# METHODS OF GOVERNMENT ASSISTANCE TO RESEARCH AND DEVELOPMENT

by
Murray L. Weidenbaum
Professor of Economics
Washington University

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Studies of the major industrialized economies suggest that advances in productivity -- rather than merely additions to the stock of capital or the labor force -- account for an important share of economic growth.[2] Hence, it has been proposed that plans for attaining rapid expansion of economic growth should emphasize speeding up technical change and innovation.[3] This paper deals with one possibility for accelerating such applications of science and technology -- governmental encouragement of the private performance of research and development (R & D). An examination of such efforts in the more rapidly developing nations reveals that a wide variety of mechanisms exists through which governmental authorities can encourage private R & D undertakings. This study both indicates the major categories of such public aid and also presents some of the limitations to their effectiveness.

## The Definition of Research and Development

Definitions of the content of research and development vary among nations, and, for different purposes, within nations. In general, this study adopts the definition generally used in the special legislation affecting research and development in the nations discussed. For example, the United Kingdom and several members of the British Commonwealth utilize a relatively broad definition of research, "any activity in the field of natural or applied science for the extension of knowledge". In many countries, product development is also linked with research.

The French tax law concerning depreciation allowances uses a most comprehensive definition of scientific research -- activities in the nature of fundamental research, applied research or development work, carried out in

design departments, laboratories, pilot plants or experimental stations, or in special circumstances within agricultural or industrial installations, and having as their object:

> the discovery and development of new production techniques, new manufacturing processes and equipment, and the improvement of any manufacturing equipment and processes already in use;
>
> the discovery and development of new processes and equipment for controlling manufacturing and the improvement of control processes and equipment already in use;
>
> the discovery of new products for new applications or applications already known, and the discovery of new applications of products already known;
>
> obtaining new plant or animal species;
>
> the improvement of the factors of production and economic profitability, in particular, automation and operational research, and the improvement of production methods and techniques;
>
> preservation and conversion of products, from the point of view of quality, yield and productivity;
>
> improvement of equipment and techniques in the medical and veterinary fields;
>
> the improvement of personal working and living conditions.[4]

In contrast, some nations do not go to any particular length to define "research" or "research and development" or "science and technology" for official purposes, choosing to depend on individual judgments and the general understanding of the term.

The Role of Private Research and Development

Clearly, the role of private undertaking and financing of research and development varies with the importance of the private sector of individual economies. For this reason, this study does not cover the various measures in the socialized economies for the encouragement of science and technology. As can be seen in Table 1 covering the United States, even in a predominantly

Table 1

FUNDS USED FOR PERFORMANCE OF RESEARCH AND DEVELOPMENT IN THE UNITED STATES, BY SOURCE AND PERFORMER, 1963
(Millions of Dollars)

| Sources of Funds | Research and Development Performers | | | | | |
|---|---|---|---|---|---|---|
| | Federal Government | Industry | Colleges and Universities | Other Nonprofit Institutions | Total | Percent Distribution R & D Sources |
| Federal Government | 2,400 | 7,340 | 1,300 | 300 | 11,340 | 65% |
| Industry | -- | 5,380 | 65 | 120 | 5,565 | 32 |
| Colleges and Universities | -- | -- | 260 | -- | 260 | 2 |
| Other Nonprofit Institutions | -- | -- | 75 | 110 | 185 | 1 |
| Total | 2,400 | 12,720 | 1,700 | 530 | 17,350 | 100% |
| Percent Distribution, R & D Performance | 14% | 23% | 10% | 3% | 100% | |

Source: U.S. National Science Foundation.

private enterprise economy, the national government may provide the bulk of the funds. However, in the case of the United States, the great majority of the work is performed by private industry and other institutions outside of the public sector. Government financing is important primarily in the industries and institutions doing research and development on military weapon systems. The companies themselves provide the bulk of the funds in the case of the drug, chemical, machinery, motor vehicle, petroleum refining, metal and similar civilian-oriented industries.[5]

Virtually all the R & D of American industrial firms is performed for their own account or for the Federal Government. However, a relatively small amount of funds ($70 million in 1960) for R & D comes from other sources, such as companies without R & D programs or without specialized competence in certain fields. In a few industries, such financing is particularly important. For example, commercial laboratories and consulting and engineering service firms mainly provide R & D services for industrial firms and other organizations on a contractual basis.

Methods of Encouragement

The following are the major methods currently in use in the more developed nations to encourage private financing of research and development: tax benefits, government-sponsored associations and institutes, patents, and technical assistance. Other possibilities range from the broad attempt to secure a good investment climate to such specifics as sales by government enterprises below standard rates. Many of these methods are not mutually exclusive. In practice, they are found in various combinations, according to the requirements and desires of the particular nation. It should also be noted that in general there is great difficulty in measuring the actual effectiveness of the various methods described below.

Tax Benefits

The most frequently used and widest varieties of governmental aids to R & D are in the nature of tax benefits. These include tax deductibility, tax exemption, liberalized depreciation allowances, and tax credits and special benefits.[6]

Current costs of doing industrial research and development, such as wages and salaries, purchases of chemicals, etc., are mostly generally deductible under the usual provisions relating to the computation of taxable income. Numerous countries have such provisions in their tax structure, including Australia, Belgium, Denmark, Greece, Iceland, Italy, New Zealand, Switzerland, Turkey, and the United States.

Some countries combine such a provision with the requirement of governmental approval for specific projects. For example, Austria allows the deductibility of expenditures on the development, improvement or protection of inventions certified by the Ministry of Trade and Reconstruction to be important for the national economy.

A few countries, notably Norway, allow the tax deductibility of both current costs and capital expenditure for research. The taxpayer has the option of treating capital expenditures as an asset and writing them off over a period of years.

Also, in most countries gifts to independent research institutes are deductible from annual income. This has been the practice in Australia, Belgium, Canada, Greece, Ireland, Italy, Portugal, Sweden, the United Kingdom, and the United States. Some countries maintain a limitation. In Austria, only one half of the gift is deductible with a maximum of two percent of income; in France, up to two tenths of one percent of the gross receipts; in Norway, only to institutes in which the state is a participant; in Spain only within the framework of business purposes.

A variety of tax exemptions also exists. In many cases the research institutes receiving gifts are exempt from taxation. In the United States this covers the relatively large and rapidly growing category of nonprofit research organizations, some of which employ several thousands of professional and technical workers on a wide variety of studies for individual business firms, industry and trade associations, and governmental agencies.

In some countries with a turnover or value-added tax, all services are exempt including services rendered by research laboratories. The sale of plans, models, drawings, etc., by the inventor is treated as a service in Australia, Belgium, Canada, Greece, Switzerland, and the United Kingdom.

In countries where services are not exempt from the turnover type of tax, research performed by scientific institutions is usually exempt (e.g., Austria and the Federal Republic of Germany). The delivery of goods for scientific and/or research purposes is tax-free in several other countries. In most countries, gifts or legacies to institutions exclusively serving charitable and scientific purposes and having an independent legal status are exempt from gift or estate duty or are taxable at a reduced rate.

Several nations grant an exemption from import duties with respect to instruments imported for nonprofit scientific research. In Canada, this is limited to institutions established solely for scientific purposes and to universities. A number of nations do not levy import duties on scientific equipment or apparatus, as signatories to the international agreement of November 22, 1950, on the Importation of Educational, Scientific and Cultural Materials.

Some countries provide for more liberal depreciation allowances for research and development facilities. In Australia, buildings, plant, and machinery for such purposes may be written off in a three-year period. In Canada, a

rapid depreciation allowance is provided if the research program has received prior approval. An example of another type of tax benefit is the special tax rate granted to independent inventors in Austria on income from patents that are considered important for the national economy.

In Spain, enterprises which have a very high profit/capital ratio qualify for preferential tax treatment if they earmark a part of their profits for research. The portion of profits in excess of six percent of capital, if invested in laboratories and research equipment used for the enterprise's purposes, is exempt from taxation. The deduction may not exceed fifty percent of net profits.

In general, the tax systems of the more developed nations vary considerably as to types of taxes utilized, rates employed, coverage, definitions, and so forth. Hence, the specific provisions dealing with deductibility, exemption, or other special treatment of research and development do not yield uniform benefits or incentives among these various nations. Also, many tax authorities retain in practice considerable administrative discretion in the interpretation and execution of the rather detailed and complex taxation statutes and regulations. Variations resulting from the operation of these factors are not covered in this study.

Government-Sponsored Associations

A number of countries have formed or encouraged the formation of various types of cooperative research associations and institutes. Such joint research ventures may at times be an attractive vehicle through which smaller companies can sponsor research. They may also be of value for larger companies. An example is the British research associations, which were established in 1918 as a result of government funding to those associations which also could obtain

industry support. The Department of Scientific and Industrial Research was set up and given one million pounds sterling to get the research associations underway. It was recently estimated that there are over fifty such research associations covering among them over one half of British manufacturing industry.[7]

The research associations now derive their income from two principal sources: the government through the Department of Scientific and Industrial Research, and their members. The government's contribution is determined by the amount subscribed by the industrial members. The primary factor in the assessment of contributions is usually the size of the company, size being based on capital, productive capacity, payroll or number of employees, or on value of actual output. The private subscriptions are often paid through some form of trade association.

The principles used by the Department of Scientific and Industrial Research for supporting the associations have undergone some changes over the years. Currently, the Department contributes only when a research association's industrial income reaches a certain minimum amount. On reaching this lower limit, the association receives a block grant, which is normally considerably less than the amount of industrial income. Income in excess of this is eligible for so-called incentive grants, until it reaches an upper grant-earning figure. Beyond this point there is no further assistance.

Other non-grant-earning income is also obtained in return for special or sponsored research carried out for particular companies or organizations to meet some specific need and which does not therefore form part of the association's own research program. Other income is also derived from patent and licence royalties[8] (see Table 2).

Table 2

SOURCES OF FINANCING OF
UNITED KINGDOM RESEARCH ASSOCIATIONS, 1960
(data in thousands of pounds sterling)

| Research Association | Grant Earning Income | Grant | Other Income | Total Income |
|---|---|---|---|---|
| Baking | 34 | 23 | 21 | 78 |
| Boots and Shoes | 60 | 30 | 12 | 102 |
| Cast Iron | 156 | 65 | 25 | 246 |
| Ceramic | 153 | 64 | 38 | 255 |
| Coal Utilization | 268 | 82 | 103 | 453 |
| Coke | 113 | 40 | 5 | 158 |
| Cotton | 309 | 92 | 62 | 463 |
| Electrical | 259 | 100 | 138 | 497 |
| Felt | 10 | 6 | 2 | 18 |
| File** | 4 | 3 | * | 7 |
| Flour-Millers | 60 | 25 | 6 | 91 |
| Food | 47 | 24 | 18 | 89 |
| Fruit and Vegetable Canning | 18 | 9 | 4 | 31 |
| Furniture | 33 | 21 | 9 | 63 |
| Gelatine and Glue | 13 | 9 | 4 | 26 |
| Glass | 46 | 22 | 3 | 71 |
| Heating and Ventilating** | 17 | 11 | * | 28 |
| Hosiery | 55 | 23 | 3 | 81 |
| Hydromechanics | 36 | 18 | 7 | 61 |
| Industrial Psychology | 10 | 7 | 8 | 25 |
| Internal Combustion | 47 | 30 | 8 | 85 |
| Iron and Steel | 758 | 120 | 67 | 945 |
| Jute | 32 | 19 | 5 | 56 |
| Lace | 19 | 14 | * | 33 |
| Launderers | 42 | 23 | 18 | 83 |
| Leather | 39 | 22 | 9 | 70 |
| Librarians | 19 | 16 | 23 | 58 |
| Chalk Lime | 11 | 7 | 5 | 23 |
| Linen | 35 | 20 | 19 | 74 |
| Marine Engineering | 243 | 70 | 215 | 528 |
| Motor Industry | 121 | 60 | 20 | 201 |
| Non-Ferrous Metals | 124 | 60 | 72 | 256 |
| Paint | 55 | 30 | 10 | 95 |
| Paper and Board | 93 | 27 | 18 | 138 |
| Printing | 84 | 44 | 19 | 147 |
| Production Engineering | 171 | 85 | 148 | 404 |
| Rubber and Plastics | 81 | 37 | 32 | 150 |
| Scientific Instruments | 43 | 43 | 40 | 126 |
| Shipbuilding | 304 | 60 | 24 | 388 |
| Spring** Manufacturers | 7 | 4 | 4 | 15 |
| Steel Castings | 61 | 31 | 11 | 103 |
| Coal Tar | 77 | 23 | 13 | 113 |
| Timber | 54 | 34 | 1 | 89 |
| Water | 50 | 27 | 3 | 80 |
| Welding | 112 | 69 | 59 | 240 |
| Whiting R.C. | 11 | 6 | 1 | 18 |
| Wool | 171 | 70 | 50 | 291 |
| TOTAL | 4,565 | 1,725 | 1,362 | 7,652 |

*Less than 500 pounds sterling
**Operated in association with a larger research association

Source: D.W. Hill (editor), "The Work of the Research Associations," Supplement to Vol. XV of Research, London: Butterworths, 1962.

The West German research association (Deutsche Forschungs-Gemeinschaft or DFG) is a nonprofit organization established in 1949 using public and private funds.[9] In 1959, the Bonn Government contributed $8.6 million and the state governments $2.3 million. The largest contributor was a private one, the Society for the Endowment of German Science, founded in 1949 by a group of distinguished citizens who wished to aid research by private means. The Society's funds came from over 3,000 organizations, business and industrial firms, and individuals.

The DFG does not engage in research of its own. The membership, and thus the individuals who run it, includes the various scientific institutions of higher learning, the academies of sciences, and the major scientific societies. The Association provides financial assistance for research projects, promotes cooperation among research investigators, advises public authorities in scientific matters, strives to improve relations between scientists in West Germany and other nations, and encourages and trains young scientists.

The Federal and state governments are represented only on those bodies within the DFG that have the power to make financial decisions on total funds to be made available. The distribution of funds is made by researchers, serving on a variety of DFG scientific commissions.

In Belgium, an initial grant is provided by the government to found the various Scientific and Technical Cénters ("Centers scientifiques et techniques," called "Centres De Groot").[10] All companies in the particular branch of industry pay a compulsory contribution which is calculated on the annual sales, the volume of production, or in proportion to the number of employees and salaries paid. Governmental organizations, such as the Institute for the Promotion of Industry and Agriculture, may contribute to the expenses. Private contributions represent a further source of income.

Business donations and gifts are free from normal taxation and enjoy special tax reductions if made for cooperative research institutes. The Belgian experience is another example of the use of several methods of promoting research in conjunction with each other.

France has a system of technical research centers which are semi-official organizations, each of which serve one branch of industry and are funded through taxes on the products of the industry itself. These centers are controlled by an administrative council consisting of representatives from industry, universities, consumers, and science.

In Sweden, during the 1940's, a number of branches of industry (paint and varnish, tannery, textiles, mining, and timber) established their own cooperative research institutes, with the aid of government subsidies. Their research activities are financed by contributions from the government and the industries concerned.[11]

Patents

Industrialized nations generally have fairly extensive patent systems for the promotion of science and industry. A patent system may encourage a company to invest in R & D so that it can develop a product or process for which it can secure a temporary monopoly that can be exploited for profit. To some extent, a patent system may unwittingly tend to encourage the reverse effect; this would occur when one company obtains a patent to prevent its competitors from exploiting a technological improvement, but does not exploit it itself in order to protect its existing capital investment.

Some countries utilize their patent systems to encourage private industry to utilize the research performed in government laboratories. The Australian Scientific and Industrial Research Organization licenses the use of its

patented inventions.[12] A potentially important device that has been carried only to the stage of laboratory operation may require a great deal of developmental work before commercial application can begin. In such circumstances, no manufacturer may be prepared to risk substantial expense on development or tooling unless assured of exclusive rights to the invention.

Technical Assistance

Government-sponsored or maintained laboratories and/or institutes may provide important technical assistance required by industrial firms who may wish to embark on research and development work. The Physikalische Technische Reichsanstalt was established in 1887 in Germany to provide instrument calibration and research and testing on standards, instruments, and materials important to the science and industry of the country. The United Kingdom and the United States set up similar agencies in 1900 and 1901.[13] Suggestions have been made in recent years for engineering or scientific extension services to industry along the lines of the agricultural extension service to farmers in the United States. In the United States, the National Aeronautics and Space Administration (NASA), the civilian agency charged with the peaceful exploration of outer space, has undertaken a technology utilization program. This program, which draws upon the resources of a number of universities and research institutes, is attempting to screen the various inventions and other technical improvements made in NASA laboratories and by NASA contractors and to bring promising results of government-sponsored science and technology to the attention of private business firms who are in a position to utilize them.[14]

In addition, the government can foster the creation of nonprofit private laboratories and research institutes through granting tax exempt status to

their operations as well as to the donations to such organizations. Such institutes can undertake a wide variety of activities, including performing research and providing technical and economic services for industry, providing technical assistance in development and industry planning, developing technical manpower and enhancing the availability of scientific and technical resources, and providing liaison with and obtaining services from foreign personnel and research organization.[15]

In a few countries, private tax-exempt foundations are important sources of research funds. Nearly half of the expenditures of such foundations in the United States on scientific work are granted to universities. The remainder goes to institutions and individual researchers.

Other Forms of Assistance

There are still other possible ways in which the government can foster private research. In Austria, the Alcohol Monopoly sells denatured alcohol at reduced prices for scientific or industrial purposes. Industrial purposes include chemical and physical investigations of all kinds. The U.S. Office of Education arranges for the donation of certain types of surplus government equipment to educational and related institutions.

Norway obtains funds for research in a rather unusual way, from the profits of soccer pools (a form of placing wagers on athletic events). The soccer pools are organized as a semi-government company with the aim of supporting sports and research. Of the profits, the first million *kroner* go to sports. Of the second million, research gets 200,000 *kroner*; of the third, 400,000 *kroner*; of the next 600,000 *kroner*; and of each additional million, 800,000 *kroner*.[16]

The proceeds for research are distributed among three semi-governmental

research councils representing government, industry, and research: the Royal Norwegian Council for Scientific and Industrial Research, the Norwegian Research Council for Science and Humanities, and the Agricultural Research Council of Norway. The Research Council for Scientific and Industrial Research also provides advice and guidance to the Norwegian Industries Research Association. The latter is supported by voluntary contributions (0.3% of gross sales receipts) by member business firms.

As Van Hoorn has pointed out, there are some countries without any special tax incentive relating to research whose tax systems viewed as a whole present a more favorable context for research than some countries which have introduced special measures. General measures to stimulate business activity and outlay without limitation as to the purpose of the expenditure may create a favorable climate for research within the overall framework of a national tax system. For example, governmental policies to stimulate higher levels of business investment in plant and equipment can also serve to aid the research effort insofar as the latter involves laboratories, office buildings, and other relatively durable plant and equipment outlays.

Various tax mechanisms have been used to encourage business investment in capital equipment, which usually is the largest portion of the expenditures required to commercialize the results of new product research and development. One such mechanism is to allow a portion of the investment in plant and equipment, as a credit against the amount of income tax payable, rather than merely treating the item as a tax-deductible expenditure. Another method is to shorten the "expected useful life" (the period over which depreciation charges are to be written off), and permitting charging a disproportionately high rate of depreciation in the earlier years. In the United States, this was done in

the Internal Revenue code of 1954 through allowing such "fast write-off" methods as double declining balance or sum of the year's digits.

Some Qualifications

A given promotional program in one country may lead to desirable results because it is designed to function in the overall framework of its governmental and economic system. If such a measure were adopted in a country with a different political or economic environment, the result might not be as fortunate or at least not the same, because the measure would lack the supporting elements found in the system from which it was borrowed.

Also, some industries may not provide attractive opportunities for research. For example, the chemical and electronics industries in most of the developed nations finance and perform large amounts of research and development, despite tremendous variations in governmental assistance. In contrast, other industries such as textile manufacturing and food products, almost uniformly participate in science and technology to a much lesser degree, almost regardless of the amounts of governmental aid. The potential opportunities for the utilization of R & D apparently may in some cases constitute important limitations to the effectiveness of measures to increase private fundings and undertakings.

Another limitation to the effectiveness of governmental financing of R & D may be more fundamental. Even in the most industrially advanced nations, expansions of expenditures for research and development may not necessarily lead to concomitant increases in the production and sale of new production. In the case of the United States, where the great bulk of the R & D effort in recent years has been devoted to defense and space programs, the commercialization of such scientific and engineering efforts -- what is often referred

to as "commercial fall-out" or "civilian spill-over" -- has been relatively small to date. Numerous reasons have been advanced for this situation, including the specialized nature of the major defense companies and the lack of incentive to diversify out of relatively low-risk and high-profit military markets to the comparatively uncharted area of new product development in the private economy.[17] Some of these obstacles may not be present in the case of research and development efforts more closely related to the needs of the civilian economy. Nevertheless, the many abandoned product diversification attempts of American industry indicate that the economic benefits of R & D, through increased employment and income resulting from manufacturing and selling new or improved products, may not be expected to happen automatically. A given increment of R & D expenditures may not yield any significant multiplier in terms of subsequent increases in production activity. Perhaps, the major civilian benefits of such research and development require a longer gestation period than has been available to date.

Some Findings and Conclusions

In this survey of alternative methods of encouraging private financing of research and development in the more advanced economies, it is clear that no standard pattern emerges.

Some of the more general environmental factors may be important determining influences on any governmental efforts to foster science and technology. Their presence may be taken for granted in many -- but certainly not all -- of the more developed nations. One such positive factor would be an economic climate which encourages private risk-taking, investment, and business growth, thus reinforcing the more specific measures concerned with increasing private sponsorship and financing of research and development.

Another important influencing factor is the essentially political choice of each nation as to the desirable size of the private sector of the economy and, hence, the necessary magnitude of governmental efforts to encourage R & D as well as other private undertakings. Clearly, threats of imminent nationalization of various branches of industry could more than offset the favorable impacts of specific R & D incentives.

As pointed out earlier in this paper, there are four broad categories of government mechanisms which have been employed in the more technologically advanced nations for fostering research and development: tax incentives, research institutes and associations, patents and technical assistance, and miscellaneous efforts such as donation of surplus government supplies to private laboratories.

In the case of a developing economy with relatively low levels of research, product development and overall economic growth, relatively strong tax concessions might be required. Mild forms of tax benefits such as tax deductibility or liberalized depreciation may not suffice. Relatively strong stimulants, such as tax credits and tax exemptions for research purchases and research activities, may be required in order to provide significant incentives for higher levels of private research undertaking. This, in turn, might require strengthening the nation's tax structure to improve its use as an allocator of resources. To the extent that strong tax incentives are developed, the government might decide to restrict them to the types of scientific and technical efforts which are considered to be of particular importance to the development of the nation's economy.

Similarly, co-operative research associations might be fostered in sectors of industry considered to be strategic from the viewpoint of economic development. The establishment of such associations might require new patterns

of economic organization involving "half-way houses" between enterprises entirely owned and operated by the government, on the one hand, and the completely private business companies, on the other.

Such research associations might require initial government funding which could be made contingent on a minimum level of private support and participation. There are numerous precedents of enterprises originally established by government sponsorship and financing which gradually have been converted to private ownership and operation.[18]

Incentive subsidies or tax benefits could also be employed to encourage continued private participation in these research associations or institutes.

Also, technical assistance might be rendered directly to private companies to help them in developing a capability to carry on research and development work and in obtaining an awareness of the possibilities of their application.

Because of the long lead times often involved in obtaining the commercial benefits of research and development, and hence the uncertainty in obtaining financial pay-offs, the need for government assistance in this area may be more pervasive and extended than is the case of many other private activities. The considerable external economies often generated by private research undertakings, of course, may provide the justification for strong governmental interest and support of R & D. Certainly, the promotion of research and development is not a matter which is independent of a nation's overall economic development policies and programs but rather an integral part of efforts to increase productivity, efficiency, and living standards.

## Footnotes

[1]An earlier version of this research was reported in Studies in Comparative International Development, Vol. 1, 1965, No. 9, pp. 123-131.

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[6]Van Hoorn, op.cit.

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