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RESEARCH AND DEVELOPMENT IN THE COMMON MARKET *vis-a-vis* THE U.K., U.S., AND U.S.S.R.

Arnold Kramish

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The Rand Corporation, Santa Monica, California

PREFACE

The Institut de la Communauté Européenne pour les Études Universitaires was founded in 1958 with the object of encouraging studies in existing European universities concerning problems of European integration and to stimulating education and research in general within the European Community. Its work has been made possible largely through the generosity of the Ford Foundation and through the time and effort contributed by many distinguished participants in the European integration movement.

Late in 1959 the Action Committee for a United Europe, under the chairmanship of Jean Monnet, recommended that a special group of competent men be formed for the purpose of compiling a report on the present situation in the fields of education and research in each of the six countries of the European Community. M. Raymond Poignant of the Conseil d'Etat of France was invited to conduct the investigation into the educational aspects for the Committee, and the author of the present report was privileged to be invited to work with the Committee on the research and development aspects. The author assisted the Institut under an arrangement between the latter and The RAND Corporation.

Members of the Institut Committee are:

Alphonse Arend, Councilor for Education, Ministry of Education, Grand Duchy of Luxembourg
Felice Battaglia, Professor of Philosophy, University of Bologna
H. von Heppe, "Senatssyndikus", Rathaus, Hamburg
Etienne Hirsch, former President of Euratom
J. Idenburg, Director General, Central Bureau of Statistics, The Hague
Max Kohnstamm, President, Institut de la Communauté Européenne pour les Études Universitaires
E. L. Massart, President, National Center of Political Science, Brussels
Andre Molitor, Chief of the Royal Cabinet, Brussels

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Father Pelosi, Director, Catholic Educational Bureau, The Hague
Pierre Piganiol, Compagnie de Saint Gobain, Paris
H. Wenke, Professor of Education, University of Hamburg

Until his untimely death in early 1961 M. Gaston Berger, former head of the Department of Higher Education of the Ministry of Public Education of France, acted as Chairman of the Committee. Following that, a dual chairmanship was instituted with Professor Andre Aymard, Dean of Letters and Sciences at the Sorbonne, in charge of educational problems and Professor Gerhard Hess, President of the German Research Association, in charge of research and development matters.

The author is most grateful to the members of the Committee for the continual assistance given him. He was also most appreciative of the opportunity to discuss these matters with the Council for the Institut which is composed of:

L. Armand, former President of the Commission of Euratom
P. Campilli, former President of the European Investment Bank
A. M. Donner, President of the Court of Justice of the European Communities
P. Finet, Member of the High Authority of the European Coal and Steel Community
P. Formentini, President of the European Investment Bank
W. Hallstein, President of the Commission of the European Economic Community
E. Hirsch, former President of the Commission of Euratom
M. Kohnstamm, President of the Institut de la Communauté Européenne pour les Études Universitaires

Special appreciation must be expressed, however, to those with whom the author collaborated in a "working committee" on a more or less continuous basis. These were: E. Hirsch, M. Kohnstamm, R. Poignant, and P. Piganiol. M. Monnet and his assistant M. Duchene, were always available and their encouragement and assistance in many diverse matters can hardly be overstated.

Other individuals who assisted in varying degree in the six countries of the European Community, the United Kingdom, the United States and in the international organisations of UNESCO, OECD and NATO, numbered literally in the hundreds. I must apologise for not naming them separately, but express my most sincere gratitude.

SUMMARY

The purpose of the study here is to present as firm a basis as possible for various actions which might be undertaken or recommended regarding improvement of the research and development situation in the Common Market. These possibilities will be discussed in other Institut reports which will utilise appropriate portions of the data which follows.

The description of national science mechanisms and research expenditures represent the first collated effort undertaken for the Common Market countries. Indeed, several of these countries had individually not previously attempted a comprehensive inventory of their national science resources, or had only recently embarked on such a survey. At the outset it can be said that one of the major results of the undertaking of this particular study has been to stimulate statistical efforts in the individual countries.

Nevertheless, the data presented here is necessarily incomplete and based upon different definitions and concepts of what constitutes research and development. Consequently, although some of the data is given with an apparent accuracy of several decimal places, it must be emphasised that these are working figures and no claim to such accuracy can be made. It is believed, however, that when the figures are rounded off a fairly good comparative picture of research and development in the Common Market can be obtained from the data presented here.

No international standards for reporting research and development statistics exist, although the Organisation for Economic Cooperation and Development, in collaboration with the U. S. National Science Foundation, is now in the process of developing such standards. Not only is there a lack of consistent definition in Europe but there is a greater degree, than exists in the U.S., of confidentiality in government and in industry. In some countries complex channels of funding complicate identification of funder and performer, but every effort has been made to eliminate in the statistics duplication of overlapping funds.

In the government budgets the identification of the research and development portion of the higher education budgets was the most difficult interpretation. In this report the interpretation preferred by each government is the one reported. However, it is recognised that others may wish to assign different fractions of the higher education budget to research and development. Thus a number of total educational budgets are given, and more detailed information of this nature will be found in the specialised reports of M. Poignant.

The OECD has just completed its "Third International Survey on the Demand for and Supply of Scientific and Technical Personnel." The OECD survey will contain the best available manpower figures for Europe and will be published sometime in 1963. Consequently, the manpower figures given here should be considered as tentative and will be replaced by the OECD figures when they are available.

Tables A and B summarise the results. It will be seen from Table A that, on the basis of the ratio of research and development expenditures to Gross National Product, the effort in the Common Market countries is still about half of that of the U.S. or the U. S. S. R. Table B attempts to evaluate the same data on the basis of a per capita effort. In attempting to assess the figures on this basis, it is necessary to adopt an exchange rate which not only reflects the official monetary values but such aspects as productivity indices, relative cost of materials, et cetera. We have taken advantage of a recent British study which assumes a British exchange rate of 6.3 dollars to the research pound. We assumed, as a simplification, that the various factors which entered into the British calculation will be similar throughout Europe. And on this basis we have calculated both an "unweighted" and a "weighted" figure for comparison, believing the latter to be the more valid. We, for the moment, have used the same weighting for the U.S.S.R. although it is felt that a somewhat smaller weighting is the more realistic one.

A more realistic estimate of the research exchange rate might be formulated if we knew more of the factors more precisely. One of these factors would be the relative costs of maintenance per research worker for each country. Unfortunately, this figure is not available for all the nations included in this study but what data exists is given in Table C.

This report, intended primarily for European audiences, uses the European term "milliard" for the quantity 1,000 million--or what is, in the U.S., a "billion".

At least three very general conclusions can be meted at this time:

I. The European research effort on a per capita basis is less than one-half that of the U.S. or the U.S.S.R., which is substantially the same conclusion reached on a G.N.P. ratio basis.

II. The costs of supporting R&D, per qualified worker, are rising sharply in every country.

III. The rate of increase of R&D expenditures in every nation of the EEC is rising at several times the rate of growth of the G.N.P., which is typical of the situation in the U.S., U.K., and U.S.S.R. The question of the proper level of R&D expenditures remains open everywhere.

Table A

RESEARCH AND DEVELOPMENT IN THE COMMON MARKET FOR 1959

THE EFFORT COMPARED TO GROSS NATIONAL PRODUCT
(At Current Prices)

County	Population[1] (thousands)	G.N.P.[2] (milliards units)	R & D (million units)	E/G.N.P. as %
Belgium	9,104	573.4 FB	3,380 FB	0.59
France	45,097	257.1 NF	2,230 NF	0.87
Germany	52,785	247.0 DM	3,022 DM	1.22
Italy	49,052	17,734.0 Lira	55,000 Lira	0.31
Luxembourg	324	21.8 FL	150 FL	0.67
Netherlands	11,346	38.7 Fl	565 Fl	1.46
U.K.	52,157	23.7 £	520 £	2.19
U.S.	177,700	483.4 $	11,845 $	2.45
U.S.S.R.[3]	210,500	1,645.0 Ruble	28,150 Ruble	1.71

1) Statistical Yearbook, 1960 (United Nations)

2) Yearbook of National Accounts Statistics, 1960 (United Nations) G.N.P. at market prices.

3) 1959 Rubles (Pre-reevaluation)

Table B

RESEARCH AND DEVELOPMENT IN THE COMMON MARKET FOR 1959

THE PER CAPITA EFFORT[1]

Country	Population[1] (thousands)	G.N.P.[2] (milliards $)	R & D Expenditures (millions $)		E/P in $	
			Unweighted[3]	Weighted[4]	Unweighted	Weighted[4]
Belgium	9,104	11.5	68.4	153.9	7.51	16.90
France	45,097	52.3	454.3	1,022.2	10.07	22.66
Germany	52,785	59.2	724.7	1,630.6	13.73	30.89
Italy	49,052	28.6	88.6	199.4	1.81	4.07
Luxembourg	324	0.4	3.0	6.8	9.26	20.99
Netherlands	11,346	10.3	149.9	337.3	13.21	29.72
Totals for Six	167,708	162.3	1,488.9	3,350.0	8.88	19.98
U.K.	52,157	76.9	1,457.8	3,280.1	27.95	62.89
Six + U.K.	219,865	239.2	2,946.7	6,630.1	13.40	30.16
U.S.	177,700	483.4	11,845.0	11,845.0	66.66	66.66
U.S.S.R.[5]	210,500	332.5	7,037.5	15,834.4	33.43	75.22

1) Statistical Yearbook - 1960 (United Nations), pp.42-43.

2) Yearbook of National Accounts Statistics - 1960 (United Nations) G.N.P. at Market Prices.

3) Based on Statistical Yearbook - 1960 (United Nations), pp. 506-515.

4) A weighting factor is required to allow for comparative wages and materials which do not follow official exchange rates. Although this factor will differ from nation to nation, this estimate assumes the enhanced European research value of 2.25 to 1, used in a comparative study of British and American industrial research. (See "Research and Development: A Comparison between British and American Industry", National Institute Economic Review [London], no. 20, May 1962, pp. 21-39.)

5) Official 1959 exchange rate of 4 rubles/dollar.

Table C

COSTS OF R&D PER SPECIALISED EMPLOYEE
(In industry, except for U.S.S.R.)

	1957	1958	1959	1960	1961	1962
France[1] (N.F.)			100,000			130,000/140,000
U.K. (£)		9,676[2] (8,751)[3]			11,800[4]	
U.S.[5] ($)	33,300	32,900	35,200			
U.S.S.R.[6] (old rubles)	112,000	120,000	122,000	117,000		

1) Personal communication from L. Villecourt, Delegation Generale a la Recherche Scientifique et Technique, Paris.

2) Industrial Research and Development Expenditure (London: D.S.I.R., 1958), p. 7.

3) Industrial Research in Manufacturing Industry 1959-60, a survey by the Federation of British Industries (London: Waterlow & Sons, Ltd, December 1961), p. 65.

4) This is for 1961-62. See Annual Report of the Advisory Council on Scientific Policy 1961-1962, Cmnd. 1920 (London: HMSO, January 1963), p. 37.

5) Funds for Research and Development in Industry 1959, NSF 62-3, a survey by the National Science Foundation (Washington: GPO, 1962), p. XI.

6) These figures are derived from the total U.S.S.R. budget divided by all scientists in research institutions. See Nancy Nimitz, Soviet Expenditures on Scientific Research, RM-3384-PR (Santa Monica, Calif.: The RAND Corporation, January 1963), p. 58.

CONTENTS

I. RESEARCH AND DEVELOPMENT IN BELGIUM

POLICY

The present political-scientific organ in Belgium is a consequence of a two-year study performed by a National Commission of Sciences, which was organised by a Royal Decree of January 1957. A Royal Decree of September 1959 created three separate state organisations charged with scientific planning responsibilities. They are:

i) The Ministerial Committee for Scientific Policies
ii) An Interministerial Commission
iii) A National Council for Scientific Policy

The functions of the bodies are as follows:

i) The Ministerial Committee for Scientific Policies

This Committee functioned for about a year previous to the Royal Decree of 16 September 1959, which confirmed its existence.

This Committee coordinates the activities of the Ministerial Departments and prepares for the Cabinet Council the broad directions of the budgetary program.

The membership is composed of the Prime Minister, who is in charge of economic coordination and the coordination of scientific policy, the Minister of National Defence, the Minister of National Education and Culture, the Minister of Agriculture, the Minister of Public Health and the Family, the Minister of Economic Affairs and Energy, and others designated by the Prime Minister.

ii) The Interministerial Commission

This Commission, which is presided upon by the Secretary General of the Ministry of National Education and Culture, and is composed of Senior Functionnaires from most of the Ministries, coordinates the preparation and execution of Government decisions in the scientific-political field.

iii) The National Council for Scientific Policy

This body is composed of 27 members, not directly involved with governmental responsibilities. The membership is composed of the top scientific, university and social scholars of Belgium. Assisting

the National Council are two special committees, a Committee for University and Industrial Liaison and a Committee of Scientific Experts.

The National Council is charged to prepare for the Ministerial Committee studies relating to the development of science in Belgium. It is available for immediate advice to the Government on all aspects of the development of scientific life.

PUBLIC ORGANISATIONS

A number of Ministries, notably those of National Education and Culture, Economic Affairs, Agriculture, Public Health and National Defense, support research laboratories appropriate to their specific needs.

The backbone of Belgian research, however, is the university structure. There are four universities, the State universities at Ghent and Liege, and the "Free" Universities of Louvain and Brussels. Some research is also supported at the engineering schools, the Polytechnic School in Mons and the Royal Military School.

In addition to the funds which accrue to the above bodies from the state budgets of the various ministries, a special fund is available for the promotion of pure science. These Fonds National de la Recherche Scientifique (F.N.R.S.) are supported by state grants and private contributions. Other organs of state support include the Interuniversity Institute of Nuclear Sciences (I.I.S.N.), the National Fund for Scientific-Medical Research (F.N.R.S.M.), et cetera.

INDUSTRIAL RESEARCH

Industry may receive state support from the Institute for the Development of Scientific Research in Industry and Agriculture (I.R.S.I.A.). I.R.S.I.A. is controlled by two Ministries, those of Economic Affairs and Agriculture. The bulk of I.R.S.I.A. grants goes to research institutes maintained by industrial associations, but a large measure of I.R.S.I.A. support is also given to the universities and to some individual enterprises for the conduct of industrial research.

Examples of some of the association research centers supported by I.R.S.I.A. are the National Center for Metallurgical Research (C.N.R.M.), Belgian High Pressure Research Institute, and the Study Center for Large Polymers.

In addition to supporting the work of these associations whose membership is entirely voluntary, I.R.S.I.A. and industry provide support for special institutes, known as the "De Groote Centers", for whose creation a 1947 decree authorises state grants. The functions of the "De Groote Centers" consist in stimulating technical progress by means of financing and coordinating research projects of existing scientific institutions, stimulating the establishment of new ones, ordering research projects to them and conducting research projects in their own services too if necessary.

A financial contribution has to be provided by each industrial plant in proportion to its relative importance in the sector, as soon as a request to create a "De Groote Center" has been accepted by governmental authority. The latter gives financial aid to start the activities of the new center. Supplementary private and governmental funds may be granted. Up to now twelve such "De Groote Centers" have been created in the chemical, ceramic, glass, leather, food, wood, textile and fabricated metal products industries as well as in some particular sectors of the construction industry. In 1961 some 24.000 industrial plants and 20.000 handicraft establishments, employing together over 530.000 units of manpower, were affiliated and contributed financially to these centers. As to their activities, four "De Groote Centers" conduct research projects in their own laboratories and only occasionally subcontract such projects to other institutions. Subcontracting research projects to other institutions is the main activity of three other centers, while the activity of four centers is practically limited to a contract with a single institution. The one remaining center has been inactive for several years.

In addition to the "De Groote Centers", forty-three other centers exist with the same general characteristics (except for

the power to levy a duty on industrial establishments). The scientific and technical personnel of the twelve "De Groote Centers" represent 15% of the corresponding total of all common research centers ("Free" centers plus "De Groote Centers").

As in all countries the larger individual industrial concerns have their own substantial laboratories and private research allocations. The largest of the research-conducting firms are:

A.C.E.C. (Ateliers de Constructions Electrique de Charleroi)
Solvay et Cie, Brussels
Union Chimique, Brussels
Univerbel, Charleroi (Glaceries et Verreries Belges)
M.B.L.E. (Manufacture Belge de Lampes et d'Electronique)
Gevaert Films, Antwerp
Bell Telephone, Antwerp

FINANCIAL AND MANPOWER RESOURCES

The state budget represents the most accurate set of research expenditure figures. These have been published for the years 1959-1961 and are shown in Table 1.

Within these figures, however, the largest uncertainty are those expenditures for higher education, such as the fractional parts of salaries and facilities up-keep, et cetera, which should be attributed to research, in addition to that amount which the budget of the Ministry of National Education and Culture specifically identifies as research expenditures. One analysis[1] has considered that one-third of the rest of the remaining part of the budget should be attributed to research. In order to supply consistent comparison with that analysis, which to date has represented the only study of the total Belgian R & D effort, the same practice is followed in the synthesis of the state budget shown in Table 2.

Table 1

(In millions of F.B)

	1959	1960	1961
I. Ministry of National Education and Culture:			
A. Section of Higher Education			
1. State Establishments of Higher Education.....	566.7	673.8	841.5
2. Free Establishments of Higher Education.....	340.9	460.5	730.4
Total.....	907.6	1,134.3	1,571.9
B. Section of Scientific Research			
1. State Scientific E Establishments.....	145.9	155.7	197.0
2. Grants for Research Activities	134.8	144.7	157.5
Total.....	280.7	300.4	354.5
C. Other Sections-Research Credits.....	41.8	54.3	65.3
General Total for the Ministry of National Education and Culture..	1,230.1	1,489.0	1,991.7
II. Ministry of Economic Affairs:			
A. Research performed by the Department (Geological and metrological services, central laboratory).....	36.7	35.4	23.3
B. Grants for Scientific Research			
1. I.R.S.I.A.....	205.0	233.0	235.0
2. I.I.S.N.....	*	85.0	90.0
3. Center for Nuclear Energy Studies, Mol.....	200.0	296.3	332.7
4. Euratom.....	51.0	61.0	69.0
5. European Organisation for Nuclear Research.....	32.0	31.2	32.0
6. National Institute for Coal Mining.....	4.0	15.0	12.0
7. Studies and Fabrication of Prototypes.....	7.0	25.0	40.0
8. Office for Increasing Production.....	6.8	8.0	8.7
9. Other Credits for Grants.	7.1	7.7	4.9
Total for B.....	512.9	762.2	824.3
General Total for Ministry of Economic Affairs.....	549.6	797.6	847.6

*In 1959 a credit of 23,5 million was shown at the Ministry of National Education and Culture.

Table 1 (continued)

(In millions of F.B)

		1959	1960	1961
III.	Ministry of Agriculture:			
	A. Scientific Establishments.....	99.4	105.2	117.4
	B. Research Contracts...	10.0	16.0	30.0
	C. Grants and Miscellaneous	4.7	5.7	6.2
	Total.....	114.1	126.9	153.6
IV.	Ministry of Public Health and Family:			
	A. Grants to the F.N.R.S.M.	20.0	22.5	12.5
	B. Other Credits.....	50.5	53.1	49.8
	Total.....	70.5	75.6	62.3
V.	Ministry of National Defense:			
	A. Credits for Research..	67.8	97.5	107.2
VI.	Other Ministerial Departments:	123.0	117.3	137.4
	GENERAL TOTALS.....	2,155.1	2,703.9	3,299.8

Table 2

	1959	1960	1961
1) Ministry of National Education & Culture			
a. Section of Higher Education (one-third of total).....	302.5	378.1	523.6
b. Section of Scientific Research.....	322.5	354.7	419.8
Total.....	625.0	732.8	943.4
2) Other Ministries Total.....	935.0	1,214.9	1,308.1
Grant Totals.....	1,560.0	1,947.7	2,251.5

INDUSTRIAL DATA

Information on the extent of industrial research and development is almost totally lacking. The Federation of Belgian Industries had conducted the only survey[4] of the last decade. It reported integrated totals for the five-year period 1954-1958.

Analysis of the Federation data indicates that the following eight segments account for the majority of industrial research in Belgium. They are:

Table 3

Sector	% of Total
Chemical	37.2
Metal Fabrication	31.4
Iron and Steel	8.4
Non-Ferrous Metals	7.3
Coal Mining	3.5
Textile	3.4
Paper, Cartons	2.8
Electrical	2.0

The sum total of industrial expenditures for the five years was 6,650,000,000 FB, of which 1,650,000,000 FB represented capital investment and 5,000,000,000 FB were operating expenditures. This represents an average total expenditure for the first five years of 1,330,000,000 FB. This, of course, was not a constant figure in a period of rising cost of research expenditures. It is, however, taken as the probable figure for industrial expenditures for the median year of that period, 1956, in one study.

The same study also assumes, for the year 1960, a figure of 2,000,000,000 FB for industrial research expenditure. For the purposes of the present study, the best figures obtainable for the base year, 1959, will be a straight-line interpolation of 1,830,000,000 FB.

MANPOWER

Less than a thousand first degrees or "Licences" in technical or scientific fields are presently awarded in Belgium. The distribution of these is approximately 50% in the engineering sciences, 30% in the natural sciences, and 20% in agriculture.

In 1954 the number of science degrees per million of total population was 85 or 210 per million of labour force. The situation appears to be improving; the latest available comparable data, for 1957, showed a rise to 93-230 respectively.

(Sum totals of scientists and engineers to be supplied later in the OECD "Third International Survey on the Demand for and Supply of Scientific and Technical Personnel," to be published sometime in 1963.)

SYNTHESIS OF DATA

It is evident that there are serious gaps in a number of sectors of the Belgian data picture. However, hazarding certain minor interpolations one can prepare the following synthesis:

Table 4

Year	Total (Millards of FB)	G.N.P.	Ratio
1956	1.94[1]	525.4	0.37
1957	*	558.9	*
1958	*	556.5	*
1959	3.38	573.4	0.59
1960	3.95	608.-	0.65
1961	4.42		

*Not available.

Thus, the ratio of research and development expenditures to gross national product appears to have increased some 60% in the four year period 1956 to 1959, while the gross national product increased only 9%. Some state expenditures appear not to have been reported in the earlier figures, thus the increase of the R & D ratio is not as large as 60%, but still would represent several-fold the rate of growth of G.N.P., a pattern which is consistent with the other countries of the Common Market.

REFERENCES

Much of the foregoing data is based upon conversations and connexions with staff members of the Conseil National de la Politique Scientifique in Brussels. The Conseil has been preparing a more comprehensive survey of the Belgian R & D picture, but it will not be available until sometime in 1963. Presentation here does not necessarily coincide with the views of the Conseil National. This task has also been aided by published materials, of which the major ones are the following:

(1) "Recherche Scientifique et Investissements", by J. Defay, Department d'Economie Appliquee de l'"Universite Libre de Bruxelles.

(2) 1st Annual Report of the Conseil National de la Politique Scientifique, 1960.

(3) 2nd Annual Report of the Conseil National de la Politique Scientifique, 1961.

(4) "Condition de la Recherche Scientifique dans L'Industrie", by Marcel de Merre, Industrie, 11 November 1959.

(5) "Premier Inventaire des Ressources de la Recherche Scientifique en Belgique - 1958", Centre d'Etude des Problemes Sociaux et Professionnels de la Technique, Bruxelles.

(6) "La Participation de la Belgique a l'Effort de Recherche Scientifique International", by Jacques They, Centre d'Etude des Problemes Sociaux et Professionnels de la Technique, Bruxelles.

II. RESEARCH AND DEVELOPMENT IN FRANCE

POLICY

While a science plan was drawn up for Napoleon as early as 1808, no serious effort to organise science in France was made until just before World War II, through the creation of two government Committees; one for pure and the other for applied research. In 1939, these Committees were merged into the National Center for Scientific Research (C.N.R.S.). The war resulted in the dissolution of all scientific planning structures, but in 1945 the C.N.R.S. was reinstated.

Still, the C.N.R.S. did not represent the essential coupling of science with other governmental problems. The C.N.R.S. had Committees formed according to the specialisation by science, rather than in consideration of broader themes. Its tasks were to create corps of research workers and technicians and to establish specialised institutions. But, by the early 1950's, the myriad of developing political-scientific problems and the simple necessity of coordinating tasks within the C.N.R.S. itself, made it evident that stronger reforms were called for.

Accordingly, a Decree of 14 September 1954 created the Conseil Superieur de la Recherche Scientifique et du Progres Technique, to act in an advisory capacity to the Prime Minister. The Conseil Superieur created, in turn, some twelve Committees, concerned with the problems classified as of "general interest" and thirty Committees dealing with problems of "collective interest". For the most part, the performance of these Committees was ineffective, one major factor being the great lack of appropriated funds for their operation. In 1957-58, re-examination of the difficulties and newer demands of science necessitated new government action. The real landmark in the present science planning structure governing France is the Decree of 28 November 1958, superseding that of 14 September 1954.

The new Decree provided for an Interministerial Committee for Scientific Research, under the direct Chairmanship of the Prime Minister; and a Consultative Committee for Scientific Research to

provide solid scientific substance and advice for the Interministerial Committee. To link the two Committees, a common Secretariat was created, the Délégation Générale a la Recherche Scientifique et Technique.

The Interministerial Committee is under the direct Chairmanship of the Prime Minister. The other members are:

The Minister of Education
The Minister for War
The Minister of Finance & Economic Affairs
The Minister for Industry
The Minister of Agriculture
The Minister of Public Health & Population
The Postmaster General

The terms of reference of the Committee are as follows:

a) to submit appropriate measures to the Government which aim at the promotion of scientific and technological research;

b) to elaborate programs for the future development of scientific institutions, and

c) to plan the distribution of Government funds for research.

The Consultative Committee membership consists of twelve scientists, not representing any particular organisation or sectors of scientific groups, but as individuals charged with providing the Interministerial Committee with the best scientific advice. The Delegation Generale, serving as the common Secretariat, operates with a very competent and over-worked staff of about eighty persons.

The parallel to the newly-developed science planning structure in the United States was almost exact. The Interministerial Committee might be compared with the Federal Council for Science and Technology. The Consultative Committee has functions similar to those of the President's Science Advisory Committee and the Délégué Générale has operating functions similar to those which are the responsibility of the Special Assistant to the President for Science and Technology. Additionally, a later Decree provided that some of the members of the Consultative Committee, and others by appointment, would serve on a Commission for Scientific and Technical

Research, under the aegis of the Commissariat for Economic Planning. Its immediate task had been the preparation of a plan for scientific research and technique, as a part of the Fourth Modernisation and Equipment Plan (1962-1965) of the Government of France. Again, the actual administrative task of working out the details of this plan was assigned to the Délégué Générale.

Thus, the Délégué Générale has major working responsibilities to back up the tasks of the newly created scientific planning Committees. In addition, new problems have made necessary the creation of other government committees. For example, a Decree of 7 January 1959, relates to the creation of a Committee for Space Research. Another decision of 9 December 1959, established a number of quite specialised Committees ("The Study Committees"), covering the most urgent sectors of science to assist the implementation of the more general scientific tasks defined by Decree.

The Study Committees were created to aid in carrying out the purposes of the simultaneously created Fund for the Development of Scientific Research Technique. This Fund is a unique feature of French scientific planning, for it enables the essential immediate financing of priority projects without encountering delay by administrative procedures. A small proportion of the Fund is devoted to the financing of various new scientific developments, but the greater part of it is used for the development of the so-called "Action Concertees" which are research projects of broad scope and of great national interest. The titles of the Study Committees represent the initial "Action Concertees" for France. They are:

1) Demographic Analysis
2) Economic and Social
3) Applications of Genetics
4) Molecular Biology
5) Cancer and Leukemia
6) Energy Conversion
7) Documentation
8) Oceanographic Exploration
9) Neurophysiology and Psychopharmacology
10) Animal and Human Nutrition
11) Economic Science and Problems of Development

The creation and the subsequent effective work of the Study Committees represents an unprecedented action in scientific planning for France. It was essentially the first time that scientists had been asked to specify clearly the objectives they had in mind in particular fields, and to make concrete plans for attaining those objectives. The Fund is judged to be highly successful and today its Budget amounts to almost 10% of the entire State scientific budget.

The Fund does not own its own laboratories, but uses existing facilities; in exceptional circumstance a new research facility may be created. The management of a research project is entrusted to the laboratories themselves. Because the Fund has legal status for a period of only five years after its creation, it must be considered temporary, but effective means of bolstering French research in certain critical areas.

PUBLIC ORGANISATIONS

Universities

Although in 1789, there existed in France twenty-two universities, it was in the following two decades that the institutions which are the foundation of France's scientific culture were born. Those years saw the birth of an awareness of the essentiality of Government support for scientific research. A multitude of Decrees resulted in the creation of such renowned institutions as the College de France, Ecole Polytechnique, the Ecole Normale Superieure, and provided the basis for the creation of important Faculties of Science. This strong base enabled the successive establishments of the Faculties of Science as follows:

1808 - Paris, Caen,Dijon, Grenable, Lyon, Montpellier, Strasbourg, Toulouse
1838 - Bordeaux
1840 - Rennes
1845 - Besancon
1854 - Marseilles, Clermont-Ferrand, Lille, Nancy, Poitiers
1909 - Alger
1958 - Rheims, Nice, Nantes

The Faculties are surrounded by a host of satellite research institutes. Thus, the scientific heritage of France is deeply instilled and is still nourished at all levels. Special mention should be made of the existence of the scientific museums, associated for the most part with the schools; the most unique of which is the Museum of Science and Discovery. They provide for the general edification of the populace, and have special programs for youth.

It is difficult to describe the structure of university research for it is almost completely a free type of research. While financed by the State, there is almost complete liberty in the choice of subjects treated. A second quality, which makes description difficult, is the great dispersion of university research throughout France in great laboratories and small. It should be noted that this research is not confined to fundamental research, but to a large unknown fraction devoted to research in applied sciences.

C.N.R.S.

The present structure of the National Scientific Research Center (C.N.R.S.) is the result of many evolutionary changes, which culminated in a new definitive Decree issued almost exactly a score of years after the founding of the first C.N.R.S. It is essential to note much of the new look of the C.N.R.S. is explained by changes which have been made in the status of scientific staff members. Previous to 1959, the research workers of the C.N.R.S. were considered "temporary workers". Thus, not having the stability and security of other civil servant jobs, the staff problems became so great as to constitute a major detriment to the effective operation of the C.N.R.S. The 1959 Decree instituted corps of directors and scientific staff and gave them benefits parallel to those of civil servants of similar responsibility and status in other sectors of the Government.

The role of the C.N.R.S. is to report to the Government annually on the status of French research efforts and to have a major role in the financing of the orientation and coordination in the specific

areas of science. These studies relate not only to the descriptions of the expanding frontiers of the world of science, and the role which France should play, but they also consider the problems of administration of research centers, organisation of work, information dissemination, staff problems, creation of new research centers, material needs, et cetera.

The first report on the future development of scientific resources was submitted by the C.N.R.S. in 1960.* This report not only makes specific propositions relative to the planning of some 70 of its laboratories and research centers, but examines the general state of world-wide knowledge in the various scientific disciplines.

Employed by the C.N.R.S. are approximately 3,500 research workers and 4,000 technicians. It is significant that 85% of the research workers and 50% of the technicians are employed by the C.N.R.S., but are made available to other public research institutions.

C.E.A.

The Commissariat a l'Energie Atomique (C.E.A.), was created 18 October 1945 by the provisional Government of France. It is a public institution, but is administratively and financially autonomous. Its first Five-Year Plan in 1952 stressed industrial application and, until that plan terminated, essentially all atomic energy activities in France were the responsibility of the C.E.A. However, the Second Plan, launched in 1957, provided that the C.E.A. did not have the responsibility for all nuclear activities in France. Rather, the applied functions were distributed among those Government Agencies appropriate to the task. For example, Electricite de France participates strongly in the research effort on nuclear power plants.

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*Rapport National de Conjoncture, C.N.R.S., 1960.

However, the C.E.A. does conduct a great deal of fundamental and applied research in its own laboratories. Since the C.E.A. also is responsible for the construction of isotope separation plants, weapon material facilities, the research budget reported here represents about 30% of the total C.E.A. budget.

O.R.S.T.O.M.

A unique scientific institution is the Office de la Recherche Scientifique et Technique d'Outre-Mer (O.R.S.T.O.M.), which specialises in technical assistance to overseas states. Its problems, of course, are of a highly practical nature, relating to the production of food crops, effects of environmental factors, demography.

The budget of O.R.S.T.O.M. is supported to the extent of some 70% by the Government of France, and the remainder of those overseas states which are signatories to an Aid and Cooperation Fund.

Other Government Research Centers

There are a great many other important Government research centers devoted to specific sectors. These include the National Institute of Agricultural Research (I.N.R.A.), the National Office of Aeronautical Studies and Researches (O.N.E.R.A.), the National Center of Telecommunications Studies, (C.N.E.T.) et cetera. These organisations work under the control of various ministries. Their structures and definitions of responsibility are not particularly different from those of corresponding institutes in other countries.

For scientific research connected with the national defence, the Scientific Action Committee for National Defence (C.A.S.D.N.) has the direct responsibility and submits its recommendations to the Prime Minister. Much of its work is done in coordination with committees like O.N.E.R.A. and C. N.E.T. Six-tenths of a percent of the national defence research and development budget is assigned to C.A.S.D.N. for its operating expenses.

PRIVATE RESEARCH

A large fraction of that, which in other countries would be termed "private research", must in France be considered within the terms of the State budget, for a great deal of it is performed by the nationalised industries.

The following maintain their own laboratories:

Charbonnages de France
Societe Nationale des Chemins de Fer Francais
Gaz de France
Electricite de France

There is still a considerable amount of research performed by the non-nationalised industries. Nevertheless, the French laws, in one way or another, have an important effect also on the non-nationalised sector of industrial research. For example, the laws of 1943 and 1948 provided for the establishment of common research centers which would pool the scientific resources of particular sectors of industry in France. The largest of these are the Institut Francais de Petrole and the Institut de Recherches de la Siderurgie. In all, there are some thirty of this type of joint research institute in France.

The 1948 law makes mandatory subscriptions to operate the joint industrial technical centers on the part of other private firms falling within those categories. However, thus far legal action has not been taken to enforce the mandatory subscriptions for those centers existing under the law of 1948.

There also exist, based on an earlier law of 1901, joint industrial research installations with very narrow research responsibilities. There are some twenty-five of these and they represent group research effort on such subjects as heating, plumbing, ceramics, vinegar, candies, laundering, et cetera.

It will be seen in the statistical section, that the sum total of industrial financial resources, outside of the research in the nationalised industries, or supported by Government contract, amounts to about one-third or less of the total industrial type support in

France. Some of these industries are members of the National Association for Research Techniques (A.N.R.T.). This organisation, founded in 1953, represents its industry members in matters of liaison, with various research bodies both public and technical. It also provides collective representation in national and international affairs for French industry.

As in other countries, emphasis on research and development varies drastically in each industry sector. The electronics industry is that which is most heavily dependent on R&D. It is estimated that 10% of the turnover of NF4 milliard in the electronics industry is devoted to research and development. A fairly high proportion, 1.5% is devoted to pure research.*

Foundations

A number of institutions of world-wide renown also were made possible by foundations. In 1887, the Pasteur Institute was created. This has branches at Lille, Lyons and in Algeria. Prince Albert I of Monaco founded, in Paris, in 1906, the Institute of Oceanography. Under his patronage, the Institute of Human Paleontology was also founded. There are several other foundation research institutes of importance. They receive various combinations of public and private funding; one of them, the Pasteur Institute, receives a large share of income through sale of serums and vaccines.

There is no equivalent to the large-scale general purpose foundations like the Volkswagen and Rockefeller Foundations in France.

FINANCIAL AND MANPOWER RESOURCES

The best figures for France have been given, in May 1961, by the Delegation Generale a la Recherche Scientifique et Technique.**

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*Situation de l'Electronique en France, Premier Rapport de la Commission, Commission Permanente de l'Electronique, Commissariat General du Plan. Paris: Imprimerie Nationale, March 1962, p. 26.

**"Le Financement de la Recherche Scientifique et Technique en France", Premier Ministre, Delegation Generale a la Recherche Scientifique et Technique, Le Progres Scientifique Numero Special, Mai 1961.

They are, of course, presented in a form for planning purposes in France and it has been found necessary to revise those figures to put them in a form so that they can be compared with statistics of other nations.

Table 5 are the statistics as presented by the Délégation Générale.

SYNTHESIS OF DATA

The Délégation Générale data are used for purposes of international comparison. The results for research and development expenditures as a percentage of the Gross National Product are:

Year	G.N.P. (milliards NF)	R & D Total (millions NF0)	Ratio
1959	257.1	2,230	0.87%
1960	(271)	2,852	1.05%
1961	(298)	3,436	1.15%

It is difficult to separate fundamental research from applied research in the French data. However, the ratio of fundamental to applied research is believed to be approximately 0.15%.

With the 1959 population of 45,097,000, the French expenditure per capita for that year was 49.5 NF. This is approximately the average expenditure for the European Community.

It is interesting to note the rate of growth in the three-year period. While the Gross National Product rose 15%, the research and development budgets experienced a growth of 55%.

Table 5

DÉLÉGATION GÉNÉRALE TABLES

	Fundamental or Oriented Research			Applied Research			TOTAL		
	1959	1960	1961	1959	1960	1961	1959	1960	1961
I. INTERMINISTERIAL DISCUSSION:									
C.N.R.S.	166	248	247	-	-	-	166	248	247
Higher Education (laboratory equipment)	23	40	58	-	-	-	23	40	58
Agronomy Research	-	-	-	36	43	51	36	43	51
National Institute of Hygiene	-	-	-	6	10	13	6	10	13
Other Ministries	-	1	2	9	13	16	9	14	18
Fund for the Development of Scientific and Technical Research	-	6	32	-	2	10	-	8	42
II. OTHER INDIVIDUAL CREDITS									
Telecommunications	-	-	-	33	35	40	33	35	40
Overseas Research	5	7	9	19	30	30	24	37	39
Other Ministries	8	10	13	3	2	2	11	12	15
TOTAL Credit for Ind.Res.	202	312	361	106	135	162	308	447	523
III. NON-INDIVIDUAL PUBLIC RESEARCH CREDITS									
C.E.A.	28	28	36	300	300	345	328	328	381
50% of the Salaries of Higher Education Personnel	115	135	157	-	-	-	115	135	157
Facilities for Higher Education	35	50	50	-	-	-	35	50	50
Studies and Prototype Construction for Civil Aviation	-	-	-	66	82	88	66	82	88
Mil.Studies & Prototypes	177	220	295	709	910	1.182	886	1.130	1.477
TOTAL Public Expenditures	557	745	899	1.181	1.427	1.777	1.738	2.172	2.676
Among which are contracts with nationalised & private organizations	106	130	180	702	840	1.010	808	970	1.190
Funds used by Public Organisations	451	615	719	479	587	767	930	1.202	1.486

Table 5 continued

	Fundamental or Oriented Research			Applied Research			TOTAL		
	1959	1960	1961	1959	1960	1961	1959	1960	1961
IV. PRIVATE & NATIONALISED SECTORS									
Centers for Industrial Techniques.....	8	10	11	77	90	99	85	100	110
Nationalised Energy and Transport.....	7	8	9	63	72	81	70	80	90
Other Enterprises.....	115	150	175	1.030	1.320	1.575	1.145	1.470	1.750
TOTAL Nationalised and Private Sectors.....	130	168	195	1.170	1.482	1.755	1.300	1.650	1.950
GENERAL TOTAL.....	581	783	914	1.649	2.069	2.522	2.230	2.852	3.436

NOTE: The above figures are given in millions of NF. As of 1963 the adjective "new" is not usually applied to the franc.

Table 6

MANPOWER

Science Degrees in France

	First Degrees*			Doctorate	
	Natural Science	Engineering	Agriculture	Doctor of State	3rd Cycle Doctorate
1954	1,418	n.a.	339	n.a.	-
1955	1,594	4,260	378	132	-
1956	1,805	4,480	369	213	-
1957	2,452	4,640	332	238	-
1958	2,766	4,930	n.a.	403	85
1959	-	-	-	387	199

*"Educating Scientists and Engineers", O.E.E.C. Document No. STP/GS(60)50, 12th January, 1960, p. 9.

In 1954, the number of engineers constituted 0.73% of the total labour force. This was the highest such proportion in any of the Common Market countries and in fact exceeded any other similar proportion by several percent.

Table 7

DISTRIBUTION OF SKILLS OF RESEARCH WORKERS IN THE FACULTY OF SCIENCE OF THE UNIVERSITIES OF FRANCE (1957)

Discipline	Total
Mathematics	145
Mechanics	135
Theoretical Physics	30
General Physics	300
Terrestrial Physics	35
Electronics	40
Nuclear Science	125
Chemical Physics	170
Chemistry	465
Bio-chemistry	110
Physiology	95
Zoology	175
General Biology	75
Botany and Plant Physiology	165
Geology	255
Mineralogy	80
TOTALS	2.400

III. RESEARCH AND DEVELOPMENT POLICY IN GERMANY

POLICY

The reforms initiated after the Napoleonic wars are still very evident in the structure of German education and research. In particular, the concept of Wissenschaft, embodying the cross-fertilisation of ideas and emphasis on humanistic as opposed to specialised science, has developed into the major philosophical basis in any planning of German education and research. History as well as physics is Wissenschaft; the entire university budgets as well as the budgets of specialised laboratories are considered under the general heading of Wissenschaft.

The difficulties of separating, for purposes of a comparative study, the various sectors of university activities are compounded in Germany by the non-central Länder structure. The existence and cultural autonomy of the Länder governments is also an historical consequence. It will be seen that the net result is an evident trend toward independent action in academies and research matters. Nevertheless, it is possible to define the responsibilities of the major bodies of authority, even if their inter-relationships are somewhat diffused.

The Basic Law (constitution) of the Federal Republic* guarantees freedom of science, research and teaching. The legislative and the administrative competence in cultural affairs resides, according to the Basic Law, with the single federal states. Therefore, no federal ministry of cultural affairs exists. The cultural departments of the Ministry of the Interior and of the Ministry of Foreign Affairs take care of the cultural tasks belonging to the federal authorities, inside Germany as well as abroad. In addition, the federal government has priority in promoting scientific research within the system of the so-called "concurring legislation", i.e. federal law precedes state law, in this case.

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*West Berlin is included in the following discussion without explicit mention each time.

The Federation discharges the functions devolving upon it with the assistance of the departments for educational affairs in the Federal Ministry of Interior and the Foreign Office. In addition, there is a Cabinet sub-committee for science and research under the chairmanship of the Federal Minister of Interior. All Federal ministries whose work includes the promotion of science and research are members of this committee. Its function is to strengthen the exchange of experience, to coordinate the measures taken by the various ministries for the promotion of science and research and to deal with all research problems insofar as they concern the Federation and are of basic importance. Some of the Federal ministries have special scientific advisory councils to assist them. Some of these are purely advisory bodies which work out the scientific point of view for the general work of the ministries; others deal directly with problems of the promotion of research for the ministry in question and are consulted about the distribution of the available funds (e.g. German Atomic Energy Commission, Commission for Space Research).

Until December 1962, there was no federal ministry coordinating or directing all these activities destined to promote research and science. At that time, however, the title of the Federal Ministry of Atomic Energy was changed to the "Federal Ministry for Scientific Research." At the present time, its two responsibilities lie in the fields of atomic energy and space research. Although it is anticipated that its areas of interest will expand, their scope cannot be delineated at the present time.

The Länder have their own ministries of education with special departments on higher education to discharge the functions devolving upon them. The Standing Committee of Cultural Ministers is another institution at the disposal of the Länder to deal with "matters of educational and cultural policy of more than regional significance in order to achieve a common view-point and purpose and to represent common interests". The plenary assembly of the Committee of Cultural Ministers consists of the eleven Cultural Ministers of the Länder and West Berlin. It meets about every six to eight weeks. Four special

technical committees, among which the Committee on Higher Education is responsible for questions of science and research, work to prepare the decisions of the plenary assembly. The committees are generally composed of the heads of the different special divisions of the ministries of education.

The German Science Council (Wissenschaftsrat):

The organisation in West Germany which has the broadest science planning charter is of most recent origin. The German Science Council was established in 1957 for the purposes of:

a) providing an overall plan for the promotion of science in the Federal German Republic, and thereby coordinate the plans of the Federal Government and the Lander, and to establish within these plans priorities and key programs;

b) to maintain a special list of priority programs on an annual basis;

c) to provide advice to the Federal Government and to the Lander on optimum use and distribution on scientific allocations.

About forty members sit on the German Science Council, some of them being the Culture Ministers of the Länder and the State Secretaries of the Ministries of the Federal Republic. The others are, for the most part, persons eminent in the scientific life, but also holding positions on the Councils of the German Research Association, the Max-Planck Society and the West German Conference of Rectors.

This complex, interlocking system of multi-lateral committee membership characterises the way in which coordination is sought between the many organisations which comprise the science planning structure of the Federal Republic.

The parallel is not exact, but in many ways the functions of the German Science Council resemble those of the Federal Council for Science and Technology in the United States.

In November 1960, the Academic Council presented the first part of its recommendations concerning the development of scientific

university institutions. Since 1961, the Academic Council considers equally the situation of research institutions outside the universities. As for the establishing of the federal and state budgets, the Academic Council has limited its activities to some recommendations concerning particular problems.

The German Research Association (Deutsche Forschungsgemeinschaft):

The German Science Council is a planning organisation. It does not receive nor distribute funds, nor does it operate research institutions, nor maintain contacts with international science. The latter functions are the responsibility of the German Research Association, which actually can be considered the central organisation for research, per se, in the Federal Republic. Although, legally, the German Research Association is not a government organisation but a private association within the terms of the German Civil Code. It is important to note that the German Research Association is by no means the sole source of government research funds or the exclusive agency for national and international contact. Approximate parallel of the German Research Association can be found in the National Science Foundation in the United States.

The principal functions of the German Research Association are to:

a) serve as a source of financial support for specific research projects;

b) to promote and coordinate research;

c) to render advice to the Federal Government and to the Governments of the Lander on specific research problems;

d) to serve as the central point for establishing and maintaining international and scientific contact.

Unlike the National Science Foundation, the German Research Association is not a Government corporation. It is chartered as a non-profit, private organisation under the control of its membership. These are the thirty-two scientific universities of the

Federal Republic of West Germany, the four West German Academies of Sciences and the five major scientific societies and institutes.

The General Meeting of the membership occurs only once a year, to pass upon actual budgets and matters of membership in the subordinate bodies of the German Research Association.

The general membership delegates the day-to-day tasks of the Association to a governing body. On a parallel basis, it and the governing body are assisted by complex committees with different responsibilities but overlapping membership.

The major committees are:

a) the Senate, which is composed of thirty-three men of scientific distinction. As such, the responsibility of the Senate is scientific in nature, but initiates and coordinates research projects;

b) the Board of Trustees is composed for the main part of Senate members, supplemented by representatives of the Federal Government, the Länder and five from the German Donor's Association. Its task is to plan and present the budget to the meeting of the membership;

c) while the Board of Trustees is concerned with general funding, the problems of specific funding and allocation, the decision on whether individual applications are to be granted or refused, are handled by the Main Committee. Again this membership is comprised of selected Senate members, Federal and Länder representatives and from the German Donor's Association.

Since the decisions of the Main Committee must encompass all of Science, they are assisted by twenty-six specialised committees covering 146 special subjects.

Problems of applied research also merit a special Committee on which are represented members of industry, science and those Ministries of the Federal Länder Governments having responsibilities in applied science.

Also, in each university or academy in the Federal Government and in West Berlin, is an appointed representative of the German

Research Association, who serves as a link between his Institution and the sciences.

It will be seen that, although the chartered responsibilities of the German Research Association are not as broad as those of the Germany Science Council, the structure of the Association is such that it is often considered to be the principal or central research organisation in Germany.

The West German Committee of Vice-Chancellors and Principals (Westdeutsche Rektorenkonferenz):

Another autonomous policy body is the West German Committee of Vice-Chancellors and Principals. This is the central organisation for those educational institutions which grant degrees and are of university status. It was founded in 1949, in order to discuss those problems of common concern to all German universities. It collaborates with the Standing Committee of Cultural Ministers consulted on all questions of common concern in academic and scientific developments.

International Relations

The close relations between science in Germany and abroad are characterised by individual contacts between scientists, the collaboration of institutes studying the same or similar projects, visits for special lectures, participation at congresses, study sojourns of different duration, the exchange of papers and documentation, and common research projects. Some institutions, e.g. the German Academic Exchange Service and the Alexander von Humboldt Foundation, dedicate themselves exclusively to international relations. Others, as the German Research Association, the West German Conference of University Rectors, the Max-Planck Society, et cetera, devote a considerable part of their activities to international exchanges.

In non-governmental organisations, the Federal Republic is represented by specialised associations or by central organisations.

This is the case for the International Council of Scientific Unions (I.C.S.U.), of which the German Research Association is a national member. The representation within the fourteen international unions is safeguarded by the concerned specialised association or by the specially constituted national committee. As for the classical and humanist studies, the same is true for the International Council for Philosophy and Humanist Studies (I.C.P.H.S.).

Academic contacts within intergovernmental agreements are assumed by way of the divers federal ministries, e.g.

with the OECD	through the Federal Ministry of Economics which is advised on questions in connection with the Committee for Scientific Research (CSR) by the Deutsche Forschungsgemeinschaft;
with UNESCO and NATO	through the Foreign Office for whose advice and assistance there is a Cabinet sub-committee. Its meetings are attended by the Standing Committee of Ministers of Education and also from time to time by representatives of the autonomous organizations and the Wissenschaftsrat;
with the Council of Europe and the European Conference of Ministers of Education.	through the Foreign Office together with the Standing Committee of Ministers of Education.

PUBLIC ORGANISATIONS

The Universities:

The university and technical school structure dominates the German research scene. These institutions total:

18 universities
8 technical universities and colleges
1 school of mining
1 school of medicine
1 school of veterinary medicine
1 school of agriculture
1 school of economics
5 schools of philosophy and theology

(In addition, the churches, as corporate bodies under public law, operate a number of schools of theology. There are no private universities in the Federal Republic. The academic and scientific institutions promote equally research and teaching. They are institutions under public law, administrated autonomously by the academic body. The Federal States are their financial supporters. Some of the academic institutions are partly supported by the municipalities. The Science Council, which is about to work out a general plan for the promotion of sciences and research, recommends the foundation of new universities and schools of medicine.)

Federal Research Institutes and Other Federal and State Research Institutes:

Federal Research Institutes, i.e. institutes maintained as institutions of the Federal Government, are found under the aegis of:

The Federal Minister of the Interior
The Federal Minister of Economic Affairs
The Federal Minister of Food, Agriculture & Forestry
The Federal Minister of Traffic & Transports
The Federal Minister of Labour

The Federal Research Institutes are serving research, but are also concerned with practical experimentation and problems of measurement.

One of the most influential of these institutes, which corresponds to the "Bureau of Standards" which exist in almost every country, is the Federal Physico-Technical Research Institute. This is under the jurisdiction of the Federal Minister for Economic Affairs. Its particular responsibility is that of maintaining, preserving and defining units of weights and measures. It certifies instrument accuracy, and collaborates closely with professional bodies of German industry.

Most of the other state sponsored institutes, within their own field of responsibility, act in a similar manner. A number of them have beyond this certain missions of sovereignty bestowed upon them by the government, e.g. in the field of food inspection and the examination of means for the preservation of plants. The Federal Research Institutes are lower grade offices of the Federal Ministries. They have differing constitutions: some of them are free in establishing their research programs, others are closely bound to the instructions or the approval of the corresponding Ministry.

It will be seen in the statistical figures that the greater part of the scientific and educational budget of the Federal Republic of Germany is the responsibility of the individual Federal States (Länder). Aside from the research which is conducted in the university, there are also independent scientific institutions maintained by the Länder; these are rarely pure research institutes, most of them being experimental stations.

The nature of the university support is similar to that given in other countries but there is another aspect of Länder supported research which is unique and deserves special notice.

Shortly after World War II, the States recognised the responsibility to support the activities of research institutions whose interests transcended local problems. By means of a State Treaty, which was signed in 1949, at Königstein, on the Taunus, the States of the three Western zones of Germany agreed to support important research on a joint basis. West Berlin joined this Treaty in 1951. The contribution of each signatory to the agreement is based upon a complicated formula relating to income, population and to the actual physical locality of the institution supported.

The major support of Länder funds are so designated, the Max-Planck Society is not the only recipient. Over thirty other supra-regional research groups, including the German Research Association, receive funds through the Königstein Agreement.

While the Königstein Agreement accounts for only approximately 6% of the Länder funds and only about 2% of the total funds expended for research and development in the Federal Republic of Germany, the Agreement fulfills an important need and, like the Donor's Association, emphasises the importance and utility of pooled resources for unrestricted research purposes.

Max-Planck Society For The Promotion of Sciences

Of the organisations which are involved in the actual performance of research in West Germany, the Max-Planck Society for the Promotion of Sciences dominates this scene. In 1961, the Society celebrated its 50th Anniversary, an anniversary which almost coincided with the establishment of the Nobel Awards in Sweden. Indeed, in that half-century the Max-Planck Society has contributed a major share of Nobel laureates. Of the thirty-one German scientists who have received the Award, seventeen have come from the Max-Planck Society or its predecessor institute, the Kaiser Wilhelm Society.

The establishment of the Kaiser Wilhelm Society helped make tradition the principal of freedom from state control in matters of conduct of basic research. There was also another fundamental aim, to free the researcher from university pedagogical and administrative responsibilities. The Society is a private organisation, which belongs to neither the government, the Länder, nor industry, but does receive substantial financial support from each.

The Kaiser Wilhelm Society was dissolved in the Spring of 1946 by the Allied Control Commission, and was reconstituted in 1948 under the name of one of its most illustrious personalities, who had died the previous year. The direction of the previous institutions of the Kaiser Wilhelm Society was assumed, as well as the responsibility for several other old and new institutions. Today the Society operates well over forty separate institutes in the Federal Republic and in West Berlin. Some of these institutes contain sections of considerable individual autonomy. Considering

these in a total count, the Max-Planck Society would comprise well over eighty autonomous or semi-autonomous research units. Staff totals some three thousand persons, of which approximately one-third are scientists.

The directors of the institutes are men of considerable attainment and distinction in their fields. As might be expected, it is extremely difficult for the Society to allocate budget sums among the numerous institutes when the great majority of research projects are of a deserving nature, and backed by scientists of eminence. Nevertheless, a highly complicated, but apparently successful, procedure has been arrived at to make an equitable distribution. Three-quarters of the total funds themselves are obtained from the Federal and Länder governments. The receipt of the Federal funds is of recent origin, since 1956. They amount to perhaps 20% of the Länder funds and their use is restricted to certain specific areas which advance the employment capacity of the institutes, contribute to scientific training and advance the international relationships of science. The greatest fraction of the rest of the income comes from private donations, but in addition to these, the institutes receive substantial but unspecified aid frequently in the form of free buildings, rooms, utilities and other facilities from the communities in which they are located.

Other Institutes With Public Support:

In addition to the already mentioned research institutions, there are some institutes supported by municipalities or semi-public institutions (chambers of agriculture); their number is small.

The four academies of science in Göttingen, Munich, Heidelberg, and Mainz (order of their foundation) are corporate bodies under public law; except for some occasional subsidies given by federal authorities in recent time, they are financed by the states. According to the statutes of one of the academies, their

task is "to promote science and research and to stimulate and to support scientific studies". The academies do not have institutes of their own, but they sponsor some organisations and long-term projects.

PRIVATELY SUPPORTED RESEARCH

Privately supported research institutes in the Federal Republic are to be found mainly in the sphere of industry. Three types must be distinguished:

a) Research within the plants - research institutes of individual firms: A number of big enterprises run research departments and laboratories of their own. Examples are given mainly by big firms of the chemical, electrical, optical and steel industries. These expenses for research as well as the results of that research are only partly published.

b) Joint industrial research and associational research: In divers branches, mainly medium-sized and small firms, which cannot afford a large-style research program of their own, have founded research associations.

The largest of these is the Association of Industrial Research Organisations (Arbeitsgemeinschaft Industrieller Forschungsvereinigungen - A.I.F.). The A.I.F. was created in 1954 by the Federal Ministry of Economics. It is a non-profit organisation and has among its aims the effecting of cooperation and coordination between the research organisations comprising its membership, the exchange of experience and know-how, to advise industry and to make it research-minded and to maintain contacts with Government organisations. Presently, some sixty research organisations have A,I.F. membership. The aims and functions of the sixty organisations are described in detail in a publication issued by the A.I.F.

Three-fourths of the operating funds of the A.I.F. are contributed by industry; the remainder is publically funded. The entire sums are distributed among numerous laboratories, for

example in 1961 the A.I.F. supported 190 research projects, of which seventy-seven were carried out in laboratories under A.I.F. control, sixty-seven in universities or other institutions of higher learning, 25 in state or Federal or Max-Planck Institutes, and twenty-one in other institutes. Altogether, this represents the distribution of funds to ninety-seven individual institutes.

c) Contractual research at small institutes: There exists a few small institutes supported by sponsored groups or individuals. Their fields of interest are narrow. Some of them are actually run at a profit by selling specialised products or by inspection activities.

Institutional, personal, and financial connections may exist between research institutes supported by public or by private organisms.

The industries often prefer that their institutes be in close contact with the universities; these institutes, founded within a university frame-work, are legally independent, but are bound to the university in all that concerns research and training of scientists. These institutional connections imply close personal contacts. Very often the director of an industrial research institute teaches within the university; in some cases the director of a university institute directs simultaneously a research institute financed by the industry.

Financial connections are given by contractual research. The industry delegates to university institutes' research projects which cannot be pursued in industrial institutes, or only at great expense. Besides that, industry sponsors the universities as training centers for its own coming generations of technical and scientific personnel.

Researchers from private and public institutes collaborate in diverse organisations supporting and sponsoring science and academic research. Continuous liaison is maintained with the Wissenschaftsrat, Deutsch Forschungsgemeinschaft and with other Federal organisms, such as the Federal Ministry for Scientific Research.

The Donor's Association for German Science (Stifterverband für die Deutsche Wissenschaft):

While German industry performs a great deal of private research and development, it maintains and fosters contact with the main body of German R & D by participation in the Donor's Association for German Science. Like the German Research Association, the Donor's Association is also a non-profit organisation. Its governing body comprises a hundred representatives of its membership. Its Board of Trustees is composed of representatives of the German Industrial Association, the German Research Association and the Max-Planck Society.

The Donor's Association is supported in its entirety by funds from industry, funds which are used for the general promotion of general sciences, without any restriction on the way they may use it. Thus, the funds are distributed principally to the German Research Association, to the Max-Planck Society, and to various foundations and the local academies of sciences. As is the case for the German Research Association, the Donor's Association does not actually participate in research activities. It is also an advisory body and carries out public relations tasks in order to foster closer relationship between industry and the scientific institutions of the country.

Although the Donor's Association has no official relationship with the Government, it does appeal to the Government for further increases in public funds for the promotion of sciences and education, and takes on such special tasks as the problem of treating donations for the promotion of science as tax exemptions.

As a means for channeling industrial funds into non-industrial research, the Donor's Association serves a unique role.

Foundations:

The Alexander von Humboldt Foundation, founded in 1925, enables foreign scholars to receive German Academic training. It remains an effective means for effecting international academic exchanges. The other foundations which support academic and

scientific work in the Federal Republic have only been created in recent years and their effects remain to be seen.

The first such organisation is the Thyssen Foundation, with headquarters in Cologne, which began its work in 1960. It presently operates on a yearly budget of about 12 million D.M. The Foundation sponsors short-term individual research projects in the arts, natural sciences and medical research, as well as broader scientific investigation. There is emphasis on the younger generation of scientists and scholars, but this aspect is more or less kept in balance with the support of research projects.

It is particularly interested in the problem of scientific cooperation of German universities with other universities in Europe and elsewhere, and coordinates its programs with those of other organisations in Germany having similar aims.

The Volkswagenwerk Foundation has just begun to make allocations from a yearly income of approximately 75 million D.M. Operating from Hanover, the Volkswagenwerk Foundation will allocate 25% of its budget to the States of the German Federal Republic to be used at their discretion. The remainder will be distributed by the Foundation on a supra-regional basis.

FINANCIAL AND MANPOWER RESOURCES

Public Funds

The Statistical Directorate (Statistisches Bundesamt, Wiesbaden) had formed in 1960 a committee to solve the problem of a census of West Germany's scientific resources, but the data will not be forthcoming for a considerable period. The best available data, therefore, is derived from the Federal and State budgets and from the individual researches of the Stifterverband and Wissenschaftsrat.

Researchers and collaborators receive financial support in two different ways:

i) by regular contributions from the supporting organisations (the institutes' budgets)

ii) special means from the supporting and from other organisations (so-called "contributions from third side")

In recent years, the budgets of the university institutes could often cover only the costs of teaching and general operation, and a small fraction of the expenses for research. The realisation of the Wissenschaftrat's suggestions is beginning to redress this situation. The budgets of the Max-Planck Institutes and of the Federal Research Institutes are characterised by richer means for research programs; for particularly expensive projects they, too, depend upon extra aid.

The budgets of the state institutes are normally limited to teaching and to experimental efforts; they allow only few research projects. The privately-supported institutes generally obtain their necessary means without difficulties, at least in so far as they belong to industrial associations or important enterprises. Besides, these organisations there exist smaller private institutes and individual researchers without regular incomes; their possibilities are more limited.

Contributions from third side or supplementary support may come from the following sources:

i) the German Association for Research, giving subsidies, scholarships and temporary lectureships in all disciplines

ii) the Federal Ministries

iii) the diverse Ministries of the Federal States, the State boards for research, and the State-supported research cooperatives

iv) the foundations, e.g. the newly created Frist Thyssen Foundation and the Volkswagen Foundation

v) industry and commerce, giving research orders or agreeing on contractual research

In one of the Federal States, an official lottery is used to promote research studies.

Scholarships for studies abroad are given, e.g. by the German Academic Exchange Service; travel grants for the U.S.A.

are given by the Fulbright Commission. There is also a certain flow of money from foreign foundations and organisations into research institutions in the Federal Republic.

Table 8

FINANCING OF HIGHER EDUCATION (Includes Federal, State and Municipal Funds) (Millions of D.M.) 1949 - 1959

Year	Universities (without clinics)	University Clinics	Institutes of Technology	Total Higher Ed. Budget
1949	129.7	118.0	55.9	303.6
1950	143.0	127.1	59.7	329.8
1951	166.5	153.0	70.6	390.1
1952	206.2	187.0	86.4	479.6
1953	218.9	231.3	98.8	549.0
1954	260.6	254.1	113.9	628.6
1955	277.8	280.9	125.3	684.0
1956	322.1	309.3	145.8	777.2
1957	377.9	358.0	175.6	911.5
1958	456.2	415.2	215.2	1.086.6
1959	501.2	495.0	235.9	1.232.1

Table 9a

FEDERAL EXPENDITURES FOR SCIENCE AND RESEARCH 1955 - 1961

(Millions of DM)

	1955	1956	1957	1958	1959	1960	1961*
1. Defense							
a) Research	-	0.8	9.9	13.1	21.9	40.8**	24.7
b) Development	-	7.9	17.3	86.5	101.8	257.9**	267.8
c) Testing	-	0.4	4.6	11.6	26.2	51.3**	57.5
Total 1	0.8	9.1	31.8	111.2	149.9	350.0**	350.0
2. Science & Research (without defense)							
a) Specific University Contracts	0.4	9.4	34.2	69.9	96.0		
b) Other	101.7	152.4	271.3	357.6	394.5	not specified	
Total 2	102.1	161.8	305.5	427.5	490.5	431.5***	782.0
Grand Total	102.9	170.9	337.3	436.7	540.4		1,132.0

*Estimated
**12 months
*** 9 months

SOURCE: Data of the Office of the Wissenschaftsrat, Document of 1/26/62.
"Wissenschaft in Daten," Table 104.
"Die Ausgaben von Bund, Ländern und Gemeinden für Hochschulen und sonstige Wissenschaft."

Table 9b

LÄNDER EXPENDITURES FOR SCIENCE AND RESEARCH 1955 - 1959

(Millions of DM)

	1955	1956	1957	1958	1959
1. Institutions of Higher Education	443.8	499.3	560.9	655.5	732.1
2. Other	92.0	137.5	132.0	159.4	210.2
Total	535.8	636.8	692.9	814.9	942.3

Table 10a

RECEIPTS OF THE DEUTSCHE FORSCHUNGSGEMEINSCHAFT 1949-1961
(in DM)

Year	State	Federal	Industry	Miscellaneous	Total
1949	1,989,000	--	--	684,765	2,673,765
1950	3,567,000	1,500,000	754,500	4,113,774	9,935,274
1951	5,000,000	1,920,040	636,200	1,509,073	9,065,313
1952	6,000,000	2,400,000	1,024,170	2,203,666	11,627,836
1953	6,000,000	9,750,000	1,348,060	1,751,043	18,849,103
1954	6,500,000	13,580,000	1,960,788	124,063	22,164,851
1955	6,500,000	14,900,000	2,246,300	1,021,627	24,667,927
1956	8,000,000	29,600,000	3,645,000	1,891,973	43,136,973
1957	8,000,000	46,283,578	5,210,859	2,109,424	61,603,861
1958	8,500,000	48,426,102	5,660,000	2,288,432	64,874,534
1959	9,000,000	56,309,094	6,640,000	3,367,265	75,316,359
1960	7,500,000	32,000,000	9,858,935	1,983,470	51,342,405
1961	12,000,000	42,521,190	10,200,000	2,850,500	67,571,690

9 months

Table 10b

DISTRIBUTION OF FORSCHUNGSGEMEINSCHAFT FUNDS BY DISCIPLINE
(in percent)

(not including funds for electronic computors and technical libraries)

Year	Humanities	Medical	Natural Sciences	Engineering Sciences	Agricultural Sciences	Diversa
1953	16	15	41	13	15	
1954	20	16	35	15	14	
1955	16	15	48	12	9	
1956	15	15	45	14	11	
1957	17	19	35	15	14	
1958	17	16	35	14	10	8
1959	15	15	46	13	9	2
1960	16	15	41	18	10	
1961	17	17	41	16	9	

Source: Annual reports of the Deutsche Forschungsgemeinschaft. Franz Steiner Verlag Wiesbaden.

Table 11

FUNDING OF THE STIFTERVERBAND 1950 - 1960

(in DM)

Year	Contributions received	Amounts turned over to Forschungsgemeinschaft x)
1950	1,372,818.34	525,000.00
1951	3,332,957.33	775,000.00
1952	3,908,421.87	1,002,000.00
1953	6,098,210.23	1,564,916.30
1954	8,470,091.25	1,600,000.00
1955	11,388,963.23	2,355,790.67
1956	13,880,379.99	3,999,344.40
1957	17,240,749.26	6,334,469.21
1958	19,715,379.84	7,650,625.10
1959	20,987,088.27	8,581,432.65
1960	26,088,739.95	10,835,000.00
1961	28,535,270.66	13,168,000.00
Total	161,019,070.22	58,391,578.33

x) In comparing with Table 10a, it must be noted that special Stifterverband donations are listed in part under "Miscellaneous".

Source: regular publications by the Stifterverband;
most recent publication: Wirtschaft und Wissenschaft, No. 47/1962.

Approximately one-third of the Stifterverband funds are given to the Forschungsgemeinschaft. This represents, on the average, about 70% of the annual income of the non-committed donations received by the Stifterverband. Another 10% of non-committed funds was turned over to the Max-Planck-Gesellschaft. For the development of future scientific manpower approximately DM 9,5 million were made available by the Stifterverband between 1950 and 1959, to various scientific, educational and exchange organizations.

Table 12

THE BUDGET OF THE ORGANIZATION OF INDUSTRIAL RESEARCH ASSOCIATIONS (AIF)

(Millions of DM)

Year	Industry Funds	Public Funds	Total
1957	22.37	8.10	30.47
1958	25.60	11.25	36.85
1959	28.83	11.91	40.74
1960[x]	29.10	10.12	39.22
1961	29.85	13.13	42.98
1962[xx]	33.6	16.5	50.1

x The fiscal year was changed to correspond to the calendar year. These figures therefore represent less than a full year.

xx Estimated

Source: the final annual reports of the Arbeitsgemeinschaft Industrieller Forschungsvereinigungen (AIF), Cologne (according to information from the headquarters).

For 1958-1961, see "Wissenschaft in Daten", Table 126.

Table 13

EXPENDITURES BY BUSINESS AND INDUSTRY FOR SCIENCE

(Millions of DM)

Year	Donations to Research, Teaching and Education	Research and Development by Industry*
1948/49	11	200[xx]
1950	15	200[xx]
1951	25	200[xx]
1952	30	300[xx]
1953	31	400[xx]
1954	34	400[xx]
1955	38	600[xx]
1956	44	792
1957	49	942
1958	51	1,055
1959	53	1,360
1960	59	1,600
1961	67	1,900
Total	507	9,949

x including contract and co-operative research

xx estimated

Manpower

Although the Wissenschaftsrat has conducted a detailed census of faculty, and has projected the manpower demands of the universities and institutes of technology, figures for scientific personnel in Germany do not exist, neither in detail nor in sum total. Nevertheless, the data which does exist is sufficient to indicate serious shortages in teaching staff and graduates.

Fortunately, for technical resources, some data is available to indicate emphasis on the various disciplinary skills. These are presented in Table 14. The presentation involves two categories of graduates from:

a) Technological Institutes (Technische Hochschulen). Thirteen years of study in primary and secondary school, and four to five years in a technological institute terminates in the award of "Diplom-Ingenieur". Further study can result in the award of "Doktor-Ingenieur".

b) Engineering Schools. These are operated mainly by the Länder or local authorities. Normally, a student is qualified to enter after graduation from ten years of primary and secondary school, and serving a two-year apprenticeship. These "higher technicians" receive their degrees in three years.

With a total 1956 labour force of 25,389,000 persons, it will be seen that advanced engineering degrees are held by 0.3%. The total number of engineering graduates comprises some 1% of the labour force.

Table 14

EXISTING NUMBER OF ENGINEERS AND HIGHER TECHNICIANS - 1956

Professional Group	Technological Institute Degrees	"Higher Technicians"	Total both type degrees
Mechanical Engineers	16,074	51,285	67,359
Electrical Engineers	11,754	24,474	36,228
Mining & Metallurgy	3,978	14,364	18,342
Architecture	16,300	37,221	53,521
Civil Engineers	12,173	28,644	40,817
Surveying	2,461	6,077	8,538
Naval Engineers	90	7,234	7,324
Aeronautics	231	355	586
Chemical Engineers	5,968	4,026	9,994
Others	5,712	15,996	21,708
Total	74,741	189,676	264,417

SYNTHESIS OF DATA

At least two factors make synthesis of German research and development data very difficult. These are:

a) the extreme amount of overlap of funding between the originators (i.e., the Federal, the Länder, the municipalities, industry and other sources) and the recipients (i. e., the universities, the special laboratories, the Forschungsgemeinschaft, the Stifterverband, et cetera) and

b) the definition of what constitutes "Wissenschaft" and what is considered "science" in other countries.

Consequently, the collated figures of an existing Stifterverband study have been used.*

Year	Total (Millions DM)	G.N.P. (Millions DM)	Ratio
1956	1644	1964	0.84%
1957	2020	2136	0.95%
1958	2439	2282	1.07%
1959	3022	2470	1.22%

With a 1959 population 52,785,000, the per capita expenditure in research and development was 57.5 DM.

Note that, during the period 1956 to 1959, the Gross National Product grew by 26%. The research and development expenditure experienced a growth of 84%.

*These are derived from "Zehn Jahre Stifterverband 1949-1959", p. 59. See also "Forschung -eine Einheit" by Prof. Dr. Richard Vieweg Braunschweig, Der Wolkswirt, no. 46, vol. 12, November 1960, pages 9-14.

REFERENCES

Much valuable data was obtained by conversation and private communication with members of the Stifterverband, Forschungsgemeinschaft, Wissenschaftsrat and otheroofficial and semi-official organisations in Germany. Especially helpful was data provided in communications from Dr. von Massow of the Forschungsgemeinschaft, Dr. Maccario of the Stifterverband, and Dr. Heim of the Wissenschafsrat.

The Stifterverband, particularly, has an important publication program and its documents, not only on German but on world science, are of great interest.

Publications of major importance to this study were:

1) Deutsche Forschungsgemeinschaft, "Aufbau and Aufgaben", Vierte Auflage 1960, Wiesbaden

2) Stifterverband für die Deutsche Wissenschaft, "Weltverbundenheit der Wissenschaft", Jahrbuch 1959

3) "Taschenbuch für das Wissenschaftliche Leben", Stifterverband für die Deutsche Wissenschaft, 1961

4) "Scientific and Academic Life in Western Germany", Stifterverband für die Deutsche Wissenschaft,1957

5) Aufgaben und Finanzierung", Deutsche Forschungsgemeinschaft, Wiesbaden, 1961

6) "Zehn Jahre Stifterverband 1949-1959", Stifterverband für die Deutsche Wissenschaft

7) "Existing Number and Future Demand of Engineering Manpower in Western-Germany", by Professor A. Rucker, Bonn, 1958

8) "Empfehlungen des Wissenschaftsrates zum Ausbau der Wissenschaftlichen Einrichtungen", Teil 1 Wissenschaftliche Hochschulen, November 1960

IV. RESEARCH AND DEVELOPMENT IN ITALY

POLICY

Italy's time-honoured scientific traditions and her contributions to world knowledge are well-known. These were developed in one of the oldest university structures in the world, which today remains the main force for future scientific contribution. But it is only recently that an awareness of research and development has developed in other sectors of the culture, in industry and in government. Probably nowhere else in the European Economic Community is there as great an opportunity for overall effective planning in research and development as there is in Italy.

In August 1962 the Italian Council of Ministers approved a Bill on the Organisation and Planning of Scientific Research. The 1962 Bill provides that these responsibilities be shared by the Inter-ministerial Committee for Reconstruction (C.I.R.) and the National Research Council. Since the C.I.R. would also be in charge of general economic planning, this action represents an attempt to integrate scientific research with the overall needs of the country.

The Bill also envisages that the members of the C.N.R. Committees shall be increased in number from seventy-two to one hundred twenty. Much of this increase will result from an expanded interest in the humanistic sciences. Another feature of the draft law is that, starting in 1963/64, all sums expended by ministries for scientific research will be fully identified in a single budget item.

Of the sum total of forty universities, twelve possess engineering faculties and twenty-two faculties for the natural sciences. In most of these, the laboratory and even the actual lecture rooms are inadequate. Thus, those research and development problems connected with the university are closely related to reforms which must be undertaken in the entire structure of the higher education system.

In 1923, the National Research Council (C.N.R.) was established. It has become the principal organisation for encouraging research in Italy, although in terms of funding, its budget represents only about

5% of the total national R & D expenditures. It can be said that the C.N.R., until 1961, was not able to develop, even within the limits of its modest budget, an appropriate research policy. It essentially reacted to outside demands from the university institutes. Beginning in 1961, increased funds became available and a policy began to be based not simply on answering requests for funds but on resolving questions of appropriate areas of research.

The C.N.R. assumes the State responsibilities for:

a) the coordination of national activities in the various branches of science and their application

b) to contribute to the financing of scientific laboratories

c) to elaborate on research programs of general interest

d) to support the publication and dissemination of scientific literature

e) to organise scientific congresses and colloquia of national and international interest

f) to represent Italy in international scientific negotiations

The seventy-two members of the National Research Council represent, for the most part, university life in Italy, but twenty members are nominated by government organisations. Members of the Council are divided into seven Committees:

a) Mathematical Science
b) Physics
c) Mechanical Engineering
d) Medical Sciences and Biology
e) Chemistry
f) Agriculture
g) Geology and Mineralogy

It is the task of each Committee to prepare a program of research and advise upon financial allocation. These funds accrue to some ninety study centers attached to universities, museums, hospitals, observatories and, in some instances, to the laboratories of private industries. It is important to note that C.N.R. remains a funding and policy group rather than a prime performer of research and development.

It is interesting that, except for the creation of an atomic energy research and development structure, there were no basic reforms relating to research and development from the early 1920's until 1962.

PUBLIC ORGANISATIONS

Universities

The Italian university remains the main seat for scientific research and, within the university, the main research body is the system of university research institutes. It should be noted that the oldest university in Euorpe is the University of Parma which was established in 1065. The University of Parma has a faculty of natural sciences, as do each of the following universities: Bari, Bologna, Ferrara, Cagliari, Camerino, Catania, Florence, Genoa, Messina, Milan, Modena, Naples, Padua, Palermo, Pavia, Perugia, Pisa, Rome, Trieste, Turin. In addition to the research conducted by these academic bodies, research is conducted at polytechnical colleges associated with the universities.

The financing of most of the institutes is, in theory, under the administrative control of the university. The university has the right to retain for the benefit of the entire university a certain percentage (generally 10%) of research appropriations which an institute might receive from outside sources. However, in order to retain the total appropriation, a significant amount of the funding of the institutes finds its way without passing through the control of the university administration.

This is one of several reasons, relating to the difficult appropriation situation, that official budgets of the university institutes do not reflect the true research and development budgets. And, aside from the difficulties presented in attempting to assemble a statistical picture, the overall situation attests to the existence of certain serious policy difficulties in the funding and performance of research and development in Italian universities.

State and State-supported Research Institutes

While the university remains the principal performer of research

and development in Italy, the role of the National Committee for Nuclear Energy (C.N.E.N.) is becoming increasingly important. The C.N.E.N. was established by law in August 1960 on the basis of the pre-existing provisional organisation, the National Committee for Nuclear Research (C.N.R.N.).

The C.N.R.N. had no guaranteed funds and, as it grew and established enterprises and contracts, financial crises became more frequent. However, this situation has recently been rectified by a public law guaranteeing the C.N.E.N. definite substantial resources for a five-year period.

The statutory tasks of the C.N.E.N. are similar to those of any major atomic energy commission. They are mainly concerned with the nuclear effort, but there is within the C.N.E.N. a growing realisation of the necessity of planning nuclear research projects in harmony with a more general national research and development plan.

Ministries

Most of the ministries have their major research institutes and stations. For example, the Higher Institute of Health under the Ministry of Health has institutes dealing with pharmaceutical and medical biological research. Some of these are operated in connection with research centers of the C.N.E.N.

The Ministry of Agriculture controls quite a number of research stations or laboratories. The extent of the research interests of the Ministry is indicated by the following listing of research institutes:

a) Agricultural chemistry for soil study and protection 15

b) Genetic improvement and cultivation of herbaceous plants. 26

c) Genetic improvement and cultivation of arboreal plants 14

d) Genetic improvement and breeding of livestock. 8

e) Protection of plants (against disease and adverse conditions). 7

f) Agricultural industries. 12

g) Agricultural mechanisation 3

It is interesting to note that, despite the large number of institutes under the Ministry of Agriculture, their financial resources are only about one-third of those of the Higher Institute of Health.

The Ministry of Industry and Commerce controls some twenty Experimental Stations for Industry. These stations have the task of promoting technology in industry and of responding to specific enquiries. Besides the funds which are granted from State sources, a substantial amount is derived from industries and from an allocation of customs tariffs from import trade involving products of interest to the individual institutes.

Chambers of Commerce and local organisations also contribute.

There are eight Experimental Stations for Industry:

a) for cellulose, paper and for textile, plant and artificial fibres
b) for silk
c) for the oil and fat industries
d) for food preservation industries
e) for the leather and tanning materials industries
f) for the industries of extracts and byproducts of citrus fruits
g) for fuels
h) for glass

There is a Higher Institute of Communications supported by the Ministry of Post and Telegraph, an Experimental Institute of the State Railways which is under the Ministry of Transportation, and an Experimental Tobacco Institute under the Ministry of Finance. These institutes and others have their specialised functions to fulfil needs of the individual ministries. The Ministry of Defence also has its specialised institutes, the funds for these being of similar magnitude as the funding dispensed by the C.N.R.

PRIVATE RESEARCH

In addition to the services available to industry through contract with the universities and through the experimental stations of the Ministry of Industry and Commerce, most of the large industries

in Italy maintain extensive research facilities. It should be noted, however, that many of the laboratories, which industry categorises as research facilities, would more accurately have to be regarded as quality control laboratories and would not be considered research facilities in the statistics of some other countries. There is, however, only the beginning of a government effort to analyse the problems of industrial research.

The problem of establishing a reasonable research and development plan in industry has only recently been attacked. In 1957, the C.N.R. created a Commission for Industrial Research, headquartered in the industrial capital of Milan. The Commission comprises some twenty members, three-quarters of them from industry and the remainder from the universities. The Commission has conducted initial enquiries into the problems of encouraging and disseminating research among the small industrial concerns of Italy. This is a natural problem for Italian industry for it is dominated by a relatively small number of large concerns. Each of these is self-contained and engages in rather large research activities. But research in the smaller industries is almost totally lacking. A partial solution to this problem is perhaps the encouragement of cooperative research organisations for the smaller industries.

Quite recently, the National Council of Economy and Labour (C.N.E.L.) has established a high-level Committee on Scientific Research, but its activities are still in the process of organisation and orientation.

At other semi-government and private levels, there is a wealth of academies, cultural institutions and foundations to encourage science in Italy, in fact over two hundred of them. The oldest and most renowned of them is the Academia Nazionale dei Lincei, successor of an earlier academy founded in Rome in 1603. The Lincei Academy had modest funds for research grants and fellowships, publishes journals, establishes contacts with equivalent scientific organisations in other nations and administers several of the private science foundations. The leading two of the latter are the Feltrinelli

Foundation for students of letters, and the Donegani Foundation for students of the natural sciences.

Table 15

GOVERNMENT SPONSORED RESEARCH

	1958-59 (milliards of lire)	1959-60 (milliards of lire)
1) Universities (scientific institutes)	6.5*	8.0**
2) National Research Council (C.N.R.)	3.1	3.8
3) National Committee for Nuclear Energy (C.N.E.N.)	12.9	14.82
4) Ministry of Health	2.1	2.2
5) Ministry of Agriculture	.8	.8
6) Ministry of Post and Telegraph	.5	.55
7) Ministry of Industry and Commerce	.09	.1
8) Treasury (to Euratom)	1.2	1.2
9) Ministry of Defence	3.45	4.6
Totals	30.64	36.07

*This figure for university research is from the report of Alessandro Quaranta in Una Politica per la Ricerca Scientifica, p. 135

**Estimated. In addition to the regular expenditures for this year, there was an extraordinary 12 milliard lire supplement for scientific equipment. For purposes of comparison it is useful to note that the higher education budget of the Ministry for Public Instruction was in 1959/60, 43.7 milliard lire so that the research and development expenditures in that sector account for less than a fifth of the total.

Table 16a

ASSIGNED FUNDS OF THE C.N.R.

Fiscal Year	Milliards of Lire
1945/46	0.061
1946/47	0.202
1947/48	0.262
1948/49	0.261
1949/50	0.359
1950/51	0.562
1951/52	0.714
1952/53	2.062
1953/54	2.161
1954/55	2.214
1955/56	2.137
1956/57	2.142
1957/58	2.468
1958/59	3.127
1959/60	3.796
1960/61	4.15
1961/62	6.25

Table 16b

RELATIVE DISTRIBUTION OF C.N.R. FUNDS FOR THE PERIOD 1958-1960

Committee	% of Total
Agriculture	13.0
Biology and Medicine	14.0
Chemistry	17.0
Physics	20.5
Geology, Mineralogy, & Oceanography	12.0
Engineering	22.0
Mathematics	1.5
	100.0

Table 17a

BUDGET OF C.N.R.N. AND C.N.E.N.

Fiscal Year	Receipts (milliards of lire)
1952/53	0.952
1953/54	0.325
1954/55	2.082
1955/56	1.55
1956/57	3.604
1957/58	3.435
1958/59	12.797
1959/60 *	10.489 *
1959/60 *	5.-- *
1960/61	20.3
1961/62	25.--
1962/63	20.--
1963/64 *	10.-- *
1963/64 *	15.-- *

*Overlap of five-year plans

Table 17b

RELATIVE DISTRIBUTION OF C.N.E.N. FUNDS FOR THE FIVE-YEAR PERIOD, 1960-64

	Milliards of lire	Percentage of total
Personnel training	3.6	4.5
Fundamental research	22.4	28.0
Geomineral research	4.8	6.0
Applied research	33.6	42.0
Radiobiological research	4.0	5.0
International activities	3.6	4.5
C.N.E.N. administration	8.0	10.0
Totals	80.0	100.0

Table 18

RESEARCH EXPENDITURES IN INDUSTRY

Industrial Sector	(milliards of lire) 1953/54	1958/59*	1959/60*
Food	0.25	0.45	0.5
Paper	0.182	0.275	0.3
Chemical	2.577	6.825	7.5
Building construction & construction materials	0.1	0.2	0.2
Mining	0.143	0.45	0.5
Mechanical	1.785	3.2	3.5
Metallurgical	1.41	2.8	3.2
Textile	1.513	2.6	2.8
Miscellaneous services (electricity, radio and telecommunications)	0.282	0.5	0.5
Totals	8.242	17.3	19.--

* Figures for 1958/59 and 1959/60 are based on extrapolation of data for the year 1953/54 presented by the General Confederation of Italian Industry.

Table 19

TECHNICAL AND SCIENTIFIC EMPLOYMENT BY ECONOMIC SECTORS AND EDUCATIONAL STATUS IN 1959*

Educational Status	Employment (thousands)			
	Agriculture	Industry	Services	Total
Elementary school examination or none	6,483	6,558	3,796	16,837
Junior secondary school examination	74	690	1,036	1,800
Senior secondary school diploma	20	190	731	941
of which:				
science matriculation	2	11	43	56
technical, industrial or agricultural diploma	6	107	218	331
other diplomas	12	72	470	554
University degree	8	49	359	416
of which:				
mathematics, physics, natural science, etc..	2	13	77	92
engineering and agriculture.	2	22	38	62
others	4	14	244	262
Total Employment.	6,585	7,487	5,922	19,994

*Source: ISTAT (Central Statistical Institute), Relevazione delle forze di lavoro. July 20, 1959. Quoted in Trained Manpower Requirements for the Economic Development of Italy: Targets for 1957, a study by SVIMEZ. Rome: Multa Paucis, 1961, p. 59.

SYNTHESIS OF DATA

Unfortunately a year-by-year growth comparison for the Italian research and development statistics is not available. To obtain a probable figure for the year of comparison, 1959, we shall take the average of the Italian fiscal years 1958/59 and 1959/60.

These individual totals will be the sum totals of the expenditures given in Tables 15 and 18, representing the totals for government-sponsored research and industrial research. Also a prorated value over a period of several years for the supplementary expenditure of 12 milliard lire in 1959/60 for scientific equipment must be included.

When all of these factors are taken into consideration an estimated expenditure of 55 milliard lire for 1959 is obtained.

On the basis of a population of 49,052,000, we find a per capita expenditure of 1,120 lire. Also in comparison with the Gross National Product of 17,734 milliard lire, we find that Italy's research and development expenditures amount to three-tenths of one per cent of the Gross National Product.

It is clear that, either on a per capita or on a GNP ratio basis, the research and development effort in Italy is the lowest of any country in the Common Market.

REFERENCES

Gatto, Franco, Organizzazione e sviluppo della ricerca scientifica in Italia, presented at the 1960 conference in Milan on Il Progresso Tecnologico sull'Economia Industriale Italiana (1938-1958). Milano: Multa Paucis, 1960, for the Centro Nazionale di Prevenzione e Difesa Sociale.

La ricerca applicata in Italia: Due indagini, published by the Centro di Ricerche Economiche e Sociali, Instituto di Statistica dell'Universita di Pavia, Pavia, Italy, March 1962.

Trained Manpower Requirements for the Economic Development of Italy: Targets for 1975, a study for SVIMEZ (Association for the industrial development of Southern Italy, Centre for studies on economic development). Rome: Multa Paucis, 1961.

Una Politica per la Ricerca Scientifica. Rome: Edizioni Cinque Lune, 1962.

Especially helpful was data provided in communications from Mr. Umberto Paniccia (through the assistance of Il Mulino, Bologna) and from Mr. Achille Albonetti of the Comitato Nazionale per l'Energia Nucleare.

V. RESEARCH AND DEVELOPMENT IN THE GRAND DUCHY OF LUXEMBOURG

A ministerial decree of December 19, 1962, which amended a decree of November 7, 1960, creating a consultative scientific commission for the Grand Duchy of Luxembourg, provides that the commission be composed of two sections:

a) exact, natural, medical and technical sciences

b) human sciences

At the present time, however, the State Research Fund amounts to only several million Francs Luxembourg. This compares to total National Education, Arts and Science budget of about 400,000,000 F.L.

The large companies support a substantially greater amount of research. For the most part, these are metallurgical companies. Some of them participate in Belgian research centers, particularly the National Center of Metallurgical Research in Liege. The Goodyear Company supports an International Rubber Research Center at Colmar-Berg in the Grand Duchy of Luxembourg. It is impossible to obtain an estimate for total industrial research expenditures. They are estimated to exceed 150,000,000 F.L.

Although there is no university, in the ordinary sense, located in the Grand Duchy of Luxembourg, mention must be made of the International University of Comparative Studies. This institution was founded on 11 April 1957, with the objective of organising international courses for university graduates, so that they might be given orientation in the problems of international collaboration and integration. Fields of study comprise the fields of comparative law and comparative economics.

For the year 1961, the estimated expenditures of the International University were 3,843,855 F.L.

To summarise for the year 1959, using a GNP of 22,482 million francs and a population of 320,000, we find:

R&D expenditures as a percentage of GNP: about 0.7%

R&D expenditures per capita: about 500 F.L.

VI. RESEARCH AND DEVELOPMENT IN THE NETHERLANDS

POLICY

The research and development picture in the Netherlands is a somewhat unique one in the Common Market, because of the presence of certain factors which might be called dominating and saturating. For example, only five major companies provide about 67% of the total industrial research and development in the Netherlands. Indeed, when the entire R & D budget, both public and private is considered, the same five companies account for about 40% of the national budget.

For some time in the Netherlands the problem of specialised personnel for the performance of research had been serious. However, the number of technical and natural science graduates has been increasing significantly in the last several years and this situation is easing. The physical problem of space for students has been alleviated, but is in some areas serious.

While these factors may have led one to expect a slow rate of growth for research and development performance in the Netherlands, it must be said that the organisation and funding of such efforts is already at a significantly high level. Very effective organisations for coordination and encouraging both applied and fundamental research have been in existence for some time.

A major consultative or advisory body is the Royal Netherlands Academy of Sciences and Letters (K.N.A.), founded in 1808. In addition to its responsibilities on an international level, the Royal Academy maintains contacts with other national Academies of Sciences. It has several small research institutions under its administration and also administrates some 20 bequests provided for special scientific purposes.

At a government level, the Ministry of Education, Arts and Sciences has a responsibility for providing the national science funds and contributions to international bodies: other ministries, however, have their financial obligations in this respect. In addition to supporting the Royal Academy, this Ministry funds the State-controlled universities and schools with university status. It also provides

subsidies to the private universities and schools. Although the major body for the promotion of applied science, the T.N.O., is funded by several Ministries, the Ministry of Education, Arts and Sciences administrates them.

The sole higher school which is not funded by the Ministry of Education, Arts and Sciences, is the School of Agriculture which is governed by the Ministry of Agriculture and Fishery. This Ministry also supports a number of smaller agricultural research institutes. Other ministries, such as the Ministry for Economic Affairs, the Ministry for Social Affairs and Public Health and the Ministry of Transport, support institutes appropriate to their particular tasks.

However, all of the above public bodies, and private ones as well, are indebted to the operation of a unique institution for the promotion of applied research, the T.N.O.

PUBLIC ORGANISATIONS

The Universities and Technical Schools

Three universities are financed by the Netherlands Government. They are Leyden, Utrecht and Groningen. Amsterdam has two universities; one belonging to the Municipality and the other a private institution (the Free University of Amsterdam). The other private university is the Catholic University of Nimwegen. It should be noted, however, that the government bears 95% of the cost of all non-government university institutes.

There are also five higher schools with university status. Two of them,at Rotterdam and Tilburg, are concerned with the economic and social sciences. The other three conduct applied research as an adjunct to their pedagogical responsibilities. They are the School of Agriculture at Wageningen, the Delft Technical School and the Eindhoven Technical School. The latter is actually only a few years old, and consideration is currently being given to the establishment of additional technical schools.

Attached to the universities and technical schools are research institutes of world-wide renown. Worthy of particular mention is the

low-temperature (Kamerlingh Onnes) laboratory at Leyden. Practically all of the university research can be classified as fundamental, while the technical schools perform research more oriented to industry. In fact, some industry leaders hold professorships at the technical schools.

In terms of funding, the educational institutions perform some 12% of research and development in the Netherlands.

T.N.O.

The necessity of planning for applied science was discussed, by special permission, in a report submitted to the Netherlands Government in 1925. In 1930 an act was passed to enable the founding of the Netherlands Central Association for Applied Scientific Research (Nederlandse Centrale Organisatievoor Toogepast Natuurwetenschappetisk Onderzoek - T.N.O.). The T.N.O. Act provides for the following tasks:

i) to ensure that applied scientific research be at the service of the community in the most efficient manner

ii) to coordinate applied scientific research

iii) to advise the Ministers, if so requested, or on its own initiative

The T.N.O. is headed by a board, whose members are proposed on an equal basis by the Royal Academy and the Social and Economic Council. Thus, the membership is composed of scientists and economists who consider the tasks of the T.N.O. to be those which are of immediate economic significance to the nation.

Five main Councils of the T.N.O. have been established. They are the National Council for Industrial Research, the National Council for Nutrition and Food Research, the National Council for Agricultural Research, the National Defense Research Council and the National Health Research Council. Each Council has its own special sub-divisions and operates research institutions. But aside from the research which is performed in the research institutions of its own Councils, the T.N.O. plays a major role in the problems of all industrial firms regardless of size, in the Netherlands. For

example, field services are maintained to visit smaller firms and to be available for consultation and advice on a free basis. There is a special fund to stimulate research in the smaller firms, half of the money being supplied by the Ministry of Economic Affairs on advice of the T.N.O. Additionally, the formation of cooperative research associations is encouraged.

Z.W.O.

While the awareness for encouraging and coordinating research was a post World War I phenomenon, the close of World War II brought the realisation that it was necessary to encourage fundamental research is applied research was to be healthily maintained in the long run. Accordingly, a committee to consider this problem was established in 1946, and a 1950 act was passed enabling the creation of a Netherlands Organisation for Fundamental Scientific Research (Zuiver Wetenschappelijk Onderzoek - Z.W.O.).

The tasks of the Z.W.O. are as follows:

i) to promote fundamental research at universities and schools with university status, as well as outside its institutions, by the provision of financial resources and coordination

ii) to fulfill special tasks legally entrusted to the Z.W.O. by the Minister of Education, Arts and Sciences

Thus, the Z.W.O. does not actually administer any research laboratories; it provides encouragement and financial assistance for fundamental research wherever it seems to be advisable. Fellowships and scholarship assistance are provided both on a national and international level. The Z.W.O., of course, maintains close liaison with the T.N.O., the Ministry of Education, Arts and Sciences, the Royal Academy and all other research bodies.

Various other institutes are also helped by Z.W.O. subsidies. Two are the Netherlands Foundation for Radio Astronomy, and the Amsterdam Mathematical Center. The latter is also helped financially by the Municipality and other institutions.

The Foundation for Fundamental Research on Matter (F.O.M.) was

established in 1946 to promote fundamental research on matter. It has its own institutes and coordinates related work in existing institutes. It is especially oriented towards the problems of higher education. Another important fundamental research organisation is the Foundation for Chemical Research (S.O.N.).

Atomic Energy Research

Atomic energy activities in the Netherlands are coordinated through the Reactor Centrum Nederland (R.C.N.) which is a government organisation represented by government, industry, electrical producers and the scientific community. R.C.N. and its principal advisory body, the Nuclear Energy Council, are located in the Hague. There are a number of nuclear research centers, both publicly- and privately-supported, in the Netherlands. The principal one is the Central Reactor Laboratory of R.C.N. at Petten. Actually many of the research activities at Petten are now supported by the Euratom community and it is the second general research center of Euratom, the first having been established at Ispra in Italy.

PRIVATELY SUPPORTED RESEARCH

Five large enterprises perform nearly 70% of the industrial research in the Netherlands. They are:

Philips
The Royal Dutch Petroleum Company (Shell)
Algemene Kunstzyde Uni (A.K.U., Rayon Artificial Fabrics)
The State Mines (Staatsmynen)
Unilever

These constitute the "Big Five" of the Netherlands R & D picture.

For the smaller industries, the T.N.O. has an important role, of course, It encourages and assists in performance of research and development in the smaller enterprises. Many of these enterprises have joined in collective research organisations in such industries as leather, wool, dairy products, brick, et cetera. The research associations have no institutes of their own and, for the most part, contract to the T.N.O. institutes. Generally, it must be mentioned that contract research in the Netherlands is, to the greater part, confined to a relationship with the T.N.O.

FINANCING AND MANPOWER RESOURCES

By far the best research and development survey in the Common Market has been conducted by the Netherlands Central Bureau of Statistics, for the base year 1959. Many of the definitions and techniques of the National Science Foundation of the United States were adapted to the special circumstances existing in the Netherlands.

While much detail is given in the Netherlands report on distribution of funds and manpower among many fields of activities, it must be noted that the detailed spectrum for the Netherlands as a whole is not available; this is due to the fact that the figures for the "Big Five" in Netherlands industry are not available except in gross. Those detailed data are proprietary; consequently, most of the Netherlands tables either group the five companies in one lump statistic, or alternately exclude one or more of them.

Table 20

EXPENDITURES

Summary of Research and Development Expenditures - 1959

	Expenditures and Costs						
	Cost of Research and Development						
	Capital Expenditures			Other Costs in 1959	/Total 1959 Costs	To other Organisations on Account for R&D for 1959	Total Costs in 1959
	1957	1958	1959				
	millions of guilder						
Enterprises:							
Industry	50.9	54.7	60.2	275.6	335.8	31.1	366.9
Others	0.6	0.6	0.6	7.3	8.0	1.2	9.2
Universities and Higher Schools	15.0	18.1	23.9	41.3	65.2	0.3	65.5
T.N.O.	14.9	15.6	19.1	51.4	70.5	3.0	73.5
Other Research Institutes	14.9	20.9	21.6	34.0	55.6	3.8	59.4
Financing Institutes.	0.0	0.0	0.0	0.4	0.4	17.4	17.9
Industrial Corporations	0.0	0.0	0.0	0.2	0.2	4.3	4.4
Total	96.3	109.9	125.4	410.3	535.7	61.1	596.1
Of which was paid to foreign countries	-	-	-	-	-	18.8	18.8

NOTE: There are discrepancies of no more than 0.1 guilder. However, totals are given as in originally reported Netherlands statistics.

Table 21

RESEARCH AND DEVELOPMENT EXPENDITURES AND COSTS IN THE MANUFACTURING INDUSTRY, BY INDUSTRY AND BY THE SIZE OF COMPANY, 1959

Branch of Industry	All Enterprises Together	Total of Expenditures and Costs — Enterprises with a Staff of: 10-24 pers.	25-49 pers.	50-99 pers.	100-199 pers.	200-499 pers.	500-999 pers.	1000 or more pers
1	2	3	4	5	6	7	8	9
				Millions of Guilder				
I. Earthenware,Glass & Stoneware	3.2	0.3	0.3	0.5	0.7	0.4	x	x
II. Diamond	0.4	0.0	0.3	x	x			
III. Graphic Industry	0.5	0.0	0.1	0.1	0.0	0.1	0.2	
IV. Chemical Industry*	35.9	1.2	2.2	4.3	2.3	6.5	x	x
V. Wood,Cork & Straw Industry	1.2	-	0.1	0.2	0.1	0.2	x	x
VI. Clothing Industry	0.5	-	0.0	0.0	0.3	0.1	x	x
VII. Laundries	0.1	0.0	0.0	0.0	0.0	0.0		
VIII. Leather Industry	0.5	0.0	0.0	0.2	0.1	0.0	x	x
IX. Oilcloth & Rubber Industry	2.0	-	0.0	0.3	0.0	0.1	x	x
X. Mining*	1.7	-	-	-	0.0	-	x	x
XI. Metal Indus.,Ship,Aircraft & Coach Bldg.	50.7	2.1	1.8	1.6	3.3	11.7	6.0	24.2
XII. Paper Industry	4.0	-	-	0.2	0.0	2.2	x	x
XIII. Textile Industry*	1.9	-	0.0	0.2	0.1	0.3	0.6	0.7
XIV. Gas, Electricity & Water Works	4.4	0.0	0.0	0.1	0.2	1.0	1.2	1.8
XV. Food, Beverage & Tobacco Manufactory	16.6	0.2	1.5	0.3	0.7	2.0	0.9	11.0
XVI. 5 unclassified large industries	243.2							243.2
All Branches of Industry Together	366.8	3.9	6.4	8.0	8.0	24.6	22.3	293.7

* Excluding one large enterprise. The totals, however, include the excluded enterprise without identification.

Table 22

MANPOWER RESOURCES

Number of Persons with a Higher Technical Professional Training engaged in Research and Development on the 31st December 1959, according to kind of training.

Discipline	Full-Time		Part-Time	
	Scientific Workers	Scientific Assistants	Scientific Workers	Scientific Assistants
Construction Engineering	11	22	7	19
Civil Engineering	13	14	11	17
Mechanical Engineering	367	369	380	165
Managerial Mechanics	3	8	9	11
Mechanical Technology	8	26	24	17
Electrotechnics	118	242	112	53
Managerial Electrotechnics	4	2	-	-
Electronics	10	13	3	14
Shipbuilding	4	2	3	7
Aircraft Design	10	21	2	26
Chemical Technology	173	230	64	49
Chemistry	54	93	67	20
Physical Technology	19	33	3	5
Managerial Economics	-	1	22	4
Geodesy	-	-	1	-
Textile Mechanics	3	-	5	-
Automobile Technology	7	-	16	-
Steel and Concrete Construction	-	2	2	-
Cybernetics	13	11	4	7
Textile Technology	19	29	46	-
Clothing Industry	-	-	3	1
Shoe and Leather Technology	2	3	24	-
Mining	-	1	8	9
Analytical Chemistry	99	475	24	17
Foreman	15	3	39	3
Other Courses	76	236	40	63
Total	1028	1836	919	507

Excluding personnel of universities and higher schools.

Table 23

MANPOWER RESOURCES

Summary of Numbers of Personnel Employed in R&D - 1959

Sectors:	Personnel Employed in R&D in Dec. 1959		
	Total	of which	
		full-time	part-time
Enterprises:		Total	Persons
Industry	17,043	11,306	5,737
Others	6,042 534	448	86
Universities & Higher Schools .	6,494	762	5,732
T.N.O.	4,677	4,319	358
Other Research Institutes . . .	4,617	2,431	2,186
Financing Institutes.	-	-	-
Industrial Corporations	-	-	-
Total	39,407 [1]		

1) Excluding Financing Institutes and Industrial Corporations.

SYNTHESIS OF DATA

It is possible to synthesise the Netherlands data only for the year 1959 and no growth rate can be inferred. It must be said however that, of all the data available in the Common Market, that from the Netherlands is probably to be considered the most accurate.

With a population of 11,346,000 and a total research and development expenditure of 565 million guilder, the expenditure per capita is 49.8 guilder. On the basis of a Gross National Product of 38.7 milliard guilder, the research and development effort of the Netherlands accounts for 1.46% of the Gross National Product.

While, on a per capita basis, this makes the research expenditures quite comparable to those of France and Germany, the ratio to the Gross National Product is significantly higher than for any other country in the Common Market.

REFERENCES

Centraal Bureau Voor de Statistiek. Speur-en ontwikkelingswerk in Nederland 1959. Vol. 1: Onderzoek buiten universiteiten en hogescholen. Uitgeversmaatschappij W. de Haan N.V. Zeist, 1961.

Centraal Bureau Voor de Statistiek. Speur-en ontwikkelingswerk in Nederland 1959. Vol. 2: a. Onderzoek bij universiteiten en hogescholen in Nederland; b. Speur-en ontwikkelingswerk in het Verenigd Koninkrijk, de Verenigde Staten van Amerika en Canada. Uitgeversmaatschappij W. de Haan N.V. Zeist, 1963.

Additional data was obtained in conversations with members of the Central Bureau of Statistics, the T.N.O. and other organisations in the Netherlands.

VII. RESEARCH AND DEVELOPMENT IN THE UNITED KINGDOM

POLICY

The roots of organised science in England were planted in the reign of Charles II, a man whose varied traits included a fondness for science. Although English scientists and philosophers had been meeting for a number of years before that time, it was not until 1660 that a formal obligation was drawn up for an organisation to meet on a regular basis to discuss matters of science. This organisation obtained a corporation charter for the Royal Society in 1662. It was during the same reign (1675) that the first state-supported research project, the Royal Greenwich Conservatory, was established.

Thus the precedents for close governmental relationship with science were set quite early. The Royal Society is an independent, private corporation, but it has always enjoyed a special relationship with the government. In addition to providing a good fraction of the support for activities and projects of the Royal Society, the government benefits from consultation with the President of the Society and from the membership of Society members on governmental advisory councils. Directly and indirectly, the Society has throughout its three hundred years of existence affected science policy in Britain.

Various organisations had been established to consider and support scientific activities of a specialised and general nature, but it was not until the second World War that a Scientific Advisory Committee to the War Cabinet was created with rather wide-reaching obligations in both defence and civilian research. In 1947 this body was replaced by an Advisory Council on Scientific Policy which was to advise the Lord President of the Council on matters of civilian research. A Defence Research Policy Committee was at the same time created to advise the Defence Minister and the Chiefs of Staff.

In October 1959 a Minister for Science was appointed. He represents science in Parliament and in the government and is assisted by a member of the House of Commons known as the Parliamentary

Secretary for Science. The Advisory Council on Scientific Policy is appointed by the Minister for Science and numbers among its representatives eminent scientists from government service, universities and industry. Administratively, his is a small office, but his responsibilities are broad. He is responsible for the activities of the research councils* and the ministerial functions of the atomic energy acts. British policy toward international scientific agencies as well as domestic policies are under his aegis.

Another unique parliamentary mechanism is the Parliamentary and Scientific Committee established in 1939. Membership is open to members of both Houses, and representatives from non-profit organisations are also nominated. With a total membership of several hundred, it provides a mechanism for the exchange of views between the scientific community and Parliament.

The Medical Research Council

The Minister for Science is Chairman of a Committee of the Privy Council for Medical Research. This Committee has the representation of appropriate secretaries of state in the various departments and the Minister of Health and Labour. The Privy Council Committee supervises the Medical Research Council (MRC) composed of members of medical eminence and three lay members.

MRC has broad research responsibilities in the investigation of both long-term and short-term medical problems. It has one large research establishment--the National Institute for Medical Research--and in addition about 70 research units in association with universities.

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*Research Council of the D.S.I.R, Medical Research Council, Agricultural Research Council, Nature Conservancy Council and Overseas Research Council.

The Agricultural Research Council

The Minister for Science is also Chairman of the Privy Council Committee for Agricultural Research. This Committee has as its principal operating body the Agricultural Research Council.

Under control of the Council are twenty-four research stations and units, but in addition to these much of the Council's work is carried out through grants to universities and other research institutions.

The Natural Conservancy Council

As another of his multiple Privy Council Committee chairmanship roles, the Minister for Science has the assistance of the Nature Conservancy Council. Established in 1949, this Council provides scientific advice on the conservation and control of the natural flora and fauna. It carries out its work through a number of research and field stations. Of particular importance is its long-term ecological research which is necessary to preserve some of the limited physical resources of Britain.

Overseas Research Council

The Overseas Research Council is the youngest of those to fall under the general control of the Privy Council Committee. Its establishment in 1959 was an important step toward Commonwealth collaboration in research and development. The O.R.C., which has no funds itself for the support of research, is however the central point for advice in Commonwealth research and development problems.

PUBLIC ORGANISATIONS

Universities

While the foundation of the Royal Society imparts some sort of historical priority to England in the organisation of scientific matters, the pre-existing university structure, as for the other countries of Europe, must be regarded as the root of scientific

endeavour in Britain. There are now twenty-three universities in the United Kingdom. All of them offer courses in science and eighteen have faculties of engineering. In addition to the university structure, there are a large number of technical colleges in the United Kingdom. Since 1956 about twelve of them, which concentrate on advanced teaching and research, have been designated colleges of advanced technology. And the latter are becoming important performers of applied research.

About 70 per cent of the university income is provided by the Chancellor of the Exchequer, and consequently liaison between university and government is close. However, in order to assure that there is no direct governmental control over conduct of university administration, these funds, for all matters including research, are made on the advice of the University Grants Committee. This Committee is appointed by the Chancellor of the Exchequer and has representation of individuals prominent in university affairs. These funds are not earmarked for specific items but the university is free to use them for any form of current expense. Capital expenditures are committed in another manner. The colleges of technology are funded through the Ministry of Education. Funds are also derived from the D.S.I.R., the other government research councils, the Research Associations, directly from various industries, et cetera. As a consequence, although the university is ordinarily regarded as the source of basic research, of the total research conducted in British universities approximately 15% is applied research.

D.S.I.R.

The outbreak of World War I stimulated the creation of a more government-integrated research policy and performance organisation. In 1915 the government established, as responsible to the Privy Council, a Committee for Scientific and Industrial Research. This body was to be assisted by a small Advisory Council composed of men of recognised scientific achievement. The following year,

under the Committee of the Privy Council, a Department of Scientific and Industrial Research (D.S.I.R.) was established as the operating body. In 1956 a Research Council replaced the former Advisory Council as the governing body of the D.S.I.R.

The Research Council, through the D.S.I.R., is charged with tasks of encouraging and supporting scientific research in universities, public and private bodies; of establishing and developing new institutes appropriate to the research demands of trade and industry; and finally of attempting to assure widespread application of the results of research and development in Great Britain. Some fifteen subsidiary national research organisations are utilised to accomplish these tasks.

In addition to its support of the research stations, D.S.I.R. currently is spending £1.5 million for the support of research in universities and several thousand students are recipients of D.S.I.R. research grants. The information services of the D.S.I.R., providing access to the largest collection of Soviet scientific literature in Western Europe as well as normal services, is an important adjunct. D.S.I.R. is largely supported by government funds although approximately 5 per cent is received from industry.

Public Corporations

About 1% of Britain's scientists and engineers are employed in nationalised industries and corporations of which the United Kingdom Atomic Energy Authority represents the largest effort.

Until 1946 nuclear research was the responsibility of the D.S.I.R., this responsibility falling to the Ministry of Supply until 1953. Early in 1954 the Lord President of the Council assumed responsibility (except for weapons production) for atomic energy research. At the same time the United Kingdom Atomic Energy Authority was created. At the present time the ministerial responsibility for this organisation falls under the Minister for Science, except that the Ministry of Aviation

is responsible for development and production of nuclear weapons. There is a Research Policy Committee for the UK AEA whose responsibility is to review the research progress in various establishments and to advise the Authority on problems of expenditure and manpower.

In addition to the research carried out in its various specialised laboratories, the Atomic Energy Authority finances a National Institute for Research in Nuclear Science which is available for joint use by universities and other groups.

Other public corporations conducting research are the National Coal Board, Electricity Council, the British Transport Commission, and the Gas Council. The National Research Development Corporation is also a public corporation but it is discussed in the section on industry, where its influence is more directly felt.

Defence Research

Since some 60 per cent of Britain's research and development, exclusive of undisclosed nuclear weapons research budgets, is funded under a defence budget, the Defence Research Policy Committee has especially important responsibility, not only in respect to their own activities but in the overall conduct of research and development in Great Britain. Actually some 75% of this amount is spent in extramural contracts with British industry.

Additionally the three service departments, the Admiralty, Air Ministry and War Office, operate their appropriate research and development laboratories and units.

INDUSTRIAL RESEARCH

Private industry conducts about 56% of all research in Britain. (It finances almost 30%.) The bulk of this is conducted in the research organisations of the individual firms. Some of these organisations, such as Royal Dutch Shell and Unilever, Ltd, complement in Britain their research organisations in other countries.

Aircraft and missile firms spend the most on research and development. Excluding government contract research, the firm which devotes the most to research in Britain is Imperial Chemical Industries, Ltd (I.C.I.). Its budget accounts for over 5% of the industrial research resources in Britain. Other major performers are Glaxo, Ltd, the British Petroleum Co., the United Steel Co., et cetera.

The R&D effort in the smaller firms is still incommensurate with that of the larger firms. Over 80% of the R&D is conducted within six industries. More than 90% is conducted by those large firms employing over 2,000 persons. About 3% of the industrial research is contracted out.

Risk capital for investment in small research and development firms has been scarce. Recently, however, over thirty insurance firms, banks and investment houses have formed Technical Development Capital, Ltd. This move, and others which may follow, may be evaluated in increasing the research and development effort among smaller firms.

Research Associations

Soon after the D.S.I.R. came into existence Parliament voted a fund of £1 million to be administered by the D.S.I.R. in assisting the formation of Research Associations to serve the varied sectors of British industry. Having survived several difficult periods of financing, organisations and other vicissitudes, the Research Association arrangement now comprises some fifty organisations supported by about twenty-two thousand firms. The total income exceed £7 million, of which about 25% is still contributed by the D.S.I.R. The policy of the latter, however, is to encourage industry to bear an increasing proportion of the total cost. The Research Associations are still supported largely by the large firms, which also support their own and other research and development activities. The smaller firms fail to take the advantage of a Research Association and some two-thirds of the smaller industrial

companies in Great Britain belong to no Research Association.* It is interesting to note that, of the companies which do contract outside research, some 40% of their problems go to Research Associations, 20% to the universities, 15% to the D.S.I.R. laboratories and 25% to various other contract research bodies.

Because each Research Association is tailored to its own industry and reflects the research and development policy, needs and attitudes of that industry, the Associations vary greatly in their characteristics. Most of them have annual incomes of less than £100,000; only one has a budget of over £500,000. Although it is natural that the bulk of research undertaken is of an applied nature, a surprising 28% of the effort is devoted to basic research.** And, although the contribution made by the Research Associations to the overall volume of industrial research is less than 2%, their contributions to British technology have been most significant.

The National Research Development Corporation

Government assistance extends clear through the final development and exploitation phases through the National Research Development Corporation (N.R.D.C.). The N.R.D.C. was established by the Board of Trade in 1949 specifically to exploit inventions originating from any source which would be in the public interest. The revenue of the N.R.D.C. comes from the licensing of inventions and through the borrowing of funds (with a limit of £10 million up to 1968) from the Board of Trade.

There are now some three thousand patents and patent applications in the N.R.D.C. portfolio, and these receive world-wide exploitation.

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*Industrial research in manufacturing industry: 1959-60, a survey of the Federation of British Industries, London: Waterlow & Sons, December 1961, p.15.

**Industrial Research in Britain, R. 4631, a pamphlet prepared by the Reference Division, Central Office of Information, London. Swindon, England: Swindon Press Ltd, 1961.

The N.R.D.C. shares the resulting income with the discoverer or inventor. Some of the well-known products sponsored by the N.R.D.C. have been the development of the towed flexible barges (dracons) for hauling of oil, the hovercraft, a process of treating milk to preserve it for eighteen months or longer, et cetera. Undoubtedly, income to the N.R.D.C. from these and other successful inventions will enable it eventually to become a self-supporting activity.

Table 24a

EXPENDITURE ON RESEARCH AND DEVELOPMENT IN UNITED KINGDOM 1958-59 (in £ million)

Sector of Performance / Source of Funds	Cost of Research and Development carried out in each sector									
	Government									
	Defense	Civil	Research councils	Public corps	Private Industry	Research assns	Univs	Other	Total finance	%
Government										
Defence Depts	88.6	2.9	0.3	--	142.0	--	0.3	0.2	234.3	49.0
Civil depts	0.3	34.7	0.7	0.1	11.7	0.2	16.8	3.4	67.9	14.2
Research councils	--	--	11.1	--	0.1	1.8	1.6	3.0	17.6	3.7
Total	88.9	37.6	12.1	0.1	153.8	2.0	18.7	6.6	319.8	66.9
Public corporations	--	--	--	6.8	0.4	0.4	0.2	--	7.8	1.6
Private industry	5.7	4.5	--	--	112.1	4.0	0.8	8.9	136.0	28.5
Universities	--	--	---	--	--	--	1.5	--	1.5	0.3
Other organisations	8.3	0.8	1.0	--	--	--	2.1	0.5	12.7	2.7
Cost of research and development carried out in each sector	102.9	42.9	13.1	6.9	266.3	6.4	23.3	16.0	477.8	
Percentage	21.6	9.0	2.7	1.4	55.8	1.3	4.8	3.4		

SOURCE: Annual Report of the Advisory Council on Scientific Policy 1959-1960, Cmnd. 1167, pp. 26-27.

NOTE REGARDING UNITED KINGDOM UNIVERSITY RESEARCH*: The university income for the academic year 1958-1959 from public funds was £37,949,036; the income from other sources was £14,324,270, making a total of £52,273,306. (Total expenditures, excluding allocation to research, were £51,526,275.)

In the university expenditures given in Table 24a, awards in the amount of £3.4 million to sustain graduate research students were not included. This amount should be added to the university total and of course to the national total.

Table 24b

SUMMARY OF EXPENDITURE ON SCIENTIFIC RESEARCH AND DEVELOPMENT IN UNITED KINGDOM 1961-62.

(£ million)

Sector providing funds	Sector carrying out work									Total	
	Government										
	Defence	Civil	Research Councils	Technical Colleges	Universities	Research Associations	Public Corporations	Private Industry	Other		%
Government											
Defence departments	84.2	1.1	0.8	0.1	0.4	0.1	1.6	156.8	0.6	247.7	38.7
Civil departments	-	56.5	1.0	2.1	21.3	-	-	19.8	9.4	110.1	17.4
Research councils	-	-	19.5	0.1	3.6	2.1	-	0.1	3.8	29.2	4.6
Total	84.2	57.6	21.3	2.3	25.3	2.2	1.6	176.7	13.8	385.0	60.7
Technical colleges	-	-	-	-	-	-	-	-	-	-	-
Universities	-	-	-	-	1.3	-	-	-	-	1.3	0.2
Public corporations	-	-	-	-	1.1	-	19.8	1.7	0.1	22.7	3.6
Private industry	3.7	3.0	1.0	0.1	0.7	5.9	-	188.8	9.8	213.0	33.6
Other organisations	5.3	1.3	0.7	-	1.6	-	-	0.5	2.6	12.0	1.9
Total cost of research and development carried out in each sector	93.2	61.9	23.0	2.4	30.0	8.1	21.4	367.7	26.3	634.0	
Percentage	14.7	9.8	3.6	0.4	4.7	1.3	3.4	58.0	4.1		100

SOURCE: Annual Report of the Advisory Council on Scientific Policy 1961-1962. Cmnd. 1920 (London: HMSO, January 1963) p. 34.

Table 25

RESEARCH AND DEVELOPMENT EXPENDITURE, 1961/62
(Industrial Establishments with 100 or more Employees)

	Total No. Employed (thous.)	Total Current Expenditure (£ million)	Total Capital Expenditure (£ million)	Qualified R&D Man-power (No.)	Av. Expenditure per Qualified Employee (£ thousand)
Food, drink & tobacco	563	5.9	7.1	981	7.2
Chemicals & allied industries (excluding mineral oil refining)	343	32.8	39.7	6,111	6.5
Mineral oil refining	29	4.8	6.0	763	7.8
Metal manufacture,	528	8.9	10.0	1,563	6.4
of which: iron & steel	413	4.9	5.5	938	5.9
light metals	115	4.0	4.5	625	7.2
Mechanical engineering, shipbuilding & marine engineering (including metal goods not elsewhere specified)	1,368	30.8	33.7	3,583	9.4
Scientific instruments, watches, clocks, etc.	106	8.6	9.2	1,108	8.3
Electrical engineering (excluding electronics)	413	33.1	36.2	3,676	9.8
Electronics	274	46.6	49.9	4,685	10.7
Motor vehicles, cycles, prams, locomotives & railway equipment	432	9.4	9.8	644	15.2
Textiles, leather & leather goods, clothing & footwear	945	7.8	8.7	1,199	7.3
All other mfg industries (excluding aircraft	966	11.0	13.5	1,969	6.9
TOTAL MFG (excluding aircraft)	5,967	199.7	223.8	26,282	8.5
Aircraft	278	137.9	140.6	4,365	32.2
TOTAL MFG	6,245	337.8	364.4	30,647	11.9
Construction	630	1.2	1.5	339	4.3
TOTAL ALL PRIVATE INDUSTRY	6,875	338.8	365.9	30,986	11.8

SOURCE: Annual Report of the Advisory Council on Scientific Policy 1961-1962, Cmnd. 1920 (London: HMSO, January 1963). pp. 36-37.

Table 26

DISTRIBUTION OF QUALIFIED MANPOWER IN THE UNITED KINGDOM
BY SECTORS OF PERFORMANCE -- 1959
(in thousands)

	Scientists	Technologists	Total
Central and local government	8.8	17.2	26.0
Public Corporations	1.1	15.4	16.5
Industry	24.3	52.0	76.3
Education:			
Staff	30.1	5.5	35.6
Postgraduates	4.2	3.0	7.2
Other	3.7	7.7	11.4
TOTAL	72.2	100.8	173.0

SOURCE: The Long-Term Demand for Scientific Manpower, Cmnd. 1490, report of the Advisory Council on Scientific Policy, Committee on Scientific Manpower, Statistics Committee, p. 17.

SYNTHESIS OF DATA

From the Annual Report of the Advisory Council on Scientific Policy 1956-57, an earlier R&D estimate can be obtained. Thus a 2 point growth pattern for the United Kingdom is available.

Table 27

Year	Total (£ million)	GNP* (£ million)	Ratio
1955-56	300.0	20,008	1.5%
1958-59	477.8	23,282	2.05%
1961-62	634.0	-	-

*These are between-year averages taken from the yearly data reported in the United Nations Yearbook of National Accounts Statistics.

For comparative purposes, in this report an interpolated total of L520 million is taken as the U.K. R&D expenditure for 1959.

Thus, while in a three-year period the Gross National Product of the United Kingdom has increased by 16%, the rate of increase in R&D expenditure was severalfold that amount, corresponding to the pattern observed in the Common Market and in the United States.

REFERENCES

Annual Report of the Advisory Council on Scientific Policy, 1959-1960, Cmnd. 1167. London: HMSO, 1960.

Annual Report of the Advisory Council on Scientific Policy, 1961-1962, Cmnd. 1920. London: HMSO, January 1963.

Industrial Research and Development Expenditure, 1958, report of the Department of Scientific and Industrial Research. London: HMSO, 1960.

Industrial Research In Britain, R.4631 January 1961, prepared by the Reference Division, Central Office of Information, London. Swindon, England; Swindon Press Ltd, 1961.

"Industrial Research in Britain," Midland Bank Review (publication of the Midland Bank Ltd, London), May 1962, pp. 3-8.

Industrial Research in Manufacturing Industry: 1959-60, survey of the Federation of British Industries. London: Waterlow & Sons, Ltd, December 1961.

The Long-Term Demand for Scientific Manpower, Cmnd. 1490, report of the Advisory Council on Scientific Policy, Committee on Scientific Manpower, Statistics Committee. London: HMSO, 1961.

The Management and Control of Research and Development, a report prepared for the Office of the Minister for Science. London: HMSO, 1961.

Payne, George Louis, Britain's Scientific and Technological Manpower prepared for the President's Committee on Scientists and Engineers) Stanford, Calif: Stanford University Press; and London; Oxford University Press, 1960.

The Promotion of the Sciences in the United Kingdom, R.5112 July 1961, prepared by the Reference Division, Central Office of Information, London. Swindon, England: Swindon Press Ltd, 1961.

La Recherche-Developpement en Grande-Bretagne, Suppl. No. 110, Cahiers de L'Institut de Science Economique Appliquee. Paris: I.S.E.A., 1961.

Report of the Research Council for the Year 1960, Cmnd. 1365, Dept of Scientific and Industrial Research. London: HMSO, 1961.

"Research and Development: A Comparison between British and American Industry," Economic Review (quarterly publication of the National Institute of Economic and Social Research, London), no. 20, May 1962, pp. 21-39.

REFERENCES (con'd.)

Returns from Universities and University Colleges in receipt of Treasury Grant, Academic Year 1959-1960, Cmnd. 1489, report of the University Grants Committee. London: HMSO, 1962.

VIII. RESEARCH AND DEVELOPMENT POLICY IN THE UNITED STATES.

POLICY

The American Philosophical Society of Philadelphia was the first association formed for cooperative scientific endeavour in the United States. It owes its origin to a proposal of Benjamin Franklin in 1743 "for promoting useful knowledge among the British plantations in America". As such it became the forerunner of a great number of s scientific societies of a broad or specialised nature and of regional academies of arts and sciences, of which the Boston Academy is the oldest.

The structure and interrelationships of the United States science policy and advisory bodies have undergone many changes in the search for a mechanism which could more adequately deal with complexities of the rapidly changing modern technology. At present, four major bodies provide the necessary connecting links between the President, the departments of the government, and the scientific resources of the nation. They are:

A) The Special Assistant to the President for Science and Technology. The Special Assistant is a member of the President's staff. In this position, his function is advisory and he has no operating responsibilities for the conduct of research. By statute, he is not required to be associated with any additional governmental science bodies; but, by presidential discretion, he actually directs the other three major governmental science functions. This being the case, the Special Assistant to the President is the essential connecting link between the President, the science policy formulating bodies, the scientific community, and the departmental scientific activities in the federal government.

B) The Office of Science and Technology is a unit within the Executive Office of the President. It is a permanent office which has the responsibility in advising the President on the formulation of major policies and assessing the scientific resources of the nation. Its director is also the Special Assistant to the President for Science and Technology.

C) The President's Science Advisory Committee is composed of eighteen eminent scientists and engineers who do not represent any governmental or private organisation. Its Chairman, again not by statute but by choice, is the Special Assistant.

D) The Federal Council for Science and Technology provides the vertical structure whereby interdepartmental science problems can be discussed and coordinated. Its membership is drawn from those departments of the government which have major responsibility for research, and also has a representative from the Bureau of the Budget. The Chairman is the President's Science Advisor.

In addition to these four positions which have the major responsibility for advice and policy formulation, there are two bodies, at a different level, which have considerable effect in the deliberations of the above. These are:

I. the National Science Foundation, whose principal advisory body is the National Science Board. The National Science Foundation is a federal agency as contrasted with

II. the National Academy of Sciences, whose associated advisory body is the National Research Council. The National Academy of Sciences is a quasi-official organisation which provides a source of independent scientific advice to any government agency requesting it.

The basic structure having been indicated, it is important to describe the functions of each of the above organisms.

The post of Special Assistant to the President for Science and Technology was first created in November 1957. The Special Assistant has far-reaching responsibilities in keeping himself informed of the entire governmental scientific efforts, and to present recommendations and evaluations to the President. He is also available for scientific advice to the members of the President's Cabinet and to other policy-making officials. His direct access to the President and his prerogatives in viewing a problem unconstrained by agency lines puts him in an especially significant position.

Previous to March 1962, the Special Assistant, despite his advantageous position for viewing government science and access to

the President, had no official responsibility for establishing governmental science policy. Now, as Director of the newly-created Office of Science and Technology (OST) within the Executive Office of the President, he does assume the policy responsibility. It is not required that the Director of the Office of Science and Technology be the Special Assistant to the President, but it has been deemed expedient to make the appointments coincide. Further, as Special Assistant he is not required to testify before the Congress; but Congress can call him as Director of OST. Specifically, the responsibilities of the Director of the Office of Science and Technology are:

1) Major policies, plans and programs of science and technology of the various agencies of the Federal Government, giving appropriate emphasis to the relationship of science and technology to national security and foreign policy, and measures for furthering science and technology in the Nation.

2) Assessment of selected scientific and technical developments and programs in relation to their impact on national policies.

3) Review, integration, and coordination of major Federal activities in science and technology, giving due consideration to the effects of such activities on non-Federal resources and institutions.

4) Assuring that good and close relations exist with the Nation's scientific and engineering communities so as to further in every appropriate way their participation in strengthening science and technology in the United States and the Free World.

5) Such other matters consonant with law as may be assigned by the President to the Office.

The President's Science Advisory Committee has no operating responsibilities. It is charged with providing scientific advice and analyses to the President and, by request, to members of the President's Cabinet and other government policy officers. The meetings of the group are not casually scheduled, meeting each month for approximately two days. It is assisted in its deliberations by a number of panels, whose membership is drawn both from the Committee and from other appropriate sections of the scientific

and engineering community. The Special Assistant is both the Chairman of the Committee and the principal recipient of its advice. The Science Advisory Committee, has the option of reporting directly to the President when they deem it desirable.

The problems of coordinating policy questions discussed at these bodies with the various governmental departments are resolved through the body known as the Federal Council for Science and Technology. This organisation is linked to the others, not by charter but by choice, again by the mechanism of having the Special Assistant to the President as its Chairman. Other members of the Council are: one member each from the Cabinet-level organisations of the Departments of Defense, Interior, Agriculture, Commerce, and Health Education and Welfare. Other members of the Council are the Director of the National Science Foundation, the Administrator of the National Aeronautics and Space Administration, and ammember of the Atomic Energy Commission. Observers at the Council meetings are representatives of the Secretary of State and of the Director of the Bureau of the Budget. Functions of the Council are to provide more effective planning in the administration of governmental scientific programs, to identify research needs which cut across departmental lines, to achieve more effective utilisation of government resources and facilities and to further international cooperation in science and technology. Each federal agency represented on the Council is supposed to furnish the Council appropriate manpower staff and to undertake special studies as required. Some of these studies are undertaken by special interdepartmental committees and panels.

Previous to the establishment of the Office of Science and Technology, the statutory responsibility for establishing science policy lay within the National Science Foundation. However, its functions were ill-defined and only after the establishment of the Office of Science and Technology did it become clear that the Foundation's responsibility lay in the realm of recommending policy proposals concerning the support of <u>basic</u> research and scientific education. These obligations are delegated to the Director of the

National Science Foundation and to its National Science Board. The latter consists of twenty-four members, appointed by the President, who have achieved eminence in the fields of science, engineering, education and public affairs. The Director of the National Science Foundation is an ex officio voting member. He also serves as Chairman of a five-man Executive Committee of the National Science Board.

The National Science Foundation deserves special emphasis in any report because of its development during the decade of its existence as a prime catalyst in the growth of U.S. science. In addition to its policy responsibilities the NSF initiates and supports basic scientific research programs in all of the sciences. Generally it does not operate its own laboratories, but in three instances serves as the major support agency for large National Research Centers for astronomical observation and atmospherics research. It is prepared to enter into this type of arrangement when the basic research requires the use of complex and expensive research tools.

The NSF is concerned with strengthening the pool of U.S. scientific resources and, consequently, has major programs involving the award of scholarships and graduate fellowships. It also supports special projects in science education, such as those involving teacher improvement, the design and introduction of special teaching material, and measures to improve public understanding of science.

In all of these activities the NSF participates and encourages international programs in science. One of its major efforts was as the inter-governmental coordinator in the International Geophysical Year. Partially as an outgrowth of that activity, it is presently involved in the extensive Antarctic research program. And it supports international science education programs and other activities related to exchange of data on research and development.

It is in the data gathering and evaluation field that the NSF performs one of its most important functions. For, if policy is to be formulated, adequate and reliable information must underlie that attempt. The Office of Special Studies of the National Science Foundation provides the data to assist in formulation of national

science policy and also to permit appraisal of the economic and social impact of research and development. The numerous publications now available as a result of the work of the Office of Special Studies provides the best national set of research and development statistics available, and indeed the criteria developed in that program are now used in many nations as the basis of their initial R&D statistics programs.

The statistics and the general scientific guidance available through the NSF has been well used by U.S. industry and government. Indeed, reliance on that source is increasing. Both the executive and legislative branches of the government draw heavily on the services of the NSF in formulating national science policy. For example, data which enables the prediction of availability of certain classes of specialists enable one to foresee problems which might arise in developing major new science programs. In another instance, knowledge of the distribution of the R&D budget among business firms of varying size enabled the development of legislative proposals to encourage increased performance of R&D by small firms.

General data is also available to industrial firms in order that they can evaluate their own position relative to the nation's total R&D program. Often universities require information on direct and indirect costs of R&D in order to relate their own programs to their total budgets.

From a budget allocation of $3.5 million for the fiscal year 1952, the National Science Foundation, through a record of demonstrated demand and need, had a 1962 budget estimate of some $210 million. For the fiscal year 1963 the budget is $300 million and this will almost double for the fiscal year 1964. Thus, although it is a comparatively young agency, it has grown into a major one in a brief period of time.

The earliest, existing science advisory mechanism is the National Academy of Sciences, which was established by President Lincoln during the Civil War. It is not a government agency and is not directly funded by the government, but it holds itself available upon call by

any department of the government to investigate and examine scientific proposals and to make recommendations. The government department stands the expense relative to any request it might make of the National Academy of Sciences. Membership to the Academy itself is an honorary distinction presently held by approximately six hundred eminent scientists. A Council of the Academy (which should not be confused with the National Research Council) is a small group of officers responsible for the general conduct of the National Academy.

Exigencies of World War II prompted the organisation of the National Research Council by the Academy of Sciences. The purpose of the National Research Council is to enable the Academy to participate in a broader range of national scientific endeavours. The members of the Council, numbering some 250, are not necessarily elected members of the Academy of Sciences but are appointed by the President of the Academy from academic, governmental and industrial organisations throughout the country. The National Research Council is divided into eight divisions encompassing all fields of scientific research. Chairmen of these divisions together with the Council of the Academy constitutes a governing board which provides guidance for the overall Academy-Research Council organisation.

Neither the Academy nor the Research Council operates laboratories of their own. But they both seek to stimulate and support the work of individual scientists. This is done by means of financial grants, formation of committees, surveys, sponsorship of scientific publications, et cetera.

A very special continuing role is that of carrying out the purpose of their original charter; that is, to provide guidance to government agencies in the conduct of scientific research. The latter activities provide the bulk of Academy-Council funds; but it also has income from endowment and gifts, and of considerable consequence is the time and effort contributed by U.S. scientists to these activities without financial compensation.

Charged with the responsibility of approving huge appropriations for research and development, the interest in science of the legislative

branch of the government has been growing rapidly. At present there are three Congressional committees concerned with reviewing the nation's scientific progress and policy. The oldest of these is the Joint Committee on Atomic Energy, which by law must be informed of all aspects of the nation's atomic energy program. In 1958 a Senate Aeronautics and Space Sciences Committee was created, as was a House Science and Astronautics Committee. Other Congressional committees touch upon science subjects as the occasion seems to demand, but there seems to be a general opinion that legislative science services and mechanisms need to be reformulated and strengthened.

PUBLIC ORGANISATIONS

Within the individual departments and agencies of the government, there are many ways of assigning primary responsibility for research and development. For example, the Departments of Navy, Air Force and Commerce have assistant secretaries for research and development or for science and technology. The Departments of State and Interior have appointed scientific advisors to the secretaries of the Departments. And the Department of the Army has a Director of Research and Development. Other agencies, like the Atomic Energy Commission and the National Aeronautics and Space Administration, obviously have a most all-encompassing R&D structure.

The Department of Defense is the major R&D funder in the U.S. government and these responsibilities are borne by the Director of Defense Research and Engineering. He is the principal scientific advisor to the Secretary of Defense; and, as such, must recommend policy, review programs and evaluate them both from a scientific and management viewpoint. He exercises administrative direction over several special organisations such as the Weapons Systems Evaluation Group and the Advanced Research Projects Agency. The latter is responsible for basic and applied research in the Department of Defense which is not identified with a specific military requirement, related to two or more arms of the military services, or for other

reasons better administrated by an agency rather than one of the military services. It utilises the services and laboratories of the military departments, other agencies, and private and university institutions.

The government laboratories are too numerous to describe individually but several of major importance, outside of those administered by the AEC, the Department of Defense and the Navy, merit special description.

One of the best known is the complex of laboratories, under the jurisdiction of the Department of Health Education and Welfare, termed the National Institutes of Health. Originally authorised by Congress about a decade before the turn of the 20th century as the Hygienic Laboratory of the Public Health Service, it was renamed in 1930 as the National Institutes of Health. As the name implies, these include seven institutes of specialised medical research, among which are the National Cancer Institute, the National Institute of Mental Health, the National Heart Institute, et cetera. In addition to their fundamental research responsibilities, the Division of Biological Standards of the Institutes has the responsibility for investigating biological products which are to be used in the United States. The Institutes also provide grants to public and private institutes for additional research.

The Federal Physico-Technical Research Institute in Germany and the National Physical Laboratory in Britain were models for the establishment of the National Bureau of Standards, which was created in 1901. Originally part of the Treasury Department, it was later transferred to the Department of Commerce and Labor (now the Department of Commerce). Its major purpose is to serve the government in providing standards of physical measurement and to serve as a contact point for the international exchange of standards and physical constants. It has a number of specialised laboratories ranging from those of atomic physics to organic and fibrous materials. In the course of striving for better standards and measurements thereof, the National Bureau of Standards has performed a great deal of important basic and applied research.

Another important institution which is ancient, as research

institutions go, is the Naval Research Laboratory which was established in 1923 and has contributed significantly to basic science as well as to the specific problems of defence. It is one of the several laboratories administered by the Office of Naval Research. It must be mentioned that the London branch office of the ONR is considered one of the most significant of U.S. liaison activities with European research.

A quasi-government institution is the Smithsonian Institution, which was the result of a bequest in 1829 of James Smithson of London. It is, however, under the guardianship of the government, having been approved and created by Act of Congress in 1846. The Smithsonian Institution comprises a number of bureaus having responsibility in the promotion of research in the broad area of the sciences and arts. In addition to operating a number of museums, including the United States National Museum and the National Gallery of Art, the Smithsonian operates the Astrophysical Observatory and conducts research on solar and other forms of energy on the earth's surface. A Tropical Research Station is maintained in the Panama Canal Zone. One of its most important international activities is the International Exchange Service which is the central agency for the United States government for exchanging scientific literary governmental publications with foreign governments and institutions.

UNIVERSITY RESEARCH

There is a great proliferation of colleges and universities in the United States -- in number and type, ranging from those which are essentially ecclesiastical in origin to the privately founded and supported and to those initiated by government action. In the latter category are the so-called land-grant institutions which were the result of funds accruing to the individual states as a result of lands granted them in the 1860's for this purpose.

Until the advent of World War II, it was the land-grant institutions which received the bulk of federal research support for their agricultural experimental station. Some of the other universities, such as Harvard, Chicago, Cornell, Columbia, and Yale, became

identified as the leaders of fundamental research in the nation. For a considerable period there was very little governmental interaction with these institutions.

1940 essentially marks the beginning of increasingly strong interdependence of government and university in the conduct of research. In that year government funding of university research was some $15 million which accrued mainly to the agricultural experimental stations. During World War II, the defence and health agencies developed close relationships with the university; and, by 1960, federal funding for university research was some $460 million. This thirtyfold increase compares with a hundred-fold increase in the total federal research and development budget during the same period. So it must be concluded that federal dependency on university research, with regard to funding, has not been proportionately as large as the increased dependence in other areas.

Of some three hundred educational institutions which have R&D programs of any size, six institutions conduct over a quarter of the nation's university research, twenty institutions conduct over 50% of the R&D, and some seventy account for approximately 90%. Of the university's total research and development budget, approximately 70% is now funded by the federal government. University research accounts for 7% of the nation's total R&D effort, but over 40% of the basic research is performed in the universities.

The government-university relationship can essentially be categorised in three ways and these are:

a) The so-called grant program in which university scientists conduct research of their own choice and are given a general grant by various agencies of the United States government for the conduct of that research. The grant program generally involves research of a basic nature. The utility of this program is multifold. Besides contributing to the increase of scientific knowledge, it provides government contact with scientists and is effective in increasing the supply and quality of scientists.

b) Often university research is carried out under contract, for the most part in order to carry out applied research on specific projects, processes

or systems. Some fundamental research, however, is also carried out under the contract arrangement.

c) A number of the major laboratories, such as the Los Alamos Scientific Laboratory, the Brookhaven National Laboratory, the Jet Propulsion Laboratory, are government-owned, but managed by the universities or groups of universities. Organisationally, these laboratories are independent of the administrative structure of the universities and are managed on a straight contract arrangement.

PRIVATE RESEARCH

Prior to the turn of the 20th century, the industrial research laboratory was a rare phenomena. The scientific demands of World War I provided the initial catalyst for a stronger fusion of research and the technological demands of business. There were some three hundred industrial research laboratories in existence in 1920, but by 1930 this number had grown over fivefold. By 1960 it is estimated that about twelve thousand industrial firms performed research and development in the United States.

The funds for that totaled almost $10 billion and accounted for about three-fourths of the nation's entire research and development activities. The federal government financed about 60% of industrial research and development activities.

Some three hundred of these companies accounted for over 90% of the industrial R&D effort and some 60% of that effort can be grouped into four major categories: chemical, electrical, transportation and machinery.

Although the greater proportion of this performance was in the realm of applied research, U.S. industry is an important factor in the realm of basic research. Some companies, such as the Bell Telephone Laboratories, can be said to be major contributors to the fund of basic knowledge in their fields of interest. It is the chemical industry which performs the major part of basic research, followed by the electrical, petroleum, and aircraft industries, in terms of funding. However, in terms of percentage of funds

allotted to basic research, the petroleum industry leads, followed by drugs and medicine. For the overall industry average for basic research, the figure is still low. It is approximately 4%.

There are other, non-industry, sources of private research in the U.S. The availability of funds from private foundations for basic research, especially in the field of social and medical sciences, is an important factor. Some of the foundation funds come from endowments of hundreds of millions of dollars and, in one instance, a basic sum of several billion dollars. One major foundation institute, which is one of the few devoted to research in the physical sciences, is the Carnegie Institute of Washington, modeled on the Royal Institution of London. Its Department of Terrestrial Magnetism is especially wellknown.

In addition to the foundation research, there is another type of non-profit activity which has grown in importance since World War II. No single pattern of financial or organisational structure can describe these groups. Some depend entirely on the federal government for their support. Others receive income from industry and foundation sources. One of the major attributes is that they rarely perform anything but research and represent extraordinary pools of diversified talent which can assume specialised urgent and long-range tasks. Non-profit research, including that of foundation but excluding the universities, accounts for about 2% of the national total of R&D and about 8% of the total national effort in basic research.

TABLES

Federal Research and Development

For the years 1960-62, the distribution of federal funds among various major agencies is as follows:

Table 28

FEDERAL OBLIGATIONS FOR RESEARCH AND DEVELOPMENT, BY AGENCY
(in billions of dollars)

Agency	1960*	1961**	1962**
Department of Defense	5.7	6.6	6.2
National Aeronautics & Space Administration	.37	.79	1.4
Atomic Energy Agency	.76	.86	.88
All other agencies	.71	.90	1.1
Total all agencies	7.5	9.2	9.6

* Actual
** Estimated

SOURCE: Federal Funds for Science X, Fiscal Years 1960, 1961, and 1962, NSF 61-82, survey of the National Science Foundation, p. 7.

It is interesting to see the rapid rate of increase in expenditures relating to the space program.

In relation to total budget of the U.S. government, research and development expenditures have assumed an ever-increasingly important role. While in the year 1940, less than 1% of the national budget was spent on R&D, that ratio is well over 10% at the present time and appears to be increasing. This is evidenced by the following table:

Table 28a

TRENDS IN EXPENDITURES, FY 1940-1962
(in millions of dollars)

Fiscal Year	Total budget expenditures	R&D expenditures[a]	Total higher education budget[b]
1940	9,062	74	--
1941	13,262	198	--
1942	34,046	280	--
1943	79,407	602	--
1944	95,059	1,377	--
1945	98,416	1,591	--
1946	60,448	918	1,088
1947	39,032	900	--
1948	32,955	855	1,895
1949	39,474	1,082	--
1950	39,544	1,083	2,260
1951	43,970	1,301	--
1952	65,303	1,816	2,486
1953	74,120	3,101	--
1954	67,537	3,148	2,903
1955	64,389	3,308	--
1956	66,224	3,446	3,525
1957	68,966	4,462	--
1958	71,369	4,990	4,544
1959	80,342	5,803	--
1960	76,539	7,738	5,813
1961	81,503	8,789[c]	--
1962	88,985	10,172[c]	--

a) Beginning with FY 1953, amounts include pay & allowances of military personnel in R&D.
b) These statistics are reported biennially.
c) Estimates are based on requested amounts presented in The Budget, 1962. However, they also reflect changes made by the incoming administration after The Budget, 1962, was submitted to the Congress on January 16, 1961. Hence, data for 1962 do not reflect congressional action.

SOURCE: Federal Funds for Science X, NSF 61-82, p. 40; and Statistics of Higher Education, biennial surveys of the Office of Education, Dept. of Health, Education and Welfare.

While federal funds account for about 65% of the nation's research and development budget, it is interesting to see how the total budget is divided, both in terms of performance and funding, among the various sectors. (see Table 28b).

Table 28b

INTERSECTORAL TRANSFERS OF FUNDS USED FOR PERFORMANCE OF RESEARCH AND DEVELOPMENT, BY SOURCE AND PERFORMER, 1960-61 (PRELIMINARY)
(in millions of dollars)

SECTORS: Funds Provided by / Funds for performance of R&D by	Federal Govt.	Industry	Colleges & Univs.	Other Nonprofit Institutions	Total	% Distrib., R&D Sources
Federal Govt.	$ 2,060	$ 6,130[a]	$ 890[a]	$ 140[a]	$ 9,220	65
Industry		4,370	50	70	4,490	32
Colleges & Univs[b]			210		210	2
Other Nonprofit Institutions[b]			50	70	120	1
Total	2,060	10,500[a]	1,200[a]	280[a]	14,040	100
Percent Distribution, R&D Performance	15	75	8	2	100	

a) This amount includes funds from the Federal Govt for research centers administered by organisations under contract with Federal agencies.

b) Data include state and local govt. funds.

SOURCE: Reviews of Data on Research & Development (publication of the National Science Foundation), no. 33, April 1962, p. 4.

Industrial Research

Government funding of industrial research has become increasingly important. However, in recent years, there appears to be a leveling off of this support to a plateau at a little less than 60%, as is shown in the following table giving total industrial R&D expenditures for 1953-1961:

Table 29

TRENDS IN FUNDS FOR INDUSTRIAL R & D PERFORMANCE, BY SOURCE, 1953-61[a]
(Dollar amounts in millions)

		Federal Government		Company[b]	
Year	Total R&D funds	Amount	% of Total	Amount	% of Total
1953	$ 3,630	$1,430	39	$2,200	61
1954	4,070	1,750	43	2,320	57
1955	4,640	2,180	47	2,460	53
1956	6,588	3,328	51	3,260	49
1957	7,718	4,336	57	3,382	43
1958	8,353	4,759	57	3,594	43
1959	9,610	5,610	59	4,000	41
1960	10,546	6,127	58	4,419	42
1961	10,891	6,436	59	4,455	43

a) Estimates of sources of funds for 1954-55 were not obtained by industry surveys. They were derived by interpolating data on sources of funds obtained in the 1953 and 1956 surveys of industrial research and development.

b) Includes all funds for industrial R&D performance except those provided by the Federal Government. Does not include company-financed research and development contracted to colleges and universities, research institutions, or other non-profit organisations.

SOURCE: Adapted from Reviews of Data on Research and Development, no. 36, Sept. 1962, p. 3.

These funds from 1956 to 1961, were distributed among the various industries in the following manner:

Table 29a

FUNDS FOR PERFORMANCE OF RESEARCH AND DEVELOPMENT, BY INDUSTRY, 1956-1961[a]
(in millions of dollars)

Industry	1961	1960	1959	1958	1957	1956
Food and kindred products	107	104	90	75	67	58
Paper and allied products	57	54	49	41	35	36
Chemicals and allied products	1,092	998	891	805	728	651
Industrial chemicals	695	663	599	560	514	459
Drugs and medicines	181	165	148	128	104	94
Other chemicals	216	170	144	117	110	98
Petroleum refining and extraction[b]	308	298	276	253	224	194
Rubber products	124	118	114	88	107	--[c]
Primary	161	160	136	126	111	93
Fabricated metal products	106	107	110	122	103	88
Machinery	924	962	938	804	698	566
Electrical equipment and communication	2,377	2,415	2,253	1,942	1,778	1,487
Motor vehicles & other transp. equip.	789	851	844	825	677	655
Aircraft and missiles	3,964	3,637	3,188	2,656	2,605	2,182
Professional and scientific instruments	385	400	339	295	249	200
Scientific & mechanical measuring instruments	190	216	185	156	139	97
Optical, surgical, photographic, and other instruments	195	184	154	139	110	103
Other industries	498	442	382	320	338	273
Total	10,891	10,546	9,610	8,353	7,718	6,588

a) These statistical data do not include company-financed research & development contracted to outside organisations.
b) Geological & geophysical exploration activities of petroleum companies are presently excluded from the definition of R&D.
c) Not separately available but included in total.

SOURCE: Reviews of Data on Research & Development, no. 36, September 1962, p. 4

Note: Detail may not add to totals or subtotals because of rounding.

Manpower

In 1959 approximately 800,000 scientists and engineers were employed in American industry, 160,000 in universities and colleges and 150,000 in the federal government. To obtain total manpower one must also include scientists employed in nonprofit organisations, state government agencies, et cetera, so that the national total is probably in the realm of 1,200,000. An additional 550,000 technicians are also employed in industry.

It is interesting that, of the national total, scientists and engineers engaged in research and development represent about 30% of the total while about 45% of scientists and engineers in the universities are engaged in R&D.

Data gathered from the National Register of Scientific and Technical Personnel for 1960, which represents a response of a little over 200,000 of the nation's scientists, indicates a professional distribution of the following nature:

Table 30

Chemistry	53,071
Biological sciences	23,901
Physics	20,882
Earth Sciences	17,642
Mathematics	15,511
Psychology	15,257
Agricultural sciences	13,140
Chemical engineering	6,563
Sanitary engineering	5,226
Meteorology	3,829
Medical sciences	3,287
Geography	1,072
Astronomy	630
Other engineering	17,526
Other specialties	3,755
All fields	201,292

SOURCE: American Science Manpower 1960, NSF 62-43, p. 7.

The distribution of manpower among the different types of employers was as follows:

Table 30a

Industry, business & self-employed	45%
Government	18%
Educational institutions	28%
Other	9%

SOURCE: American Science Manpower 1960, NSF 62-43, p. 6.

For 1959 the cost per scientist or engineer occupied in industrial research and development averaged $35,200.

SYNTHESIS OF DATA

In terms of a ratio of the Gross National Product, U.S. R&D expenditures are growing rapidly, the percentage having essentially doubled in a period of seven years. It is important to note that, during this period, expenditures on basic research have also been continuously increasing at approximately the same rate.

R&D FUNDS IN RELATION TO THE GROSS NATIONAL PRODUCT, 1953-1960
(Dollar amounts in millions, at current prices)

Calendar Year	GNP	R&D funds (revised)	R&D funds as % of GNP	Basic Research Funds	Basic res. funds as % of GNP
1953-1954	$365,385	$ 5,150	1.41	$ 432	0.12
1954-1955	363,112	5,620	1.55	485	0.13
1955-1956	397,469	6,390	1.61	547	0.14
1956-1957	419,180	8,610	2.05	694	0.17
1957-1958	442,769	10,030	2.26	834	0.19
1958-1959	444,546	11,070	2.49	1,016	0.23
1959-1960	482,783	12,620	2.61	1,150*	0.24
1960-1961	504,448	14,040	2.78	1,302*	0.26

* Preliminary

SOURCE: Reviews of Data on Research & Development, no. 33, April 1962, pages 3 and 7.

Note: For the comparative year of this report (1959) an interpolated U.S. R&D figure of $11,845 million will be used.

REFERENCES

American Science Manpower 1960, NSF 62-43, report of the National Register of Scientific and Technical Personnel by the National Science Foundation. Washington: GPO, 1962.

Annals of the American Academy of Political and Social Science, Vol. 327, January 1960. (issue on "Perspectives on Government and Science").

Dupree, A. Hunter, Science in the Federal Government. Cambridge, Massachusetts: Belknap Press of Harvard University Press, 1957.

Federal Funds for Science V, NSF 56-19, report of the National Science Foundation. Washington: GPO, 1956.

Federal Funds for Science VIII, NSF 59-40, report of the National Science Foundation. Washington: GPO, 1959.

Federal Funds for Science IX, NSF 60-80, report of the National Science Foundation. Washington: GPO, 1960.

Federal Funds for Science X, NSF 61-82, report of the National Science Foundation. Washington: GPO, 1962.

Federal Organization for Scientific Activities, 1962, NSF 62-37, report of the National Science Foundation. Washington: GPO, 1963.

Funds for Research and Development in Industry, 1958, NSF 61-32, survey by the National Science Foundation. Washington: GPO,1961, 1961.

Funds for Research and Development in Industry, 1959, NSF 62-3, survey by the National Science Foundation. Washington: GPO, 1962.

Investing in Scientific Progress, NSF 61-27, report of the National Science Foundation. Washington: Author, 1961.

Knight, Douglas M. (ed.), The Federal Government and Higher Education, Englewood Cliffs, N.J.: Prentice-Hall, 1960. Chapter 3, pp. 76-139.

Reviews of Data on Research & Development (a bulletin published periodically by the National Science Foundation, Washington).

Science and Public Policy, Vol. One: A Program for the Nation, a report to the President by John R. Steelman, Chairman, the President's Scientific Research Board. Washington: GPO, August 27, 1947.

REFERENCES (con'd.)

Science and Public Policy, Vol. Two: The Federal Research Program, a report to the President by John R. Steelman, Chairman, the President's Scientific Research Board. Washington: GPO, September 27, 1947.

Scientific and Technical Personnel in American Industry, NSF 60-62, a report prepared for the National Science Foundation ; by the U.S. Dept. of Labor, Bureau of Labor Statistics. Washington: GPO, 1960.

Scientific and Technical Personnel in the Federal Government, NSF 62-26, a report of the National Science Foundation. Washington: GPO, 1962.

Scientific Progress, the Universities, and the Federal Government, statement by the President's Science Advisory Committee, November 15, 1960. Washington: GPO, 1960.

Scientific Research and Development of Nonprofit Organizations, NSF 61-37, a survey by the National Science Foundation. Washington: GPO, 1961.

Silk, Leonard S. The Research Revolution. New York, Toronto, and London: McGraw-Hill, 1960.

Statistics of Higher Education 1955-56, biennial survey of the Dept. of Health, Education and Welfare. Washington: GPO, 1959.

Statistics of Higher Education 1957-58, OE-50023-58, biennial survey of the Dept. of Health, Education and Welfare. Washington: GPO, 1961.

Summary Report of Financial Statistics of Institutions of Higher Education, 1959-60, OE-52007, September 1962. Washington: Dept. of Health, Education and Welfare, September 1962.

IX. RESEARCH AND DEVELOPMENT IN THE U.S.S.R.

POLICY

Twice during his lifetime Peter I of Russia had an opportunity to become acquainted with the scientific culture of Europe through personal visits. He was particularly impressed by the academies of science in Berlin and Paris and by the Royal Society of London, and resolved to found an imperial academy of sciences in St. Petersburg. Peter personally drew up the plan for the academy and signed it in February 1724, but did not live to fulfill it. The academy was established the following year by his widow, Catherine I, and it can be said to have distinguished its early history principally as a mecca for foreign scientists.

It was not until the realm of Catherine II, which commenced in 1762, that Russian science can be said to have begun to flower. While Russian scientific pursuit waxed and waned under the successive reigns, it was not until a decade or so after the Russian revolution that large-scale encouragements of science and technology was instituted and serious efforts brought to bear on integrating science with the demands of the state. Although, during the New Economic Policy period (1921-28), numerous meetings and planning occurred, it was not until the Academy of Sciences was moved to Moscow in 1934 and placed under the authority of the Council of People's Commissars that the present structure of Soviet science planning can be said to have started to evolve. Important statutes, adopted in 1936, defined the relationships of the Academy of Sciences to the government; these statutes were redefined and adopted in March 1959. And after much deliberation the Council of Ministers defined, in April 1961, the present research planning structure. The relationships of the scientific structure to the economic bodies was redefined in November 1962. Generally, the nature of the latter changes was to emphasize more strongly "concentrating scientific effort on the most important tasks directly connected with the development of production."

Since government, university and industrial research in the U.S.S.R. are all subject to the same central structure, it is necessary to briefly describe that structure. The highest executive and administrative body of the U.S.S.R. is the Council of Ministers which unites and directs the work of the All-Union and Union Republic ministries of the U.S.S.R., the state committees and the economic councils. The All-Union bodies have nation-wide responsibility while the Union Republic administrative bodies have responsibilities limited within the Union Republics of the U.S.S.R. The Union Republics often have administrative bodies paralleling the All-Union administrative bodies, although it is not an exact correspondence in each instance. Separate economic councils for each Union Republic have important responsibilities in the management of local production and economic activities. These local economic bodies are subordinate now not only to the Union Republic Council of Ministers but to the U.S.S.R. Council of Ministers and the National Economic Council.

In addition to the industrial and economic bodies there are, attached to the Council of Ministers of the U.S.S.R., special agencies and organisations such as the Academy of Sciences of the U.S.S.R.

A special role is undertaken by the state committees of the U.S.S.R. The state committees fall into essentially two categories. In the first category are those state committees which coordinate a particular industry throughout various branches of industry,in the U.S.S.R. In March 1963, several Ministries concerned with technical production were transformed into state committees. Research enterprises and development enterprises may be attached directly to the state committees. Examples of this type of state committee are those of Aviation Technology, Radio Electronics, Chemistry, Shipbuilding, Defence Technology, Grain Products, Medium Machinery, Geology, et cetra.

The second type of state committee is less specifically oriented and has broad planning responsibilities for the Council of Ministers. These committes include the State Planning Committee (Gosplan), the

State Construction Committee, the National Economic Council (SOVNARKHOZ or SNKH SSR), the State Automation and Machine Building Committee, the State Committee for the Coordination of Research, et ceteras. All of these bodies were made subordinate in March 1963 to a powerful new economic body of the Council of Ministers, the Supreme Council of the National Economy (VSNKH SSR).

The State Committee for the Coordination of Research, is the central organisation for R&D planning in the U.S.S.R. It is entrusted with control of the research institutions engaged in major scientific-technological problems and is subject to the directives of the party and the government. It coordinates its work with the Academy of Sciences of the U.S.S.R., the Academies of Sciences of the Union Republics, and all U.S.S.R. ministries and departments. It collaborates closely with the National Economic Council, Gosplan and the Ministry of Finance to draft plans for research work and the application of discoveries. The draft plans are presented for confirmation to the Council of Ministers of the U.S.S.R. The Chairman of the State Committee is a Deputy Chairman of the Council of Ministers.

Research, which is either not considered to be of major importance or is not highly diversified throughout government ministries or departments, is coordinated by the ministries and departments themselves.

The Chairman of the State Committee for the Coordination of Research is at the same time a Deputy Chairman of the U.S.S.R. Council of Ministers. Other members of the Committee include the Chairmen of the State Committee for Automation and Machine Building, and of the State Committee for Chemistry, the Deputy Chairmen of Gosplan and of the National Economic Council, the President of the Academy of Sciences, the Minister of Higher and Specialised Secondary Education, and the Chairman of the Committee on Discoveries and Inventions. It will be seen from the nature of the membership that the Committee for Coordination of Research assures a highly centralised coordination.

Attached to the Committee is a Learned Council of scientific advisors. The Learned Council determines the main trends of the

nation's research and is supplemented by appropriate learned committees to consider special problems.

This then is the structure which is charged with drafting the State Plan for Scientific Research. The Plan consists of three sections:

a) Major national economic problems that are in the stage of experimental-and-design work;
b) Long-range scientific research aimed at the solution of problems of the national economy that have already been defined;
c) Basic research aimed at disclosing laws of nature that may open up new paths of progress.

This Plan is implemented by the entire U.S.S.R. R&D structure which includes work in industrial laboratories under the various industrial ministries, in university laboratories under the Ministry of Higher and Specialised Secondary Education, the special laboratories of the state committees and in the Academies of Sciences.

Having defined these objectives of the Plan, the Central Committee found it necessary in 1961 to transfer a number of institutions, of an applied or narrowly specialised nature from the Academy of Sciences to the state committee and ministries. While scientific and methodological direction of these institutes will remain the responsibility of the Academy, its responsibilities in applied research have been lessened. This reorganisation will enable the Academy of Sciences to concentrate more on basic research and on the resolution of scientific problems of special importance to the state. The Academy of Sciences remains as it has been -- the most important research body in the U.S.S.R.

THE ACADEMY OF SCIENCES

The Academy of Sciences of the U.S.S.R. is directly subordinate to the Council of Ministers and is responsible for scientific research in all branches of Soviet science but is not the sole performer of such research, particularly in the field of the technical sciences. Periodically, the Academy submits to the Council of Ministers long-range plans for the accomplishment of complex scientific and technological tasks. The most important scientific research projects are approved by the Council of Ministers and carried out by their

directives.

In addition to its major tasks, the Academy of Sciences has general responsibility for promoting science in the country, for investigating natural productive resources, for providing scientific advice to various government agencies, for publishing and publicising scientific works and achievements, for convoking scientific meetings and congresses, and has the responsibility for carrying out international scientific collaboration.

The U.S.S.R. Academy of Sciences is made up of members and corresponding members numbering over five hundred at the present time. They, as a body, constitute the General Assembly of the Academy of Sciences. The General Assembly is the highest body of the Academy and, at meetings held at least twice a year, establishes the general trend of the Academy's scientific work, discusses organisational projects, approves the summary reports of the Presidium of the Academy, periodically elects members, et cetera.

Although by statute the responsibility for most decisions rests within the General Assembly, it is the Presidium of the Academy of Sciences which assumes what is essentially the day-by-day operating responsibility. The Presidium is composed of the President of the Academy of Sciences, the Vice Presidents, the Chief Learned Secretary of the Presidium, and the academician secretaries of the Academy's departments. All the members of the Presidium are elected for specified terms ranging from three to five years.

It is the responsibility of the Presidium to implement the decisions of the General Assembly, and it calls sessions of the General Assembly whenever such sessions are necessary. The Presidium bears the main responsibility for distributing the funds of the Academy of Sciences and is assisted by an auxiliary staff and special councils and committees for individual problems. The U.S.S.R. Academy of Sciences has nine departments:

a) Physical and mathematical sciences
b) Chemical sciences
c) Geological and geographical sciences
d) Biological sciences

e) Technical sciences
f) Historical sciences
g) Philosophical and juridical sciences
h) Literature and languages
i) Economic sciences

Each of the departments is governed by a General Assembly of the Department in counterpart to the General Assembly of the Academy. Corresponding to the Presidium of the Academy is the Department Bureau which effectively exercises administrative control over the institution in the Department.

The research institutes of the Academy of Sciences may be attached either to the Presidium or to a department of the Academy. The post of Institute Director is also an elective post of three year's duration. Directors are elected either by general meeting of the Department or by the Presidium, depending upon which body exercises administrative control.

In addition to the main body of the Academy in Moscow there are seven branches of the Academy of Sciences in the Russian Republic (R.S.F.S.R.). Additionally, in May 1957, the Siberian Division of the U.S.S.R. Academy of Sciences came into existence, subordinate both to the R.S.F.S.R. Council of Ministers and to the Presidium of the U.S.S.R. Academy of Sciences and operating according to plans approved by these bodies. Administratively, it is governed by a General Assembly and Presidium paralleling the parent bodies.

Besides the U.S.S.R. Academy of Sciences, its seven branches and the Siberian Division, there are fourteen Union-Republic Academies of Sciences--one in each of the member republics of the U.S.S.R. except the R.S.F.S.R. The Union-Republic Academies maintain their ties with the Moscow Academy through the Presidium, and each has an administrative structure paralleling that of the main body.

THE ACADEMY OF MEDICAL SCIENCES

Unitl 1944 there was no centralisation of medical research. At that time the Academy of Medical Sciences was founded in Moscow to

coordinate medical research. The Academy has some sixty members and is in charge of about thirty institutes. It is responsible to the Council of Ministers and to the Ministry of Public Health. Its administrative structure parallels that of the Academy of Sciences.

HIGHER EDUCATION

Research in institutions of higher education

Under the control of the Ministry of Higher and Specialised Secondary Education are forty universities and a number of polytechnical institutions. The Ministry allocates a separate research sum to each of these institutions, but in addition the faculties are permitted to carry out contractual research with other ministries, with state committees and with regional economic councils. For the latter type work, the professor and his assistants usually receive extra compensation.

Because of the dual system of financing, both basic and applied research is conducted in the universities and polytechnical institutions, with somewhat greater emphasis on applied research in the latter.

There are in addition some 750 specialised educational institutions in the U.S.S.R. which also conduct research, almost always of an applied nature. Some of these institutions are also under the direction of the Ministry of Higher and Specialised Secondary Education, but the majority of them are administered by either an All-Union or Union Republic ministry or by the regional economic councils. Their problems may be assigned either by state or local administrative organisations or may be arranged under contract with local enterprises.

In its relationships with industry, the staff of an educational institution can undertake the work either at the institution itself or, as often happens, the work may be performed by the professors and students at the industrial enterprise. Not all of this type work results in additional income for the educational institute or the professor. Some of the research may fall under a Socialist

Agreement for Cooperation. Under the terms of the Socialist Agreement the institutes cooperate with the enterprises without payment. The subjects selected are those which are not only of importance to the industrial enterprise but also of scientific interest to the staff of the educational institution.

INDUSTRIAL RESEARCH

In addition to the research facilities afforded the technical ministries through contract with the Academy of Sciences and the higher educational institutions, the industries administer their own institutions and research centers. A large number of these are under the direct jurisdiction of the regional economic councils in collaboration with the appropriate ministries. For the most part the work conducted in this type of industrial institute should probably be considered more as development rather than research.

R&D DATA

The Russian work nauka has a broader connotation than "science". It is somewhat akin to, but not as broad as, the German work "wissenschaft" in that it means knowledge in its broadest sense. The data reported here are for nauka. It includes all spheres of knowledge, not only the physical and biological sciences but law, history, linquistics, et cetera.

A total research and development figure is available for each year. For most years a breakdown into "budget" and "economic" outlays can be found. In the first category are included the expenditures of the Academy of Sciences and major institutes of state committees and ministries. The outlays of the economic organisations appear to be devoted to problems of a specialised nature in unspecified levels of the ministries and state committees. At least until 1958, the budget figure did not include non-contract research performed in the higher education institutes. These endeavours were included in the budget of the Ministry of Higher Education but were not separately identifiable. Another type of R&D not covered in

the budgetary figures was the research performed in individual enterprises which was deemed chargeable to the cost of production of products.

Generally, for most years, the planned and actual R&D expenditures are available. For 1958, there is considerable difference between planned and actual R&D budget figures. This is due to broadening of the categories of items to be reported in the R&D budget. It is possible that, as of 1958, the R&D performed in the universities is included in the budget figures, although probably this research does not alone account for the increased coverage, which amounts to about 32%. Much of this increase, for example, might be accounted for by a greatly increased space research budget.

As of 1 January 1961, ten old rubles were exchanged for one new ruble, and budgetary data was revised accordingly. The data reported in Table 31 is in terms of old rubles. All figures given are actual expenditures, unless designated by an asterisk, in which case they are the planned expenditures for that year.

Table 31

RESEARCH AND DEVELOPMENT EXPENDITURES - U.S.S.R.
(Milliards current pre-1961 rubles)

Year	Budget	Total R&D (Budget & Economic)***	Total Higher Education Budget****
1950	5.388	9.01	.721
1953	6.244	11.3	NA
1956	10,297	17.3	1.072
1958	16.958	24.19	1.141
1959	20.043	28.15	1.152
1960	23.389	32.93	1.167
1961	27 - 28**	38. **	NA
1962	NA	43. *	NA

*planned
**provisional estimate
***under expanded coverage definition of 1959
****Expenditures on research and development in institutions of higher education are not included in this column. Contract research performed at colleges and universities is included in column 2, but whether or not other higher education research expenditures are included in column 2 is not known. However, such amounts are believed to total only a small percentage of column 2.

NOTES: A comprehensive analysis of U.S.S.R. research and development data is available in RM-3384-PR, Soviet Expenditures on Scientific Research by Nancy Nimitz, a publication of The RAND Corporation, Santa Monica, California.

Higher education budget figures were obtained from GOSUDARSTVENNII BYUDZHET SSSR I BYUDZHETY SOYUZNYKH RESPUBLIK. Moscow, 1962. p. 48.

Table 32a

DISTRIBUTION OF SCIENTIFIC PERSONNEL BY BRANCH OF SCIENCE
(a/o 1 October 1960)

Branch of Science	Total Scientific Personnel	%	Scientific Personnel with science degrees*	
			Doktor	Kandidat
Technical	129,843	36.7	2,304	26,396
Medical & Pharmaceutical	32,174	9.1	2,852	15,607
Physico-Mathematical	28,966	8.2	990	6,814
Chemical	26,237	7.4	695	5,652
Agricultural & Veterinary	21,186	6.0	825	7,550
Philological	21,234	6.0	323	5,212
Historical & Philosophical	19,831	5.6	409	8,752
Biological	15,091	4.2	1,133	6,804
Pedagogical	14,093	4.0	136	2,289
Economic	13,884	3.9	277	4,932
Geological & Mineralogical	10,671	3.0	591	3,016
Social	5,614	1.6	80	707
Geographical	4,274	1.2	167	1,594
Juridical	2,249	0.6	105	1,339
Architectural	1,438	0.4	36	466
Miscellaneous	7,373	2.1	22	1,132
TOTALS	354,158	100.0	10,945	98,262

* The Soviet Kandidat level is somewhere between the American Master's and Ph.D degrees, and probably closer to the latter in equivalence of academic requirements and training. The Doktor degree is normally awarded for scientific achievement, consequently an older age group and higher degree of professional accomplishment than for the American Ph.D characterise the Doktor.

Source: Narodnoye Khozyaistvo SSR v 1960 godye, Tsentral'noye statistichyeskoye upravlyeniye, Moscow 1961, p. 784.

Table 32b

SCIENTIFIC PERSONNEL
(in thousands a/o 1 October)

Location	1914	1940	1950	1953	1955	1956	1957	1958	1959	1960
Scientific Institutions	4.2	26.4	70.5	80.0	96.5	106.4	121.5	141.0	164.8	200.1
Higher Educational Schools	6.0	61.4	86.5	105.4	119.1	125.0	132.3	135.7	137.8	146.9
Others	--	10.5	5.5	6.5	8.3	8.5	7.8	7.3	7.4	7.2
TOTALS	10.2	98.3	162.5	191.9	223.9	239.9	261.6	284.0	310.0	354.2

SOURCE: Narodnoye Khozyaistvo SSR v 1960 godu, Tsentral'noye statistichyeskoye upravlyeniye, Moscow 1961, p. 782.

Narodnoye Khozyaistvo SSR v 1958 godu, Tsentral'noye statistichyeskoye upravlyeniye, Moscow 1959, p. 843.

Table 32c

SCIENTIFIC PERSONNEL BY SCIENTIFIC DEGREE AND PROFESSIONAL STATUS
(in thousands)

	1950	1953	1955	1956	1957	1958	1959	1960
Scientific Degrees:								
Doktor	8.3	8.5	9.5	9.8	10.0	10.3	10.5	10.9
Kandidat	45.5	59.5	78.0	85.7	87.2	90.0	94.0	98.3
Professional Status:								
Professors	8.9	8.5	9.0	9.1	9.4	9.6	9.7	9.9
Asst. Professors	21.8	24.7	28.6	30.4	31.6	32.7	34.3	36.2
Senior Scientific Staff	11.4	12.9	14.6	15.6	16.7	17.2	18.4	20.3
Junior Scientific Staff and Assistants	19.6	19.8	17.1	17.8	21.3	23.6	26.3	26.7
Others	47.0	58.0	67.1	71.5	85.4	100.6	116.8	151.9
TOTALS	162.5	191.9	223.9	239.9	261.6	284.0	310.0	354.2

SOURCE: Narodnoye Khozyaistvo SSR v 1960 godu, Tsentral'noye statistichyeskoye upravlyeniye, Moscow 1961, p. 783.

Narodnoye Khozyaistvo SSR v 1958 godu, Tsentral'noye statistichyeskoye upravlyeniye, Moscow 1959, p. 843.

Table 33

ESTIMATE OF THE GNP OF THE USSR

Estimates of the GNP of the USSR are difficult and subject to wide variation depending upon the interpretation of the analyst. For the purposes of comparison with R&D data, the analyses of Bergson[1]) supplemented by the extended data of Nimitz[2]) have been used. In order to project the GNP after 1958, a growth rate of 7% per year[3]) has been used.

Year		GNP (Milliards of current rubles)
1948		776.4
1949		903.8
1950		911.7
1951	1)	971.0
1952		1,016.4
1953		1,041.8
1954		1,093.8
1955		1,183.9
1956		1,283.5
1957	2)	1,397.6
1958		1,537.1
1959		1,645
1960	4)	1,760
1961		1,885
1962		2,020

1) Abram Bergson, The Real National Income of Soviet Russia Since 1928, Cambridge, Massachusetts, Harvard University Press, 1961, p. 300.

2) Nancy Nimitz, Soviet National Income and Product, 1956-1958, RM-3112-PR, prepared by The RAND Corporation, Santa Monica, California, for the U.S. Air Force, June 1962, p. 6.

3) Francis P. Hoeber, et al, "Soviet Economic Potential and Strategies," Journal (Stanford Research Institute, Menlo Park, California), Fourth Quarter, 1959, Vol. 3, pp. 160-172.

4) Extrapolated.

Table 34

SYNTHESIS OF DATA

Year	R&D Expenditure as % of G.N.P.
1950	0.99
1953	1.08
1956	1.35
1958	1.57
1959	1.71
1960	1.87
1961	2.02**
1962	2.13*

*Planned expenditures. All other figures are on basis of actual expenditures.

**Estimated planned expenditures.

For comparison with other countries, the 1959 ratio of R&D expenditures to G.N.P. is 1.72%. On the basis of a population of 210,500,000 the per capita expenditure was 134 Rubles, or in terms of the official rate at that time $33.50. While the G.N.P. increased from 1950 to 1959 by a factor of 1.8, expenditures increased 3.1 times.

REFERENCES

Abram Bergson, The Real National Income of Soviet Russia Since 1928, Cambridge, Massachusetts, Harvard University Press, 1961.

Nicholas DeWitt, Soviet Professional Manpower, National Science F Foundation, Washington, 1955.

Nicholas DeWitt, Education and Professional Employment in the U.S.S.R., National Science Foundation, Washington, 1961.

Gosudarstvennii Byudzhet SSSR i Byudzhety Soyuznykh Respublic, Moscow, 1962.

Francis P. Hoeber, et al, "Soviet Economic Potential and Strategies", Journal (Stanford Research Institute, Menlo Park, California), Fourth Quarter, 1959, Vol. 3, pp. 160-172.

Francis P. Hoeber and Robert W. Campbell, Soviet Economic Potential 1960-1970, Stanford Research Institute, Menlo Park, California, May 1961.

Alexander G. Korol, Soviet Education for Science and Technology, published jointly by The Technology Press of Massachusetts Institute of Technology and John Wiley & Sons, Inc., New York, 1957.

Nancy Nimitz, Soviet National Income and Product, 1956-1958, RM-3112-PR, prepared by The RAND Corporation, Santa Monica, California, for the U.S. Air Force, June 1962.

Nancy Nimitz, Soviet Expenditures on Scientific Research, RM-3384-PR, prepared by The RAND Corporation, Santa Monica, California, for the U.S. Air Force, January 1963.

The Training, Placement and Utilization of Engineers and Technicians in the Soviet Union, published by Engineers Joint Council, Inc., New York, 1961.

"Measures for Improving Co-ordination of Scientific Research in the Country and Work of the Academy of Sciences of the USSR", adopted April 3, 1961 (see Pravda and Izvestiya, April 12, 1961, p. 1).

Narodnoye Khozyaistvo SSSR v 1958 godu, Tsentral'noye statistich-yeskoye upravlyeniye, Moscow, 1959.

Narodnoye Khozyaistvo SSSR v 1960 godu, Tsentral'noye statistich-yeskoye upravlyeniye, Moscow, 1961.

Yearly budget speeches which appear in Pravda and Izvestiya each December