre, such participation increasing to the midpoint of the program and then levelling off. The remaining costs would largely be covered by the federal government.

NET COST OF PROGRAM^{1/}

	Years of Program							<u>Total</u>
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	
	- '000 -							
Total Cost	\$ 30	\$ 80	\$160	\$160	\$110	\$ 60	\$ 60	\$660
Industrial Participation	10	20	30	40	40	40	40	220
Net Cost	20	130	120	70	20	20	20	440

^{1/} S.R.C.--"Proposal to Establish an Industrial Minerals Centre of Technology in Saskatchewan", December 1972

The work of the centre would comprise limited development programs for specific industrial minerals. The program envisaged by the SRC involves research on potash mining and geology, pollution control, transportation of industrial minerals, ceramics, sodium sulphate, marl, iron tailings and lignite coal. Investigations would be directed towards deriving alternative products from these minerals, solving production problems and developing economical methods of upgrading and of processing suited to Saskatchewan conditions.

Clearly, the work of the proposed centre could have important economic benefits for Saskatchewan in terms of potential development of some of the province's underutilized resources, cost reductions in particular industries, an improved provincial trade balance and expansion of some existing industries--e.g. the sodium sulphate industry. Given the

abundance of industrial minerals present in the province, such a concentrated research effort is called for if the province is to benefit from possession of these resources.

--cold climate technology--Saskatchewan represents an ideal natural laboratory for a nationally significant R&D program related to the wide range of problems arising from living and operating in cold weather. The program would utilize novel approaches to problems of urbanization, housing and industrial activity in an old climate. It would be directed at providing solutions that allow for the climate, take advantage of its good features during the winter, and realize their possible industrial benefits. Specific areas of research might include:

- aspects of energy affected by the cold--e.g. batteries
- the reuse of waste heat
- the design of housing suited to the peculiarities of a cold climate
- improvements in existing, and development of new, building materials appropriate to a cold climate--e.g. better insulating materials
- investigation of low temperature transportation problems
- investigation of the utilization of the prairie winter climate in various industrial processes--e.g. low humidity air for drying processes; cold for refrigerational freeze drying, etc.
- snow utilization.

Such R&D could prove of economic benefit to Saskatchewan in terms of the generation of new products that endure the rigours of the cold, the fostering of new industries to produce these spinoffs, and improvements in living styles which might act to reduce the outflow of population from the province.

--more economical modes of transportation--it is generally held that the prime deterrent to the development of the Saskatchewan economy over the years has been the high cost of transportation, in regard to both the shipping of Saskatchewan products to distant markets and the development of resources located in the more remote areas of the province. It is obviously in the provincial interest to have more R&D performed related to the province's peculiar transportation problems. Such research would be aimed at reducing the transportation disadvantages faced by Saskatchewan, all the time realizing that the most significant disadvantage is a structural one--i.e. inequitable freight rates.

As has been indicated under the section on the current research activities of the Saskatchewan Research Council, the SRC has been funded to continue its work on solids pipelining. One of the long-term objectives of the program is to improve the competitive position of the Saskatchewan minerals industry.

The National Research Council, through its Associate Committee on Air Cushion Technology, has indicated its desire to have some prototype testing of air cushion vehicles transferred to Saskatchewan. Mr. D. Eyre of the SRC has prepared a report on the application of ACV's to agricultural

and industrial uses in the prairie provinces; NRC has pointed out possible uses of large-scale transporters to solve some of Saskatchewan's northern transportation problems. The results of a survey sent to various industries, research centres and government departments in the three western provinces indicate widespread interest in the potential employment of ACV's to meet various needs and to cope with various problems particularly in more remote areas. Mr. Eyre's proposal to establish a collaborative research program between NRC and interested parties in Saskatchewan to assess the utility of the ACV in Saskatchewan remains open. If a development or testing program for ACV's is initiated in Saskatchewan, it is possible that a portion of the Canadian ACV manufacturing industry would move to the province.

--cheaper, alternative sources of energy, with minimal environmental impact, particularly of use in northern Saskatchewan.^{1/} As has been indicated, the Saskatchewan Power Corporation is actively involved in energy research and development. Its plans for future research programs comprise three major schemes:

- 1) In association with Saskatchewan Minerals, Sodium Sulphate Division, a study of the melting and casting of sodium sulphate for an off-peak electric heating furnace with heat storage. This project is based upon research conducted by Saskatchewan Power under an NRC/IRAP grant and involves transfer of the results of the research

for mass production. The project is oriented toward the establishment of a Saskatchewan based furnace industry. The two-year project, scheduled to commence in 1975-76, has estimated total costs of \$100,000, to be evenly cost-shared between the federal and provincial governments.

- 2) High voltage test facilities to establish a prairie regional laboratory to be used by the Manitoba, Saskatchewan and Alberta power utilities. The first three years of operation of the lab, beginning in 1975-76, involve estimated total costs of \$2 million, to be evenly cost-shared between the federal and provincial governments.
- 3) Small-scale hydro development at Patuanak, Nistowiak Falls and Twin Falls in northern Saskatchewan. The project is related to supplying cheap energy that might assist northern development. The projects are similar to the one at Stanley Mission described previously. The two-year development, scheduled to commence in 1976-77, has estimated total costs of \$1 million, with the federal government providing \$700,000.

--communication--some opportunities exist for expanded R&D in this area in Saskatchewan, due largely to the need in Western Canada for more support for telecommunications. A centre of expertise in communications research already exists in SED Systems Ltd. in Saskatoon.

VI CONCLUSIONS--THE ROLE OF DREE

(i) Present support of research development

The Department of Regional Economic Expansion has not, up to this time, supported research and development activities in Saskatchewan to any significant extent. The one major exception has been the funding of water studies. Under the Agricultural and Rural Development Act, DREE has cost-shared a program of water studies at the Saskatchewan Research Council. The objectives of the groundwater component of the program have been:

- to locate and evaluate water-bearing zones or aquifers throughout the agricultural area of Saskatchewan;
- to assess the amount and variability of the water supply by studying how the aquifers interact with the climate of Saskatchewan.

The objectives of the surface water component of the program have been:

- to study and evaluate sloughs and small drainage basins as sources of fresh water;
- to determine some factors affecting small prairie lakes by an inexpensive means using natural tritium.
- to carry out studies concerning the improvement of saline water quality.

As Table 16 indicates, the program commenced in 1963 and, up to March 31, 1972, had cost the federal government \$1,860,000. DREE support of SRC water studies terminates on March 31, 1974.

(ii) Future policies

Given the case for an expansion of the R&D effort in Saskatchewan, and given the potential effects of such an expansion on provincial economic development, the Department of Regional Economic Expansion clearly has a role to play in assisting the growth of scientific and technological activities in Saskatchewan. The precise nature of this role is determined by DREE's mandate and by the specific need of Saskatchewan for improved mechanisms designed to foster technological activity oriented towards the solution of regional problems.

At the federal level, the responsibility for stimulating the process of technological innovation in Canada is borne primarily by the Department of Industry, Trade and Commerce and the National Research Council. These agencies administer the federal government's major research, development and innovation programs, which provide partial funding of specific R&D projects. It is not a DREE responsibility to fund such projects. However, given the proper circumstances and recognized need, and upon close consultation with the federal agencies concerned with innovation, DREE might undertake to fund particular projects in Saskatchewan. The general principal underlying any DREE involvement in expanded R&D activities in the province should be the following:

TABLE 16

SRC WATER STUDIES--FEDERAL COSTS TO MARCH 31, 1972

	<u>1963-64</u>	<u>1964-65</u>	<u>1965-66</u>	<u>1966-67</u>	<u>1967-68</u>	<u>1968-69</u>	<u>1969-70</u>	<u>1970-71</u>	<u>1971-72</u>	<u>Total</u>
Groundwater	68272	64503	87418	120345	123835	131567	137288	184578	114000	1031806
Surface Water	<u>21604</u>	<u>45180</u>	<u>48383</u>	<u>65650</u>	<u>70731</u>	<u>108992</u>	<u>100237</u>	<u>95470</u>	<u>91947</u>	<u>648194</u>
TOTAL	89876	109683	135800	185995	194566	240559	237525	280048	205947	1680000

Source: Saskatchewan Research Council, "Application for ARDA Support of SRC Water Studies",
Volume I, p. 19

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DREE should support only those R&D projects and activities which other government agencies are unable to fund, and which possess promise of a demonstrable impact on the provincial economy. In short, DREE should be considered a funder of last resort. In this regard, one of the Department's functions ought to be to make known its views on the need and importance of R&D in a Saskatchewan context to the government agencies administering innovation programs. In addition, the Department could support specific, economically viable R&D proposals from provincial groups to these federal agencies.

However, the main focus of departmental concern must necessarily be the support of mechanisms which might stimulate technological innovation in Saskatchewan, expand the province's technology base and generate increased R&D activity. It is recommended that, in pursuit of these objectives, DREE assist in the funding of the following three activities:

- 1) establishment of a Saskatchewan Innovation Corporation.^{1/} The rationale behind the creation of this organization is that, since innovation is crucial to development and since innovation by private industry in Saskatchewan is minimal, government must assist in the process. The main objective of the corporation will be to establish viable new industries in Saskatchewan which will be profitable and will

^{1/} See I.S. Evans "Brief to the Special Committee on Business of the Saskatchewan Legislature", November 24, 1972.

create employment. The funds at the disposal of the corporation will be used to a) purchase selected Saskatchewan research and inventions and develop them to the commercial stage. This function will include assisting individual inventors and small companies in developing working models of their inventions to test their technical and economic feasibility. Such prototype testing might be performed at the SRC. No federal program exists that covers this matter of prototype development; and b) purchase selected research and inventions from outside Saskatchewan when economic benefit to the province appears likely, i.e. when the product, process or service can be made or used in Saskatchewan.

The corporation will sell the developed processes and products first to Saskatchewan industry or crown corporations and, failing that, to the best bidder. It is estimated that first-year costs for starting up the corporation would amount to \$495,000, a share of which could be covered by DREE. DREE might then provide financial support to the corporation, to the extent required, for a five-year period, at the end of which the value of the corporation's work could be assessed. It is anticipated that the corporation, as a trading company, will eventually become self-supporting.

- 2) expansion of industrial services at the Saskatchewan Research Council. As has been indicated previously, substantial economic benefits appear likely from significant expansion of the technological information and assistance services of the SRC, which are directed at improving the performance of small industry in Saskatchewan. A doubling of the level of activity of this function will involve additional costs of about \$150,000 annually.

- 3) formation of a Saskatchewan science policy group. This group will comprise leading members of Saskatchewan scientific community, representatives from the provincial government and representatives from the federal government, preferably from the Ministry of State for Science and Technology. Under a one-year mandate, this group will consider the present and future role of science and technology in Saskatchewan. Its objectives will include the formulation of a provincial science policy for Saskatchewan,^{1/} the establishment of research priorities in the province and the presentation of recommendations as to specific R&D projects that could be undertaken. Total costs of the groups activities have been estimated at \$75,000.

^{1/}The creation of provincial science policies has recently been recommended by the Science Council of Canada.

The implementation of these recommendations would undoubtedly improve the state of science and technology in Saskatchewan, as well as link them more closely to the generation of real economic benefits for the population of the province. However, it must be emphasized that those involved in the R&D industry in Saskatchewan must also help themselves and act vigorously to better the scientific and technological position of the province. Fuller advantage could be taken of the federal government's research, development and innovation programs. In addition, joint SRC--industry applications for development contracts under the new federal government make or buy policy for R&D, administered by the Department of Supply and Services, might be highly competitive. These other avenues could also conceivably assist in expanding R&D activities in Saskatchewan. And, in the long run, perhaps the general development programs of DREE, by improving the overall economic environment, will prove the most potent stimulant to increased, economically relevant R&D in the province.