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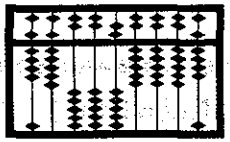


INTRODUCTION AND SETTING

In 1964 the President of the United States directed the Department of Commerce to explore new ways for "speeding the development and spread of new technology." [1] Because one of the ways in which a government can accomplish this end is to improve the *climate* for technological change, the Secretary of Commerce created an ad hoc *Panel on Invention and Innovation* and asked it to explore the opportunities for improving such climate-setting policy areas as antitrust, taxation and the regulation of industry. What follows is the report of the Panel.

[1] *Economic Report of the President to the Congress of the United States, 1964.*

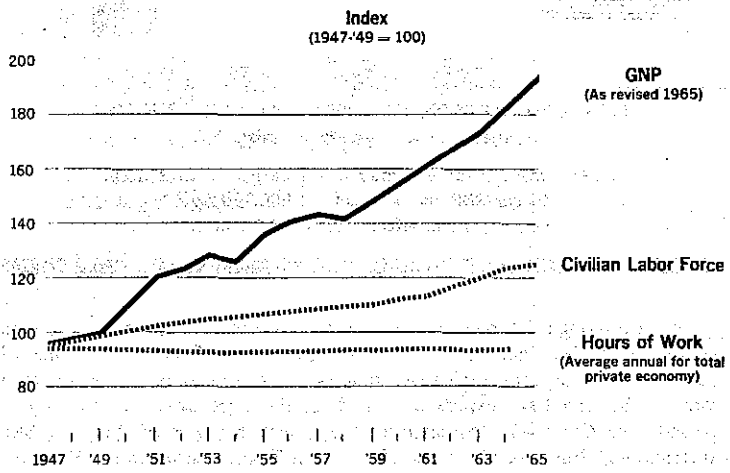
The answer is that invention and innovation lie at the heart of the process by which America has grown and renewed itself.

Let us expand upon this simple truth and explore more specifically some of the reasons why the Federal Government must be concerned about the climate for invention and innovation.

First, there is a very significant relationship between innovation and economic growth. Although estimates of the contribution of technological progress to increases in the Gross National Product (GNP) are imprecise, economists agree that the contribution is substantial.[2] For example, if we compare the change in the labor input ("Hours of Work" in Chart 2) with the change in GNP over the period 1947-1965, we see a marked difference between these two factors.

CHART 2

INDEXES OF GROSS NATIONAL PRODUCT, LABOR FORCE, ANNUAL HOURS WORKED, 1947-1965



The average annual hours of work remained practically constant, while the GNP rose substantially during the period in question. Indeed, the GNP nearly doubled. Without presuming to say how much of this increase in GNP was attributable to technological innovation, we are confident that

[2] *See, for example, Denison, E.,* The Sources of Economic Growth in the United States, *Committee for Economic Development, 1962; Kendrick, J.,* Productivity Trends in the United States, *National Bureau of Economic Research, 1961; and Solo, R., "Technical Change and the Aggregate Production Function,"* Review of Economics and Statistics, *1957.*

CHART 4

A FEW EXAMPLES OF TECHNOLOGICALLY INNOVATIVE COMPANIES THAT HAVE EXPERIENCED MUCH OF THEIR GROWTH IN THE LAST 20 YEARS (1945-1965)

AVG. % ANNUAL GROWTH (Compounded)

	Net Sales	Jobs
Polaroid	13.4%	7.5%
3M	14.9%	7.8%
IBM	17.5%	12.1%
Xerox (Haloid Co.)	22.5%	17.8%
Texas Instruments (1947-1965)	28.9%	10.0%

Average % annual sales growth of above companies*: 16.8%

Average % annual growth of GNP: 2.5%

*Excluding Texas Instruments for which data are available only for the past 18 years.

INTERNATIONAL TRADE

If we consider the effects of technological change on international trade, we can see another very persuasive reason why the Federal Government should be concerned about the promotion of invention and innovation.

An important element of our international balance of payments is what is called the "technological" balance of payments. This international account reflects payments for technical know-how, patent royalties, and the like. In a recent study of the technological balance of payments of various countries, the Organization for Economic Cooperation and Development (OECD) published data for the United States, which are depicted in Chart 5.

The OECD compliation shows the United States receiving roughly ten times as much in technological payments from abroad as goes out in payments to other nations. This is a very significant secondary effect of innovation in the American economy.

Technological change affects international trade in subtle ways. Let us consider, for example, the so-called "displacement" innovations. These do not have the dramatic result of a new company, such as the Xerox Corporation or an entirely new product or process for which no substitute existed before—the electronic computer is a good example. "Displacement" innovations displace existing products or processes. The effect of such innovations is illustrated by the invasion of the cotton and wool fiber market by synthetic fibers.

We can see in Chart 6 that synthetics, which sprang from considerable innovative effort, have maintained our share of the international yarns and fabrics market. The total exports of cotton and wool yarns and fabrics have declined by about a third over the period 1956-1965, whereas the total exports of synthetic yarns and fabrics have increased by over 50%. The export of high-technology synthetic yarns and fabrics has therefore maintained the U.S. export of yarns and fabrics roughly at the level it was in 1956.

We could give other examples of the secondary effects of innovation. We are satisfied that the international stature of a nation with respect to trade—and, it is important to note, assistance to under-developed countries—becomes increasingly dependent upon its innovative performance.

INNOVATION AND COMPETITION

There are other reasons why the Federal Government should be interested in promoting invention and innovation, among which is the close and complementary interaction between innovation and competition.

Competition has traditionally involved rivalry among manufacturers of like products, as well as the stimulating effect of innovators who introduce new products and reduce costs through new methods of production and distribution. For example, the advent of the airplane had a powerful influence on competition in public transportation, and the automobile brought entirely new forces into the private transportation sector. To take more recent examples, the introduction of the transistor and integrated circuits has stimulated competition in the electronics industry.

The influence of innovation on competition has become stronger and clearer with the accelerated pace of technological change. Competition has developed between entirely new types of products that perform old functions better or make possible entirely new functions. To give just three examples, consider electrostatic copying ("xerography"), synthetic wash and wear fabrics, and instant photography.

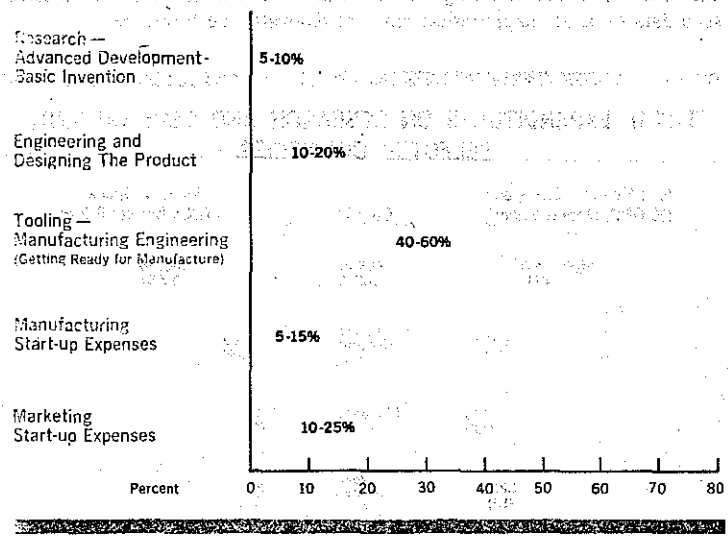
The importance of innovation has become so strong that no longer may we look only to the conventional limits of a given industry to examine competition. Increasingly, innovations of importance are coming from companies that do not fit within the conventional classifications of individual industries. For example, synthetic fibers came from the chemical industry, not the textile industry. High-speed ground transportation is now as much the domain of the aerospace and electrical manufacturing industries as it is that of the automotive and railroad industries. Instant photography (the Polaroid camera) was not developed by the photographic industry. And electrostatic copying came from outside the conventional office equipment industry.

It is easy to see, therefore, that innovation from the outside (across conventional industry boundaries) is a powerful force influencing competition. Consequently, a climate conducive to technological progress is important not only with respect to economic growth and international stature, but is also essential to the maintenance of a vigorous, competitive, economic climate.

Accordingly, in order to arrive at a reasonable indication of the distribution of costs in successful product innovations and, particularly, to examine the role of research and development in the total process of bringing a new product to market, we pooled the knowledge of experienced members of the Panel. On this basis, we tried to discern a representative pattern in the distribution of costs in successful product innovations. There was sufficient similarity in the experiences we covered to convince us that it would be desirable to present the following "rule of thumb" figures as the basis for our discussion.

CHART 7

TYPICAL DISTRIBUTION OF COSTS IN SUCCESSFUL PRODUCT INNOVATIONS



This breakdown of cost and effort indicates that the step we commonly call research, advanced development or basic invention, accounts, typically, for less than 10% of the total innovative effort. The other components, which we do not usually associate with the innovative process, account for something like 90% of the total effort and cost. Engineering and designing the product, tooling and manufacturing-engineering, manufacturing start-up expenses, and marketing start-up expenses, are all essential to the total process. It is obvious, therefore, that research and development is by no means synonymous with innovation.

The above analysis concerns successful product innovations. We tried to

If R&D percentages of GNP were an appropriate measure of innovative performance, the above data, compiled by the Organization for Economic Cooperation and Development (OECD), would imply that innovation is as significant a factor in the non-military, non-space sectors of the United Kingdom (1.4%) and Belgium (1.5%) as it is in the United States (1.5%). However, it is clear that these countries are not running a close race with respect to innovative successes and economic growth. Such R&D data are obviously misleading when they are relied upon as indexes of innovative capability or accomplishment.

It is important to bear in mind, therefore, that an oversimplified assumption is probably made whenever it is assumed that more money spent on research and development automatically has some kind of multiplier effect on innovation into the market place. Those who equate R&D expenditures with innovative accomplishment are not looking at the innovative process the way businessmen must. For the main concern of businessmen is the total cost and the total profitability or loss of the *entire* venture.

This is not to say that R&D is unimportant. It should be understood that we appreciate the vital role of R&D and that our discussion is not meant to imply that there are not important sectors of the economy in which additional R&D effort would be desirable. For we believe that there are several sectors of the economy which should be given special attention in any analysis of the innovative process, including the role of R&D.

SOCIAL INNOVATION IN THE PUBLIC SECTOR

There are many pressing, public-sector problems that require innovative solutions. By way of illustration, we have listed a few examples of some of the problems that call for social innovation.

CHART 9

SOME PROBLEMS REQUIRING SOCIAL INNOVATION

Environmental Pollution	Urban Redevelopment
Fresh Water	Poverty
Crime Prevention	Highway Safety
International Organization	Urban Transportation
Arms Control and Disarmament	

Any consideration of the total innovative process should include analysis of the interrelations between social and private innovation. Private innovation in the industrial sector has produced conditions which call for social innovation in the public sector. Moreover, advances in private innovation are dependent upon the climate provided by social innovation.

REGIONAL DIFFERENCES

Cities and regions appear to vary markedly with respect to successful generation of new technologically based enterprises. Unfortunately, there are no statistical data to show this. But our personal experiences—and we claim no more proof than that—tell us that cities and regions do vary widely in their propensity to exploit their innovative potential. We surmise that important factors exist which go beyond such indexes as the total number of scientists in the area, or the total R&D expenditures, or the availability of capital.

CHART 10

VARIATIONS — CITY TO CITY IN THE PROPENSITY TO GENERATE NEW TECHNOLOGICALLY BASED COMPANIES

e. g., Many Such Companies	e. g., Few Such Companies
Boston	Philadelphia
Palo Alto	Chicago
Washington, D.C.	Kansas City
Pittsburgh	Atlanta

We tried to analyze—again, of necessity, largely on the basis of our personal experiences—what differentiates cities with respect to their propensity to generate new technological enterprises. As we have indicated, Boston is an area which generates many new technological enterprises, whereas Philadelphia, by comparison, apparently generates few. We asked ourselves, first of all, whether the difference between these two areas is due to the existence of greater potential venture capital in one over the other—whether this factor is a major barrier to the creation of new technological enterprises. We are unaware of any evidence to this effect.

There is abundant potential venture capital available in the Philadelphia area. What we are led to believe is that in the Philadelphia area there is poor linkage, poor communication, between potential venture capital sources and technological entrepreneurs. There are also other factors that bear on this problem. We shall explore them, but at this time it would be well to analyze the one piece of evidence we have that compares the attitudes of technological entrepreneurs in the Philadelphia and Boston areas with respect to the climate for generating new technological enterprises in these localities. This evidence was developed by the Federal Reserve Bank of Philadelphia.[2] It is a report based on interviews with scientist-businessmen regarding the problems of seeding science-based industry.

[2] *Elizabeth P. Deutermann, "Seeding Science-Based Industry,"* Business Review, *Federal Reserve Bank of Philadelphia (May 1966).*

Viewed in this sense, unsympathetic bankers, inattentive educational institutions, overzealous tax authorities, and other environmental barriers, are negative charges that work against the entrepreneur.

VARIATIONS AMONG INDUSTRIES

Many industries are apparently under-spending on innovation. (Again, we must emphasize that we lack adequate empirical data to substantiate this feeling.) A number of factors bear on this problem, the most important of which would be the absence of adequate managerial and technological skills in an industry. We often see companies with an abundance of these skills enter such an industry for the first time and make significant contributions. The invasion of the textile industry by the chemical industry (Nylon, Acrilan, etc.) is a case in point.

We looked at variations among selected "big sales" industries. Since empirical data on *innovation* were unavailable, we resorted again to R&D percentages. In particular, we selected the steel, transportation, chemical, and drug industries—and noted the variation in the ratio of company-financed R&D to net sales.

CHART 11

VARIATIONS IN COMPANY-FINANCED R & D AS A PER CENT OF NET SALES, BY INDUSTRY

	Net Sales (Billions)	R & D (Billions)	R & D Net Sales
Steel (Primary ferrous products)	17.8	0.111	0.6%
Transportation Equipment (Excluding aircraft)	34.3	0.865	2.5%
Chemicals	25.6	0.830	3.2%
Drugs	5.03	0.224	4.5%

Source: NSF (1966) — Figures are for 1964.

The above tabulation shows the steel industry (primary ferrous products) spending, in 1964, a mere 0.6% of its $17,800,000,000 in net sales on R&D. In contrast, the drug industry was spending 4.5% of its $5,400,000,000 in net sales on R&D, a percentage almost eight times that of the steel industry.

We asked ourselves several questions about the differences between highly innovative industries and those which are relatively uninnovative.

Are the highly innovative industries progressive because of the manner in which they respond to technological opportunities? Are they primarily this way because their managements have extraordinary capabilities for grasping

and innovations of the 20th century, which the authors selected for analysis, over half of them stemmed from independent inventors or small firms.[4]

—Professor Daniel Hamberg of the University of Maryland studied major inventions made during the decade 1946-55 and found that over two-thirds of them resulted from the work of independent inventors and small companies.[5]

—Professor Merton Peck of Harvard studied 149 inventions in aluminum welding, fabricating techniques and aluminum finishing. Major producers accounted for only one of seven important inventions.[6]

—Professor Hamberg also studied 13 major innovations in the American steel industry—four came from inventions in European companies, seven from independent inventors, and none from inventions by the American steel companies.[7]

—Professor John Enos of the Massachusetts Institute of Technology studied what were considered seven major inventions in the refining and cracking of petroleum—all seven were made by independent inventors. The contributions of large companies were largely in the area of improvement inventions.[8]

Chart 13, which is based on the above studies, illustrates some of the important inventive contributions made by independent inventors and small companies in this century. One finds the range and diversity of these inventions impressive. Indeed, the mercury dry cells in our electronic watches, the air conditioners in our homes, the power steering in our automobiles, the FM circuits and vacuum tubes in our Hi-Fi and television sets, the electrostatic-copying machines in our offices, the penicillin and streptomycin in our medicine cabinets, and the list goes on—all of these inventions, which are generally taken for granted, take a new meaning when one identifies them with their sources. The point to be made is that independent inventors and small firms are responsible for an important part of our inventive progress, a larger percentage than their relatively small investment in R&D would suggest.

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[4] *J. Jewkes, D. Sawers, and R. Stillerman,* The Sources of Invention, *St. Martin's Press, 1958, particularly pp. 72-88, and Part II.*

[5] *D. Hamberg, "Invention in the Industrial Research Laboratory,"* Journal of Political Economy, *April 1963, p. 96. See also,* Concentration, Invention, and Innovation, *U. S. Senate Antitrust Subcommittee, 89th Cong., Part III (Government Printing Office, 1965), p. 1286.*

[6] *M. J. Peck, "Inventions in the Post-War American Aluminum Industry," in* The Rate and Direction of Inventive Activity: Economic and Social Factors, *National Bureau of Economic Research, (Princeton, New Jersey, 1962), pp. 279-92. See also, U. S. Senate Antitrust Subcommittee, op. cit., p. 1296 and 1438-1457.*

[7] *Hamberg, op. cit., p. 98. See also U. S. Senate Antitrust Subcommittee, op. cit., p. 1287.*

[8] *J. L. Enos, "Invention and Innovation in the Petroleum Refining Industry," in* Rate and Direction of Inventive Activity, *op. cit., pp. 299-304. See also, U. S. Senate Antitrust Subcommittee, op. cit., p. 1287 and pp. 1481-1503.*

III

THE SMALL COMPANY ENVIRONMENT

We turn now to an analysis of the environment for innovation at the company level. We will do this first for an illustrative small company, then for a large company. We will analyze these large and small company environments by describing their growth cycles and some of the characteristics and problems encountered in each case. Our recommendations will then be made in reference to these factors.

We analyzed the growth cycle of an illustrative technologically based small company and divided the cycle into what we perceived for our purposes to be the key stages of growth. These are shown in Chart 14.

Let us discuss each of the stages of the growth process in detail.[1]

THE IDEA STAGE

We begin with the idea stage. An inventor, or an inventor-entrepreneur, has an idea to which he is committed. Typically, the product or process which underpins the idea is the subject of a patent application. The people we are talking about are *individualists*, who usually have voluntarily "spun-off" from another organization. Their educational backgrounds are usually in science or engineering.

[1] *Italicized words in the text correspond to terms appearing in Chart 14.*

As we have noted, the path between an invention and the market place is a very tortuous obstacle course and, therefore, in this first stage of the cycle, there is a high degree of *uncertainty* as to the ultimate outcome of the venture.

Typically, these individualistic, technical people have little or *no business experience,* but are *totally committed* and prepared to risk their livelihoods and their future security in order to champion their idea.

We turn now to the problems the inventor and the entrepreneur have in this stage of their venture. We have listed two which are pertinent to some of the recommendations that we shall make. First of all, they need *capital.* As a rule they have none, and nothing will happen to their idea until they get some financial backing. It is not just any kind of money they are seeking. What they require is venture capital, and they must know something about the intricacies of venture capital acquisition or find somebody who does.

Secondly, they are faced with a legal issue of whether or not they are *"in business."* As we shall see, this question is important from the standpoint of the tax laws, for the deductibility of expenses that they incur at this stage in the growth cycle of their hoped-for company will depend upon, first of all, their tax acumen and, secondly, whether or not they are in business. Although we shall explore this question in detail later, it may be helpful to note at this point that even if the Internal Revenue Service regards them as being in business at this stage, they probably have no personal income against which to deduct the expenses in excess of income which the "business" is incurring.

THE MONEY STAGE

Venture capital is very *high risk* money. High risk money requires *high potential return.* It is important to note the very *high risk* that venture capital sources assume in underwriting the formation of new technologically based enterprises; and governments, the universities, and society need to understand this risk. There must be opportunities for large gains from a few successful ventures to offset the risk of losses from the many failures. Notwithstanding the risk element, venture capital *is* available (to those who know where and how to get it) precisely because there are extraordinarily high potential returns for the successful undertakings. We need only recall the histories of the ventures listed in Chart 4, Chapter I.

The money needs of a fledgling technological venture in its first two years are *comparatively small,* typically under $500,000. These costs, however, are much greater now than they were only twenty years ago.

By and large, the technical people, who have the idea and want to build a company on it, have little if any business experience and know nothing about the venture capital market. On the other hand, the sources of capital —banks, wealthy individuals, underwriters, investment trusts, and others— usually have *no technical background* and only rarely have available to them adequate staffs to perform the complex investment appraisals required to measure the merit of any single entrepreneurial proposal. We are dealing here with ideas that have high technical content. The venture capitalist needs to weigh their prospects. He may have a great many new ideas presented to him. He must pick winners some of the time and make educated gambles

firm, on the other hand, can probably survive such a cancellation, although we appreciate that such a cancellation is always a shock to any organization.

THE SECOND STAGE BUSINESS

Our company is maturing. It is now maybe as much as five years old, has annual sales in the millions of dollars, and is in business in every sense of the word. The loss of a single customer is no longer decisive. It now has many impersonal customers.

The company is no longer solely dependent on technology. Its central problems are now related to product manufacturing—to improving product quality and lowering manufacturing costs.

It needs a *new kind of financing.* But this new money will not be exclusively high-risk, high-return, venture-type capital. The earlier risks and uncertainties have been reduced and, therefore, obtaining secondary financing is usually easier than was the acquisition of venture capital. This time the company can look to conventional sources of capital—through public stock offerings, for example. After additional financing has been acquired, the equity of the original owners of the company has probably been significantly diluted in terms of the degree of ownership control they can exercise.

What are some of the new problems? To get to this stage, a company has to solve the key management problem we discussed with respect to the previous stage of its life. But now *key functional staff* are probably missing. Research, development, marketing, and production are new problem areas, and skilled personnel are needed to handle them. *Control techniques* are now needed to keep the business on course and operating effectively and efficiently. Costs have taken a new meaning and complexity.

Market analysis is also a new problem. In this stage of its life the firm may find that its product is not just a domestic item, but has international possibilities.

The company has become successful and, thus, has attracted other companies to its field. The competition intensifies.

A SUCCESSFUL GROWTH BUSINESS

The company, in its wisdom, persistence and good fortune, has solved its initial problems. It has become a successful growth business. Its contribution to the gross national product is growing, its products are filling many additional demands, and it is employing many more people.

It has new problems. The founders—the entrepreneur and the inventor—are not the central figures they used to be. They may want to escape. They championed their idea into a success story and the challenge may not be there any more. The time for taking a high return on their total commitment over the years may have come. They might want to do this by selling their interest in the company. Or they might want to sell the company or merge it with another corporation. For the first time, a new word appears in their vocabulary: "Antitrust." To them it may appear as an unwarranted governmental restriction that prevents them from realizing the maximum possible return on their personal investment and commitment; and yet, in larger perspective, the restriction may be required to safeguard the public interest.

The company has annual sales of one billion dollars, derived from established products, in a series of markets which it has penetrated, on the average, to the extent of 25%. The total demand for the oldest of these products is falling at a rate of 5% per year ($50 million). Moreover, the price erosion of its whole range of products is 2% per year ($20 million).

This company is well-managed and has substantial resources. It is not content to deteriorate by $70,000,000 each year. Nor will it be satisfied merely to remain static. On the contrary, it wishes to grow at a fairly high rate—say, 10% per year ($100 million). Adding these figures up, then, this company finds that it needs $170 million of added sales in the first year of its growth program.

The new sales can only come from a combination of (a) increased sales of its established products through greater market penetration or the invasion of new markets, (b) development of new products in its current businesses, or (c) entry into completely new businesses.

With the demand for some of its established products declining, an increase in the sales of its better performing products (amounting to a 17% year-to-year rise) will be hard to achieve, particularly in view of the substantial market penetration the company already has. Ultimately, therefore, the company will have to enter new business fields or abandon its growth objective. The important point to bear in mind, as we proceed now to discuss briefly an example of the large company environment, is that this requirement for growth leads a large company to launch innovative business ventures. The small, fledgling firm is therefore not alone in this respect. Whatever the differences between the small and large firm, the goal in each case is a successful new growth business.

For purposes of discussion, we have divided the management of technological innovation in a large company into four stages, as shown in Chart 16.

We identify the first phase as the business planning stage. Next comes the period of experimental appraisal. Out of this, if all goes well, an embryo business appears. And if everything falls into place, the result is a successful growth business. Let us consider each of these stages in turn.

BUSINESS PLANNING

In almost every detail the large company environment for innovation is different from the small company situation we have discussed. In one crucial respect, however, they are identical. At the *very* beginning of a new "business innovation project" there is an individual who has an idea on how to solve a problem, or how to create a novel product, or how to fill a need which he believes will be manifested in the market place.

Because the company is committed to innovation, this individual has an opportunity to perform some experiments to develop his concept; he then has a chance to present his idea for consideration by management.

We come now to an important difference between new and established companies. In the large company the merit of the idea is judged by analyzing the totality of the proposed new business venture as an alternative investment opportunity. This analysis in the most sophisticated companies can be used to establish a "best guess" for the net present value of the new venture con-

cept, taking into account the risk of failure, the time value of money, and the company's performance in its established businesses. The new idea is thus judged as an alternative to other investment opportunities available to the company. Such alternatives are not available to a new company of the kind we explored in Chapter III.

As part of its *venture analysis* [1] the company also engages in directional planning, based on the realities of the market place and aspirations and capabilities of the organization. Directional planning involves questions such as: "Where are we?" "Where are we going?" "How will we get there?" "How did we get to where we are?" "What business are we in?" "What should we be in?" "How does the idea we're considering fit in with what we are or should be?"

Despite the logic and helpfulness of the planning process, it cannot cope with certain internal barriers to the new idea being considered. If it has come from outside the company, the new idea may undergo a fatal battering because of the *"not invented here"* syndrome. As Charles Kettering once put it, "The greatest obstacle course in the world is trying to get a new idea *into* a factory." [2]

A large company has greater concern for the *time value of money*. Unlike a small company beginner, a large established company has the option of applying its money to a number of alternatives. An investment that will not yield returns for several years is made less attractive because it is discounted substantially. As a consequence, the company may choose less ambitious shorter-run opportunities.

A large company tends to be *inbred;* in extreme cases the company may thereby actively resist any change. More important, however, is the problem that a new market represents to the large company's established marketing staff. Indeed, there is no question that good innovative opportunities often are not exploited because the company lacks the requisite *market familiarity*. The irony, as we have seen, is that new markets are the key to the kind of new growth businesses that the large company needs to develop.

EXPERIMENTAL APPRAISAL

In those cases, however, where the large company management elects to try to develop a new business opportunity, it proceeds next to an experimental appraisal of the key elements of the new business. This often involves a research effort for which the company has an *institutionalized research* and development activity.

However, the company may be missing some of the technical skills needed in the new field it is exploring. If, for example, its traditional business is in electronics, but the new venture has to do with washing machines, its technical people may not possess the required mechanical skills for the new business. But a large company has the resources to acquire these skills.

The large company is a complex social organization. The fast reaction

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[1] *Italicized words in this chapter correspond to terms appearing in Chart 16.*

[2] *See* Concentration, Invention and Innovation, *U. S. Senate Antitrust Subcommittee (Government Printing Office, 1965), pp. 1099, 1115.*

years, the embryo business fails to meet the established criteria for *return on investment,* the large company may drop the venture altogether.

A SUCCESSFUL GROWTH BUSINESS

Just as the desired final stage of the small-company cycle was a successful growth business, so it is for the new business development within a large technologically based company. Here, too, the characteristics of the firm include growth contributing to the gross national product, jobs to provide new employment opportunities, and products to fulfill needs and to diffuse technology.

Antitrust can be a problem if, for example, the corporation seeks to enhance its new business by acquiring other companies that are capable of complementing it. It should also be noted that if, in the first instance, the large corporation, instead of developing a new business venture completely internally (as in our illustrative example), had preferred to add a new business through *external* acquisition or merger, antitrust questions could have arisen then.

As a further observation on the large-company example discussed in this chapter, we should mention the difficult problem of *assimilating* the new growth business into the parent corporation. Adjustments and dislocations are inevitable; disharmonies will occur. This is a painful but absolutely necessary step, since the full value of the new business cannot be realized if it operates separately from the supportive strength of the entire company, to which it can also add strength and skill.

It is apparent, therefore, that small and large technologically based companies have similar goals and problems, though different environments. Both wish to develop successful growth businesses, but they go about the task in very different ways.

No attempt has been made to construct a *generic* model of the innovation process as it occurs in "the" small firm or in "the" large firm. We chose instead two illustrative examples of the process. Much more could have been said about the problems and characteristics of large and small technologically based companies. We believe, however, that we have identified an adequate number of problems and characteristics of the innovation process in large and small firms to enable us to explore, in a more reasoned approach, possible ways to improve the environment for technological change.

Moreover, what we have noted regarding the *respective* characteristics and problems of large and small technologically based firms suggests an important challenge to the business world. The challenge is to explore new ways for large companies to work with small technologically based companies, while maintaining the creative qualities of each—or, alternatively, for large companies to develop, *within* themselves, sub-environments that foster the enthusiasm and entrepreneurial spirit of the small firm, while benefitting from the over-all resources of the total corporate environment.

enterprises are an important part of the process that differentiates our rate of progress from that of the rest of the world.

How, then, have we decided to recommend some tax proposals while rejecting so many others? We have tried to give adequate consideration to tax incentives that operate across the total process of innovation, and have avoided recommendations which, in our view, would result in unreasonable or unjustified economic distortions. We are wary of proposals that would lead one to believe that a tax incentive for R&D alone would automatically lead to major increases in innovation.

In this vein, a common proposal is a 75% tax credit on all R&D expenditures. Let us review our reasoning in *rejecting* this proposal. Its cost in lost tax revenues would fall in the range of *1.25 to 1.5 billion dollars a year*, for between 5 and 6 billion dollars per year is now being spent on industry-supported research. It should be understood that a 75% tax *credit* means the government would, in effect, be bearing three-fourths of the cost of industry-supported R&D. At the present corporate tax rate of 48%, it bears roughly half the cost. An additional 25% of the burden would therefore be a very costly tax change.

This recommendation generally flows from an assumption that what our society really needs to get more innovation is simply more research and development. We have indicated earlier that we are unable to conclude that our country is lacking in this regard. Also, and more important, we believe we must look increasingly at the innovative process the way businessmen do—that is, at the *total* new venture, the *total* cost, the *total* profitability or loss, not just the R&D portion, which is usually only a small segment of this total.

It is very likely that an across-the-board (and therefore costly) tax credit would be enjoyed largely by the very large and already technologically-oriented companies. As recently as 1960, only 300 companies accounted for 90% of the R&D expenditures. As we have already noted, to many of these companies, research and development is increasingly a way of life.

We should seek to provide incentives that will increase the nation's total innovative potential and should aim our efforts at companies where the extra incentives are genuinely needed, or will provide the maximum innovative response per dollar spent. We do not believe an across-the-board 75% tax credit for R&D expenditures meets these criteria.

In looking for unique cost-benefit relationships, we were impressed, as we have already noted, by the apparent leverage of small companies and individual inventors and entrepreneurs in the whole process of invention and innovation. We were also impressed by the great difficulty that apparently exists in communicating the availability of tax benefits to small companies and individuals.

It is not enough to say that a given tax change will produce dramatic results. Even if the economic theory is sound, this assumes people will know about the tax change and grasp its implications. The Sloan School at the Massachusetts Institute of Technology recently conducted a study of the impact of tax benefits on small technologically based companies.[2] It would

[2] *Baty, Gordon,* Initial Financing of the New Research-Based Enterprise in New England, *Report to Federal Reserve Bank of Boston No. 25 (1964), Master's Thesis, M.I.T., pp. 72-73.*

CHART 17

LARGE vs. SMALL COMPANY IMPACT OF CURRENT 5 YEAR LOSS CARRY FORWARD

(1) Large companies generally have other profits against which innovation project losses can be written off immediately...therefore,

Government shares currently in 48% of these losses.

(2) Small companies often do not make profits for five years or longer...therefore,

The government either defers its contribution until profits are realized, or if losses persist for longer than five years, the government is never called upon to share in these losses.

Our task is to look for ways to remove tax disincentives or provide incentives for innovation. Tax changes that have little effect on *innovation* are not within the scope of our mission. Thus, if we are to favor extension of the period of loss carry-forward, as we do, we feel it desirable to limit the applicability of this extension to companies or activities that involve innovation.

We have struggled with this question. To allow such an extension for *all* companies would be to often allow benefits for incompetence rather than risky innovation. On the other hand, to allow such benefits only for *projects* that are "innovative" would be to require advance *certification* procedures which would likely be cumbersome at best and destructive of the innovation process, at worst.

We have therefore decided that the approach most likely to strike the right balance in defining the right targets for tax incentives, without imposing anti-innovative certification procedures. is to describe the kinds of companies that are most likely to produce the desired kind of innovation.

As we indicated in our analysis of the small company environment (Chapter III), small, technologically based companies, which in the past have generated so much effective innovation, would probably have

1. A product or know-how that can be sold or licensed.
2. A bigh ratio of technical people to the total number of employees.
3. A high value added as percentage of sales.
4. A small size in terms of (1) number of people, (2) dollar sales, and (3) net worth.
5. No affiliations with other companies (e.g., as a subsidiary).

These are illustrative criteria. A more refined and definitive list should be based on a detailed, empirical study of the characteristics of such firms.

CHART 18

SOME OF THE MAJOR 1964 REVISIONS OF STOCK OPTION PLANS ENTITLED TO CAPITAL GAINS TREATMENT

	Before 1964	After 1964
	85% of Market Value	100% of Market Value
	10 Years	5 Years
	6 Months	3 Years

The latter two changes pose, we believe, especially significant problems for the small company. We believe that at the time of the change, the major thrust of Congress' intent was to minimize certain abuses of *large company* option holders. We question whether there was adequate understanding, at the time, of the special impact of this change on the small company. But first, let us consider the small technically based company's need to attract and motivate experienced managerial talent.

As we noted in the discussion of these small companies (Chapter III), they tend to go through a growth cycle where, in the early stages, technical know-how is the dominant skill required. Then, commercial products are developed from this know-how. Initially, the number of customers is very limited. Later, as markets grow, new requirements develop: how to manufacture and market products on a broader scale and how to control increasingly complex operations. This stage requires managerial talents that are more likely to be found in larger companies than in the small companies.

The problem, of course, is how to attract these men from the larger companies. Stock options in the small companies are, relatively speaking, substantially less desirable than they were, and less desirable than many large-company options. There are at least two reasons for this:

—First, the absence of a broadly based public market for the stock of many small, technologically based companies increases substantially the borrowing difficulties of the sought-after employee (the stock can be offered as security on loans), especially over a three-year period.

—Second, the employee of a large company can limit his downside risks, in the event the stock market declines, by selling his stock *immediately* should the stock fall below a given point. The very limited market for the stocks of many small companies makes the downside hazard of the stock option of such companies much greater than that of a large company.

For reasons we have already expressed, it is our belief that there would be

fail to take adequately into account the realities of the innovative process, with its very uncertain initial stages. Accordingly, we make the following recommendation.

RECOMMENDATION 3

The Internal Revenue Code should be amended so that a casual inventor or innovator can deduct out-of-pocket expenses legitimately incurred for the purpose of ultimately producing income.

Also, we see cases where the inventor-entrepreneur was indeed seriously intent upon going into business by the fact that he is *now* in business. At the time he was doing his research and development, he may not have declared his costs as a deduction. We need only recall the great uncertainty in the first (the "idea") stage of our small company example (see Chapter III). This failure to declare deductions frequently happens because the inventor-entrepreneur is usually not a sophisticated person in the tax aspects of his work and does not get adequate counsel *until he has an established business.* Accordingly, we make the following proposal.

RECOMMENDATION 4

The successful inventor who has a going business but did not declare his earlier development costs should receive a "generous backward look" by the Internal Revenue Service and be permitted to reconstruct his development costs and write them off over a period of five years.

b. New Lines of Business In a recent case before the United States Tax Court,[6] the Commissioner of Internal Revenue unsuccessfully argued that Section 174, allowing a current deduction for research and development expenditures, is not available in the case of such expenditures incurred to develop new products unrelated to the taxpayer's current products. This contention has an obviously adverse impact on a business that seeks to develop a new product. Accordingly, we urge the Internal Revenue Service to issue a ruling that it will no longer make this contention in litigation.

The Internal Revenue Service has indicated it will review this case and consider whether it needs to clarify the treatment of R&D outlays directed toward launching a new product line. That such a position was ever taken in litigation is in itself evidence of a point of view that, at least occasionally, puts the innovation process on the defensive. Almost by definition, the more significant the innovation, the more likely it is to be a "new product line." Accordingly, we make the following recommendation.

[6] Best Universal Lock Co., Inc. *45 T.C. No. 1 (1965).*

minimum advance payment, for he is uncertain as to how aggressively a given company will exploit his patent. In other words, he negotiates a final contract in an early atmosphere of very imperfect knowledge as to whom he is dealing with and the extent to which the other party will tap the potential uses of his invention.

From the *company's* standpoint, the value of the patent is not clear, because it often does not know its value until further development work is pursued, practical production or engineering problems solved, and market explorations conducted.

Thus, at this early point of *maximum ignorance* on both sides of the negotiation, the inventor and the company must make a commitment for "all substantial rights," if the inventor is to receive capital gains treatment. Several panel members have had personal experience on both sides of this kind of negotiation and are convinced it substantially deters the process of getting patents translated into commercial products.

For this reason, we believe that the two provisions of the Code should be reconciled to permit qualification under Section 1235 in the case of a transfer of substantially all the rights in a patent limited to a particular field of use, or to a particular geographical area within a country. This would afford to the professional inventor the same capital gains advantage available under present law to the amateur inventor. We believe there is ample evidence that much effective invention is done by inventors who are prolific—i.e., professionals. If we want to encourage these individuals who, by any study of history, have contributed so much to the innovative status of this country, we feel a positive incentive is warranted.

RECOMMENDATION 6

Professional inventors should be placed on the same tax footing as amateur inventors by interpreting or amending Section 1235 of the Internal Revenue Code so that a patent license qualifies as a transfer of "substantially all rights," even though the grant is legally limited to a particular field-of-use or a particular geographical area.

We recommend that the Treasury first consider whether it would be feasible to accomplish this by amendment of its Regulations, without legislation. If this cannot be accomplished, we recommend that appropriate legislation be sought.

6. TAXABLE PURCHASES OF TECHNOLOGICAL ASSETS

The Treasury Regulations issued under Section 174 of the Internal Revenue Code draw a distinction between research and experimental expenditures incurred by a business in its development of an invention or innovation and the cost of acquiring another's invention or innovation. While expenditures incurred for internal development are deductible against *current* income, the cost of acquiring another's patent or process must be *capitalized*. (U. S. Treasury Regulations, Section 1.174–2(a)(1)).

(5) Such values of technological assets could be written off over an interval of 17 years, which corresponds to the period over which the cost of an acquired patent can be amortized.

To further narrow the scope of the above recommendation, it may be desired to limit its applicability to purchases *from* individuals or companies that qualify as "small technologically based companies." [9] It should be noted, however, that the illogicality of retaining the tax distinction between internally developed technological assets and those externally acquired is not dissipated where the seller is a *large* company. The distinction is illogical and improper irrespective of the size and wherewithal of the seller.

A FINAL WORD ABOUT TAXES

Considerable effort and time will be required to review and act on the tax recommendations discussed here. *In the meantime,* while these tax recommendations are being considered, we urge an intensive effort:

(1) To acquaint responsible employees of such agencies as the Internal Revenue Service, the Small Business Administration, and the Department of Commerce with the importance and unique problems of small technological enterprises; and

(2) To apprise such firms of the *existing* governmental aids and incentives directed to them. There is good reason to believe that important, *existing* tax incentives are having far less than their maximum potential impact on the encouragement of innovation in this country.

B. THE FINANCING OF INNOVATION

We turn now to the role of venture capital in the innovation process, its sources, some rough estimates as to the amount potentially available, and its significance with respect to the creation of jobs. We could summarize this subject by saying we have found an abundance of ignorance—in government, in business, and in the universities—on what the venture capital business is about. It should be apparent by now that the lack of knowledge, understanding and appreciation of the innovative process is the central theme of our report.

1. THE AVAILABILITY OF VENTURE CAPITAL

Quantitative information on the availability of venture capital is not readily obtained. We were unable to find any published data to support the widely stated notion that there is a lack of adequate *potential* venture capital in this country. Accordingly, we tried to develop our own rough estimates of potentially available venture capital through discussions with experienced individuals in the business and financial communities. Extensive conversations

[9] *See Page 33.*

attitudes. A large number of investment banking groups also operate in the venture capital field.

e. **Small Business Investment Companies**—Although less than 10% of the total amount of available SBIC capital is currently invested in technologically oriented businesses, the SBIC as an institution has undoubtedly created interest in the venture capital business, and some $500,000,000 is *potentially* available from this source.[10] Because of its relatively small size, however, the typical SBIC has had difficulty in developing a competent staff to tackle the formidable project appraisal problem and in carrying the necessary overhead to administer a complicated portfolio of new technical enterprise investments. It is doubtful, in our view, that an SBIC can be successful in a diversified program of financing technologically oriented ventures, if its size is less than 15 to 20 million dollars. Only a few SBIC's are currently of this size. Much can be learned from the developing experience of these few.

It is important to re-emphasize the project-appraisal problem which faces all sources of venture capital. Entrepreneurship is at best a risky business. Markets are rapidly changing, and the success of any venture is closely coupled to management ability. Capital requirements for new businesses are almost always in excess of initial estimates. The time required, particularly today, to reach the stage of profitability is usually several years longer than originally anticipated.

The more experienced and sophisticated venture capital sources compete with each other for the most attractive investment opportunities. Their decisions to invest are keyed to their judgments of the quality of the management, the quality and proprietary character of the product, and the timing with respect to the market. Experience shows that investments fail, primarily, because of *management* problems—the inadequacy of the key individual as a manager of people, or his lack of sensitivity to external conditions, which prevents him from developing a realistic time schedule for achieving goals with available capital.

In view of the above considerations, and our feeling that the alleged absence of potentially available venture capital is not really the problem, we see no basis for the establishment of any new federally supported programs for the furnishing of venture capital. Accordingly, we make the following recommendation.

RECOMMENDATION 8

In view of present information on the availability of venture capital, the Federal Government should take no action with respect to the establishment of new federally supported programs for the furnishing of venture capital. However, appropriate mechanisms should be developed to provide information on capital availability and the problems of new enterprise development at the regional level.

[10] *It is interesting to note that some 40% of the SBIC's (on a dollar basis) are located in three states, which already have large, well-organized and long-established venture capital sources.*

19 concern primary employment only and do not account for the much greater secondary employment (in the food and service industries, etc.) that usually builds on the primary job base.

C. SOME ASPECTS OF FEDERAL RESPONSIBILITY

There are several areas in which the government bears a special responsibility with respect to various aspects of technological innovation, but in which, through action or inaction, this responsibility is being either ignored or frustrated. Perhaps this is because the areas in question are relatively less important than other, more noteworthy fields, such as antitrust and taxation. We considered three areas which have been neglected: studies of the innovation process, the adverse impact of government contracting on small technologically based firms, and the absence of an effective federal spokesman for such firms.

1. STUDIES OF THE INNOVATION PROCESS

This nation spends tens of billions of dollars every year on innovation—twenty billion on the research and development component of innovation alone. Yet we know very little about the processes of technological change and growth. As we have noted time and again throughout our analysis, insufficient effort is being devoted to the development and expansion of our knowledge of these processes. Until adequate data and better insights are developed, we will have to continue to rely on inappropriate information, educated guesses and, unwittingly at times, on lore. It is inexcusable that decisions, both in and out of government, as to the probable impact of proposed policy changes on technological innovation, have to be made on the basis of such information.

Additional research on the processes of technological change is therefore badly needed. The initial studies being worked on in the Commerce Department's National Bureau of Standards, should be expanded and made more comprehensive. These studies, concerning the processes of invention and innovation and the social, economic and legal forces with which they interact, should be undertaken in close cooperation with the universities, industry, and other students of the subject.

Accordingly, we make the following recommendation.

RECOMMENDATION 9

The Department of Commerce should broaden and complement its studies of the innovative and entrepreneurial processes by initiating an integrated program, in cooperation with the universities, including the preparation of empirical data and case materials on these processes, studies of the venture capital system, and experimentation with teaching methods to develop innovative and entrepreneurial talents.

3. A FEDERAL SPOKESMAN

The above recommendation can at best be only a palliative. For it does not go to the heart of the problem. It merely treats one of the symptoms. The basic problem is that the small technologically based companies, despite all they have contributed to American progress, really have no effective representation in Washington.

There is *no Federal spokesman* for them. Within the Federal Government there is no single place which is specifically concerned with the generation of new technological enterprises and the problems of these unique organizations.

The Small Business Administration cannot deal effectively with these inherently *high-risk* enterprises because its enabling statute prevents it from doing so. In any event, there is very little understanding in the SBA or elsewhere in the government (indeed, as we have noted, in society at large) of the special problems and needs of these businesses. We therefore make the following recommendation.

RECOMMENDATION 11

The Department of Commerce should serve as the Federal spokesman representing the interests of new technologically based enterprises and should develop the necessary competence and organization to deal effectively with problems associated with venture capital availability and the generation of such enterprises.

This recommendation is closely related to the program of studies proposed in Recommendation 9. For only through greater understanding of the processes of invention and innovation will the Department of Commerce be able to perform the role we urge.

D. ANTITRUST AND THE REGULATION OF INDUSTRY

It is probably fair to say that most well-informed individuals, who are not directly concerned with the fields of antitrust and regulation, are unaware of the numerous Federal agencies that are active in these fields.[12]

Chart 20 is a partial tabulation, not intended to be comprehensive, which illustrates the magnitude of the government's involvement in what we loosely call a "free enterprise economy." Of course, our economic system is not literally free; it is much too complex for that.[13]

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[12] *An excellent discussion of government activities in these fields appears in* Massel, Competition and Monopoly, *Brookings Institution, 1962.*

[13] *See Appendix B for some of the relevant statutory provisions affecting competition in the American economy.*

Sometimes, a given practice furthers both of these objectives. Sometimes it does not. If it does, problems of concern to us are unlikely to arise. Practices that promote both competitive and innovative objectives or that promote one and are neutral as to the other, are acceptable in terms of our mission. Practices that impede both or impede one without promoting the other, are unacceptable. A practice that promotes one of the objectives and impedes the other, however, is another matter. In this event, we must try to find an accommodation that minimizes the conflict between the two, and decide which objective shall prevail in those circumstances where the conflict cannot be resolved or reduced.

Past judicial, legislative or administrative efforts to resolve this conflict disclose no clear-cut, uniform pattern. *Nor do we have satisfactory empirical analyses of actual situations to serve as the basis for such resolution.* Sometimes, competitive objectives seem to be the dominant concern in the consideration of competitive problems; sometimes, innovative objectives prevail. Often, the objective fastened upon is pursued without apparent concern for the possible adverse effects upon other objectives.

Neither objective can safely be disregarded in our present social, economic and political circumstances. The support and furtherance of *both* are too important in terms of public interest for either to be heedlessly pushed aside in the interests of promoting the other. Fortunately, only minimal conflicts seem likely to arise in the areas under discussion, since it appears that *on the whole, a well-balanced and healthful, competitive economy stimulates, rather than frustrates, innovation.*

Let us turn now to an examination of those areas in which *conflicts* are most likely to arise—since it is conflict, not complementary action, that poses the problems we are concerned about.

2. AREAS OF POSSIBLE CONFLICT

The thrust of the antitrust laws is against (1) commercial or industrial combinations which prevent or limit the competition upon which our free enterprise system depends, (2) the creation of monopolies that destroy or impede such competition, and (3) unfair competitive and business practices that hinder competition and contribute to monopoly. Our concern, therefore, is directed to those structural characteristics of the innovative process and specific practices involving innovation that may result in monopoly, restraint of trade, or unfair trade practices of the kind mentioned.[14]

Technological innovation may be undertaken by (1) individuals or other single entities, or (2) two or more entities (of an industrial, governmental, educational or other nature) acting cooperatively. Neither of these ordinarily need give us concern, *as such,* in dealing with the competitive-innovative relationship.

The conduct of innovation by individual, independent entities is not only

[14] *See Appendix C for some hypothetical situations that illustrate possible conflicts between Federal policies on competition and various practices involving innovation.*

policy in question is determined at the legislative, administrative or judicial level.[15]

Beyond this, in the vast area of *private* action and policy making—where the businessman, the entreprencur, the inventor and the innovator operate—decision and conduct, and the effect thereof, may be even less well defined and more haphazard. Here, it not only becomes increasingly difficult for the decision-makers to evaluate and properly balance the effects flowing from their conduct and the public policy considerations involved, but they may also be influenced by *mistaken notions* of what the law permits and what it prohibits.[16]

In terms of influencing their conduct, it is not what the law really is that matters. It is what the decision-makers *think* it is.

We want to emphasize that what we are saying is not limited to *technological* innovation. The problems go deeper, and so must our inquiry into them. Innovation occurs in finance, marketing, methods of distribution, business structure, business administration, labor relations—indeed, in virtually every area of activity that the processes of business touch upon.

In methods of distribution, for example, it may show up in brand selling, introduction of new products, price discounts, offer of side inducements and collateral attractions, advertising, dealer relationships and development, service and advisory activities, extension of credit, and so on. Here, as in technological innovation, the activities may run afoul of the antitrust laws, including the Robinson-Patman Act. They may also come into conflict with other trade regulation laws, such as fair trade laws, trademark laws, labeling laws, the Shipping Act, the Food, Drug and Cosmetic Act. These interrelationships have been a part of our inquiry.

The problems, described generally in the foregoing discussion, may be summarized as follows:

(1) Long-standing and settled public policy supports and demands the promotion of competitive objectives.
(2) Public policy also supports and demands the promotion of innovation.
(3) These two public policies, while usually compatible, may at times comes into conflict with each other.
(4) It is often difficult to detect, define and evaluate these conflicts. We have not, on the whole, developed satisfactory procedures for achieving an understanding of their relationship and their accommodation to each other. This is true at all levels of decision and policy-making: private, legislative, administrative and judicial.

3. RESOLUTION OF CONFLICTS

Our investigation has helped us to see what some of the problems are. It has not enlightened us on how to solve them. We must promote *both* com-

[15] *See, for example, a current study by the Office of Invention and Innovation, National Bureau of Standards, entitled* Judicial Consideration of Technological Factors in Antitrust Actions. *The study will be published in early 1967.*

[16] *For a lucid discussion, aimed at providing a better understanding of the field of antitrust to business executives and others who are not expert in the field, see Kintner,* An Antitrust Primer, *MacMillan, 1964.*

access to information concerning the effect of their policies upon both competition and innovation, and should be in a position to evaluate such information in order to achieve a proper balance and coordination between these policies. In today's fast-evolving economy, both the necessary information and the means for evaluating it are often seriously lacking.

(2) While the ultimate formulation of specific "black-and-white" rules or guidelines for determining the legality or illegality of given practice seems desirable, this cannot be done, except in a few small areas, until more extensive studies have been made of the many ramifications of the relationships between competition and innovation.

(3) Antitrust, regulation and innovation have all demanded increasing attention in recent years. As a result, agencies operating in all three areas have proliferated. Inevitably, conflict and lack of mutual assistance among them have resulted. This condition is a matter of concern to many, including the agencies themselves. Unfortunately, the independent and separate status of those affected has made it difficult to resolve or lessen this conflict. Moreover, the formulation of the rules and guides referred to in the preceding paragraph becomes the most difficult at the very time that their need becomes the greatest.

In these circumstances, we believe that the ultimate development of such rules and guides, as well as the day-to-day administration of policies concerning competition and innovation, would be furthered if a group existed, *independent of the agencies charged with the administration and enforcement* of the antitrust and regulatory laws, to whom these agencies could turn for expert and unbiased advice and assistance. The creation of such a group, we emphasize, is a response to recognized needs for coordination and mutual accommodation. It does not infer any unreasonableness or known remediable deficiencies in existing policies and administration.

Hence, the function of such a group would be to offer advice and assistance rather than exercise authority of any sort over its "clients." It should be a continuing staff, designed to service the administering agencies and the policy-makers by conducting studies and providing information, data, and suggestions for modifying policy and procedure.

Greater understanding and judgment should also accrue to the affected public, thus lessening the likelihood of conduct based upon misunderstanding and misinformation. The group could, for example, provide information, analysis and advice concerning the competitive and innovative aspects of various types of joint R&D programs, foreign trade and technology transactions, patent pools, mergers and acquisitions, restrictive or limited licenses relating to patents or know-how, government policies in awarding and framing R&D contracts, and so on.

Such a group should operate subject to the following conditions:

—It should concentrate on empirical analyses.

—It should be an advisory rather than a supervisory unit, maintaining continuous communication with the pertinent agencies and departments and with the Congress.

structure and operation be kept as *flexible* as possible in order to permit experimentation and adjustment in the light of experience.

Pending the establishment of the central group we urge be formed, we believe that much could be done in the legislative, executive and judicial branches to broaden understanding of the problems under discussion. In particular, we make the following recommendations.

RECOMMENDATION 14

To enable the antitrust and regulatory agencies to give greater attention to questions concerning technological innovation, their staffs should be strengthened by increasing the number of personnel who have a deep understanding of economic and technological development.

RECOMMENDATION 15

In the legislative and judicial processes involving antitrust and regulation, more consideration should be given to the interaction of technological change and competition.

We should note in this regard the continuing efforts of the Senate Antitrust and Monopoly Subcommittee to explore the interrelationships between competition, invention and innovation. We have referred to their work elsewhere in this report.

RECOMMENDATION 16

(a) The antitrust and regulatory agencies should provide guidelines clarifying the legality or illegality of business conduct affecting competition and technological innovation.

(b) The agencies should also devote more attention to the effect of remedies, orders, and decrees on innovation in relation to competition.

During the past year, the Antitrust Division of the Department of Justice, with whom we have had a very rewarding relationship, has been developing guidelines to help clear away some of the inevitable uncertainties that emerge as antitrust policies evolve. We are hopeful that these guidelines will help resolve some of the issues we have discussed in our analysis of the policies affecting competition *and* innovation.

understanding and appreciation of the problems and opportunities associated with technological change.

RECOMMENDATION 17

(a) A White House conference on "Understanding and Improving the Environment for Technological Innovation."

(b) Soon thereafter, a series of regional innovation conferences, composed of governors, mayors, bankers, academicians, scientists, engineers, entrepreneurs, and others—aimed at removing barriers to the development of new technological enterprises, jobs, and community prosperity in the respective regions.

Summing up, we find that the concepts, uncertainties, and other realities of technological innovation are like a foreign language, indeed a strange world, to too many of us. Because of this, we believe the most important initial task before us is to become more widely acquainted with the "language" and "world" of innovation.

Understanding, as Alexander Pope might have put it, is the key to a drawer wherein lie other keys. When we come to appreciate and understand the problems and the opportunities associated with innovation, we can more effectively act on programs that will best encourage beneficial change and the continued renewal of our society.

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Larry L. Yetter is a member of the staff of the Office of Invention and Innovation in the National Bureau of Standards.

Name of Agency	Nature and Scope of Regulation	Statute
	Prohibits any vessel engaged in foreign trade of the U.S. from entering or passing through the Panama Canal if such vessel is owned, chartered, operated or controlled by a person or corporation doing business in violation of the antitrust laws.	Panama Canal Act, 37 Stat. 567; 15 U.S.C. 31; P.L. 337; 62nd Cong.
	Prohibits contracting with any person who has entered or proposed to enter into a combination to fix the price of bids, or to induce others not to bid, for postal supply contracts.	62 Stat. 704; 18 U.S.C. 441 (1948).
B. *Supplemental Enforcement of the Antitrust Laws*		
Federal Trade Commission	Created the Federal Trade Commission (FTC) and declared unfair methods of competition and unfair or deceptive acts or practices in commerce unlawful, including the dissemination of false advertisement. The FTC was also given the power to investigate and require annual reports providing information on organization, business conduct and practices.	Federal Trade Commission Act, 38 Stat. 717; 15 U.S.C. 41ff; P.L. 203; 62nd Cong. (1914).
Federal Trade Commission	Declares the manufacture for sale and sale of any wool product, which is misbranded, unlawful and a violation of the Federal Trade Commission Act (FTCA).	Wool Products Labeling Act of 1939, 54 Stat. 1129; 15 U.S.C. 68a; P.L. 850; 76th Cong. (1940).
Federal Trade Commission	Declares the manufacture for sale, sale, or advertising of any fur product, which is misbranded or falsely or deceptively advertised or invoiced, unlawful and a violation of the FTCA.	Fur Products Labeling Act, 65 Stat. 175; P.L. 110; 82nd Cong. (1951).
Federal Trade Commission	Declares the manufacture for sale, sale, importation into the U.S., or transportation in commerce of any article of wearing apparel which is defined under the Act as highly inflammable, as to be dangerous when worn by individuals, unlawful and a violation of the FTCA.	Flammable Fabrics Act, 67 Stat. 111; 15 U.S.C. 1191–1200; P.L. 88, 83rd Cong. (1953).
Federal Trade Commission	Declares the manufacture for sale, sale, advertising, transportation in commerce, or importation into the U.S. of any textile fiber product, which is misbranded or false or deceptively advertised, unlawful and a violation of the FTCA.	Textile Fiber Products Identification Act, 72 Stat. 1718; 15 U.S.C. 70a; P.L. 85–897 (1958).

Name of Agency	Nature and Scope of Regulation	Statute
	trust, or form the subject of any contract or conspiracy in restraint of trade in the mining or selling of specified minerals.	
Secretary of Agriculture	Declares unlawful, certain practices in the sale or transfer of meats, livestock, poultry or poultry products, such as apportioning their supply if it has the tendency or effect of restraining commerce or creating a monopoly, manipulating or controlling prices in commerce, creating a monopoly in the acquisition of any article in commerce, or conspiring or combining to apportion territories. It also prohibits any unfair, unjustly discriminatory, or deceptive practice or device in commerce.	Packers and Stockyard Act, 42 Stat. 159; 7 U.S.C. 181ff, P.L. 51, 67th Cong. (1921).
Securities Exchange Commission	Declares unlawful, unless approved by the Chairman of the SEC, the acquisition of any securities, utility assets, or any other interest in any business, or the acquisition of any security of any public utility by a registered holding company or its subsidiary. The Commission is authorized to examine and review the corporate structure of any registered holding company for purpose of simplifying the structure, eliminating complexities, distributing voting power among shareholders, and confining properties and business to the operations of an integrated public utility system.	Public Utility Act of 1935, 49 Stat. 817; 15 U.S.C. 791; P.L. 333, 74th Cong.
Secretary of the Treasury	Declares unlawful certain practices or conduct by persons engaged in business as a distiller, brewer, rectifer, blender or bottler of distilled spirits, wine or malt beverages. Such practices declared unlawful are exclusive retailing arrangements; acquiring an interest in any retailer's license or real or personal property; furnishing or renting equipment or fixtures, etc. to retailer; paying or crediting the retailer for advertising; guaranteeing or repayment of retailer's financial obligation or providing other similar benefits; inducing any trade buyer to purchase such products by commercial bribery or offering of a bonus or compensation to said buyer; and to sell or to purchase	Federal Alcohol Administration Act, 49 Stat. 977; 27 U.S.C. 202ff.; P.L. 401, 74th Cong. (1935).

Name of Agency	Nature and Scope of Regulation	Statute
	formal advertising were not independently reached in open competition. He is required to refer any bid he considers to be evidence of an antitrust violation to the Attorney General.	
Atomic Energy Commission	Declares that nothing contained in the Atomic Energy Act of 1954 shall relieve any person from the operation of the antitrust laws, and in the event a licensee is found by a court to have violated the antitrust laws in the conduct of the licensed activity, the AEC may suspend, revoke, or take such other action deemed necessary with respect to any license issued by the AEC. In addition, the Commission is required to report to the Attorney General any activity concerning nuclear material or atomic energy which appears to violate or tends toward the violation of the antitrust laws.	Atomic Energy Act of 1954, 68 Stat. 938; 42 U.S.C. 2135; P.L. 703, 83rd Cong. (1954).
Federal Power Commission	Provides that, in addition to bringing suits in the Federal Courts to enforce compliance with the Natural Gas Act and to enjoin acts or practices which constitute violations of this Act, the FPC may transmit evidence concerning apparent violations of the antitrust laws to the Attorney General who may institute the necessary criminal proceedings.	Natural Gas Act, 52 Stat. 832; 15 U.S.C. 717; P.L. 688, 75th Cong. (1938).
Federal Power Commission	Declares that combinations, agreements, arrangements, or understandings, expressed or implied, to limit the output of electrical energy, to restrain trade, or to fix, maintain, or increase prices for electrical energy or service are prohibited.	Federal Power Act, 41 Stat. 1070; 16 U.S.C. 803(h); P.L. 280, 66th Cong. (1920); as amended, 49 Stat. 844; 16 U.S.C. 803(h); P.L. 333, 74 Cong. (1935).
Board of Governors of the Federal Reserve System	Provides that corporations organized under the Federal Reserve Act may purchase or acquire stock in another corporation, and sets forth the conditions under which such mergers or acquisitions are permissible, including the consent of the Board of Governors. It prohibits any corporation or its agents and employees organized under the Act from directly or indirectly controlling or fixing the price of commodities in commerce which subjects the corporation's charter to forfeiture.	Federal Reserve Act, 41 Stat. 379, 380, 381, Sec. 25(a); 12 U.S.C. 615 and 617; P.L. 106; 66th Cong. (1919).

Name of Agency	Nature and Scope of Regulation	Statute
	vided such association is not restraining trade within the U.S., or in restraint of a domestic competitor in export trade. In addition, mergers or acquisitions of corporations engaging solely in export trade are exempt, unless the effect of the acquisition substantially lessens competition within the U.S. Unfair methods of competition prohibited under the FTCA do apply to competition in export trade.	
Federal Maritime Commission	Prohibits certain anticompetitive practices on the part of a common carrier by water and gives the Commission the authority to refer any violation to the Commissioner of Customs who shall refuse a violating carrier entry in any port of the U.S. Notwithstanding these prohibitions, the Commission shall, upon application, permit the use, provided criteria is met by carriers, in foreign commerce of any contract, which is available to all shippers and consignees on equal terms and which provides lower rates to a shipper who agrees to give all or any fixed portion of his patronage to such carrier or conference of carriers.	Shipping Act, 1916, 39 Stat. 733; 46 U.S.C. 812; P.L. 260, 64th Cong. (1916).
Civil Aeronautics Board	Prohibits consolidations, mergers and certain interlocking relationships between common carriers by air without the approval of the CAB, and requires the CAB to disapprove agreements between carriers which are adverse to the public interest. However, any person or corporation affected by any order of the CAB, under the sections prohibiting the practices listed above, is relieved from the operations of the antitrust laws.	Federal Aviation Act of 1958, 72 Stat. 770; 49 U.S.C. 1384; P.L. 85-726 (1958).
Interstate Commerce Commission	Prohibits any common carrier subject to the provisions of the Act from pooling or dividing traffic unless the Commission finds that such practice will be in the interest of better service to the public or of economy in operation, and will not unduly restrain competition. It permits two or more carriers to consolidate or merge with the approval and authorization of the Commission upon its finding that such action will be consistent with the public interest after weighing certain stipulated factors.	Interstate Commerce Act, as amended, 63 Stat. 486; 49 U.S.C. 5; P.L. 197, 81st Cong. (1949).

Name of Agency	Nature and Scope of Regulation	Statute
Secretary of Agriculture	Permits original producers of agricultural products to acquire, exchange, and disseminate past, present, and prospective crop, market, statistical, economic and other similar information by direct exchange between such persons and/or such associations thereof.	Cooperative Marketing Act, 44 Stat. 802; 7 U.S.C. 451 ff. at 455; P.L. 450, 69th Cong. (1962).
Secretary of Agriculture	Secretary is authorized, after notice and hearing, to enter into marketing agreements with processors, producers, associations of producers, and others engaged in the handling of any agricultural commodity, only with respect to such handling which directly burdens, obstructs, or affects interstate commerce. Such agreements are exempt from the antitrust laws.	Agricultural Adjustment Act, as amended, 61 Stat. 208, Title II, Sec. 206(d); 7 U.S.C. 608(b); P.L. 132, 80th Cong. (1947).
Secretary of Agriculture	Exempts from the operation of the antitrust laws awards or agreements resulting from the arbitration of bona fide disputes between cooperative associations of milk producers and the purchasers, handlers, processors, or distributors of milk or its products, as to the terms and conditions of the sale of milk or its products.	Agricultural Marketing Agreement Act of 1938, 62 Stat. 1258; 7 U.S.C. 671 ff; P.L. 897, 80th Cong. (1948).
Secretary of Interior	Permits persons engaged in the fishing industry, as fishermen or as planters of aquatic products to act together in associations in collectively catching, producing, preparing for market, processing, and marketing in commerce, such products. The Secretary of the Interior is authorized to issue a complaint and an order to cease and desist any activity which he believes monopolizes or restrains trade to such an extent that the price of an aquatic product is unduly enhanced.	Fisherman's Collective Marketing Act, 48 Stat. 1213; 15 U.S.C. 521, 522; P.L. 464; 73rd Cong. (1934).
Securities and Exchange Commission	Provides that the provisions of this Act, permitting the association of brokers and dealers in securities, shall prevail where any provision conflicts with any law of the U.S.	Maloney Act, 52 Stat. 1070; 15 U.S.C. 780–3; P.L. 719; 75th Cong. (1938).
State Insurance Commission	Provides for the regulation by the states of companies in the insurance business. It provides that the antitrust laws shall not apply to the business of insurance or to acts in	McCarran Act, as amended; 61 Stat. 448; 15 U.S.C. 1011 ff; P.L. 238, 80th Cong. (1947).

Name of Agency	Nature and Scope of Regulation	Statute
	ticultural organizations, instituted for purposes of mutual help, and not having capital stock or conducted for profit . . .; nor shall such organizations or their members be held or construed to be illegal combinations or conspiracies in restrain of trade under the antitrust laws.	
	Exempts from the operation of the antitrust laws an association entered into by marine insurance companies to transact a marine insurance and reinsurance business in the U.S. and in foreign countries.	Ship Mortgage Act, 1920; 41 Stat. 1000; 46 U.S.C. 885; P.L. 261; 66th Cong. (1920).
	Provides that the Robinson-Patman Act shall not apply to purchase of supplies for their own use by schools, colleges, universities, public libraries, churches, hospitals, and charitable institutions not operated for profit.	Exemption of Nonprofit Institution from Price Discrimination Provisions, 52 U.S.C. 13C; P.L. 550; 75th Cong. (1938).
	Exempts from the operation of the antitrust laws any agreements or contracts prescribing minimum or stipulated prices for the resale of a commodity which bears the trademark or trade name of the producer or distributor, when such contracts or agreements are lawful as applied to intrastate transactions under any *state law*. It does not exempt contracts or agreements providing for minimum resale price on any commodity, between manufacturers, or between producers, or between wholesalers, or between brokers, or between retailers, or between persons or corporations in competition with each other.	Miller-Tydings Act, 50 Stat. 693; 15 U.S.C. 1; P.L. 314; 75th Cong. (1937). Amended the Sherman Act.
	Cooperative associations or method or act thereof which comply with and are bound by the District of Columbia Cooperative Association Act are not deemed a conspiracy or combination in restraint of trade or an illegal monopoly, or an attempt to lessen competition or fix prices arbitrarily.	District of Columbia Cooperative Association Act, 54 Stat. 490; 29DC Code 840 ff (1940 ed); P.L. 642; 76th Cong. (1940).
	Exempts from the operation of antitrust laws the enforcement of the right of action created by *state law* to obtain damages for advertising, offering for sale, or selling any commodity at less than the price or prices	McGuire Act, 66 Stat. 632; 15 U.S.C. 45(a); P.L. 542, 82nd Cong. Amendment included in Sec. 5(a) of the Federal Trade Comm. Act.

Appendix C

EXAMPLES OF POSSIBLE CONFLICTS BETWEEN POLICIES ON COMPETITION AND VARIOUS PRACTICES INVOLVING INNOVATION

The following hypothetical situations illustrate various business practices concerning technological matters which could possibly conflict with national policies concerning antitrust and competition. These examples also illustrate the kinds of questions with respect to which the group, proposed in Recommendation #13, would conduct research and provide advice, based upon the results of its investigations.

Situation 1: The owner of a small manufacturing corporation, invents and patents an invention highly important in its field, and useful in other fields as well. He is willing to grant licenses under his patent but only if he can impose what he regards as appropriate conditions on his licensee in order to protect his own best interests. Such conditions might include restrictions with respect to some or all of the following: price, quality, quantity of production, geographic area in which the licensee manufactures and sells, field of use, and grant-back of nonexclusive rights under improvement patents.

Situation 2: In order to strengthen its position vis-a-vis competitors, a company which dominates its industry, engages in the following practices:

(a) imposes stringent contract conditions on its employees which preclude divulgence or use of inventions made or learned of while in its employ and for two years following termination of employment with the company;

(b) bars employees from working for competitors for two years after leaving its employ;

(c) hires away competitor's key research personnel and follows a practice of outbidding competitors for promising new personnel;

(d) deliberately delays by lawful means the issuance of an important patent covering a product that is unlikely to become commercially significant for 20 years.

Situation 3: A corporation owns a number of patents under which it licenses other corporations to manufacture articles covered by its patents. The licensing agreement includes a provision which requires the licensee to grant-back exclusively to the licensor any patentable invention or improvement relating to the field of the licensed patent.

Situation 4: A group of companies within a specified industry forms a restrictive or closed patent and know-how pool.

Situation 5: A number of companies form patent and know-how pools by which:

(a) Parties cross-license conflicting and competing patents on a nonexclusive basis and grant one licensee the right to sub-license under all the patents. Licenses are granted to all applicants on condition of a grant-back of inventions in the licensed field. Licenses are granted only by ac-

Situation 11: An independent inventor sells his invention to the highest bidder, which is the dominant company in the field to which the invention relates.

Situation 12: Similarly, a technically-oriented entrepreneur (individual or corporate) seeks to sell out to the highest bidder, who is dominant in the field. The adverse effect upon competition if the sale is permitted, and adverse effect on innovation stimulus if prohibited, present conflicting considerations.

Situation 13: A machinery company, the dominant firm in its industry, invents an attachment that will make its machine so much more effective than those of its competitors as to reduce seriously the effectiveness of their competition. However, fear of antitrust vulnerability causes it to:

(a) refrain from incorporating the device in its machine;

(b) sell machines containing the device at a higher price than it otherwise would; or

(c) refrain from the vigorous sales efforts that the improved machine would justify.

Situation 14: In the interests of more effective and economical merchandising, a company considers undertaking the following:

(a) forming, with other concerns, a buying cooperative to take advantage of quantity discounts;

(b) forming, with other concerns, a cooperative merchandising program, including such features as joint advertising and common use of a collective symbol; or

(c) forming, with others in the industry, a quality control program to improve the industry's performance and reputation.

However, it decides against these because of possible antitrust and Robinson-Patman complications.

Situation 15: A company, in order to introduce a new product:

(a) Gives a distributor a long-term exclusive distributorship within a limited territory.

(b) Offers the product at a price below the cost of producing it.

Situation 16: A corporation, attempting to break into a new market, reduces its selling price in that market below its price in other areas.

Situation 17: A corporation, introducing a complex and experimental product into the market, requires that purchasers buy their supplies and replacements, and obtain their servicing, from the corporation.

Situation 18: Building contractors and their labor union enter into an agreement (in the face of a strike threat) not to use certain new materials and methods of construction. The new methods and materials will improve the quality of building and reduce its cost, but will also sharply reduce the amount of manual labor required.

is an option granted by a corporation to an individual, for any reason connected with his employment, to purchase stock in the corporation. The two conditions are: (1) the individual must hold the stock for three years, after the transfer pursuant to the exercise of the option, before he makes a disposition, and (2) if the individual ceases to be employed by the corporation granting the option, he must exercise the option within three months following the termination of the employment.

The option must also meet a number of criteria, the two most pertinent for present purposes being: (1) "the option by its terms, must be exercised within five years after the date the option is granted" and (2) the optionee cannot own stock possessing more than 5% of the total combined voting power or value of all classes of stock of the employer corporation, except where the equity capital of the corporation is less than $2,000,000 (where this exception applies, a formula is used to determine the permissible percentage of voting powers, which may range from 10%, the maximum, down to 5%).

Sec. 1235 IRC *Sale or exchange of patents.* This section permits long term capital gains treatment for payments received by a holder from the "transfer of property consisting of all substantial rights to a patent". The payments qualify for this treatment even though they are "payable periodically over the time of the tarnsferee's use of the patent," or they are "contingent on the productivity, use or disposition of the property transferred." The "holder" is defined as "any *individual* whose efforts created the property, or who has acquired his interest in the property . . . from the creator prior to actual reduction to practice of the invention covered by the patent, if such individual is neither the employer of or related to the creator."

Appendix E

THE RECOMMENDATIONS RECAPITULATED

	Page
RECOMMENDATION 1	
We recommend that losses of small, technologically based companies, meeting criteria along the lines we have suggested, be allowed as a carry-forward against profits of the succeeding ten years instead of only five years.	34
RECOMMENDATION 2	
We recommend a liberalization of the stock option rules for small technologically based companies by (1) extending the permissible option period from a maximum of five years to ten years, and (2) reducing the holding period required to receive capital gains treatment to less than three years, preferably to six months.	36
RECOMMENDATION 3	
The Internal Revenue Code should be amended so that a "casual" inventor or innovator can deduct out-of-pocket expenses legitimately incurred for the purpose of ultimately producing income.	37
RECOMMENDATION 4	
The successful inventor who has a going business but did not declare his earlier development costs should receive a "generous backward look" by the Internal Revenue Service and be permitted to reconstruct his development costs and write them off over a period of five years.	37

RECOMMENDATION 9

Page

The Department of Commerce should broaden and complement its studies of the innovative and entrepreneurial processes by initiating an integrated program, in cooperation with the universities, including the preparation of empirical data and case materials on these processes, studies of the venture capital system, and experimentation with teaching methods to develop innovative and entrepreneurial talents. 45

RECOMMENDATION 10

An interdepartmental ad hoc review of current contracting policies and procedures of such agencies as the Department of Defense, the National Aeronautics and Space Administration, the Atomic Energy Commission, and the National Institutes of Health, to ensure that these policies are conducive to the long-range growth of small enterprises. 46

RECOMMENDATION 11

The Department of Commerce should serve as the Federal spokesman representing the interests of new technologically-based enterprises and should develop the necessary competence and organization to deal with problems associated with venture capital availability and the generation of such enterprises. 47

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RECOMMENDATION 14	
To enable the antitrust and regulatory agencies to give greater attention to questions concerning technological innovation, their staffs should be strengthened by increasing the number of personnel who have a deep understanding of economic and technological development.	55
RECOMMENDATION 15	
In the legislative and judicial processes involving antitrust and regulation, more consideration should be given to the interaction of technological change and competition.	55
RECOMMENDATION 16	
(a) The antitrust and regulatory agencies should provide guidelines clarifying the legality or illegality of business conduct affecting competition and technological innovation.	55
(b) These agencies should also devote more attention to the effect of remedies, orders, and decrees on innovation in relation to competition.	
RECOMMENDATION 17	
(a) A White House conference on "understanding and improving the environment for technological innovation."	
(b) Soon thereafter, a series of regional innovation conferences, composed of governors, mayors, bankers, academicians, scientists, engineers, entrepreneurs, and others —aimed at removing barriers to the development of new technological enterprises, jobs, and community prosperity in the respective regions.	57

THE ROLE OF NEW TECHNICAL ENTERPRISES IN THE U.S. ECONOMY

by John O. Flender & Richard S. Morse

Many factors --- domestic and world-wide --- influence the U.S. economy and employment. Because of the increasing cost of imported energy, declining supply of domestic natural resources, and competition from goods manufactured abroad with low cost labor, the U.S. must rely more heavily on the export of high technology products in order to maintain a high level of employment and a favorable balance of payments. Technology does play a very important role in the maintenance of a sound domestic economy, the enhancement of productivity, and our ability to compete in the world marketplace. Against this background, it is important to review the current environment for technological innovation in the United States.

Many foreign countries recognize the importance of maintaining a healthy climate for technical innovation and have taken positive steps, particularly in the support of new product development, to encourage the innovative process. This country unfortunately has no effective spokesman for either the entrepreneur or new enterprise generation. Congress has historically shown an increasing lack of understanding of the innovative process, the need for incentives for the entrepreneurs, the venture capitalist, and the role of new technical enterprises in the U.S. economy.

While mechanisms for more effective applications of science, technology, and innovative management, represent a general requirement of both large and small companies, the "new technical enterprise" has made a unique contribution to the American economy. The environment for a new generation of "technical enterprises" to become a future Texas Instruments, Xerox, or Polaroid appears to have deteriorated significantly in recent years.

In 1967 the Technical Advisory Board of the U.S. Commerce Department studied and reported on technical innovation.(1) One important fact came to light, namely, that the rate of sales growth and job creation occurs more rapidly in the innovative high technology companies than it does in the more mature organizations. The data for those relatively new innovative companies shown in the 1967 report has been revised to cover the period 1945 - 1974 and appears below. For comparative purposes, data for the same period for selected mature companies from a variety of industries is also shown.

Messrs. Morse and Flender are President and Treasurer respectively of the M.I.T. Development Foundation, Inc.

(1) Technological Innovation: Its Environment and Management, U.S. Department of Commerce (Washington, D.C.: Government Printing Office, 1967).

During the five-year period 1969-1974, the average per cent annual growth of the companies in each of the above three groups was:

	Sales	Jobs
Innovative Companies	13.2%	4.3%
Mature Companies	11.4%	0.6%
Young High Technology Companies	42.5%	40.7%

Although complete data is appended, it is worth noting here that during the five-year period the six mature companies with combined sales of $36 billion in 1974 experienced a net gain of only 25,000 jobs, whereas the five young, high technology companies with combined sales of only $857 million had a net increase in employment of almost 35,000 jobs. The five innovative companies with combined sales of $21 billion during the same period created 106,000 new jobs.

It would appear that our more mature large corporations tend to reduce employment via such mechanisms as improved productivity. The technically based new enterprise has the ability to create new job opportunities and products which are competitive in the world markets. It is suggested that the concept of innovation within the large corporation is viewed in terms of cost reduction and increased productivity in an effort to remain competitive. In the small new technically based enterprise innovation is a way of life and is responsible for the creation of new products, processes and job opportunities.

The foregoing data, while in no way a statistical study of different groups of companies, does nevertheless, indicate trends in the business community and does point to the importance of new innovative companies in the development and commercialization of new technology.

The business environment which led to the growth of companies like IBM, 3M, Polaroid, Texas Instruments, and Xerox in the post World War II years, and which encouraged the establishment of Digital Equipment, National Semiconductor, and other high technology companies in the 1950s and 1960s was a favorable one. Entrepreneurs were plentiful and enthusiastic. They were encouraged by economic incentives and by the freedom of the system which allowed them to function and to be creative without the constraints of large corporations. Government research and development funds were available to small companies, and more than a few entrepreneurs built successful businesses on DOD and NASA contracts which provided the basis for commercial products. Capital was attainable, either from established venture capital sources, invididual investors or through the sale of securities to the public.

In the late 1960s and early 1970s changes took place in the environment for the establishment of new high technology enterprises. This resulted in a reduction in the rate at which new companies were started and restricted the development of many of the small companies which were established during the period. These changes appear to fall in the following areas:

Government Funding of Research and Development. About five years ago a growing disenchantment with science and echnology began to develop in this country as a result of ever

finds that the potential "after tax" gain from starting his own company may not be commensurate with the risks, and that employment by a large company at a relatively high salary may have greater overall attraction.

Regulatory Environment. During the last five years, the role of the government regulatory agencies has been an ever increasing one. Environmental requirements, the need for impact statements for new activities, safety and health regulations, etc., at all levels of government have changed the business climate for both large and small companies. Sometimes the small company can operate more freely than the large company within this new climate, but when conformity is required, the small entrepreneur is less well equipped both financially and with respect to manpower than the large organization.

The direct cost of conforming with specific new regulatory requirements is easily identified, but what about the indirect costs to the small company which have resulted from compliance with the expanded requirements of the established regulatory agencies? Consider the Securities and Exchange Commission. One of the leading national auditing firms estimated recently that in the last five years, the requirements for a Form S-1 registration have been expended to the point where an equivalent registration statement today would take two and a half times the number of man hours it would have required five years ago. The resulting increase in cost combined with the effect of inflation has made registration prohibitively expensive for the small company. Furthermore, expanded reporting requirements are now so onerous and expensive that many small publicly held companies are looking for ways to reduce their number of stockholders to a point below which reporting will no longer be required.

Reduction of Liquidity. In recent years, many professional investors have been discouraged from providing seed capital to new companies because of concerns about liquidating their investments in a reasonable time period. Three factors have contributed to the reduction in liquidity; first, the cost of "going public" has for many companies become prohibitively expensive; second, the public, as a result of bad experiences, is unwilling to invest in speculative securities; and third, SEC regulations significally restrict the large stockholder from disposing of his securities in a reasonably short period of time. The SEC's new Rule 144 has been beneficial to investors by clarifying a number of unanswered questions regarding the resale of unregistered securities when a public market exists. The problem is that in the absence of an established market, Rule 144 does not apply. For many years, the SEC has been promising a Secondary Private Placement Rule, but the rule has not been forthcoming. At the present time, there is no way a large investor can liquidate a significant portion of his holdings in a private transaction without running the risk of being in violation of the Securities Act.

Reporting Procedures and Public Disclosures. In recent years the SEC has pushed for more prompt and detailed disclosure of matters pertaining to the business of a so-called "Reporting Company". The result has been a staggering increase in legal and auditing costs as well as in the non-productive work load. Small companies have been particularly hard hit by these requirements which take a disproportionately large percentage of overhead effort and executive time.

In late 1974, a survey was made of the members of the National Venture Capital Association (NVCA) regarding the number and amount of private financings concluded during a period of approximately 5 years. Fifty seven firms or 71% of the membership responded to this survey as tabulated below:(4)

	No. of Venture Capital Firms Involved in New Financings	Number of New Financings	$ Value of Financings (Millions)
1970	39	223	$66.4
1971	48	225	84.5
1972	47	223	89.8
1973	46	185	93.5
1974 (nine months)	37	93	47.8

The statistics indicate a distinct decline in venture capital investments in new projects during the period 1973 through 1974. Although the 1974 data is for a 9 month period and may not be indicative of the level of activity during the entire year, NVCA officials indicate that there were very few financings during the last quarter of 1974. The opinion is substantiated by the public issues data, taken from Venture Capital.

Unfortunately, data regarding the financings of technical "start-up" situations and very new companies is almost non-existent; first, because the sources of early srage venture capital have been both varied and diverse and, second, because most independent, as well as organized investors, are reluctant to discuss their activities. The NVCA data does not show, nor was it intended to show, the nature of the investments or the stage in a company's development during which a financing was completed. Information gathered independently from within the venture capital community, however, suggests that recent financings involved relatively conservative investments in seasoned companies as contrasted with the more speculative, early stage investments made at the start of the five-year period. There is sufficient information in the NVCA study to support this contention.

If, as indicated by the NVCA data, the number of private venture capital financings is declining, the question can quite naturally be raised, "Is there unused capital available?" The survey indicated that about 22% of the capital of those groups who responded was in cash, but went on to say, "Since most venture firms tend to hold cash reserves for contingencies, it would appear the venture industry is currently rather fully invested."

Both the public issues data and the private financings data reflects the declining number of financings by clearly identifiable segments of the financial community. There is no data regarding the individual and truly private source of seed money. One possible, but as yet unproven, source of venture capital may come from corporate groups which are interested in diversification and the development of windows on new technologies through the acquisition of minority interest in small companies.

(4) Survey of Venture Capital Industry and Its Impact on Public Companies Financed, prepared for the National Venture Capital Association by Aharon R. Ofer, Asst. Prof. of Finance, Northwestern University.

or expedite the generation of new business enterprises. The following recommendations are suggested for Executive and Legislative action in order to enhance the initiation and growth of new technically based enterprises:

1. Change Capital Gains Tax. A reduced capital gains tax rate for direct investment in small technical enterprises should be an effective incentive to make venture capital available for "Start-ups". Such an incentive should be available to both corporate and individual investors.

2. "Founders'" Stock. A new mechanism is needed to facilitate the acquisition of "Founders'" stock by officers, directors, and key employees during the formative years of the company. Care should be taken to prevent adverse tax consequences which negate the value of the stock in attracting key talent to the enterprise team.

3. Recognize the Role of Corporate Investors. The institutionalization of the venture capital community and the increasing use of the industrial corporate venture mechanism suggest that it would be desirable to allow corporate and partnership participation under both Sub-Chapter S and Section 1244 of the Internal Revenue Code.

4. Tax Incentive for Direct Investment in Small Technical Enterprises. An immediate deduction against income for individual, institutional and corporate investors for their direct investment in small technical enterprises would be an effective incentive for start-up financing. The investors would assume a zero tax base, and capital gains tax liability would be incurred only upon sale of the investment.

5. Review SEC Rules. SEC rules, not withstanding Rule 144, continue to restrict the small company investor's liquidity. New combinations of holding periods and rates of distribution (for both private and public companies) should be considered.

6. Review Reporting Procedures. Reporting requirements under the rapidly growing state and federal regulations rules should be reviewed with the intent of simplifying the requirements for small companies.

7. Review Tax and SEC Regulations. General cost increases and inflation have made dollar limits in certain rules too small. For ~~1255~~ 1244 stock, the maximum asset value should be increased to $1,000,000; the loss allowance should be increased to $50,000 on an individual basis, and $100,000 on a joint return basis. Similarly, the capitalization limit for a Reg. A registration should be increased to $1,000,000. The small business (22%) tax rate should be applied to the first $100,000 of income rather than $25,000. The tax-loss carry-forward period should be extended from five years to ten years.

8. Review Incentives for Management. For the new small enterprise, the value of stock options as a management incentive can be restored by reducing the holding period for shares issued under a qualified.

Sales & Employment Data
1945 - 1974 & 1969 - 1974

	Sales Data					Employment Data				
	Sales 1974	Sales 1969	Sales 1945	Annual Rate 1969-1974 %	Annual Rate 1945-1974 %	Employment 1974	Employment 1969	Employment 1945	Annual Rate 1969-1974 %	Annual Rate 1945-1974 %
	($000 omitted)									
Young High Tech. Companies										
Data General	83,196	1,034	--	140.5	--	3,452	170	--	82.5	--
National Semiconductor	213,550	22,904	--	54.3	--	17,610	1,710	--	59.4	--
Computographic	61,412	8,067	--	50.2	--	1,864	637	--	24.0	--
Digital Equipment	421,884	87,868	--	36.8	--	17,600	4,615	--	30.7	--
Marion Labs	77,303	23,861	--	24.5	--	1,440	465	--	25.4	--
Total	857,345	145,734	--	42.5	--	41,966	7,597	--	40.7	--
Innovative Companies	($000,000 omitted)									
Polaroid	757.3	522.2	16.75	7.7	14.0	13,019	10,506	1,058	4.4	9.0
3M	2,937	1,613	63.55	12.7	14.1	83,609	66,260	6,795	4.8	9.0
IBM	12,675	7,197	141.7	12.0	16.8	292,350	258,662	17,500	2.5	10.2
Xerox (Haloid Co.)	3,576	1,483	6.716	19.2	24.2	101,380	54,882	593	13.1	19.4
Texas Instruments ('53-'74)	1,572	831.8	27.53	13.6	21.2	65,524	58,974	2,300	2.1	17.3
Total	21,517	11,647	N.A.	13.2	16.9	555,882	449,284	N.A.	4.3	11.1
Mature Companies	($000,000 omitted)									
Bethlehem Steel	5,381	2,928	1,327	12.9	4.9	122,000	130,000	202,095	(1.3)	(1.7)
DuPont	6,977	3,655	631.6	13.8	8.6	136,836	118,079	63,939	3.0	2.6
General Electric	13,413	8,448	1,298	9.7	8.4	404,000	400,000	148,233	0.2	3.5
General Foods	2,987	1,894	307.1	9.5	8.2	47,000	42,000	13,000	2.3	4.5
International Paper	3,095	1,777	240.0	11.7	9.2	52,715	54,500	23,414	(0.7)	2.8
Proctor & Gamble	4,912	2,708	342.5	12.6	9.6	49,800	43,214	14,800	2.9	4.3
Total	36,795	21,410	4,146	11.4	7.8	812,351	786,793	465,481	0.6	1.9

Source: Moody's Industrial Manuals, Moody's Investor Services, Inc., New York, New York

JOF:cjl
October 3, 1975

APPENDIX IX

"PRIORITIES AND EFFICIENCY IN FEDERAL RESEARCH AND DEVELOPMENT," A COMPENDIUM OF PAPERS SUBMITTED TO THE SUBCOMMITTEE ON PRIORITIES AND ECONOMY IN GOVERNMENT, JOINT ECONOMIC COMMITTEE, CONGRESS OF THE UNITED STATES, OCTOBER 29, 1976, PAGES I–V, 85–115

94th Congress
2d Session } JOINT COMMITTEE PRINT

PRIORITIES AND EFFICIENCY IN FEDERAL RESEARCH AND DEVELOPMENT

A COMPENDIUM OF PAPERS

SUBMITTED TO THE

SUBCOMMITTEE ON PRIORITIES AND ECONOMY IN GOVERNMENT

OF THE

JOINT ECONOMIC COMMITTEE
CONGRESS OF THE UNITED STATES

WITH THE ASSISTANCE OF THE

CONGRESSIONAL RESEARCH SERVICE

OF THE

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OCTOBER 29, 1976

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LETTERS OF TRANSMITTAL

OCTOBER 22, 1976.

To the Members of the Joint Economic Committee:

Transmitted herewith is a compendium of papers entitled "Priorities and Efficiency in Federal Research and Development," prepared for the Subcommittee on Priorities and Economy in Government and the Library of Congress by William D. Carey, Louis Fisher, Edwin Mansfield, Albert H. Rubenstein and Lester C. Thurow.

This compendium results from Senator William Proxmire's concern about the allocation of Federal funds for research and development and the way those funds are spent. In view of the large annual outlays in this area, the Subcommittee saw a need to obtain independent reviews by outside experts of the procedures followed by the executive and legislative branches, and assessments of the quality of information available, in the determination of research and development priorities, policies, programs and project support levels.

As the studies concern ways to improve research and development allocation decisions and enhance the beneficial effects of research and development on the economy, I believe the Members of the Joint Economic Committee will find them most useful.

The responsibility for planning, coordinating and editing the studies was carried out by Richard F. Kaufman, General Counsel of the Committee, Susan Doscher Underwood of the Library of Congress, and Larry Yuspeh of the Committee staff. The assistance of Walter Hahn of the Library of Congress and Ellen Crosby of the Committee staff is gratefully acknowledged.

The views expressed in the study are those of the authors and do not necessarily represent the views of the Members of the Joint Economic Committee.

HUBERT H. HUMPHREY,
Chairman, Joint Economic Committee.

OCTOBER 18, 1976.

Hon. HUBERT H. HUMPHREY,
Chairman, Joint Economic Committee,
U.S. Congress, Washington, D.C.

DEAR MR. CHAIRMAN: Transmitted herewith is a compendium entitled "Priorities and Efficiency in Federal Research and Development." The compendium consists of five studies authored by William D. Carey, Louis Fisher, Edwin Mansfield, Albert H. Rubenstein, and Lester C. Thurow.

The Subcommittee on Priorities and Economy in Government has long been concerned with the way Federal funds for research and

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sector, we regard all privately owned firms and nonprofit organizations as belonging to the private sector. However, we recognize that some such firms and organizations do a heavy volume of business with the government and are so closely linked with government agencies that the distinction between the private sector and the public sector can be somewhat blurred.

2. Federal Contracts and Grants for Research and Development

To begin with, we must look briefly at the present extent and pattern of Federal support of R. & D. activities in the private sector. An important part of this support is encompassed by Federal contracts and grants for research and development. As shown in table 1, total expenditures in the United States for R. & D. were about $32 billion in 1974, of which about $17 billion were financed by the Federal Government. Thus, about 53 percent of our Nation's R. & D. expenditures were financed by the Federal Government in 1974, and much of this federally financed R. & D. was carried out by the private sector. As shown in table 1, government laboratories carried out only about 30 percent of federally financed R. & D. About 50 percent of federally financed R. & D. was carried out by industry.

Federal R. & D. expenditures are concentrated heavily in a relatively few areas. In 1972, as shown in table 2, almost $9 billion was spent on defense R. & D., and almost $3 billion was spent on space R. & D. Health R. & D. accounted for about $1.4 billion, and energy R. & D. accounted for about $0.4 billion. Other areas where significant amounts of federally financed R. & D. took place were environmental protection, transportation, agriculture, and education. A considerable amount was spent by the Federal Government on the general advancement of science and technology. Despite the fact that defense and space R. & D. were a smaller percentage of total federally financed R. & D. than they were a decade before, they still constituted about 70 percent of the total.

The extent to which various Federal agencies perform R. & D. outside government laboratories differs considerably. As shown in table 3, the Department of Defense performs about one-fourth of its R. & D. in government laboratories; most of the remainder is performed by industrial firms. Similarly, NASA performs about one-quarter of its R. & D. in government laboratories; the rest is performed largely by industrial firms. On the other hand, the AEC (now ERDA) performed the bulk of its R. & D. in federally funded research and development centers (like Oak Ridge, Sandia, Brookhaven, and Los Alamos), some of which are administered by firms, some by universities. And other agencies, like the Department of Agriculture and the Department of Commerce, perform most of their R. & D. in their own laboratories.

There are also very substantial differences among industries in the extent to which the R. & D. that they perform is financed by the Federal Government. As shown in table 4, in 1973 the Federal Government financed about 80 percent of the R. & D. in the aircraft industry, about 50 percent of the R. & D. in the electrical equipment industry, and about 20 percent of the R. & D. in the instruments industries. These are the industries where the largest share of the R. & D. performance is federally financed. On the other hand, in the chemical,

TABLE 4.—FUNDS FOR RESEARCH AND DEVELOPMENT PERFORMANCE, BY INDUSTRY AND SOURCE, 1973

[In millions of dollars]

Industry	Industry financed	Federally financed	Total
Food and kindred products	268	2	270
Textiles and apparel	63	1	64
Lumber and furniture	(1)	(1)	55
Paper and allied products	197	1	198
Industrial chemicals	940	191	1,130
Drugs and medicines	(1)	(1)	618
Other chemicals	(1)	(1)	330
Petroleum refining and extraction	490	14	504
Rubber products	251	33	285
Stone, clay, and glass products	173	3	176
Primary metals	262	11	273
Fabricated metal products	255	12	267
Machinery	1,806	334	2,141
Electrical equipment and communication	2,678	2,652	5,330
Motor vehicles	2,035	402	2,437
Aircraft and missiles	1,090	3,961	5,051
Professional and scientific instruments	721	175	896

[1] Not separately available but included in total.

Source: Science Resources Studies Highlights, National Science Foundation, Dec. 4, 1974.

Turning from industry to the universities, it is also clear from table 1 that our Nation's colleges and universities are heavily dependent upon the Federal Government for R. & D. funds. About three-fourths of the R. & D. carried out by the colleges and universities is financed by the Federal Government. The leading source of these funds is the Department of Health, Education, and Welfare. Table 5 shows the 40 universities that received the most Federal obligations for R. & D. in 1973, and the amount each received. As would be expected, the leading research-oriented universities, such as MIT, Harvard, Berkeley, Michigan, and Stanford, tend to rank among the highest. In 1973, the 100 universities and colleges at the top of this list received about 85 percent of the total Federal obligations to colleges and universities. Since the mid-1960's, there has been some pressure to allocate such funds more evenly.

3. Federal R. & D. Contracts and Grants: Rationale and Incentives for Efficiency

Given that Federal R. & D. contracts and grants to the private sector amount to over $12 billion per year, it obviously is important that we consider the reasons why support of this kind is in the public interest. The rationale for such support varies from one area of support to another. Many of the areas characterized by relatively large amounts of federally financed R. & D. are intended to provide new or improved technology for public sector functions. National security and space exploration, for example, are public goods—goods where it is inefficient (and often impossible) to deny their benefits to a citizen who is unwilling to pay the price. For such goods, the Government is the sole or principal purchaser of the equipment used to produce them; and since it has the primary responsibility for their production, it must also take primary responsibility for the promotion of technological change in relevant areas. Even though much of the R. & D. of this type is performed by the private sector, it is important to note that the primary objective of this R. & D. is not to promote technological

because the results of such research are unpredictable and usually of little direct value to the firm supporting the research, although potentially of great value to society as a whole. In other words, basic scientific information has many of the characteristics of a public good.[6]

Incentives for efficiency

We shall return to the question of the rationale for Federal support of R. & D. in the private sector; but for now, we turn our attention to the incentives for efficiency and cost reduction in federally financed R. & D. In a free enterprise economy, there are important incentives for efficiency, one of the most important being that a firm can increase its profits (or reduce its losses) by reducing its costs. In other words, since firms under normal market conditions use fixed price contracts, increased efficiency means increased profit. Unfortunately, such incentives, which are so important in most areas of the economy, cannot be transferred at all easily to research and development, because R. & D. is so risky that fixed price contracts are generally not feasible. It is very difficult to establish a contract whereby the contractor agrees to obtain a certain quantum of information or to develop a certain product or process for a fixed price, because it is so difficult for the contractor to estimate how much it will cost to achieve this result. Thus, many government contracts for research and development are basically geared to reimburse the contractor for whatever his costs turn out to be (within reason) to achieve the desired result. As is well known, these costs often tend to be much higher than are initially estimated. Alternatively, for some types of R. & D., a certain contract amount is stipulated, and the contractor is expected to achieve as much as he can with that amount. In either case, the incentives for reducing costs undoubtedly are less than they would be if a fixed price contract of the ordinary sort were feasible.

However, this does not mean that there are no incentives for efficiency. In particular, if the award of new contracts is known to depend, at least in considerable part, on past performance, this can be a very important incentive. But for this incentive to operate, at least two conditions must be met. First, the contracting government agency must be in a position to judge the contractor's performance reasonably well. Clearly, this is not as easy as it may seem, since apparent failure may be due as much to luck as to lack of skill, and since the product of a research project may be difficult even for leading experts to evaluate. Second, there must be a reasonable amount of competition among potential contractors. If the Government allows itself to get locked in to particular contractors, this incentive cannot operate at all well. Based on the studies at RAND,[7] by Peck and Scherer,[8] and by others, the problem of creating adequate incentives for efficiency in government funded R. & D. carried out in the private sector is very real and very difficult to solve in anything other than a very approximate way. Certainly, however, the Government should make sure that reasonably objective and unbiased judgments are made of contractor and grantee performance and that competition is en-

[6] See Arrow [1] and Nelson [43].
[7] For example, see Klein [22] and Marschak, Glennan, and Summers [32].
[8] See [52].

considerations, we know very little about the effects of various kinds of regulation on R. & D. in the private sector. This is unfortunate since about 10 percent of the Nation's gross national product arises from the regulated industries, and since regulation has effects throughout the economy.[12]

Antitrust

Our Nation's antitrust policies seem to have important effects on research and innovation in the private sector. Although the evidence is limited, it appears that relatively strong competition tends to promote research and development, so long as firms are above some threshold size. Since it appears that new entrants are often significant sources of innovation, it seems important to eliminate unnecessary barriers to entry. However, the effects of antitrust policy are certainly not unmixed. For one thing, antitrust policies may cut the incentive of the dominant firm (or firms) in an industry to generate relatively rapid technical advance. Also, the fact that antitrust policy is at odds with the patent system may in some cases reduce the incentives for R and D in some industries.[13]

Technology Transfer

The Government currently invests in a number of activities to transfer the results of government R. & D. to the private sector. To the extent that these activities are effective, they are likely to encourage private R. & D. Perhaps the best known of these activities is NASA's technology utilization program. This program has included a number of research institutes and universities. For example, the Midwest Research Institute and the Aerospace Research Applications Center at Indiana University have received information concerning technological developments in the space program, and disseminated them to private industry. The success and effectiveness of this dissemination program, and others of a similar type, are difficult to measure.

Education

The Federal Government's policies to support education (in science and technology, and other fields as well) also encourage R. & D. in the private sector. Clearly, the extent of private R. & D. is determined in part by the quantity and quality of scientific and engineering talent available in the society. Further, better educated managers and workers seem to be better able to utilize research results, and more inclined to invest in R. & D. The links between education, science, and technology are important, and the Federal Government's attempts to strengthen education certainly have helped to support R. & D. in the private sector.[14]

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[12] See Capron [5], Mogee [37], and Noll [46].
[13] See Scherer [56], Markham [31], and Noll [46].
[14] See Mansfield [30] and references cited there.

While the preceding arguments have a considerable amount of force, they by no means prove that there is presently an under investment in civilian technology. For one thing, these arguments generally are based on the supposition that markets are perfectly competitive, whereas in fact many important markets are oligopolistic. In oligopolistic markets, many economists believe that firms often stress product improvement as a form of rivalry, rather than direct price competition. Because of tacit agreement among the firms, this may be the principal form of rivalry, with the result that more may be spent on research and development than is socially optimal. One industry in which this is sometimes claimed to be true is the ethical drug industry. This is not, however, a proposition that is easy to prove or disprove.

Despite the arguments listed above, another reason why there may be no under investment in various forms of civilian technology is that the government is already intervening in a large number of ways to support civilian technology. For example, as we saw in section 4, there are already some general tax incentives that encourage R. & D. Beyond this, in particular industries like aircraft, there are a host of government influences promoting R. & D. and technological change. For example, the Government has paid for R. & D. related to aircraft. It has increased the demand for new airplanes by providing subsidies to the airlines and by regulating the airlines in such a way as to discourage price competition. Of course, the aircraft industry is hardly typical in this regard, but, as we have seen, there is considerable government support for R. & D. of various kinds in the private sector, and it is not obvious, on *a priori* grounds, that the Government has not already offset whatever latent under investment in R. & D. that was present in particular parts of the economy.[16]

Going a step further, some economists have argued that, even in the absence of oligopoly or government intervention, a private enterprise economy might not under invest in R. & D. For example, it has been pointed out that the inventor might be in a position to predict and thus speculate on price changes resulting from the release of his new technology. In principle at least, this might offset the fact that he could not appropriate all of the benefits directly. But it is important to recognize how difficult it is to foretell what price changes will be, particularly since there are many factors other than the technology to be considered.[17]

In sum, there are several important factors, related to the inappropriability, uncertainty, and indivisibility of R. & D. that seem likely to push toward an under investment in R. & D. by the private sector. But these factors may be offset, partially or fully, by oligopolistic emphasis on nonprice competition, by existing government intervention, or by other considerations. Thus, on *a priori* grounds, it is impossible to say with any reasonable degree of certainty whether there is an under investment in R. & D. in particular parts of the private sector.

[16] See Enos [8].
[17] See Hirshleifer [10].

One of the first studies to use this approach was Griliches's study of hybrid corn.[19] Based on data concerning the increase in yields resulting from hybrid corn, the value of corn output each year, and the price elasticity of demand for corn, he could estimate the area corresponding to ABCE in figure 1 each year. Then using data concerning the amount spent each year on hybrid corn research, he could estimate the rate of return from the investment in hybrid corn research, which turned out to be 37 percent. Clearly, a 37 percent rate of return is high. However, in evaluating this result, it is important to bear in mind, that this is the rate of return from an investment which was known in advance to have been very successful. Thus, it is not surprising that it is high.

Another study, based on much the same principles, was carried out by Peterson[20] to estimate the rate of return from poultry research. This study, unlike the previous one, looked at the rate of return from all research in this particular area, successful or not. In other words, it included the failures with the sucesses. The resulting rate of return was 18 percent, which again is a rather high figure. However, as would be expected, this figure is lower than that for hybrid corn. A further study, by Schmitz and Seckler, used basically the same kind of techniques to estimate the social rate of return from the investment in R. & D. pertaining to the tomato harvester. The result depends on how long workers displaced by the tomato harvester remained unemployed, but the authors report that, even if the tomato workers received compensation of $2 to $4 million per year for lost jobs, the net social rate of return from the harvester would still have far exceeded 100 percent.[21]

It is important to recognize that all of the rates of return cited so far are average rates of return. That is, they are the average rate of return from all of the amounts spent on the relevant R. & D. For many purposes, a more interesting measure is the marginal rate of return, which is the rate of return from an additional dollar spent. This is the measure that is most relevant in determining whether there is an under investment in civilian technology. If the marginal rate of return from investment in civilian technology is higher than the marginal rate of return from using the extra resources in other ways, more resources should be devoted to civilian technology. Thus, a very high marginal rate of return from investments in civilian technology is a signal of an under investment in civilian R. & D.

Using econometric techniques, a number of studies have estimated the marginal rate of return from agricultural R. & D. One study, by Grilichcs,[22] investigated the relationship in various years between output per farm in a state and the amount of land, labor, fertilizer, and machinery per farm, as well as average education and expenditures on research and extension in a State. The results indicate that, holding other inputs constant, output was related in a statistically significant way to the amount spent on research and extension. Assuming a 6-year lag between research input and its returns, these results indicate a marginal rate of return from agricultural R. & D. of 53

[19] See Griliches [14].
[20] See Peterson [53].
[21] See Schmitz and Seckler [57]. Since the concept of rate of return varies somewhat from study to study, the results are not always entirely comparable.
[22] See Griliches [15].

computed the average rate of return from this firm's total investment in innovative activities during 1960–72, the result being 19 percent, which is not too different from the median private rate of return given in the previous paragraph. Also, we computed lower bounds for the social rate of return from the firm's investment, and found that they were about double its private rate of return, which also agrees with the results in the previous paragraph.

The foregoing results pertain to the average rate of return. In earlier investigations based on econometric estimation of production functions, Mansfield [27] and Minasian [28] estimated the marginal rate of return from R. & D. in the chemical and petroleum industries. Mansfield's results indicated that the marginal rate of return was about 40 percent or more in the petroleum industry, and about 30 percent in the chemical industry if technical change was capital embodied (but much less if it was disembodied). Minasian's results indicated about a 50 percent marginal rate of return on investment in R. & D. in the chemical industry.

In a more recent study, Terleckyj [29] has used econometric techniques to analyze the effects of R. & D. expenditures on productivity change in 33 manufacturing and nonmanufacturing industries during 1948–66. In manufacturing, the results seem to indicate about a 30 percent rate of return from an industry's R. & D. based only on the effects of an industry's R. & D. on its own productivity. In addition, his findings show a very substantial effect of an industry's R. & D. on productivity growth in other industries, resulting in a social rate of return greatly exceeding that of 30 percent. No evidence was found, however, demonstrating that government contract R. & D. has any effect on the productivity increase of the industries performing it.

Griliches [30] has carried out an econometric study, based on data for almost 900 firms, to estimate the rate of return from R. & D. in manufacturing. His results pertain only to the private, not the social, rate of return. He finds that the private rate of return is about 17 percent. It is much higher than this in chemicals and petroleum, and much lower than this in aircraft and electrical equipment. He finds that the returns from R. & D. seem to be lower in industries where much R. & D. is federally financed.

Based on computations for the economy as a whole, Denison concluded that the rate of return from R. & D. was about the same as the rate of return from investment in capital goods. His estimate of the returns from R. & D. was lower than the estimates of other investigators, perhaps due to his assumptions regarding lags.[31] In his presidential address to the American Economic Association, Fellner [32] estimated the average social rate of return from technological-progress activities, his conclusion being that it is "substantially in excess" of 13 or 18 percent, depending on the cost base, and that this is much higher than the marginal rate of return from physical investment at a more or less given level of knowledge.

To sum up, practically all of the studies carried out to date indicate that the average social rate of return from industrial R. & D. tends to

[27] See Mansfield [24].
[28] See Minasian [35].
[29] See Terleckyj [59].
[30] See Griliches [16].
[31] See Denison [7].
[32] See Fellner [11].

disciplinary areas among several laboratories normally devoted to basic research. There have been "concerted actions," which establish committees to support research in fields like molecular biology and applied mechanics. There has been an "aid to pre-development" program, designed to help cooperative research organizations to development work on new technologies. There has been an "aid to development" program, providing loans (which may be forgiven) to cover development costs incurred by private firms.

Additionally, there are a variety of tax incentives. All of the operating expenses in research and development are fully deductible costs of doing business. Investments in buildings for R. & D. can be written off by 50 percent in the 1st year, the rest being depreciated over the structure's normal life. Firms that combine their R. & D. resources into a new organization can benefit from a tax deduction on their investment in the new organization. And to promote industrial funding of research institutions, there is a 50 percent depreciation rate for shares taken in public or private R. & D. institutions, deductions of payments to R. & D. institutions from profits taxes (up to 3 percent of the firm's turnover), and exemption of taxes on legacies to approved R. & D. institutions.[84]

In industries like electronics, French policy seems to have been to maintain at least one domestic supplier of each politically significant technology. In the eyes of many observers, this policy has had important drawbacks. According to Zysman:

> The dilemma has been that the protection and support required to produce specific products of interest to the state may, in fact, have weakened the firms that must be the long-term instruments of state policy . . . Before the reality of technological independence, strong and innovative firms, can be realized, the symbol of particular goods produced by subsidized but feeble national companies may have to be abandoned.[85]

Japan

There has been a well-known Japanese emphasis on the importation of technology. The Japanese Government has played a very important role in determining which technologies should be purchased from abroad, and which firms should receive them. Besides relying heavily on foreign technology, Japan has spent significant amounts on R. & D. As shown in table 7, Japan's R. & D. expenditures, as a percent of gross national product, have been lower than in the United States, United Kingdom, West Germany, or France. But if one looks only at nonmilitary R. & D., the gap between Japan's R. & D. expenditures, as a percent of gross national product, and that of the other countries is narrowed considerably. This, of course, is due to the fact that Japan spends very little on defense.

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[84] See Hollomon and Associates [20].
[85] Zysman [63].

preciation for the building of R. & D. facilities and for startup expenses of research associations, and a partial tax exemption of receipts from foreign sale of technology.

Most observers seem to give high marks to Japan's programs in support of civilian technology. But it is difficult, particularly for outsiders, to characterize in a precise or detailed way the nature of some of these programs, since the Ministry of International Trade and Industry (MITI) has relied on informal guidance and intervention, as well as on formal controls, to influence the import of technology and the direction of civilian technology. However, one noteworthy feature of these programs is that they tended to view R. & D. as merely a part of the entire process of technological innovation, and that technological development has been viewed simultaneously with such other parts of the innovation process as investment, markets, and labor.[35a] These views coincide with the emphasis in many recent studies of the innovation process.

9. Advantages and Disadvantages of Various Mechanisms for Federal Support

As stressed in sections 5–7, existing evidence is too weak to indicate with any degree of certainty whether there is an underinvestment in civilian R. & D. of various sorts. All that can be said is that practically all of the studies carried out to date conclude that the average and marginal social rate of return from R. & D. have tended to be very high. Nonetheless, most economists who have studied the question[36] seem to feel, on the basis of the existing evidence, that it is likely that some underinvestment of this sort exists. If so, it is important to consider the various means by which Federal support for civilian R. & D. might be increased. In this section, we discuss the major advantages and disadvantages associated with each of a number of mechanisms for Federal support of private sector R. & D.

First, consider tax incentives for privately financed R. & D. Perhaps the most important advantages of this mechanism are that it involves less direct Government control than some of the other techniques, and that it would be relatively easy to administer. Its most important disadvantages are that it would reward firms for doing R. & D. that they would have done anyhow, that it would not help firms that have no profits, and that it would be likely to encourage the same kind of R. & D. that is already being done (rather than the more radical and risky work where the shortfall, if it exists, is likely to be greatest). Furthermore, according to estimates made by former Secretary Peterson of the Department of Commerce, a 25 percent tax credit for R. & D. would mean that the Treasury would lose about $2–3 billion annually.[37] Also, any program of this sort might run into difficulties in defining R. & D., since firms would have an incentive to use as wide a definition as possible. More will be said about tax credits in section 11.

Second, consider Federal contracts and grants in support of civilian technology. This, of course, is the route taken by the Department of Defense and the National Aeronautics and Space Administration in

[35a] See Peck [51], Oshima [48], and Gilpin [13].
[36] See the papers in [41], Nelson, Peck, and Kalachek [45], Arrow [1], and Capron [4].
[37] See Weidenbaum [62].

of goods and services are very substantial. The Federal Government could encourage innovation by using performance criteria, which specify the desired end result without limiting the design to existing products, rather than product specifications. Proponents of performance-based Federal procurement argue that it will free industry to innovate (limited only by the requirement that it perform certain specified functions), encourage cost reduction for the Government, and encourage the Government to serve as a pilot customer for technical innovations in areas where it represents a big enough market or a market sufficiently free from local restrictions or codes to make it worth industry's while to innovate. The disadvantages of this mechanism are that performance criteria may be expensive to develop and administer, and that the procurement process may be made less efficient by adding innovation to the list of socioeconomic objectives that already influence this process.[42] Another suggestion is that the Government could make greater use of life cycle costs in purchasing decisions.

TABLE 8.—*Government sales as a percent of total sales, 1967*

Product line	*Percent sold to Federal Government*
Food and kindred products	1.86
Tobacco manufactures	3.53
Textile mill products	1.13
Lumber and wood products	0.96
Furniture and fixtures	1.99
Paper and allied products	0.82
Chemicals and allied products	1.53
Petroleum and coal products	1.45
Rubber and miscellaneous plastics products	2.57
Leather and leather goods	4.19
Stone, clay, and glass products	0.83
Primary metal industries	1.08
Fabricated metal products	3.20
Machinery except electrical	3.39
Electrical machinery and supplies	14.05
Transportation equipment	28.01
Instruments	11.05
Miscellaneous manufacturing	1.97
Wholesale trade	1.60

Source: Study Group 13A on Commercial Products, *Final Report to the Commission on Government Procurement*, Washington, February 1972, p. 42.

Sixth, the Federal Government could use its regulatory policies to try to encourage R. & D. in the private sector. According to some observers, some (but by no means all) of the Federal regulatory agencies have, through their policies and procedures, tended to restrain or distort technological innovation in the industries they regulate.[43] Because so little is known about the effects of regulation on technological change, it is hard to specify exactly what changes might be effective (and cost-effective). Among the suggested alternatives are that technology advisers be located in the regulatory agencies, and that a technology impact statement be appended to all major regulatory decisions. Based on existing knowledge, it is hard to say whether such actions would be worthwhile.[44]

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[42] See Davenny [6] and Weidenbaum [62].
[43] For example, former President Nixon, in his 1972 message on science and technology, cited excessive regulation as a barrier to innovation in the United States.
[44] See Mogee [37] and Eads [8].

The National Science Foundation's Experimental Research and Development Incentives Program

This includes a number of experimental programs. Among other things, it has made federal laboratories available for performance validation in cases where an entrepreneur obtains a conditional commitment to buy from a public jurisdiction, it has made university research capabilities available to several industrial sectors not currently doing much R. & D. it has established interdisciplinary training and community clinics at several universities for the development of entrepreneurial talent and the planning of innovations, it has experimented with the use of a structured national system to deliver technical services to small and medium sized cities through the use of a technology agent, and it has established a training program and organized procedure for obtaining clinical validation of new medical equipment.

Like the other programs discussed in this section, too little time has elapsed to be able to say much concerning the nature of the results. However, one thing that this program has demonstrated is the difficulty of establishing experiments that are feasible and susceptible to precise evaluation. To formulate an experiment that can shed unambiguous light on any of the relevant questions is not as easy as it may seem. To do this, and at the same time remain within the bounds of political and economic feasibility, is harder still. Nonetheless, it is to be hoped that, when they become available, the results will clarify a number of the issues considered in this report.

The National Bureau of Standards' Experimental Technology Incentives Program

This experimental program was started in 1972, but for various reasons it was not until September 1973 that a full-time director was present, and operating funds were not available until February 1974. This program has focused its attention largely on federal procurement and regulation. In the area of federal procurement, it is working with the Federal Supply Service to introduce life cycle costing and value incentive clauses in the procurement of power mowers, air conditioners, hot water heaters, and a variety of other products. Also, it is working with the Public Building Service in the development of a life cycle costing methodology for use in planning and acquiring federal space, and with the Veterans Administration and the state and local governments in experiments involving performance specifications and other procurement changes. In the area of federal regulation, it is working with the Nuclear Regulatory Commission to see whether the formulation of standards can be expedited, with the Environmental Protection Agency to see whether it is possible to reduce the high costs of complying with regulations concerning the development of pesticides, with the Federal Power Commission and the Occupational Safety and Health Administration to experiment with the use of computers and modern information handling technology, and with the Federal Rail Commission and Food and Drug Administration on other problems. Finally, it is also engaged in some studies of civilian R. & D. and of ways to encourage innovation by small business.

According to the program officials, the results to date are encouraging. For example, they estimate that the use of life cycle cost

increases in R. & D. spending would be less objectionable on these grounds, but it too is frequently regarded as inefficient because it is not sufficiently selective. To get the most impact from a certain level of Federal support, it seems to be generally agreed that a more selective technique would be desirable.

However, to utilize more selective techniques, some way must be found to determine where the social payoff from additional federal support is greatest (or at least relatively high). The way that most economists would approach this problem is to use some form of benefit-cost analysis to evaluate the pay-off from additional Federal support of various kinds of R. & D. Unfortunately, although such methods are of some use, they are not able to provide very dependable guidance as to how additional Federal support for civilian technology should be allocated, due in large part to the fact that the benefits and costs from various kinds of R. & D. are very hard to forecast. As the Department of Defense knows so well, it is difficult indeed to forecast R. & D. costs. And even major corporations have difficulty in using various forms of benefit-cost analysis for R. & D. project selection, even though they have a much easier benefit concept to estimate than most Government agencies do.

Thus, the choice between the general and more selective forms of support is not as simple as it may seem at first. And when one recognizes that the estimates constructed to guide the selective forms of support may be biased for parochial, selfish, or political reasons, the choice becomes even more difficult. As Eads [46] has pointed out, the organizations and individuals that benefit from, or have a positive interest in, a certain R. & D. program may inflate the benefits estimate by claiming various "secondary" or "external" benefits that in fact are spurious or at least exaggerated. Given that it is so hard to estimate with reasonable accuracy the true social benefits of various R. & D. programs, the result could be a distortion of social priorities, if the estimates are taken seriously. And if they are not taken seriously, it would be difficult to prove them wrong.

Another consideration also bears on this choice. As noted in section 7, some studies have concluded that an industry's R. & D. expenditures have a significant effect on its rate of productivity increase, but that the amount of federally financed R. & D. performed by an industry seems to have little or no such effect. In part, this may be due to the possibility that output measures in industries like aircraft are not reliable measures of social value. But it may also be due to a difference in the effectiveness of federally financed and privately financed R. & D. At present, there is no way to tell how much of the observed difference is due to the latter effect; but if it turns out to be substantial, this would seem to favor tax credits rather than increased Federal contracts and grants.[47]

To sum up, although selective forms of support have obvious advantages (where they are at all appropriate), it would seem that they might well be supplemented with more general forms of support. Tax credits for increases in R. & D. spending are less objectionable than a tax credit for R. & D. spending. Although there are problems in de-

[46] See Eads [3].
[47] For an argument favoring the use of tax credits for increments in R. & D. expenditures, see Boretsky [3].

stead, the available evidence seems to indicate that, when governments become involved in what is essentially commercial development, they are not very successful at it.[50]

Fourth, in any selective government program to increase support for civilian technology, it is vitally important that a proper coupling occur between technology and the market. Recent studies of industrial innovations point repeatedly to the key importance of this coupling. In choosing areas and projects for support, the government should be sensitive to market demand. To the extent that it is feasible, potential users of new technology should play a role in project selection. Information transfer and communication between the generators of new technology and the potential users of new technology are essential if new technology is to be successfully applied. As evidence of their importance, studies show that a sound coupling of technology and marketing is one of the characteristics that is most significant in distinguishing firms that are relatively successful innovators from those that are relatively unsuccessful innovators.[51]

Fifth, in formulating any such program, it is important to recognize the advantages of pluralism and decentralized decisionmaking. If the experience of the last 25 years in defense R. & D. and elsewhere has taught us anything, it has taught us how difficult it is to plan technological development. Technological change, particularly of a major or radical sort, is marked by great uncertainty. It is difficult to predict which of a number of alternative projects will turn out best. Very important concepts and ideas come from unexpected sources. It would be a mistake for a program of this sort to rely too heavily on centralized planning. Moreover, it would be a mistake if the government attempted to carry out work that private industry can do better or more efficiently.

13. Technological Change and Antitrust Policy

Besides the considerations discussed in previous sections, it is important to point out that our general economic policies may have a notable impact on R. & D. and technological change in the private sector. Like other economic variables, the rate of technological change is influenced by the general economic climate or environment, which in turn is influenced by our general economic policies. Thus, our policies regarding market structure, competition, unemployment, inflation, foreign trade, and a host of other economic matters are important in this regard. In this section of this paper, we take up the effects of one aspect of our general economic policy, namely, our antitrust policies.

There has been a considerable amount written by economists concerning the effects of market structure and antitrust policy on the rate of technological change. Although we are far from having final or complete answers, the following generalizations seem warranted, based on the available evidence.

First, the role of the small firm is very important at the stage of invention and the initial, relatively inexpensive stages of R. & D. Studies by Jewkes, Sawers, and Stillerman, Hamberg, Mueller, and

[50] See Eads and Nelson [9]. Pavitt [49] reports that, according to a recent study by Gardner, the British government since the Second World War has recovered less than one-tenth of its outlays on launching aid for aircraft and aircraft engines.

[51] See Freeman [12], Mansfield, Rapoport, Schnee, Wagner, and Hamburger [28], and Mansfield, Rapoport, Romeo, Villani, Wagner and Husic [29].

plementarities or interdependencies exist among firms of various sizes. There is often a division of labor, smaller firms focusing on areas requiring sophistication and flexibility and catering to specialized needs, bigger firms focusing on areas requiring larger production, marketing, or technological resources.

To sum up, the available evidence does not indicate that we must permit very great concentration of American industry in order to achieve rapid technological change and the rapid adoption of new techniques. Instead, it seems to suggest that public policy should try to eliminate unnecessary barriers to entry and to promote competition in American industry. At the same time, it is worth noting that the effects of the antitrust laws are not unmixed. For example, the antitrust laws may reduce the incentives of the dominant firm (or firms) in an industry to innovate.

14. Summary and Conclusions

In conclusion, the federal government supports R. & D. in the private sector in a variety of ways. In 1974, the federal government financed about $8 billion of R. & D. carried out by firms, about $3 billion of R. & D. carried out by colleges and universities, and about $1 billion of R. & D. carried out by other nonprofit organizations. (Of course, some recipients, such as State universities, are not in the private sector.) Much of the R. & D. performed by the private sector for the federal government is directed toward technological change in public goods like defense and space exploration, not toward private-sector problems. The rationale for federally financed R. & D. directed at private sector problems is generally that the private costs and benefits from R. & D. do not adequately reflect the social costs and benefits. Besides its contracts and grants, the federal government also supports and encourages private-sector R. & D. through the patent laws, the tax laws, some aspects of regulation, the antitrust laws, federal programs to transfer technology, and its educational policies. There is no way to put an accurate dollar figure on the amount of support from these activities.

Due to the inappropriability, uncertainty, and indivisibility of R. & D., an under-investment in R. & D. may occur in the private sector. But this may be offset, partially or fully, by oligopolistic emphasis on nonprice competition, by existing government intervention, or by other considerations. Based on simple models, economists have attempted to estimate social rates of return from various kinds of investments in R. & D. and technological innovation, both in agriculture and industry. The results seem to suggest that both the marginal and average social rates of return have been very high, and many economists have interpreted these results as evidence of a possible under-investment in R. & D. However, these estimates suffer from many important limitations, and should be viewed with caution.

There are a variety of ways that the government might stimulate additional R. & D. in the private sector—tax credits, R. & D. contracts and grants, expanded work in government laboratories, loan insurance for innovation, purchasing policies with greater emphasis on performance criteria and life cycle costing, altered regulatory policies, and prizes. An important problem with a general tax credit is its in-

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APPENDIX X

"INNOVATION AND ENTREPRENEURS—AN ENDANGERED SPECIES?" PANEL COMPOSED OF RALPH LANDAU, RICHARD S. MORSE, AND KENNETH H. OLSEN, IN CONNECTION WITH THE THIRTEENTH ANNUAL MEETING, NATIONAL ACADEMY OF ENGINEERING, NOVEMBER 10, 1977 (PUBLISHED FEBRUARY 1978)

Innovators and Entrepreneurs—An Endangered Species?

Presentations at the Technical Session
Thirteenth Annual Meeting
November 10, 1977

NATIONAL ACADEMY OF ENGINEERING
Washington, D.C.
February, 1978

vironment, encompassing the government and industrial sectors and probably the academic community, have changed to produce adverse effects on innovation and entrepreneurship. Three major factors influencing innovation—government R&D, new enterprise generation and the industrial environment—are discussed. In conclusion, Dr. Morse presents results of a broad survey on these subjects including the opinions of the principal executives and the directors of research of major US corporations, heads of selected small high-technology companies and venture capital organizations.

In the final paper, Dr. Olsen draws on his personal experience in the early days of computer development to provide a perspective on the current condition of the entrepreneurial spirit. His comments highlight the major points raised by Dr. Landau's detailed case history and Dr. Morse's general observations on the state of innovation and entrepreneurship. He concludes by recommending a positive attitude and encouragement for entrepreneurial investment as an important element in the economy of the United States.

The general discussion that followed the three presentations underscored the major current barriers to innovation and entrepreneurship highlighted by the speakers, including government taxes and regulations. However, other factors were cited as being of equal importance. These included productivity, technology transfer, labor and engineering education concerned with productivity and product development.

Lincoln Laboratory by the section which he headed. Mr. Olsen's public service has included appointments to the President's Science Advisory Committee, the Governor of Massachusetts' Management Task Force and the National Academy of Sciences Computer Science and Engineering Board. He is also a member of the MIT Corporation and a director of several other organizations.

Entrepreneurship in the Chemical Industry and in the United States

RALPH LANDAU

Brief History of a Technological Enterprise— Halcon International, Inc.

There are many definitions of entrepreneurship, but I like Norman Macrae's description of what it is not as well as of what it is:[1]

> [My critics say that I] confuse originality and innovative talent with business judgment and the sensible assessment of risk; [they say] it is the latter two which in ordinary language are the skills of the entrepreneur. Oh no, they aren't. Those are the skills of the banker. The role of the entrepreneur (the 'man who undertakes') is that, having identified a market opportunity for widgets or for some particular service, he strives every day to find a better way (sometimes an innovative way, sometimes an organizational change) of producing more widgets or more units of that service more effectively. There is a grave danger when that role is . . . lost in the recesses of business bureaucracies.

The entrepreneur, in short, brings people, money, concepts, skills and markets together to create something that did not exist before, and is profitable; that is essentially our company's role from our inception as a systems, multinational, high-technology organization.

However, the concepts of "systems", "multi-national" and "high-technology" used to describe our company's early beginnings had not yet been invented in our day. They evolved from experience and the needs of the marketplace. No ideology or preconceived philosophy has led to the wide usage of these terms, since in other entrepreneurial companies, too, they were responses to market needs. And this is the hallmark of the entrepreneur—he listens to the market, and shapes his strategy accordingly. Following is a brief account of how we evolved, leaving out many of the setbacks, frustrations, failures and heartaches that are the lot of the entrepreneur!

portant chemical intermediate, widely used in resins, insecticides, etc. While this technology was not invented by us, radical improvement in the catalyst and the modernization of processing methods have led to the establishment of our widespread position in this product.

We had, a little earlier (1957), also formed a catalyst manufacturing company and entered the chemical plant construction field as well. The flow of royalties and other income thus building up permitted us to think once again about entering the chemical manufacturing business ourselves.

Our ticket of entry to manufacturing appeared when we invented a third piece of original chemistry (in 1962), the direct oxidation of propylene to propylene oxide, again in lieu of the older and universally employed chlorhydrin process, but by very different technology than that involved in ethylene oxide. This led to our reorganization to exploit it, by forming Halcon International, Inc. in 1963 (17 years after we started). Within three years, our changed mode of organization had successfully identified the best commercial opportunity for us, and led to the formation in 1966 of the Oxirane Group with the Atlantic Richfield Company. Thus, 20 years after our founding, we had created enough capital and technology to accomplish what we had hoped for since at least 1948, namely, the establishment of our own chemical manufacturing, without surrendering control of our enterprise to outside financial sources, via a 50:50 joint venture. Much has been written elsewhere of the extraordinary success of this effort in its first 11 years,[2] but once again I want to pay tribute to the imagination and innovative business skills of a great oil company, our partner, ARCO. These qualities are often difficult to sustain in large enterprises. At ARCO, the Chairman, Robert O. Anderson, is himself one of the leading entrepreneurs in the US, and this accounts significantly for ARCO's innovative spirit.

Since then our fourth major discovery has occurred (1968), in the form of our new high-yield direct ethylene glycol process, which has just started up at Oxirane. But we are also developing our fifth, sixth and seventh pieces of original technology, which we believe offer us opportunities for further diversification. We recently announced the organization of Halcon Chemical Company to focus the efforts of the Halcon Group on continuing to explore various forms of investment in our manufacturing. We are working on many aspects of the initial endeavors of this company, as well as other joint ventures (we have had one for several years in Brazil), and acquisitions, but we are confident that our original work to develop new processes for such products as vinyl acetate, methacrylic acid, methyl methacrylate, ethylene oxide, phenol, aniline and other important chemicals will lead to commercialization in a variety of forms in the future.

The foregoing brief account, it is hoped, will have some general meaning for others. I am not all that sure: we started at a particularly fluid moment

> Once a new company gets on its feet, it may need new capital for expansion, and since few enterprises can go public, many face the choice of either stagnating or selling out to large corporations. That limits competition in new fields.
>
> Whatever the obstacles, the most talented of the entrepreneurs will find ways to win. . . Because the best of the breed is good at clearing hurdles does not, of course, mean that the hurdles—such as burdensome regulations and punitive tax schedules—are good for society.

It is my purpose in this paper to add my own verification and amplification, based on direct experience, to Bylinsky's astute journalistic observations. Entrepreneurship is fragile, and requires, even more than big companies do, the creation of a climate that is uniquely favorable, for it to flourish.

Barriers to Innovation from Government

I have said in previous papers,[7] in chorus with many other businessmen, that there are excessive and unnecessary barriers to innovation imposed by governments, which barriers may be classified as regulatory, tax, inflation and uncertainty.

A. REGULATION

Society must have some regulation, and there always has been. For example, businessmen have never been allowed to shoot the competition's chief executive or burn down his building. Where a society concludes a particular minimum of social behavior is necessary in the marketplace, the rules must be binding on all so that no one competitor can have an unfair advantage. Thus, there exists a legitimate basis for regulations as to child labor, pollution, sales to potential enemies, unsafe factories, toxic or otherwise unsafe substances or products, and the like.

However, it is essential that regulation-makers come to understand that every regulation has its price and its practical limits—in the cost people pay for the goods and services produced, in competitive posture worldwide, in impact on jobs and in possibly stifling new investments that, if successful, can mean a better quality of life for our people. In other words, there are always tradeoffs and each must be carefully weighed, debated and decided. As the *National Review*[8] put it, "The [Federal Drug Administration's] saccharin ban crystallized a well-nigh universal anti-regulatory sentiment that had hitherto been confined to highbrow journals. . . Even *The New York*

programs for regulatory compliance seem a roundabout way to get at this problem, and in any event they do nothing to ease the nonpecuniary costs of regulation.

There just must be some way that the businessman (and those financing him) can have reasonable assurances in advance of investing thousands or more likely millions or billions in a product, process or plant, that he won't go broke after proceeding in good faith, because the rules of the game change in the sixth inning. The *speed* with which the ground rules have been changing in the last decade has had a great deal to do with the declining growth rate of the economy, which for private plant and equipment, excluding pollution control expenditures, was an average 4.3% per year in 1965-70, 3.3% in 1970-75, and may be expected to decline further to 2.5% per year in 1975-77.[11] Dr. Charles L. Schultze, now Chairman of the Council of Economic Advisers, has recently written a very interesting analysis of some of these problems,[12] and favors economic incentives over regulations wherever possible.

An entrepreneurial company often finds that premature "going public" soon alters its innovative attitudes, and the management, under SEC* and other external pressures, shifts to a short-term and less risky strategy, often to the detriment of its long-term growth and innovation. Privacy is a great help to boldness, but if boldness is to be sustained over longer periods of time, the investors must be confident that ultimately they will be rewarded by financial gains.[13] Here, tax considerations are playing a major role, and these are examined in greater detail below.

B. TAXES, CAPITAL FORMATION AND TECHNOLOGY

It is no secret that if the nation is to get the capital investment it so desperately needs, the tax laws have to be revised. We are faced presently with a sick situation, and Wall Street is sending us a message which is not capricious.[14] A 1975 US Treasury study showed that for 1960-1973 the US ranked last among the seven principal industrialized countries in business fixed investment as a percent of real gross domestic product, last in rate of percentage growth in productivity and next to last in percentage gain in output growth. It is the belief of the business community and many economists that investment has lagged because the real after-tax return on investment for non-financial corporations (adjusted for inflation) has declined from 7.3% in 1955, and 9.9% in 1965, to only about 4% in 1976.[15] This is the real message of Wall Street, according to Dr. Arthur Burns, for a long time Chairman of the Federal Reserve Board.[16]

*Securities and Exchange Commission.

investment to improve labor productivity, but even if the present inhibitions regarding capital formation are ameliorated, this effect is still low relative to the need. Most industries—such as steel, textile fibers, cement, housing, autos, wood products, etc.—are mature in the sense of requiring a lot of capital for even small increases in productivity, not to mention capacity. But the return on this capital under present conditions cannot be expected to induce risk-taking or indeed any new investment in most cases.

While not neglecting existing older industries, clearly what is most needed for the economy as a whole is a greatly increased capital investment in the *newer* industries, particularly those having a high technological component, with, if possible, a lead over other countries in the world. This happened after World War II, with the burgeoning of chemicals and pharmaceuticals, and the creation of new technological industries like computers, modern agriculture, instant reproduction, telecommunications, jet transport, transistors and silicone chip systems, electronics, nuclear systems, aerospace, fast foods, etc. These are now also approaching relative maturity, so that we need more new ideas and enterprises. Furthermore, it is well documented that big companies do not create such new technology as frequently, but generally tend to improvement of the old, although there are many advances which cost so much that only big companies can participate in such projects. Also, smaller companies tend to provide more employment; large companies, it is well known, can often expand by better usage of their existing employees. We need companies and industries with radical new ideas and technology, and the infusion of new technology even into the older industries such as steel, copper, aluminum, energy production and consumption, agriculture, airlines, etc. All of this takes a lot of encouragement in capital formation, and entrepreneurial growth. Government cannot do the job of the private sector, but it can create the climate which will be required.

Technology is also a key factor in improving the environmental and safety aspects of our society. In our industry, and indeed directly in our own discoveries, more efficient processes are also the ones that pollute the least and are the most energy-efficient, and as described above, some of these replaced toxic oxidants with either air or oxygen. Generally, it is the older industrial establishments which have the greatest environmental and energy problems and the solution to these (often a very costly one, as in steel) also requires more capital formation and higher technology. But here, also, we see the contradictory effects of different regulations and policies as inhibitors of progress. The current clean air "offset" requirements that "old pollution" be reduced before new plants can be built in the area means that "old polluters" have been granted a high value by the law, under a sort of grandfather clause, whereas the new, efficient, less polluting plants (such as those

Chairman of the Federal Reserve Board, Mr. G. William Miller, to *The New York Times* on January 8, 1978:

> Last January, I noted . . . that one of the best places to stimulate the economy is in capital spending, and I pointed out that one of the larger capital spending periods in our history came in the early 1960s, when capacity utilization was quite low. I argued that low capacity utilization was not necessarily a barrier to creating conditions that would stimulate capital spending. Our plant and equipment in this country is 'way out of date in comparison with some other leading nations . . . I still feel the same today. One of the soundest approaches to continued expansion and job creation, which would not generate inflation, would be to create those kinds of conditions that would encourage business enterprises to expand their capital spending.

In this succinct statement he refutes effectively the arguments of some academic economists (like Lester Thurow in *The Economist* of December 24, 1977) who forget the role of technology and international competition, and believe our existing idle capacity requires no urgency of capital formation. Nevertheless, it is important that businessmen and economists learn from one another, and engage in more such extensive investigation of the realities of our technological age and of our free enterprise society.

My experience and observations, as summarized in this paper, clearly support Mr. Miller's thesis. Efforts at equity for those able to work should be largely concentrated on structural problems for the next 10 years, such as on the hard-core unemployment situation, remedial education and assistance in labor adjustment and retraining of displaced workers, without major new general spending programs. The reward system all the way up the ladder must be intensified. And the growth in government spending (which has contributed to the decline in productivity growth as mentioned above) must be steadily but not suddenly reined in, not only to make possible the necessary tax reductions but also to remove the inflation effects of chronic budget deficits, while the productive private sector of the economy recovers its dynamism. A convincing comparison of the productivity of state employees in the UK and the US versus those in private enterprise was recently made in England.[25] Another such study which deals directly with this issue and the impact thereon of technology was also published recently in London.[26] In a review by *The Economist*[27] of this book, two very important points are made:

> . . . Mr. Harlow only skirts the most important question of all: if the growth in productivity depends on technical change rather than capital intensity,

even if the percentage of profits for R&D spending remains constant, the absolute amount will rise. With higher profitability, the fruits of R&D will be more quickly realized, and new investment in such technology will also become easier to justify.

It is certainly true that some of the new wealth that would be created by the tax relief measures I will propose might turn out to be employed in less useful investments than would be optimal, but this is an inevitable consequence of the alteration in economic climate. Old wealth tends to be conservative and non-risk-taking; new wealth tends to support new ventures, growth stocks of the riskier types and new technology investment. A healthy stock market would be a reflection of such underlying changes.

I am not a tax expert *per se*, although an expert in paying taxes! However, here are some ideas that make sense to me in implementing the foregoing considerations, based on my experience, and I think they at least deserve some serious debate:

a. We should stop applying the corporate income tax to profits that really aren't profits at all. For example, depreciation allowances usually don't generate enough cash flow even to replace existing facilities, let alone construct better ones. There are various ways of taking care of this matter—faster writeoffs, indexing depreciation schedules to inflation and others—but whatever the technique, that problem must be solved.
b. We have been hearing a lot about getting rid of double taxation of corporate profits through "integration", etc. This is a very complicated issue,[33] and there may be some real mine fields in how financial markets would actually respond. But, at the very least, it would make sense to reduce the corporate tax rate substantially while the whole integration idea is being thrashed out. After all, the lower that tax, the lower the doubling effect.
c. It should finally be recognized that there are legitimate reasons to tax long-term investment income differently from earnings realized every year. The patient risk should be rewarded, and at the very least, the fact that because of inflation the dollars received on sale of the investment won't buy as much as the dollars invested and reinvested over the years, should be taken into account. Maybe what we need is to get rid of the term "capital gains treatment", and substitute something like "AFRAI", meaning "Adjustment for Risk And Inflation". It is not too well known yet that the Revenue Acts of 1969 and 1976 have raised the capital gains tax maximum rate from 25% to over 49%, which applies to many transactions of this kind. Taking into account the patient risk, inflation and lack of yield before sale which an investor in a new or growing enterprise must face, this

held longer than five years. Obviously, other features of the economies of these countries may well provide countervailing negative influences—but there is no ideological or practical reason why the US cannot adopt good ideas from any source—and certainly these countries have concluded that lower capital gains taxation is beneficial. One reason may be their greater experience than we have had with inflation and higher personal income taxation brought about by social policy, which makes them more conscious of the patient investor's need for incentives to invest at all.

d. Next, let's get rid of the term "unearned income". I'll make no bones about it: I think anybody who saves and invests "earns" his income from those savings. If there is outrage that by investing in tax-free bonds for schools and housing projects for the poor, by charitable giving, by investing in dry holes, etc., a small number of wealthy people (for those with incomes over $30,000 in 1975—perhaps 19,000 out of, say, 82,000,000 individuals who file tax returns or 0.09% and some 61,000,000 who pay some tax!) end up paying no federal income taxes, then so be it. Impose some minimum income tax on them. But, let's not tax income from an investment differently from income from daily labors on some theory that investments are not as important as daily work; both are vital. Progressivity? Sure, but do it through the tax tables, not by pretending the yield on investments, whether interest, dividends, royalties or rents, deserves to be hit harder.

Yet, it should not take great imagination to visualize that a tax structure which taxes so-called "unearned" income the same as "earned" income but gives no tax advantage to "capital gains" as opposed to other kinds of income, will result in a total destruction of the riskier growth stocks (perhaps not of the IBM's which can be safely bought by institutions). It is obvious that investors confronted with these ground rules would gravitate strongly toward high-yield safe securities, mostly bonds or other debt instruments, and not stocks—particularly stocks of risky new technological enterprises. The incentives to take risks would simply evaporate, and that is why there is and would be a dearth of risk capital. The most important single point in all this is that, whether the government tax experts agree with this assessment or not, it is nevertheless what the investor will perceive, or be advised—and in Wall Street it is the perception that counts, not necessarily the underlying reality, as so many frustrated investors know to their sorrow. An example of only one among many market letters which are passing out such advice to the public is given in McGraw Hill's *Personal Finance Letter* (PFL) of September 5, 1977:

. . . What's more, Carter's new tax package, which might end the preferential tax treatment of long-term capital gains, would make bonds even more

all taxation coupled with a negative income tax, which would reduce much of the welfare and unemployment still unfortunately too widespread in this country.

C. INFLATION

Wall Street is now increasingly an institutionalized market because our tax structure in an inflationary era is inimical to individual investment in equities. As *Business Week*[39] put it:

> Before secular inflation took hold in the 1960s, the total return on stocks had averaged 9% a year over 40 years, and AAA bonds, while infinitely safer, had hardly ever paid more than 5%. Now, with secular inflation in the saddle, the situation is reversed. The annual total return on stocks over the last two market cycles averaged less than 1%. AAA utility bonds—still infinitely safer—yield more than 8%.
>
> Seeing the writing on the wall, in fact, individual investors have been bailing out of stocks and getting into safer securities. Even with a rally as strong as last year's, figures compiled by Merrill Lynch, Pierce, Fenner & Smith Inc. show that individuals continued to take their money out of the market. Since 1969 they have taken $79 billion in cash out of the stock market. Since 1973 more than 7 million individual shareholders have ceased to 'own a share of American business.' . . . Institutional investors, by contrast, have stayed with stocks. . .

Whereas years before, individuals accounted for about 70% of the trading in securities, financial institutional trading is now 54.7%,[40] and is growing at the expense of individuals, who were responsible for only 23.1% in 1976 (the remainder was by Wall Street member firms, not strictly speaking investors, trading for their own accounts); yet it is individuals who are most likely to take the risk in financing new entrepreneurial companies. Of the $230.4 billion of primary debt and equity issued in 1976, five out of every six invested dollars were institutional.[41] Institutions are not only bureaucratized, they are bound by ERISA rules and others to invest very cautiously. But the personal income of the individuals who used to be so active in the stock market continues to be taxed at highly graduated rates, and this, coupled with other factors such as those discussed in this paper, largely accounts for the foregoing shift in trading patterns. Thus, the Tax Foundation surveyed 1975 tax returns and found that the highest 10% of the taxpayers, earning $23,420 and over, paid nearly 50% of the total federal income tax bill to individuals. Five percent of the taxpayers, earning $29,272 and over (and it is this category which was most likely in the past to invest in riskier equities)

paid more than one-third of the revenue, while the lowest 50% of taxpayers accounted for only 7%, as an expert on capital formation for new ventures, Alvin Zises, pointed out in *The New York Times* of November 13, 1977. It is also interesting to note that whereas for all taxpayers the percent of adjusted gross income which was paid in taxes was slightly under 14%, this number rises rapidly until above $100,000/year adjusted gross income it becomes just under 40%, and in the higher brackets just under 50%, even with all the deductions and incentives the present tax code permits in order to increase our economic efficiency.

There is certainly a close relationship between the better entrepreneurial record of the US versus Western Europe and Japan, and the relatively better control we have had until recently over inflation. It's tough enough to face the uncertainty, the inherent risks, of new products, new processes, and new plants, even in the best of economic climates; today's is very far from ideal! But we must take further steps to ensure that the proper conditions for risk-taking will prevail in the future.

Inflation is now a major concern of the accounting profession, with unpredictable results. For example, the recent attention to unfunded pension liabilities will result in due course in further incentives to limit employment and declines in stock market values as investors realize the potentially large magnitudes of these liabilities. As a result of inflation, these are almost equal to corporate net worth in many cases, and may exceed market value of the stocks by several fold.[42] The burden of these liabilities has been placed on the shareholders by ERISA.

Inflation can only be solved by governmental action that creates a favorable climate for new investment to produce more and better goods and services and that gets rid of large government deficit financing as a way of life. Indeed, Ambassador Kingman Brewster, former President of Yale, puts it even more bluntly:[43] "The inflationary bias of representative government seems to be the greatest threat to the survival of a democratic political economy." So we are back to the other parts of this section, and the vital importance of encouraging capital formation in freedom. Again looking abroad, we find that while Britain makes it almost impossible to become rich out of income, West Germany allows people to become rich only to discourage them from using that money creatively to set up new companies.[44] In fact, the German equity market is largely dominated by a few large banks, a situation which is not permitted in the US. Herein lies the American opportunity!

D. UNCERTAINTY

Perhaps above all else, business (large and small, but particularly the entrepreneur) needs a higher degree of certainty by way of general economic and

attractive [emphasis in original]. Under the Carter tax proposals [then under consideration within the Administration],* capital appreciation in a stock, which historically accounts for a hefty chunk of an investor's total return, would be taxed at the same rate as interest income (PFL, August 22, 1977). That would kill much of the incentive to take risks in the stock market. Hence, investors will probably turn to bonds because they're not as risky as stocks and generally have a higher yield. And that's already the name of the game. The promise of future earnings increases or capital gains no longer carries much weight.

e. Stock options, *per se*, have for a long time ceased to have much incentive for most company employees and managers because of the unfavorable trends in capital gains and other taxation as well as the decline of the Wall Street markets generally. Recent trends to treat the appreciation in the stock as earned income have renewed interest in such arrangements, but the absence of a healthy equities market for the companies' stocks is still a serious obstacle. Yet, a new entrepreneurial company needs stock options, stock sales or the equivalent to attract able personnel in the absence of ability to pay high salaries, pensions and other perquisites.
f. We need to expand the provisions that allow ordinary loss if an investment goes sour. This is vital to the entrepreneur, and he needs special help.
g. And let's stop talking about "loopholes". One person's loophole is another person's "social incentive". Let's look at the host of these incentives on the books. If some have seen their day and are no longer needed to foster this or that economic or social goal, then let's get rid of them. But if they are needed—or indeed need enlarging—to meet current goals (and that includes more capital formation in the private sector and especially more help to the budding entrepreneur), then let's not be afraid to provide those "loopholes", those incentives that will get the job done. As *Barron's* points out,[38] the US government has steadily widened the greatest tax "loophole" of all, the personal exemption and the standard deduction, expanding thereby the number of those who pay no levy to Uncle Sam (now including the approximately 20,000,000 who file but pay no tax at all). This increases what *Barron's* also says has been called "representation without taxation"! Why should there not be, perhaps, some kind of a small minimum federal tax on all citizens, also, so that they too make a contribution to the cost of their government? Perhaps a better system would be a lower ceiling on

*These were widely discussed at the time the advice was published. More recently, the Administration has been signaling a change in its tax proposals for 1978, but this does not affect the point that what the investor perceives must be carefully studied; and the past damage to capital gains taxation as well as proposals to end its remaining preferential treatment were facts when the advice cited was published.

tax level is a capital levy of a confiscatory nature, and is a gun pointed right at the head of such enterprises. While this trend in taxation may not be directly coupled with the decline in new equity issues since 1969, as the following table[34] shows, there is no question that there is a close relationship:

Year	New Issues
1969	1298
1975	24
1976	50
1977	25 (to mid-year)

The total value for these 1977 issues was $230 million, compared to $3.3 billion in 1972, and much more in the '60s. This poses severe problems in the venture capital field.[35]

A further example of the steady deterioration in venture capital investment is seen in the fact that in 1972 there were 418 underwritings for companies with a net worth of less than $5 million, and which raised $918 million; in 1975 there were four such underwritings totaling $16 million. Over the same period of time similar offerings under the SEC Regulation A fell from $256 million to $49 million, and many of these were unsuccessful.[36] I understand that leading investment bankers today won't touch a public issue unless the company has had earnings over $2.5 million per year for the last seven years. What fledgling enterprise can expect to show that kind of record for many years? Some investment advisers tell their readers "stay out of new issues altogether".[37] To be sure, there are potential sources of capital available to the venturer other than Wall Street, such as a few large companies which have policies supporting venture capital subsidiaries, and other venture capital organizations (many of which have become bureaucratized), but it is the general climate in the largest risk-taking capital market which fundamentally sets the tone of the venture capital markets as a whole. And the basic liquidity which every venture capitalist ultimately seeks can only be found on the Wall Street markets, or by a sell-out to large companies.

Some very significant reduction in the effective tax on sales of assets held for true investment over a longer period of time is required, such as a declining rate scale on a sliding basis with length of holding. This distinguishes between profits made in short-term trading of securities, and true longer-term risk-taking investment. Other ways can no doubt be found to accomplish the same end-result. The US, that bastion of free enterprise, taxes "capital gains" at the highest rate among industrial powers. For example, West Germany and Japan have none; the French and British are much lower; the Swedes have no tax when property is

> on the quality of investment rather than its quantity, why create state monopolies which can stimulate growth only if they can reproduce the conditions of competition by their own volition? Surely there must be an easier way.

Indeed there is, and it is the American system thus far, if we will only have the insights to improve and protect it!

If one estimates that the average GNP growth in real terms over the last decades has been perhaps 3.5% per year, technology has contributed somewhere between 25-50% of this growth. The effect of technology on productivity growth is treated as a "residual" by economists after calculating labor and capital factors.[28] Notwithstanding the general inability of econometricians to measure this factor with precision, it is clear that technology advances are a key element of healthy, sustainable growth.[29] Indeed, this matter is of such importance that I feel one or more of our leading universities should seek to set up professorships and programs in the *economics of technology*. For example, how much of our postwar GNP growth is due to the computer? The scholars who can answer such questions, and develop the intellectual framework for the subject, would surely merit a Nobel Prize or two!

It is also a fact that consistently about three-fourths of our manufactured goods exports have been technologically intensive while roughly half of our manufactured imports are in this category.[30] If agricultural products are counted as technologically intensive, and in my judgment they surely qualify, then obviously the impact of technology on our exports is substantially greater than 75%.

In my opinion, it is unassailable that technology is at the heart of our national dilemma, and that money in the private sector (capital and incentives for its formation) is the key to unleashing it. This in no way denies that there is great need for general national support of research and development, both basic and applied, from which the new technology will come. Nevertheless, it is my long-term experience that leads me to state unequivocally that technology and its interface with government policy (e.g., taxation and regulation, including anti-trust), require an urgent change in approach, with the creation of new and greater financial and tax incentives, and with more reasoned government intervention. A recent National Science Foundation Symposium[31] has focused extensively on the improvement of our research and development efforts, and the role that government policy might play in bringing this about. Its head, Dr. Richard Atkinson, recently estimated that perhaps 40-50% of our growth in GNP comes from R&D.[32] If he is right, the urgency of really understanding the economics of technology is underlined. In any event, it is my observation that the best way to increase private R&D spending is to allow an increase in profitability of the private sector, so that

I mentioned above) cannot easily be built, except in remote locations far from the existing infrastructure such as modern industry demands. This further penalizes the economies of our larger cities and industrialized areas. Since these new plants also require much more capital than the depreciated older plants, it is difficult for business or investors to justify so long-term a risk as these new technologies represent. With energy, the environmental regulations have a different but no less stultifying effect: substitution of "clean oil" by "dirty coal", which the nation's economy requires, is retarded.

The relationships are complex indeed, but the overall conclusion is clear to me. There has to be a recognition at the highest levels in the United States that a trade-off is necessary between encouraging new risk-taking wealth among corporations and individuals—wealth that will translate into investment—and the desire for equity and redistribution of income. Considering the great need for break-throughs, this trade-off will have to be settled largely in the direction of wealth creation and new entrepreneurial incentives by tax reduction and regulatory reasonableness. *Nothing else will realistically work.* This wealth formation is not being encouraged for its own sake, but because it is the only way the country's economic and social welfare can be improved—for all the people—in a free society. Dr. Schultze has also said this eloquently in other words:[24]

> The final virtue of market-like arrangements that I wish to stress is their potential ability to direct innovation into socially desirable directions. While the formal economic theory of the market emphasizes its ability to get the most out of existing resources and technology, what is more important is its apparent capacity to stimulate and take advantage of advancing technology. Living standards in modern Western countries are, by orders of magnitude, superior to those of the early seventeenth century. Had the triumph of the market meant only a more efficient use of the technologies and resources then available, the gains in living standards would have been minuscule by comparison. What made the difference was the stimulation and harnessing of new technologies and resources.

There is a growing recognition of the validity of these interrelationships. One recent example is the policy paper by the NAACP* which supports energy growth and the application of technology thereto because of the clear recognition that only in a growing economy amply supplied with energy can jobs be found, particularly for their own constituency which has very high unemployment, and also for others of the American working population.

Another example appears in an interview given by the newly appointed

*National Association for the Advancement of Colored People.

These figures are based on using replacement capital costs in computing return on investment. While this is a legitimate attempt to correct for inflation, there is some disagreement whether such a calculation is the best way to express it. In particular, it is clear to a technologist that most plants, if replaced today, would not involve the same technology or scale, so that any precise estimate of the effects of inflation by these types of calculations is unattainable. Far more important in the plans of investors and business are the calculations regarding the profitability of *future* investments, and these are further discussed below. Nevertheless, businessmen do make their forward investment plans in the light of past experience, and there is considerable evidence that profitability has lagged in recent years[17] and that the capital requirements of this country in the near future will require a substantially higher level of investment.[18]

The recently concluded report by the National Academy of Engineering on technology and foreign trade[19] stresses as a basic conclusion that the US must examine its capital formation and productivity processes so as to improve its innovative capacity. As a participant in this study it seemed logical to me to start doing just that in this article.

The annual productivity growth rate of the American economy fell from 2.4% in 1965-70 to 1.0% in 1970-75.[20] There are many reasons for this drop, such as the deficiencies in the capital formation process described herein; social attitude changes; union restrictions; the increase in the proportion of the GNP represented by government at all levels; and increase of the service sector at the expense of the productive sector—the service area being notoriously a difficult one in which to increase productivity, let alone maintain it. *Fortune* calls all these factors "social drag".[21]

Yet, without a productivity increase of an adequate amount each year, our regularly escalating wage demands, farm price supports, higher overhead costs such as more services, military, health, pollution control, education and other social expenditures, etc., must result in inflation. At the same time the balance of payments problems likewise become enlarged. An extraordinarily perceptive analysis of these worldwide trends is contained in a speech given recently by J. A. Boeckh.[22] As the late Philip Sporn said,[23] "Everything, everything in the way of improvement in human society that came about within the 200 years that we've had since the start of the Industrial Revolution in England, *everything* has come out from only one source and that is increased productivity of the human being."

It follows, therefore, with political and governmental realities as they are, that only major improvements in the productivity of the private sector can hope to offset inflation and ultimately unemployment (or to pay the cost of the latter). This, of course, is partially possible by conventional capital

Times joined the roaring masses: 'Consumers want safety, but total, absolute safety—assuming that were possible—would have as its price a bureaucracy of staggering cost, reaching into every corner of American life.' "

This saccharin episode thus dramatized for the public at large what the business community, the economy generally, and especially the entrepreneur have long suffered from in obscurity. As an example, E. A. Gee, Senior Vice President of du Pont (the largest chemical company), recently made the following statement:[9]

> [Du Pont's] expansion and modernization program for the next ten years will be capital-limited. We expect to have about $10 billion available. Air, water and noise pollution abatement facilities will soak up $3 billion of that amount if present trends continue—30%, up from the 12% estimated for this year. Three billion dollars spent on productive capacity would, incidentally, build the equivalent of about 27 new plants and directly create in du Pont over 20,000 jobs, and about $4 billion in annual sales.
>
> Now, here's the punch line—three quarters of the $3 billion will be unjustified in terms of environmental improvement—in short, it will be wasted. And it doesn't end here—annual operating costs for environmental facilities by 1985 will be over $1 billion—about 8% of sales—unless the present trend is changed.

If this is du Pont's situation, one can imagine how smaller and especially new companies would be affected!

The Small Business Administration (SBA) was created in an attempt to aid smaller business. But, as *Fortune* says:[10]

> The main capital-raising problems plaguing small businessmen today are created largely by government itself, through programs and policies that have rendered investment in small businesses less and less attractive. For one thing, as the spread between the maximum federal tax rate on capital gains and ordinary income has narrowed, the individual has lost a lot of his incentive to sink money in risky small businesses. Smaller pension funds, which many hoped would become a major source of capital for small business, have just about stopped investing in risky ventures because of highly restrictive fiduciary standards set by the Employee Retirement Income Security Act (ERISA) . . .
>
> The simplest solution to this problem is not a government loan program. It is to reform the tax, pension and other laws that increasingly weigh on small business . . .
>
> Another genuine need of the small-business community is for relief from the large and growing burden of government regulation. The SBA's loan

in history, when life was simpler, the needs seemed greater, and the now existing obstacles to progress from governments had not all been invented yet.[3] In short, I doubt we could start today and expect 31 years from now to achieve a comparable success in this very competitive and capital-intensive industry of ours. I have dealt with the current characteristics of this industry in a recent address.[4] Indeed, I feel it is virtually impossible now to enter the chemical manufacturing business, except in the specialty areas where capital requirements are low, unless one is already a large company. Luck will beat brains any time, and we were lucky in our timing. Nevertheless, I have some views of a more general nature, and I would like to put them down herein. My discussions over the years with many entrepreneurs, executives, financial experts, university economists, lawyers, government officials, technologists and other specialists have helped me in formulating what follows.

The Desire to be an Entrepreneur Still Flourishes

Entrepreneurship is not dead, is needed, and can be nurtured. In my academic experience as Adjunct Professor at the University of Pennsylvania, I have seen how eagerly young people today seek opportunities to go into business for themselves. At my other alma mater, the Massachusetts Institute of Technology, 25% of the graduating doctoral students in chemical engineering have similar desires. Both institutions are searching for ways to teach entrepreneurship. We at Halcon have funded a Professorship of Technological Entrepreneurship at Penn which will link the Wharton School and the Engineering School. Other institutions no doubt are active in this area. The United States is unique in this attitude, and I hope we will seek to encourage it in every way, although the paths will surely be different from the ones we followed. *Science* recently carried an article[5] on the reasons for the failure of West Germany and Britain to encourage growth of new companies based on technological innovation, yet these two countries were leaders in this activity in the nineteenth century! There is no permanent advantage for any country, unless it is assiduously cultivated.

The current changing climate in this country is best summarized in a recent article by Gene Bylinsky, who has specialized in studying the technological entrepreneur, and says:[6]

> Despite recent successes, the atmosphere in which all these entrepreneurs have operated is unquestionable less encouraging than that of the 1960s when new companies proliferated. . . This, of course, limits the opportunities for untried innovators.

Our corporation, initially called Scientific Design and founded in 1946, provided the "systems" approach to design of chemical plants, adapting ideas from the pre-war period as applied to petroleum refining. We perceived a need for organic and petrochemical technology as a result of World War II. The greatest areas of devastation (Europe, then Japan) offered us broader market opportunities than a more prosperous US; hence, the early introduction of the "multi-national" aspect of our work. And, because we knew that innovation and proprietary high technology had been the keys to the successful development of roughly comparable companies like UOP and M. W. Kellogg in the petroleum field, we started our own original research early in our career (1947) with a laboratory on 32nd Street near Park Avenue in New York. Our direct oxidation ethylene oxide research was commenced there; we realized that the chlorhydrin process used since World War I to make this valuable chemical would have to become too expensive and we considered this a challenge to our technical skills (although the discovery that ethylene could be oxidized with molecular oxygen over a silver catalyst had been made in the '30s by Lefort in France and commercialized shortly thereafter by Union Carbide). Since then we have licensed 30 companies, designed 66 plants in 24 countries, and they provide more than one-third of the world's installed capacity. Evidently our understanding of the requirements of the market was not mistaken.

Nevertheless, in the first five years of our existence, we hung on literally by our eyeteeth. Without any capital resources of our own (so typical of young technological companies), we could sell only services and ideas. Then came our first US engineering work, and a bit later (1954) our first really original chemical discovery—the bromine-assisted air oxidation of p-xylene to terephthalic acid (the main ingredient of polyester fibers), replacing the previously utilized nitric acid oxidant. We wanted very much to use this process as a basis for entering the manufacturing area ourselves, but couldn't quite muster the muscle. As an alternative, we sold the whole technology to Standard Oil Company (Indiana), where it now forms one of the principal businesses of Amoco Chemicals Corporation. Something like 6 billion pounds per year are currently made by Amoco and its licensees. So, by 1956 (the end of our first 10 years), we were moderately well known, and had some capital and new annual income.

Most of the income was invested in more research, which generated in 1959—among others—our second piece of original chemistry, the oxidation of cyclohexane in the presence of boric acid to make the basic intermediates for nylon, in much higher yield than had previously been attainable. We now have 1.6 billion pounds per year of capacity licensed to ICI, Monsanto, Rhone Poulenc, Farbenfabriken Bayer and Mitsubishi Chemical, among others. Also flowing from the research in this period came our maleic anhydride process, which accounts for approximately 60% of the world's capacity of that im-

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The Contributors

DR. RALPH LANDAU is a recognized entrepreneur by his industry. In 1973, the Society of Chemical Industry (American Section) awarded him the Chemical Industry Medal for "conspicuous service to applied chemistry", and in 1977 the Winthrop-Sears Medal for "chemical entrepreneurship" was awarded him by the Chemical Industry Association. Mike Hyde of London's *Chemical Insight* called him "one of the few true entrepreneurs of the manufacturing chemical industry". He is co-founder and chairman of Halcon International, Inc. Dr. Landau is a trustee of the University of Pennsylvania and a life member of the MIT Corporation. He is vice-chairman of the American Section of the Society of Chemical Industry, and a former vice president of that British society. He was elected to the NAE in 1972 and to its governing Council the following year.

DR. RICHARD S. MORSE, President and Founder of National Research Corporation, is a pioneer in the field of industrial applications of high vacuum technology. He organized Vacuum Metals, Minute Maid and NRC Equipment Corporations. He has also served in government for many years, including positions as Director of Research and Assistant Secretary of the Army (R&D); with the Department of Commerce; and as a member of the Defense Science Board. Dr. Morse has had a long association with the Massachusetts Institute of Technology—of which he is an alumnus—notably as President of its Development Foundation and Senior Lecturer, Sloan School of Management. He also serves as director to numerous organizations. Dr. Morse was elected to the National Academy of Engineering in 1976.

MR. KENNETH H. OLSEN, a newly elected member of the Academy, is President of Digital Equipment Corporation, which he founded in 1957. This company has influenced in a major way the development of the computer field. In fact, Mr. Olsen is often called the "father of the minicomputer". The first fully transitorized computer, the TX-0, was built at MIT's

Foreword

This document contains the keynote presentations of the technical session held in conjunction with the Thirteenth Annual Meeting of the National Academy of Engineering on November 10, 1977.

Academy members Ralph Landau, Richard S. Morse and Kenneth H. Olsen discussed various environmental, financial, legislative and psychological factors in today's society that adversely affect the process of moving innovative technology from its conception to its introduction in the marketplace. The presentations were based on the personal entrepreneurial and management experiences of the speakers in the chemical, high-vacuum and computer industries. Inductive in approach, they were intended to identify problem areas as well as remedial approaches deemed necessary to revitalize the art of innovation and entrepreneurship in both new enterprises and large corporations. The papers reproduced herein represent the views of the authors; they are being published by the National Academy of Engineering in response to many requests for copies received subsequent to the meeting at which they were presented.

In the first paper, Dr. Landau presents a case history detailing his personal entrepreneurial experience in the chemical process industry beginning shortly after the end of World War II. He includes some observations on the continuing interest in entrepreneurship as evidenced in the student bodies of universities with which he is presently associated. This interest and desire continue despite various barriers to innovation imposed by the government, which Dr. Landau classifies as regulatory, tax, inflation and uncertainty. He discusses each of these categories and offers suggestions for ways to eliminate or moderate the effect of these governmental barriers to innovation. Dr. Landau concludes with some ideas on organization for innovation, recognizing the continuing need for entrepreneurship, risk-taking and innovation.

In the second paper, Dr. Morse presents some general observations on the state of the national environment for technological innovation and generation of new technical enterprise. He notes that many factors in the national en-

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efficiency; an important advantage is that it involves less direct government controls. An important problem with more selective support mechanisms is that it is so difficult to estimate in advance the social benefits and costs of particular types of R. & D. projects. In my own opinion, if a program of this sort were started, a combination of selective and more general forms of support would be most effective.

Although many economists suspect that there may be an underinvestment in certain areas of civilian technology, there is at the same time some concern that the federal government, in trying to improve matters, could do more harm than good. In this regard, it seems to be generally agreed that any selective program should be neither large-scale nor organized on a crash basis, that it should not be focused on helping beleaguered industries, that it should not get the government involved in the latter stages of development work, that a proper coupling be maintained between technology and the market, and that the advantages of pluralism and decentralized decision-making be recognized.

In previous sections of this paper, I have discussed (all too briefly) a variety of policy alternatives that have been suggested for improving the existing federal posture concerning civilian technology, as well as the broad issues that bear on the relative desirability of many of these policy alternatives. Perhaps the most important point to emphasize in this connection is the extent of our ignorance and uncertainty. There sometimes is a tendency to slur over—or perhaps not to recognize—the fact that very little really is known concerning the effects of many of these policy alternatives, or concerning the desirability of their effects. (Indeed, in some areas, no one really knows how to study these questions effectively, let alone provide answers here and now.) Given the current uncertainties, it would seem wise to proceed with considerable caution, and to build into any program the capacity and necessity to resolve many of the key uncertainties before too big a commitment is made.

Finally, it is important to recognize that the nation's basic economic policies may have a notable impact on R. & D. and technological change in the private sector. Technology policy, after all, must be integrated with and viewed in the context of, our overall economic policy. With regard to antitrust policy, which is an important element of our basic economic policy, the available evidence does not indicate that we must permit very great concentration of American industry to achieve rapid technological change and the rapid adoption of new techniques.

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others [52] indicate that small firms and independent inventors play a large, perhaps a disproportionately large, role in conceiving major new ideas and important inventions. Further, although full-scale development often requires more resources than small firms command, the investment required for development and innovation is seldom so great or so risky that only the largest firms in an industry can do the innovating or the developing. Studies of the drug, coal, petroleum, and steel industries indicate that, in all of these industries, the firms that carried out the most innovations, relative to their size, were not the biggest firms.[53] Only in the chemical industry does it appear that the largest firm has done the most innovating relative to its size.[54]

The available evidence does not seem to indicate that giant firms devote more resources, relative to their size, to inventive and innovative activities than their somewhat smaller competitors. There seems to be a threshold effect. A firm has to be a certain size to spend much on R. & D. (as defined by the National Science Foundation), but beyond a certain point, increases in size no longer bring a proportionate increase in R. & D. expenditures.[55] As would be expected, the threshold varies from industry to industry, but it appears that increases in size beyond an employment level of about 5,000 employees generally do not result in more than proportioual increases in innovation inputs or outputs. Moreover, there is some evidence that the biggest firms produce less inventive and innovative output, per dollar of R. & D., than smaller firms.

Turning from size of firm to industrial concentration (which can be quite a different thing), most studies of the relationship between industrial concentration and the rate of technological change conclude that a slight amount of concentration may promote more rapid invention and innovation. For example, very splintered, fragmented industries like construction do not seem to be able to promote a rapid rate of technological advance. But beyond a moderate amount of concentration, further increases in concentration do not appear to be associated with more rapid rates of technological advance. Thus, the evidence does not seem to indicate that very great concentration must be permitted to promote rapid technological change and the rapid adoption of new technologies.[56]

Several other points should be noted. First, new firms and firms entering new markets play a very important role in the process of technological change. Existing firms can he surprisingly impervious to new ideas, and one way that their mistakes and inertia can be overcome in our economy is through the entry of new firms. Second, cases sometimes occur where industries contain such small firms or markets are so fragmented that technological change is hampered. In such cases, as we pointed out in section 2 (in connection with agriculture), it may be good public policy to supplement the R. & D. provided by the private sector. Third, it is generally agreed by economists that the ideal market structure from the point of view of promoting technological change is one characterized by a mixture of firm sizes. Com-

[52] See Jewkes, Sawers, and Stillerman [21], Hamburg [18], Mueller [38]. and Scherer [56].
[53] See Mansfield [26] and Mansfield et al. [28].
[54] See Mansfield et al. [29].
[55] See Scherer [56]. An exception here is the chemical industry.
[56] See Scherer [56].

fining R. & D. (and thus in measuring increases in R. & D. expenditures), a tax credit for increases in R. & D. spending might be considered, if it seems desirable to increase federal support for civilian technology. If adequate measures were available to guide more selective forms of support, perhaps they alone could do the job; but such measures are presently in their infancy.

12. Major Considerations in Formulating Programs

The choice of the general type (or types) of program is only one of many decisions that would have to be made, if some new federal support for R. & D. in the private sector were deemed desirable. This section takes up five additional points concerning the formulation of such a program. First, to the extent that such a program were selective, there seems to be a considerable amount of agreement among economists that it should be neither large scale nor organized on a crash basis. Instead, it should be characterized by flexibility, small-scale probes, and parallel approaches. In view of the relatively small amount of information that is available and the great uncertainties involved, it should be organized, at least in part, to provide information concerning the returns from a larger program. On the basis of the information that results, a more informed judgment can be made concerning the desirability of increased or, for that matter, perhaps decreased amounts of support.[48]

Second, any temptation to focus the program on economically beleaguered industries should be rejected. The fact that an industry is in trouble, or that it is declining, or that it has difficulty competing with foreign firms is, by itself, no justification for additional R. & D. More R. & D. may not have much payoff there, or even if it does, the additional resources may have a bigger payoff somewhere else in the economy. It is important to recall the circumstances under which the government is justified in augmenting private R. & D. Practically all economists would agree that such augmentation is justifiable if the private costs and benefits derived from R. & D. do not adequately reflect the social costs and benefits. But in many industries there is little or no evidence of a serious discrepancy of this sort between private and social costs and benefits. Indeed, some industries may spend too much, from society's point of view, on R. & D.

Third, except in the most unusual circumstances, the government should avoid getting involved in the latter stages of development work. In general, this is an area where firms are far more adept than government agencies. As Pavitt has put it, government programs in support of civilian technology "should be managed on an incremental, step-by-step basis, with the purpose of reducing key scientific and technical uncertainties to a degree that private firms can use the resulting knowledge to decide when (with their own money) they should move into full-scale commercial development."[49] "Although there may be cases where development costs are so high that private industry cannot obtain the necessary resources, or where it is so important to our national security or well-being that a particular technology be developed that the government must step in, these cases do not arise very often. In-

[48] Some of the material in this and the next section closely parallels parts of [27].
[49] Pavitt [49], p. 16.

methods has resulted in a saving to the government of $400,000 in the case of air conditioners and of $300,000 in the case of water heaters purchased in one year alone. Relatively straightforward changes in the nuclear standards formulation process seem to have expedited this process considerably. With regard to the encouragement of innovation in the private sector, the program's officials feel that progress has been made. As in the case of the Experimental Research and Development Incentives Program, it is very difficult at this point to say what the net effect of each of these experiments has been and to tell whether they will result in social benefits exceeding their social costs. Nonetheless, it seems reasonable to expect that this program will shed light on a number of the major issues considered in this report.[45]

11. General Versus Selective Support Mechanisms

In section 8, we described briefly some of the mechanisms used by the governments of Britain, France, and Japan to support R. & D. in the private sector. In section 9, we discussed the advantages and disadvantages of various mechanisms that could be used in the United States to increase Federal support of private-sector R. & D., if this were deemed desirable. In section 10, we described several programs currently being carried out by government agencies which should shed light on the relative desirability of some of these mechanisms, as well as on the desirability of further Federal support for private sector R. & D. With this material as background, we turn now to a discussion of some of the major considerations that probably should be kept in mind in appraising the policy options in this area.

To begin with, it seems fair to say that most economists who have studied this problem have come away with the impression that our nation's programs in support of civilian technology are *ad hoc*, and that it is difficult to understand why we have allocated this support in the way that we have. For example, an enormous amount of support has been provided for civilian aviation technology, but very little has been provided for railroad technology; an enormous amount of support has been provided for agricultural technology, but very little has been provided for construction technology; and so on. (Perhaps this allocation of support can be defended, but I know of no serious attempt to do so.) Also, many economists who have written on this topic seem somewhat uncomfortable about the extent to which federal support of R. & D. in the private sector is related to a relatively few high technology areas. When one looks at federal expenditures for R. & D. performed in the private sector, the data, shown in Table 4, indicate that the lion's share goes to industries like aircraft, electrical equipment, and instruments. Yet the marginal rate of return from R. & D. may be higher in less exotic areas like textiles or machine tools than in these high-technology fields.

If these misgivings are close to correct, it is likely that a general tax credit for R. & D. would be a relatively inefficient way of increasing federal support for R. & D. in the private sector. This is because, as pointed out in section 9, it would reward many firms for doing what they would have done anyway, and it would be likely to encourage the same sorts of R. & D. that are already being done. A tax credit for

[45] For some recent discussion of this program, see Science, September 26, 1975.

Seventh, the Federal Government might establish prizes for important industrial innovations and developments. Such prizes would of course, make privately financed R. & D. more attractive; if a firm or individual felt that a prospective R. & D. project might lead to results worthy of such a prize, the rewards would appear higher than without the prize. An important disadvantage of this mechanism is that it is so difficult to figure out which innovations are worthy of prizes and which are not. Given the enormous problems in measuring the social importance of an innovation, this mechanism may not be as feasible as might appear at first glance.

10. Three Federal Programs Designed To Illuminate the Issues

On March 16, 1972, former President Nixon, in his special message to the Congress on science and technology, established three programs related to Federal support of R. & D. in the private sector. One was to be an analytical program at the National Science Foundation to support studies of barriers to technological innovation and the effects of various possible Federal policies on these barriers. The other two, one to be carried out at the National Science Foundation and one at the National Bureau of Standards, were to be experimental programs to determine effective ways of stimulating R. & D. in the private sector and to provide experience with incentives that the Federal Government might use to promote the application of science and technology in the civilian sector. In this section, we describe the nature and status (as of 1975) of these programs, each of which has an obvious bearing on the topic of this report.

The National Science Foundation's National R. & D. Assessment Program

Established in August 1972, this is the analytical program cited above. This program analyzes the patterns of R. & D. and technological innovation in the United States, the incentives and decisions that underlie these patterns, and the effects of various Federal policy options on future patterns of R. & D. and technological innovation in this country. More specifically, this program attempts to shed light on the following sorts of questions: How are decisions made with regard to R. & D. and technological innovation? How does government regulation affect R. & D. and technological innovation? How do tax policies, patent policies, and antitrust policies affect R. & D. and technological innovation? What are the social benefits and costs from technological innovations? What are the effects of international technology transfer on U.S. balance of trade and employment?

To carry out its work, the National R. & D. Assessment Program supports both intramural and extramural work. A great many of the extramural projects have yet to reach completion, since most of them were not begun until fiscal 1974. Thus, it is too soon to attempt to summarize the results obtained to date. However, it is clear that this program will add to the stock of fundamental knowledge in this area. For example, some of the works cited earlier in this paper were supported by this program. It is to be hoped that a number of the issues considered in this report will be clarified considerably by the results to be obtained by this program.

much of their work. This is the route also taken by the National Research and Development Corporation in Britain and by some proposals in the United States.[38] It has the advantage of being direct and selective, but it can involve political problems in the choice of contractors, as well as problems relative to the disposition of patents resulting from such contracts and grants. At present, different Government agencies have adopted different policies with respect to patents. Some, notably the Department of Defense, allow the title to the patent to remain with the contractor; others, like the Atomic Energy Commission, have retained title to the patents. There has been a longstanding argument over the relative merits of these different patent policies.[39] Still another, more fundamental difficulty with this mechanism for supporting private sector R. & D. is that it is so difficult to estimate the social costs and benefits of a proposed R. & D. project in advance. More will be said about this in section 11.

Third, the Federal Government could support additional civilian R. & D. by initiating and expanding work of the relevant sorts in government laboratories. This technique has the advantage of being direct and selective. But there are great problems in having R. & D. conducted by organizations that are not in close touch with the marketing and production of the product. It is very important that there be unimpeded flows of information and good coordination of R. & D. on the one hand, and marketing and production, on the other. Otherwise, the R. & D. is likely to be misdirected, or even if it is not, it may be neglected or resisted by potential users. This is a difficult enough problem for various divisions of a firm, and it would seem to be made worse if the R. & D. is done in government laboratories. In the last decade, many governments have tended to convert government laboratories and to increase the amount of government-financed R. & D. done in industrial firms in order to bring R. & D. into closer contact with application and commercialization.[40]

Fourth, the Federal Government could insure a portion of private credit to firms for R. & D. and innovation costs. It is frequently claimed that the reluctance of lenders to extend credit to risky and long term projects is an undesirable barrier to innovation. To the extent that this is the case, such a program might help to remedy the situation. The government could, for a fee, share the risk with the private lender for loans for R. & D. and related purposes. The advantages of such a program are that it would not commit the government to large expenditures, the administrative costs would be low, and there would be little federal interference in the lending decision. The disadvantages are that it results in a contingent liability for the Treasury, political problems could arise in awarding the loan insurance, and, most important of all, there is very little hard evidence that the capital markets operate so inefficiently (from a social point of view) that such a program is needed.[41]

Fifth, the Federal Government could use its own purchasing procedures to encourage technological change in the private sector. As shown in table 8, the Federal Government's purchases of many kinds

[38] See Nelson, Peck, and Kalachek [45].
[39] See Mansfield [25].
[40] See OECD [47].
[41] See Piekarz [55].

TABLE 6.—PERCENTAGE DISTRIBUTION OF PUBLIC RESEARCH AND DEVELOPMENT EXPENDITURES DEVOTED TO VARIOUS FUNCTIONS, 1968–69

Country	Military, space, nuclear	Economic, agriculture, manufacturing	Welfare, health, environment	Other, including universities	Total[1]
United States	79	6	13	2	100
Canada	29	49	11	11	100
Belgium	24	27	4	45	100
United Kingdom	59	22	4	15	100
Norway	17	40	8	35	100
Japan	9	25	4	62	100
Sweden	52	13	8	26	100
Netherlands	19	18	9	53	100
France	55	16	3	26	100

[1] Because of rounding errors, items sometimes do not sum to total.

Source: OECD statistics, as quoted in Gilpin [13].

TABLE 7.—RESEARCH AND DEVELOPMENT EXPENDITURES AS A PERCENTAGE OF GROSS NATIONAL PRODUCT, 1969

Country	Total R. & D.	Nonmilitary R. & D.
United States	2.8	1.9
United Kingdom	2.2	1.7
Japan	1.5	1.5
France	1.9	1.6
West Germany	2.0	1.8

Source: Science and Technology Agency, Japan, as quoted by Peck [51].

An interesting feature of Japan's technology policy is that a very low percentage of the nation's R. & D. is financed by government. Japanese industry supports a much larger share of the nation's R. & D. than does industry in the United States, the United Kingdom, or France. About three-fifths of the Government's R. & D. expenditures on economic development are for the programs of the Agency of Industrial Science and Technology, which has run about a dozen national R. & D. programs on electronic computers, electric cars, sea water desalting, and other such topics. The projects are chosen on the basis of their potential importance to the economy, and the appearance of market failure which has prevented the private sector from carrying them out. Also, the Agency provides subsidies (amounting to one-half of the costs) for particular development projects proposed by industry. This program is smaller than the previously mentioned one, its total funding in 1972 approximating $9 million.

Japan also has used a variety of tax credits for industrial R. & D. In 1967, it introduced a program whereby a firm is permitted a 25 percent tax deduction on R. & D. expenses up to the point where they represent an increase of no more than 12 percent over the firm's highest annual R. & D. expenses since 1967, and a 50 percent tax deduction on additional R. & D. expenses, the maximum tax deduction being 10 percent of the corporate tax. Further, there is accelerated depreciation for the construction of pilot plants for new technology, accelerated de-

be very high. Moreover, the marginal social rate of return also seems high, generally in the neighborhood of 30–50 percent. As in the case of agriculture, there are a variety of very important problems and limitations inherent in each of these studies. Certainly, they are very frail reeds on which to base policy conclusions. But recognizing this fact, it nonetheless is remarkable that so many independent studies based on so many types of data result in so consistent a set of conclusions.

8. Mechanisms of Government Support in Other Countries

Having discussed the available evidence bearing on whether or not there may be an under-investment in civilian R. & D. of various kinds, we turn now to a brief description of some of the mechanisms used in three other countries—the United Kingdom, France, and Japan—to support R. & D. in the private sector.

United Kingdom

Like the United States, the United Kingdom has devoted a large share of its government R. & D. expenditures to defense and atomic energy (table 6). At the same time, however, it has tried in a variety of ways to support civilian technology as well. The National Research and Development Corporation is a public corporation that supports the development of innovations by paying part or all of the development costs, licenses firms to exploit public sector innovations, and enters into joint ventures with private firms. The British Government provides financial support for small firms, research associations, and universities to further the practical applications of research. Recently, the level of this support approximated $10 million per year. In 1970 it spent about $10 million to support research associations. In addition, it has engaged in large programs of grants to industry for research on processes, provided "launching aid" for the development of civilian aircraft and engines, and lent advanced machine tools without fee to potential purchasers or users.[32a]

Although it is difficult to evaluate programs of this sort, there seems to be a widespread feeling that Britain's programs have not been very successful. This is often attributed, at least in part, to the fact that the Government has been too inclined to assume the entrepreneurial role and to engage in commercial development activities. The Government has tended to commit itself to the full-scale development of particular technologies too soon and too massively. In other words, according to many experts in the United Kingdom and elsewhere, the British Government has tended to engage in activities that might better have been left to the private sector.[33]

France

There have been a number of French programs to support civilian technology, particularly in high technology fields or in fields thought to be important for industrial independence. There have been "thematic action programs," meant to coordinate applied work in inter-

[32a] See Hollomon and Associates [20].
[33] See Gilpin [13].

percent. Another study, by Evenson,[23] uses time-series data to estimate the marginal rate of return from agricultural R. & D., the result being 57 percent. Also, Peterson's study of poultry R. & D.[24] indicates that the marginal rate of return for this type of agricultural R. & D. is about 50 percent. Schultz's study indicates a marginal rate of return of 42 percent.[25]

In sum, every study carried out to date seems to indicate that the average social rate of return from agricultural R. & D. tends to be very high. The marginal social rate of return from agricultural R. & D. also seems to be high, generally in the neighborhood of 40 to 50 percent. Of course, as stressed above, these studies are based on a number of simplifications, and it would be very risky to attach too much significance to them, since they are rough at best. All that can be said is that the available evidence, for what it may be worth, suggests that the rate of return from agricultural R. & D. has been high.

7. Measurement of Social Benefits From New Technology: Industry

Having summarized the available results concerning the social rate of return from R. & D. in agriculture, we must now provide the same information for industry. Recently, a study was made by Mansfield, Rapoport, Romeo, Wagner, and Beardsley[26] of the returns from 17 specific industrial innovations. These innovations occurred in a variety of industries, including primary metals, machine tools, industrial controls, construction, drilling, paper, thread, heating equipment, electronics, chemicals, and household cleaners. They occurred in firms of quite different sizes. Most of them are of average or routine importance, not major breakthroughs. Although the sample cannot be regarded as randomly chosen, there is no obvious indication that it is biased toward very profitable innovations (socially or privately) or relatively unprofitable ones.

To obtain social rates of return from the investments in each of these innovations, my colleagues and I used a model somewhat like that described in figure 1, except that we extended the analysis to include the pricing behavior of the innovator, the effects on displaced products, and the costs of uncommercialized R. & D. and of R. & D. done outside the innovating organization. The results indicate that the median social rate of return from the investment in these innovations was 56 percent, a very high figure. On the other hand, the median private rate of return was 25 percent. (In interpreting the latter figure, it is important to note that these are before-tax returns and that innovation is a risky activity.)

In addition, my colleagues and I obtained very rich and detailed data concerning the returns from the innovative activities (from 1960 to 1972) of one of the Nation's largest firms. For each year, this firm has made a careful inventory of the technological innovations arising from its R. & D. and related activities, and it has made detailed estimates of the effect of each of these innovations on its profit stream. We

[23] See Evenson [10].
[24] See Peterson [54].
[25] See Schultz [58].
[26] See [29]. Part of the relevant material will appear in E. Mansfield, J. Rapoport, A. Romeo, S. Wagner, and G. Beardsley, "Social and Private Return from Industrial Innovations," *Quarterly Journal of Economics*, forthcoming issue.

6. Measurement of Social Benefits From New Technology: Agriculture

Since we cannot rely solely on *a priori* theorizing to tell use whether there is an under investment in R. & D. in the private sector (and if so, where it is most severe), we must turn to the available empirical studies of the returns from R. & D. of various types. These results should provide some information concerning what society has received from various forms of R. & D. investment in the past. Of course, there are a variety of problems in measuring the social benefits from new technology. Any innovation, particularly a major one, has effects on many firms and industries, and it obviously is difficult to evaluate each one and sum them up properly. Nonetheless, economists have devised techniques that should provide at least rough estimates of the social rate of return from particular innovations, assuming that the innovations can be regarded as basically resource-saving in nature.

To estimate the social benefits from an innovation, economists have used a model of the following sort. If the innovation results in a shift downward in the supply curve for a product (such as from S_1 to S_2 in figure 1), they have used the area under the product's demand curve (DD^1) between the two supply curves—that is, ABCE in figure 1—as a measure of the social benefit during the relevant time period from the innovation. If all other prices remain constant, this area equals the social value of the additional quantity of the product plus the social value of the resources saved as a consequence of the innovation. Thus, if one compares the stream of R. & D. inputs relating to the innovation with the stream of a social benefits measured in this way, it is possible to estimate the social rate of return from the R. & D. investment.[18]

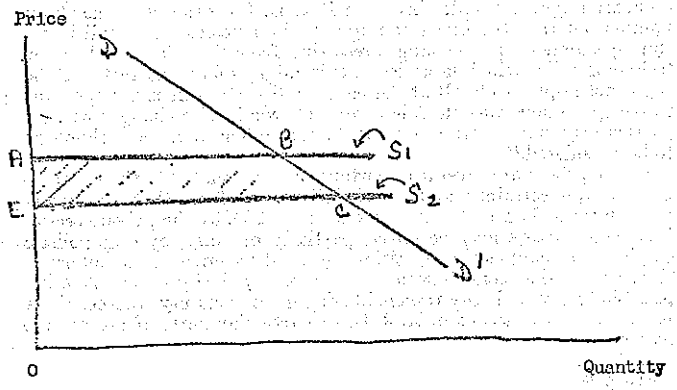

Figure 1.—Measurement of Social Benefits from Technological Innovation.

[18] See Mishan [36] and E. Mansfield, "Case Studies of the Measurement of Benefits from Scientific Information and Technological Innovation," presented at the First U.S.-U.S.S.R. Symposium on the Economics of Information, Leningrad, 1975.

3. The Basic Economics of Government Support of Civilian Technology

In recent years, economists have made some attempt to determine, on the basis of general economic theory, whether it is likely that existing Federal programs in support of civilian technology are adequate. In this section, we summarize some of the arguments bearing on this question. To begin with, it is generally agreed that, because it is often difficult for firms to appropriate the benefits that society receives from new technology, there may be a tendency for too few resources to be devoted to the development of new technology. It is also generally agreed that the extent to which these benefits are appropriable is probably related to the extent of competition faced by the potential innovator and to the kind of research or development activity in question. In particular, the more competition there is and the more basic the information, the less appropriable it is likely to be. However, this argument is blunted somewhat by the obvious fact that some inventive activity is carried on with little or no economic motive. Clearly, inventors and technologists are not motivated solely by dollars and cents.

Economists seem to agree that, because R. & D. is a relatively risky activity, there may be a tendency for firms to invest too little in it, given that many firms seem to be averse to risk and that there are only limited and imperfect ways to shift risk. On the one hand, if firms are big enough so that their R. & D. program is reasonably large compared to particular projects, uncertainty is likely to be handled more effectively. On the other hand, since the threat of competitive innovation is an important stimulus to make firms more willing to accept the uncertainties involved in R. & D., there are obvious disadvantages in firms becoming too large relative to the total market. In any event, it seems to be generally agreed that the riskiness of R. & D. is likely to result in less R. & D. than may be socially optimal.

Still another reason why there may be an under investment in particular kinds of R. & D. is that they may be characterized by significant indivisibilities. In other words, they may be characterized by economies of scale that prevent small organizations from undertaking them efficiently. This argument seems much more applicable to development than to research. It is important to recognize that, while firms may have to be a certain minimum scale to do many kinds of R. & D. effectively, this scale may be a relatively small share of the market. Furthermore, it is important to recognize that small firms have been responsible for many important innovations, while many big firms have concentrated on more minor improvement innovations. Nonetheless, bearing these qualifications in mind, it is often argued that some industries are so fragmented, they cannot do the proper amount of R. & D.[15]

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[15] For a discussion of the considerations involved in this and the previous two paragraphs, see Noll [46].

couraged wherever possible. Although these steps will not solve the problem, they will certainly be a step in the right direction.[9]

4. Patents, Tax Incentives, and Other Existing Policy Instruments

Federal contracts and grants for R. & D. are by no means the only way in which the Federal Government currently supports R. & D. activities in the private sector. In this section, we provide a brief (and necessarily sketchy) description of some of the other important ways that the Federal Government provides such support.

The Patent System

The U.S. patent laws grant an inventor exclusive control over the use of his invention for 17 years, in exchange for his making the invention public knowledge. Proponents of the patent system argue that these laws are an important incentive for invention, innovation, and early disclosure of new technology. Critics of the patent system stress the social costs arising from monopoly and question the importance of patents as an incentive in many parts of the modern economy. Few critics, however, would go so far as to say that the patent system does not encourage additional R. & D. in at least some parts of our economy.[10]

Tax Laws

The tax laws provide some stimulus for private R. & D. If the tax treatment of investment in plant and equipment and in R. & D. were neutral in terms of its effects on incentives, R. & D. would be classified as a capital investment, and depreciated over its useful life. Instead, our tax laws allow R. & D. expenditures to be treated as current expenses, which means that they are made more profitable relative to other forms of investment. Another provision of the Internal Revenue Code allows the sale of patents to be taxed at capital gains rates (which generally are lower than ordinary rates), even if the person is a professional inventor and in the business of making and selling patentable inventions.[11]

Regulation

Some aspects of Federal regulation seem to encourage R. & D. activities in the private sector. For example, with regard to the airlines, it has frequently been concluded that attempts to keep prices above the competitive equilibrium level have resulted in a high rate, perhaps too high a rate, of technological change and innovation. Obviously, however, this is not true of all regulated industries. For example, in the railroad industry, it is frequently claimed that regulation has dampened research and innovation, e.g., in the case of the Big John covered hopper grain cars. Despite recent studies of the Averch-Johnson effect, regulatory lag, and a variety of other relevant

[9] But the competition obviously should be real, not just a facade. The encouragement of many proposals that have no chance of being accepted to give the appearance of competition merely results in additional social waste. See [28].

[10] See Markham [31] and Scherer [56]. For a British study, see C. Taylor and Z. Silberston, *The Economic Effects of the Patent System*, Cambridge, 1973.

[11] See Weidenbaum [62].

change in the private sector but in the public sector. Although there is unquestionably some beneficial spillover, the benefits to the private sector seem decidedly less than if the funds were spent directly on private sector problems.[4]

TABLE 5.—*Total Federal obligations for R. & D. to the 40 universities and colleges receiving the largest amounts, 1973* [1]

	Rank and university	Millions		Rank and university	Millions
1	MIT	$114	21	USC	$22
2	University of California, San Diego	49	22	University of California, San Francisco	22
3	Stanford	46	23	Colorado	21
4	Harvard	46	24	Duke	20
5	University of Washington	45	25	Rochester	19
6	University of Wisconsin, Madison	44	26	Yeshiva	19
7	UCLA	44	27	Cal Tech	18
8	Berkeley	41	28	Purdue	18
9	Columbia	41	29	University of Miami	18
10	Michigan	37	30	University of Texas, Austin	16
11	Johns Hopkins	35	31	University of California, Davis	16
12	Minnesota	32	32	Utah	16
13	Cornell	31	33	Pittsburgh	16
14	Chicago	31	34	Penn State	16
15	Yale	30	35	UNC	15
16	Pennsylvania	29	36	Baylor	15
17	University of Illinois, Urbana	28	37	Iowa	14
18	NYU	25	38	Case-Western	14
19	Washington University	23	39	Northwestern	14
20	Ohio State	22	40	Hawaii	14

[1] Of course, not all of these universities and colleges are in the private sector. According to the National Science Foundation, about 40 percent of total Federal obligations went to private colleges and universities.

SOURCE: National Science Foundation, Federal Support to Universities, Colleges, and Selected Nonprofit Organizations, Washington, 1975.

In other cases, the rationale for large federally financed R. & D. expenditures is some form of market failure. In the case of energy, for example, it has been claimed that the social returns from energy R. & D. exceed the private returns because of the difficulties faced by a firm in appropriating the social benefits from its R. & D. Also, it has been argued that risk aversion on the part of firms may lead to an under-investment (from society's point of view) in R. & D. Further, the availability of energy is frequently linked to our national security.[5] In the case of agriculture, the fact that farms are relatively small productive units has been used to justify federally financed R. & D. The argument that farms are too small to engage in an efficient R. & D. effort certainly was more compelling when there were fewer and smaller industries supplying agriculture. But according to many experts, there still seem to be important aspects of farming that are not reflected in obvious markets for these suppliers.

Finally, as we saw in table 2, some federally financed R. & D. is directed toward the general advance of science and technology. Such expenditures seem justified because the private sector will almost certainly invest less than is socially optimal in basic research. This is

[4] See Mansfield [25], pp. 224–28. Mathematica [33] has carried out a study, based on the sort of techniques discussed in section 6 (and illustrated in figure 1), to estimate the returns to the civilian economy from several NASA innovations. The results indicate that these innovations resulted in benefits to the civilian economy amounting to about $7 billion.

[5] For example, see Tilton [60].

petroleum, drug, rubber, primary metals, and food industries, among others, the percentage of R. & D. performance that is federally financed is much smaller. Thus, just as federally financed R. & D. is concentrated in a few areas, so federally financed R. & D. tends to be concentrated in a relatively few industries.

TABLE 1.—SOURCES OF RESEARCH AND DEVELOPMENT FUNDS AND PERFORMERS OF RESEARCH AND DEVELOPMENT BY SECTOR, UNITED STATES, 1974

[In millions of dollars]

Source of R. & D. funds	Research and Development performance				
	Federal Government	Industry	Colleges and universities	Other nonprofit organizations	Total
Federal Government	4,900	[1] 8,320	[1] 2,883	[1] 852	16,955
Industry		13,700	96	120	13,916
College and universities			683		683
Other nonprofit organizations			211	280	491
Total	4,900	22,020	3,873	1,252	32,045

[1] Includes associated federally funded research and development centers. According to the National Science Foundation, such centers accounted for about $600,000,000 of Federal R. & D. obligations administered by industry, about $800,000,000 of Federal R. & D. obligations administered by colleges and universities, and about $200,000,000 of Federal R. & D. obligations administered by other nonprofit organizations.

Source: National Science Foundation, "National Patterns of R. & D. Resources," Washington, 1975.

TABLE 2.—FEDERAL RESEARCH AND DEVELOPMENT EXPENDITURES FOR SELECTED FUNCTIONS, 1965 1970 AND 1972

[In millions of dollars]

Function	1965	1970	1972
National defense	7,179	8,067	8,703
Space	4,638	3,597	2,960
Health	663	1,164	1,387
Advancement of science and technology	372	590	705
Environment	213	370	509
Transportation	198	451	607
Energy conversion and development	281	341	405
Agriculture	169	239	288
Economic security	42	144	154
Education	19	94	126

Source: "Science Indicators," National Science Foundation, 1973.

TABLE 3.—FEDERAL OBLIGATIONS FOR RESEARCH AND DEVELOPMENT IN MAJOR AGENCIES, BY PERFORMER FISCAL YEAR 1973[1]

[In millions of dollars]

Agency	Intramural	Industrial firms	Colleges and universities	Total
Department of Agriculture	248	2	90	361
Department of Commerce	123	51	42	228
Department of Defense	2,421	5,734	219	8,774
Department of Health, Education, and Welfare	370	94	1,002	1,957
Department of the Interior	142	64	30	256
Department of Transportation	118	185	20	381
Atomic Energy Commission [2]	16	238	89	[3] 1,375
National Aeronautics and Space Administration	899	2,077	130	3,275
National Science Foundation	20	6	435	526
Total	4,598	8,683	2,126	17,791

[1] These figures were estimated in late 1972.
[2] Now Energy Research and Development Administration.
[3] Almost $1,000,000,000 was spent in federally financed research and development centers administered by firms or universities.

Source: "Federal Funds for Research, Development, and Other Scientific Activities," National Science Foundation, 1972.

FEDERAL SUPPORT OF R. & D. ACTIVITIES IN THE PRIVATE SECTOR

By EDWIN MANSFIELD

1. INTRODUCTION

This paper, prepared for the Congressional Research Service at the request of the Joint Economic Committee of the Congress, is concerned with the following questions: To what extent does the Federal Government support research and development (R. & D.) in the private sector? How is this support distributed among industries, universities, research centers, and other organizations? What incentives are there for private recipients to control costs or improve the efficiency of federally funded R. & D. activities? Why is support of this kind regarded as being in the public interest? What measurements have been made of the social benefits of additional investments in R. & D., both in agriculture and industry? Is there any evidence of an under-investment in particular types of civilian technology? What mechanisms of government support have been used in other countries, such as Japan, France, and the United Kingdom? In the United States, what are the major advantages and disadvantages associated with each of the mechanisms for Federal support of private sector R. & D.? What are some possible approaches to improving the effectiveness of Federal programs in support of R. & D. in the private sector?

Needless to say, we shall have to treat many of these questions rather cursorily in order to keep the paper to a reasonable size. For those who want to pursue some points or issues in more detail, a rather lengthy set of references is included. Also, to prevent confusion, it is important to define at the outset what we mean by "research and development" and by "the private sector." The National Science Foundation's definition of research and development is used here. National Science Foundation includes basic research, applied research, and development as parts of research and development. Basic research is defined as "projects which represent original investigation for the advancement of scientific knowledge and which do not have specific commercial objectives * * *."[1] Applied research includes "projects which represent investigation directed to discovery of new scientific knowledge and which have specific commercial objectives with respect to either products or processes."[2] Development includes "technical activity concerned with nonroutine problems which are encountered in translating research findings or other general scientific knowledge into products or processes. It does not include routine technical services to customers * * * [or quality control, routine product testing, market research, sales promotion, or sales service]."[3] As for the private

[1] See National Science Foundation, *Methodology of Statistics on Research and Development*, 1959, p. 124.
[2] *Ibid.*
[3] *Ibid.*

development are allocated and spent. An estimated $23.5 billion will be spent by the Federal Government for research and development in fiscal year 1977. Of that sum about $14.9 billion or 63 percent will be spent for military and space activities. The Subcommittee saw a need to obtain independent studies from outside experts because of the high annual outlays of public funds, their concentration in the areas of military and space activities, the fragmentation and apparent lack of coordination of decisionmaking and review in the executive and legislative branches and the absence of good information about the economic and social benefits of research and development.

The compendium was undertaken to shed light on the way Federal research and development decisions are made, the relative priorities of different types of activities, the results of federally supported programs, and their effects on the economy. It was hoped that the studies would highlight the strengths and weaknesses in existing decisionmaking procedures. I believe the studies accomplish the intended purposes and that they also underline the need for additional studies.

The studies were performed under five topic areas selected by the Subcommittee and the Library of Congress. For each topic, a series of issues of particular interest were developed to serve as general guidelines to the authors.

The responsibility for planning, coordinating and editing the studies was carried out by Richard F. Kaufman, General Counsel of the Committee, Susan Doscher Underwood of the Library of Congress, and Larry Yuspeh of the Committee staff. The assistance of Walter Hahn of the Library of Congress and Ellen Crosby of the Committee staff is gratefully acknowledged.

Sincerely,

WILLIAM PROXMIRE,
Chairman, Subcommittee on Priorities and Economy in Government.

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Appendix B

New Small Company Public Issues
($ In Millions)

	Small Companies		Small Technical Companies	
	Dollars	Number	Dollars	Number
1969	$1,103	649	$349	204
1970	386	210	149	86
1971	528	244	138	73
1972	921	418	194	104
1973	158	67	38	19
1974	16	9	6	4
1975 (6 mos.)	4	1	0	0

Includes all "firm" underwritings of equity securities of less than $5 million for companies with net worth, prior to offering of less than $5 million. Excludes Regulation A offerings, "best efforts" sales, government securities and foreign issues. Data from Venture Capital published by S.M. Rubel and Company, Chicago, Illinois.

plan and arranging to defer tax liability for shares issued under a non-qualified plan. Other forms of financial and tax incentives should be developed for the management and key employees of the higher risk new technical enterprise.

The most serious shortage of capital has been experienced by those individuals and organizations looking for seed money or "start-up" capital. Investors, who were always ready to provide limited funds to a brand new enterprise which appealed to them, now shun a "start-up" situation. First, tart-ups require far more money than was needed five to eight years ago. Higher costs have resulted from inflation, increased regulation of business and the absence of government R&D to expedite the initiation of technologically based companies. Second, because of the current economic environment, investors have tended to put money into more seasoned companies where markets are known, management teams have been developed, and investment can be made in the form of an interest bearing note with warrants or other debt plus equity arrangements. Start-up ventures should be considered solely as equity investments usually in unproven market areas with untried management teams. Third, the venture capitalist is no longer able to leverage his investment in a new enterprise with bank debt after a new company begins to make sales. This type of money is extremely difficult to find and if such loans are made, personal guarantees of officers and directors are usually required.

Considering the problems of venture capital today, it is remarkable that any new companies have been started and financed in the last three years.

CONCLUSIONS

As observed in the 1967 CTAB report on technological innovation, the entrepreneurial process, particularly as it relates to high technology companies, is not well understood. It has been noted, however, that the rocess can occur only in a favorable environment. This environment has teriorated over the last few years in the following manner:

1. Government R&D programs are a less significant factor in stimulating high technology companies. The character and complexity of government procurement policy and procedures and management methods has deteriorated significantly.

2. Financial incentives for the entrepreneur and the investor have declined.

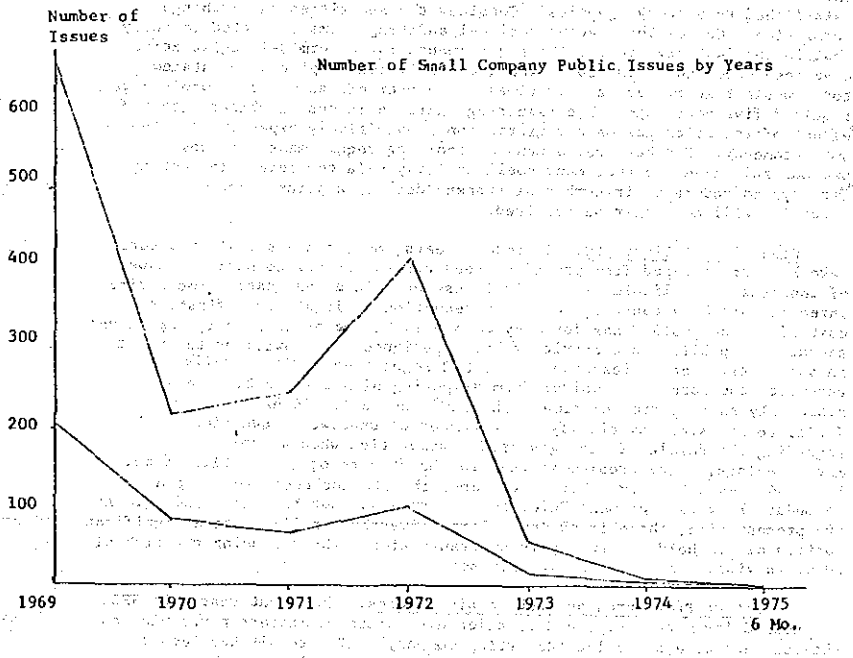
3. Government regulation has greatly increased the operating cost and management problems of new business enterprises.

4. The liquidity of investments in small companies has been reduced by the absence of a receptive public market and by regulation.

5. The supply of capital for starting new high technology ventures is almost non-existent. Private capital for seasoned new companies is difficult to obtain and public financing is essentially unavailable.

These changes in the entrepreneurial environment present a serious problem for the country. Under conditions as they exist today, the new high technology growth companies are not being organized in sufficient numbers to provide the jobs and the technical products for export which will be needed the decades ahead. If the future economic health of the country is to be ured, it is apparent that something must be done to improve the business environment. It is probably impossible to quantitatively predict the extent to which any specific legislative of administrative change might stimulate

Capital Supply. Probably the most important change in the environment for starting and developing new high technology companies during the period has been the decline in the supply of risk capital for small companies. Not only has the supply contracted, but there appears to have been a shift away from investment in technical companies. Small new public issues in the U.S. by companies with a net worth of less than $5 million before the offering declined from $1.1 billion in 1969 to only $16 million in 1974. But what is more disturbing is the fact that the percentage of dollars invested in technical companies included within the group of small companies described above, declined from an average of 33% in 1969 and 1970 to an average of only 23% in the years 1971 through 1974. It should also be noted that there have been no public financings of Small Technical Companies of the type described between March of 1974 and August 1, 1975.



Note: See Appendix B for complete data and source.

increasing government spending for R&D without, what many people believed, were benefits which justified the expense. The level of government financed R&D (in constant dollars) began to decline. Other measures, particularly the Jopticn of the Mansfield Amendment, tended to restrict DOD funding of R&D to specific goal-oriented tasks and to limit the programs which might have important commercial significance.

Both small companies and universities were directly affected by these cutbacks, but there was also an indirect effect which was much less obvious. Not only were government R&D contracts no longer a mechanism for small companies to get started, but government-sponsored university research was so oriented that opportunities for the establishment of new companies to commercialize new technologies were greatly reduced. (The RANN -- Research Applied to National Needs -- Program of the National Science Foundation may be an exception to this generalization.)

Another change related to government funding of R&D has been the reduction in acceptance of unsolicited and of sole source proposals in favor of competitive bidding for R&D procurement. Although not generally understood, the unsolicited proposal has played a unique role in the development of innovative technologies by providing relatively small amounts of money to bring a new concept or technology to the point where a product might emerge. Now an unsolicited proposal may provide the basis for a request for additional proposals and competitive bidding. The practice of competitive bidding tends to favor the large corporation which has the ability to submit and resubmit detailed and costly proposals to fit the requirements of a particular situation.

Contract administration of government programs also has become overwhelmingly burdensome and often, particularly in small companies, the monitoring and reporting requirements have grown all out of proportion to the size of the task.

Financial Incentives. At the same time the government was under pressure to reduce spending for research and development, the long establishished practice of granting stock options came under attack. It was felt by many, and not without some justification, that there were an increasing number of abuses of the stock option programs in large corporations. As a result, the rules governing the granting and tax treatment of qualified stock options were tightened. Abuses in the large corporations were to some extent curbed, but the unique incentives previously offered by stock options to the entrepreneur were essentially eliminated.

Income taxes have now been adjusted so that salaries and wages became taxable by the Federal Government at a maximum rate of 50% while capital gains taxes have increased from the maximum of 25% to a maximum of 35%. Simultaneously, more and more states have levied new income taxes or increased old ones. In some states coosiderably higher rates are applied to unearned income and to capital gains than are applied to salaries and wages. The result has been a significant narrowing of the gap between income tax and capital gains tax rates and the corresponding reduction in financial incentives for the entrepreneur. As a result of the changes the tax structure and in the stock option rules, the entrepreneur now

Average Annual Growth (Compounded)[2]
1945-1974

Innovative Companies	Sales	Jobs
Polaroid	14.0%	9.0%
3M	14.1%	9.0%
IBM	16.8%	10.2%
Xerox	24.2%	19.4%
Texas Instruments (1953-1974)	21.2%	17.3%
Weighted Average	16.5%	10.8%

Mature Companies	Sales	Jobs
Bethlehem Steel	4.9%	-1.7%
DuPont	8.6%	2.6%
General Electric	8.4%	3.5%
General Foods	8.2%	4.5%
International Paper	9.2%	2.8%
Proctor & Gamble	9.6%	3.8%
Weighted Average	7.8%	1.9%

The above data covers the 29 year period from 1945 through 1974. Over the short 5 year period 1969 through 1974, young, high technology companies have shown a far more spectacular growth rate.

Average Annual Growth (Compounded)[2]
1969-1974

Young High Technology Companies

Date Incorp.		Sales	Jobs
1968	Data General	140.5%	82.5%
1959	National Semiconductor	54.3%	59.4%
1960	Compugraphic	50.2%	24.0%
1957	Digital Equipment	36.8%	30.7%
1964	Marion Labs	24.5%	25.4%
	Weighted Average	42.5%	40.7%

(2) Moody's Industrial Manual, Moody's Investors Services, Inc., New York, New York

Appendix VIII

"The Role of New Technical Enterprises in the U.S. Economy," by John O. Flender and Richard S. Morse, M.I.T. Development Foundation, Inc., Cambridge, Mass., October 1, 1975

THE ROLE OF NEW TECHNICAL ENTERPRISES IN THE U. S. ECONOMY

by

John O. Flender and Richard S. Morse

M.I.T. Development Foundation, Inc.
50 Memorial Drive
Cambridge, Massachusetts 02139

October 1, 1975

RECOMMENDATION 12

Page

We recommend, at this time, no legislative changes in the antitrust and regulatory laws. However, we do recommend that in the interpretation and administration of these laws, the effect on innovation, as well as on competition, be taken into account. 52

RECOMMENDATION 13

A group should be established within the Federal Government to aid and advise the regulatory and antitrust agencies by performing such activities as:

(1) Developing criteria for helping these agencies judge the impact of antitrust and regulatory policies on invention and innovation.

(2) Systematically analyzing the consequences of past antitrust and regulatory activities in light of these criteria. 54

(3) Advising the responsible agencies on the probable consequences of proposed policy changes affecting invention and innovation.

(4) Providing technological forecasts as an additional factor for antitrust and regulatory planners to weigh in their policy formulations.

RECOMMENDATION 5 Page

Research and development expenditures incurred to develop new products or processes should not be disallowed as a business deduction merely because they are unrelated to a taxpayer company's current products or processes. 38

RECOMMENDATION 6

Professional inventors should be placed on the same tax footing as amateur inventors by permitting qualification under Section 1235 of the Internal Revenue Code so that a patent license qualifies as a transfer of "substantially all rights," even though the grant is limited to a particular field-of-use or a particular geographical area. 39

RECOMMENDATION 7

Companies making taxable purchases of technological assets should be permitted some depreciation and tax write-off of these assets in excess of the value of tangible assets. 40

RECOMMENDATION 8

In view of present information on the potential availability of venture capital, the Federal Government should take no action with respect to the establishment of new federally supported programs for the furnishing of venture capital. However, appropriate mechanisms should be developed to provide information on capital availability and the problems of new enterprise development at the regional level. 43

Sec. 1244 IRC *Losses on small business stock.* This section provides that "a loss on Section 1244 stock issued to an individual or to a partnership . . . shall be treated as a loss from the sale or exchange of an asset which is not a capital asset," and therefore, deductible from ordinary income. The loss on the sale or exchange of 1244 stock may not exceed $25,000, or $50,000 in the case of a joint return by a husband and wife for any taxable year.

1244 stock is defined as stock in a domestic corporation if (1) the corporation adopted a plan to offer the stock for a period specified in the plan, not exceeding two years after the date such plan is adopted; (2) the corporation was a small business when the plan was adopted (a corporation is a small business if "the sum of the aggregate amount which may be offered under the plan, plus the aggregate amount of money and other property received by the corporation, for stock, as a contribution to capital, and as paid-in surplus does not exceed $500,000; and the sum of the aggregate amount which may be offered under the plan, plus the equity capital of the corporation does not exceed $1,000,000"); (3) at the time the plan was adopted, no portion of a prior offering was outstanding; (4) the stock was issued, pursuant to such a plan, for money or other property, excluding stock and securities; and (5) the corporation, "during the period of its five most recent taxable years ending before the date of the loss on the stock is sustained . . . derived more than 50% of its aggregate gross receipts from sources other than royalties, rents, dividends, interest, annuities, and sales of stock or securities."

Appendix D

RELEVANT TAX PROVISIONS

Sec. 172 IRC — *Net operating loss deduction.* This Section permits a deduction, in the taxable year, for net operating loss carryovers and carry-backs to the taxable year. Net operating loss means the excess of allowable deductions over the gross income. A net operating loss can be carried over to each of the FIVE taxable years following the taxable year of such loss, and deducted from income.

Sec. 174 IRC — *Research and experimental expenditures.* This section permits a taxpayer to treat research and experimental expenditures, which are paid or incurred by him in connection with his trade or business, as current deductible expenses. It also contains the option to treat these expenditures as deferred expense which the taxpayer may amortize over a period not less than five years, beginning with the month in which he first realizes benefits from the expenditures.

Research and development experimental expenditures do not include expenditures made for depreciable research equipment nor for the cost of constructing depreciable property designed for production as distinguished from pilot model purposes.

Sec. 421 and 422 IRC — *Stock options.* Section 421 provides that no taxable income shall result from the transfer of a share of stock to an individual who has exercised an option that meets the requirements of Section 422. (Note: this section also applies to other stock option plans which are covered under Sections 423 and 424, but which are not applicable to the subject being considered here).

Section 422 defines a qualified stock option and lists two conditions which must be met before the exercise of such option will be accorded the treatment provided under Section 421, as described above. A qualified option

ceptance of the entire package. Only one licensee can grant licenses under the whole package. Licenses are on standard terms and royalties.

(b) The licensing party grants a license under the package to a foreign licensee, which is exclusive outside the U.S. The foreign licensee grants a return license under its patents, exclusive for the U.S., with rights to sub-license.

Situation 6: Company A licenses Company B under Company A's foreign patents in exchange for a license from Company B under Company B's U. S. patents.

Situation 7: A foreign company wants to get the benefit of the American market for a product involving technology not known in the U. S. It is unwilling to license a U. S. company for fear the latter will compete with it in its own markets, using its know-how. It introduces the new product into the U. S. market through a *joint venture* agreement with a U. S. company under which it retains a share of the profits and management authority. The new company created by the venture receives exclusive rights for the U. S. but no rights elsewhere. This is the only way that the technology is likely to get into the U. S. within a reasonable time, for the U. S. partner cannot itself develop the technology in a timely manner. Another U. S. company is the sole U. S. producer of the product, under a different, patented process. This U. S. company now dominates the field which the joint venture seeks to enter. Barring the joint venture, the parties to it might each have gone into the market separately, but this would have delayed the introduction of the product approximately eight years.

Situation 8: Two companies engage in a joint research activity, but exclude others from participating or obtaining licenses.

Situation 9: Several companies ask an independent R&D laboratory to do R&D for them, for the purpose of developing new processes in a certain industrial field. It is agreed that each must pay a certain amount per annum for this R&D, and each will have nonexclusive rights in the results. However, the final agreement to undertake the project is deferred pending the parties agreement on the legal implications of issues such as: (a) Must the project be open to all applicants on the same terms? (b) Since applicants in later years will not have paid as much as those in earlier years and will thus get the benefits of the R&D done with money contributed by the others in earlier years, can the later applicants be required to pay the assessments for prior years?

Situation 10: Corporation A acquires Corporation B, a research-oriented concern and a potential competitor of Corporation A, with the objective of expanding and enlarging Corporation B's research activities to cover as well the area in which Corporation A has been operating.

Name of Agency	Nature and Scope of Regulation	Statute
	prescribed in resale price maintenance agreements or contracts, whether or not the person so advertising, offering for sale, or selling is or is not a party to such an agreement or contract.	
D. *Unfair Methods of Competition*		
The President	Declares unlawful, unfair methods of competition and unfair acts in the importation or sale of articles into the United States with the effect or tendency of destroying or substantially injuring an industry, efficiently and economically operated, in the U.S., or to prevent the establishment of such an industry, or to restrain or monopolize trade and commerce in the U.S. The FTC is authorized to investigate possible violations, hold hearings, and report its findings to the President.	Unfair Practices in Imports Act, 46 Stat. 703; 19 U.S.C. 1337; P.L. 361, 71st Cong. (1930).
Federal Trade Commission	Specific practices declared to be unfair methods of competition are contained in the Federal Trade Commission Act (dissemination of or causing to be disseminated any false advertisement); Wool Products Labeling Act of 1939 (misbranding of wool products); Fur Products Labeling Act (misbranding of fur products); Flammable Farbics Act (manufacture, sale transportation, etc. of highly flammable wearing apparel); and Textile Fiber Products Identification Act (misbranding and false advertising of any textile fiber product), all of which are described in Part B of this compilation of laws.	
E. *Miscellaneous*		
Food and Drug Administration	Prohibits the adulteration or misbranding of any food, drug, device, or cosmetic and the introduction or delivery for introduction of any adulterated or misbranded food, drug, device or cosmetic in interstate commerce. Prohibits any act which causes a drug to be a counterfeit drug; or the sale or dispensing, or the holding for sale or dispensing, of a counterfeit drug.	Federal Food, Drug and Cosmetic Act, June 25, 1938, Ch. 675, Sec. 301; 52 Stat. 1042; 21 U.S.C. 331.

Name of Agency	Nature and Scope of Regulation	Statute
	conduct thereof, except to the extent that such business is not regulated by state law. It does not exempt Sherman Act application to any agreement to boycott, coerce, or intimidate or act of boycott, coercion, or intimidation.	
Small Business Administration	Provides that no act or omission to act in the formation of corporations provided for in this Act, if approved and found by the SBA as contributing to the needs of small business, shall be within the prohibitions of the antitrust laws. It also exempts, from the operation of the antitrust laws, any act or omission to act pursuant to and within the scope of any joint program for research and development under any agreement approved by the Administrator.	Small Business Act, 72 Stat. 388; 15 U.S.C. 636(a)(6); P.L. 85–536 (1958).
The President	Authorizes the President to encourage the making by representatives of industry, business, finance, agriculture, labor and other interests, of voluntary agreements and programs to further the objectives of the Defense Production Act of 1950. It exempts from the operation of the antitrust laws any act or omission to act pursuant to this act, if requested by the President pursuant to a voluntary agreement or program approved under the provisions of the Act and found by the President to be in the public interest as contributing to the national defense.	Defense Production Act of 1950, as amended, 69 Stat. 581, Sec. 6; 50 U.S.C. App. 2158; P.L. 295 (1955).
	Exempts from the operation of the antitrust laws any joint agreement, by or among persons engaged in the organized professional team sports of football, baseball, basketball, or hockey, by which any league or clubs participating in these sports sells the rights of such league's member clubs in the sponsored telecasting of the games engaged in by such clubs. The exemption is limited to this specific type of agreement only.	Telecasting of Professional Sports Contests, 75 Stat. 732, Sec. 1; 15 U.S.C. 1291–95; P.L. 87–331, 87th Cong. (1961).
	Provides that nothing in the antitrust laws shall be construed to forbid the existence and operation of labor, agricultural, or hor-	Clayton Act, 38 Stat. 731; 15 U.S.C. 17; P.L. 212, 63rd Cong. (1914).

Name of Agency	Nature and Scope of Regulation	Statute
Interstate Commerce Commission	Provides that the ICC shall approve any agreement between two or more carriers of the same class (except under certain situations) relating to rates, fares, classifications, divisions, allowances, or charges, if it finds such agreements will further the national transportation policy declared in the Act, and if so, the parties to the agreement shall be relieved from the operation of the antitrust laws.	Reed-Bulwinkle Act, amended the Interstate Commerce Act by adding this provision to it; 62 Stat. 472; 49 U.S.C. 5(b); P.L. 662, 80th Cong. (1948).
Federal Communications Commission	Permits telephone companies to consolidate or acquire the whole or any part of another telephone company and domestic telegraph carriers to consolidate or acquire all or any part of another domestic telegraph carrier, upon the approval of the FCC and its finding that such action will be of advantage to the persons to whom service is to be rendered and in the public interest. Upon such approval such consolidations or mergers shall be exempt from any laws making consolidations and mergers unlawful.	Communications Act of 1934, 48 Stat. 1064; 46 U.S.C. 151 ff; P.L. 416, 73rd Cong.; as amended, 70 Stat. 932, Sec. 3; 47 U.S.C. 221(a); P.L. 915, 84th Cong. (1956).
Secretary of Agriculture	Permits the Secretary to enter into agreements with manufacturers and others engaged in the handling of anti-hog-cholera serum and hog-cholera virus for the purpose of regulating the marketing of such serum and virus in order to maintain an adequate supply. Such agreements are specifically exempt from the antitrust laws.	Anti-Hog-Cholera Serum and Hog Cholera Virus Act, 49 Stat. 781; 7 U.S.C. 851 ff; P.L. 320, 74th Cong. (1935).
Secretary of Agriculture	Permits persons engaged in the production of agricultural products to act together in associations, corporate or otherwise, in collectively processing, preparing for market, handling, and marketing in commerce such products. The Secretary is authorized to issue a complaint and hold a hearing to determine whether any such association monopolizes or restrains trade to such an extent that the price of any agricultural product is unduly enhanced. He also has the authority to issue a cease and desist order.	Capper-Volstead Act, 42 Stat. 388; 70 U.S.C. 291 and 292; P.L. 146, 67th Cong. (1922).

Name of Agency	Nature and Scope of Regulation	Statute
Federal Deposit Insurance Corporation Comptroller of the Currency Board of Governors of the Federal Reserve System	Prohibits the merger, acquisition, or consolidation of an insured bank with any other insured or non-insured bank without the consent of one of the listed agencies, depending upon whether the bank involved in the merger is a National Bank, State Bank (member of FRS), or a non-insured bank. The Act sets forth the criteria upon which the agency shall determine its approval or disapproval of a proposed merger.	Federal Deposit Insurance Act, 64 Stat. 873; 12 U.S.C. 1828(c), as amended by the Bank Merger Act; P.L. 89-356, 89 Cong. (1966).
Federal Communications Commission	Prohibits interlocking directorates between or among carriers subject to this Act, unless holding the position of director or officer in more than one carrier is authorized by the Commission upon the finding that neither public nor private interests will be adversely affected thereby.	Communications Act of 1934, 49 Stat. 1087; 47 U.S.C. 314; P.L. 416, 73rd Cong.; as amended, 70 Stat. 931, Sec. 1; 47 U.S.C. 212; P.L. 899, 81st Cong. (1956).
Federal Communications Commission	Provides that no person engaged in the business of transmitting and/or receiving for hire, energy, communications, or signals by radio shall purchase, lease, or otherwise acquire control or operate any cable or wire telegraph or telephone line system if the purpose or effect thereof may be to substantially lessen competition or restrain commerce, or unlawfully to create a monopoly in any line of commerce. The same prohibition applies to a telegraph or telephone line system acquiring or merging with a business engaged in transmitting and/or receiving communications by radio.	Communications Act of 1934, 41 Stat. 1087; 47 U.S.C. 314; P.L. 416, 73th Cong.
Federal Communications Commission	Specifically provides that Sherman Act prohibitions apply to the manufacture, sale of and trade in radio apparatus and devices affecting interstate commerce. In addition, a license issued under the provisions of this Act shall be revoked when any licensee is found guilty of violating the provisions of the antitrust laws.	Communications Act of 1934, as amended by 74 Stat. 893, Sec. 5(b); 47 U.S.C. 313; P.L. 86-752 (1960).
C. *Exemption from Antitrust Laws*		
Federal Trade Commission	Provides that an association, entered into for the sole purpose of engaging in export trade and actually engaged solely in export trade, is exempt from Sherman Act violations pro-	Webb-Pomerene Act, 40 Stat. 516; 15 U.S.C. 61-65; P.L. 126, 65th Cong. (1918).

Name of Agency	Nature and Scope of Regulation	Statute
	such products on consignment or on any basis other than a bona fide sale. It also prohibits interlocking directorates in companies engaged in business as a distiller, rectifier or blender of distilled spirits.	
Secretary of Commerce	The Secretary of Commerce at his discretion may declare any person or corporation, convicted of a violation of that section of the Merchant Marine Act, 1936, listed above, ineligible to receive any benefits or a charter under the provisions of that Act.	Merchant Marine Act, 1936; 49 Stat. 2014, Sec. 806(C); 46 U.S.C. 1228; P.L. 835; 74th Cong.
Postmaster General	The Postmaster General is authorized to employ any means to provide for the inland transportation of mail by star routes, without reference to laws concerning the employment of personal services or the procurement of conveyances, materials, or supplies, whenever he has reason to believe that a combination of bidders has been entered into to fix the rate for star-route service or the bids are exorbitant or unreasonable.	39 Stat. 161; 39 U.S.C. 433 (1916).
The President	The President may direct the manufacture of naval aircraft engines, parts and equipment at any Government Plant if it reasonably appears that persons or firms bidding on the construction of these items have entered into agreements to restrict competition in the letting of the contracts for such work.	70A Stat. 454; 10 U.S.C. 7343; P.L. 1028, 84th Cong. (1956).
Administrator of General Services	All executive agencies are required to obtain clearance from the Attorney General on the question of whether the disposal of plant, plants, or other property would tend to create or maintain a situation inconsistent with the antitrust laws. In addition, the Administrator of General Services is required to furnish the Attorney General such information as is necessary for the latter to determine whether any disposition of surplus property violates or would violate any of the antitrust laws.	Federal Property and Administrative Services Act of 1949, 63 Stat. 391; Title II, Sec. 207; 40 U.S.C. 488; P.L. 152, 81st Cong.
Department of Defense	The head of an agency is authorized to negotiate contracts for the purchase of property or services which are required to be made by formal advertising, where he determines that the bid prices received after	Armed Services Procurement Act, 70A Stat. 127; 10 U.S.C. 2304–2305; P.L. 1028, 84th Cong.; 78 Stat. 341; P.L. 88–390 (1964)

Name of Agency	Nature and Scope of Regulation	Statute
Federal Trade Commission	Amended Section 2 of the Clayton Act. In addition, it forbids the payment of a broker's commission in cases where an independent broker is not employed. It forbids sellers to provide supplementary services rendered them by buyers unless available to all buyers on proportionally equal terms. It forbids the establishment, in one locality of prices lower than those charged elsewhere, and prohibits the sale of goods at unreasonably low prices for the purpose of destroying or eliminating a competitor.	Robinson-Patman Act, 49 Stat. 1526; 15 U.S.C. 13, 13a, 13b, 21a; P.L. 692; 74th Cong. (1936).
Secretary of Treasury	Imposes a double duty on any article imported into the U.S. under an exclusive dealing or selling agreement, but does not apply to the establishment of an exclusive agency in the U.S. by the foreign producer.	Revenue Act 1916, 39 Stat. 798; 15 U.S.C. 71–77; P.L. 271; 64th Cong. (1916).
Secretary of Agriculture	Declares unlawful, the manipulation or attempt to manipulate the price of any commodity in commerce or for the future delivery on any board of trade. It also prohibits the cornering or attempt to corner any commodity, or knowingly or carelessly delivering or causing to be delivered for transmission through mails or otherwise in interstate commerce, false and misleading reports concerning crops or market information or conditions that affect the price of grain in commerce.	Commodity Exchange Act, as amended by 49 Stat. 1491; 7 U.S.C. 13; P.L. 675, 74th Cong. (1936).
Secretary of Agriculture	Authorizes the Secretary of Agriculture to require all contract markets to suspend all trading privileges and to suspend or revoke the registration, as a future merchant or floor broker, of any person who is found, after a hearing, to have violated any provision of the Commodity Exchange Act, rules and regulations issued pursuant thereto, or has manipulated or attempted to manipulate the market price of any commodity in interstate commerce.	Commodity Exchange Act, as amended by 49 Stat. 1498; 7 U.S.C. 9; P.L. 675, 74th Cong. (1936).
Secretary of Interior	Provides that any lease, option or permit used under the Mineral Leasing Act of February 25, 1920, shall be forfeited by appropriate court proceedings if any lands or deposits shall be subleased, trusteed, or controlled so that they form an unlawful	Mineral Leasing Act of Feb. 25, 1920, 41 Stat. 488; 30 U.S.C. 184; P.L. 1461, 66th Cong.; amended, 74 Stat. 781, P.L. 86–704, Sec. 3(k).

Appendix B

MAJOR FEDERAL POLICIES THAT REGULATE COMPETITIVE ACTIVITIES AND PRACTICES

Name of Agency	Nature and Scope of Regulation	Statute
A. *General Provisions* (NOT LIMITED TO A SPECIFIC AGENCY)	Declares unlawful (1) contracts, combinations, and conspiracies in restraint of trade, and (2) the monopolization or attempt to monopolize trade.	Sherman Act, 26 Stat. 209; 15 U.S.C. 1–7; Public Law No. 190, 51st Cong. (1890).
	Declares unlawful, price discrimination, exclusive dealing arrangements, and mergers and acquisitions by corporations that may lessen competition or tend to create a monopoly. It also places restrictions on interlocking directorates among banks and among corporations.	Clayton Act, 38 Stat. 730; 15 U.S.C. 12ff.; P.L. 212, 63rd Cong. (1940).
	Declares unlawful, any contracts, combinations and conspiracies by persons or corporations engaged in importing articles from a foreign country into the U.S. which restrain trade or are intended to increase the price of articles imported into the U.S.	Wilson Tariff Act, 28 Stat. 570; 150 U.S.C. 8–11; P.L. 227, 53rd Cong. (1894).
	Declares unlawful, the importation and sale, by persons engaged in importing articles from a foreign country into the U.S., of articles within the U.S. at a price substantially less than the actual market value or wholesale price of such articles in the principle markets of the country of their production, or other foreign countries where they are exported, after allowance for freight, duty, and similar expense.	Revenue Act, 1916, 39 Stat. 798; 15 U.S.C. 71–77; P.L. 271, 64th Cong. (1916).
	Declares unlawful, the disclosure of the amount or terms of a bid, or any combination or agreement that would deprive the U.S. of the benefit of full, free and secret competition in the awarding of a contract or charter under the Merchant Marine Act of 1936. It declares unlawful any agreement or concerted action by any contractor or charterer of vessels under the Act which is unjustly discriminatory or unfair to any citizen who operates a common carrier by water.	Merchant Marine Act, 1936; 49 Stat. 2014; 46 U.S.C. 1224, 1227 and 1228; P.L. 835, 74th Cong.

Appendix A

PANEL MEMBERS AND THEIR ASSOCIATES

The Panel

Robert A. Charpie (*Chairman*) is President, Union Carbide Electronics.

Lawrence S. Apsey is General Counsel, Celanese Corporation of America.

John F. Costelloe is an attorney and member of the firm of Chadbourne, Parke, Whiteside and Wolff.

John F. Dessauer is Executive Vice President for Research and Engineering, Xerox Corporation.

John McK. Fisher is a consultant, Schenley Industries, Inc.

Aaron J. Gellman is Vice President, North American Car Corporation.

Peter G. Goldmark is President, CBS Laboratories.

Earl W. Kintner, former Chairman of the Federal Trade Commission, is a member of the firm of **Arent, Fox, Kintner, Plotkin and Kahn.**

Mark S. Massel is a member of the Senior Staff, Brookings Institution.

Richard S. Morse is a senior lecturer, Sloan School of Management, Massachusetts Institute of Technology, and former Assistant Secretary of the Army for Research and Development.

Peter G. Peterson is President, Bell and Howell Company.

Sidney I. Roberts is an attorney and member of the firm of Roberts and Holland.

Dan Throop Smith is Professor of Finance, Graduate School of Business Administration, Harvard University.

John C. Stedman is Professor of Law, University of Wisconsin School of Law.

William R. Woodward is General Patent Attorney, Western Electric Company.

Daniel V. De Simone (*Executive Secretary*) is Director of the Office of Invention and Innovation in the National Bureau of Standards.

VI

CONCLUSIONS AND OVER-ALL RECOMMENDATION

One more recommendation remains and it is, in our view, of key importance. We have stressed the reason for it throughout this report. It has to do with the abundance of ignorance about the processes of invention, innovation and entrepreneurship.

For whether we talk about the problems and contributions of a large or small company, a regulated or unregulated industry, or an individual inventor or entrepreneur, there is too little appreciation and understanding of the process of technological change in too many crucial sectors:

—Throughout much of the Federal Government.
—In some industries.
—In many banks.
—In many universities.
—In many cities and regions.

More important, therefore, than any specific recommendation concerning antitrust, taxation, the regulation of industry, or venture capital, is one central proposal:

> The major effort should be placed on getting more managers, executives, and other key individuals—both in and out of government—to *learn, feel, understand* and *appreciate* how technological innovation is spawned, nurtured, financed, and managed into new technological businesses that grow, provide jobs, and satisfy people.

We therefore propose a high-level conference on technological innovation to dramatize the importance of this vital process, and urge that this conference be followed by a nationwide program for broadening recognition,

—Since the conditions to which it addresses itself are dynamic, not static, and also massive and complex, it should be a permanent entity.

—It should give appropriate attention to the need for clarity and administrability and to the importance of accommodation, insofar as possible, to existing procedures and structures of authority.

—Although its responsibilities should be primarily to the appropriate governmental agencies, its operations should be conducted with full attention to the need for informing and generally advising interested parties and the public, as well.

With these considerations in mind, we urge that such a group be formed.

RECOMMENDATION 13

A group should be established within the Federal Government to aid and advise the regulatory and antitrust agencies by performing such activities as:

(1) Developing criteria for helping these agencies judge the impact of antitrust and regulatory policies on invention and innovation.

(2) Systematically analyzing the consequences of past antitrust and regulatory activities in light of these criteria.

(3) Advising the responsible agencies on the probable consequences of proposed policy changes affecting invention and innovation.

(4) Providing technological forecasts as an additional factor for antitrust and regulatory planners to weigh in their policy formulations.

We would be remiss if we did not point out that we had much difficulty on the question of where this group should be located in the Federal Government. We have already explained that the objectivity it must rigorously pursue requires that it not be a part of any of the agencies responsible for *administering and enforcing* the antitrust and regulatory laws.

If we consider again the large number of independent agencies affecting competition (See Chart 20), it is not difficult to understand the need for some *central* location of the group we propose. The issues with which it would deal stretch from one end of Washington to the other. The most logical housing for such a group would therefore be in the Executive Office of the President, but we are aware of the reluctance to add "appendages" to that Office.

In any event, we have chosen *not* to make any specific recommendation as to the location of the proposed group. We would only urge that its initial

petition and innovation to the extent that this can be done, by minimizing or eliminating the conflicts to the extent possible. Where this cannot be done, we must decide under what circumstances the one or the other shall prevail.

The formulation of procedures in this area poses a dilemma: The desirability, and hence the ultimate legality, of a given restriction may turn upon the nature of the transaction, its subject matter and the economic and technological status of the parties affected. This suggests a case-by-case, *rule-of-reason* approach, guided by the sometimes conflicting objectives of promoting innovation and of preserving a satisfactory competitive structure. At the same time, it is important to formulate relatively *certain* rules in order to tell businessmen what they can and cannot do and to preserve the effectiveness and administrability of the antitrust and related laws. This suggests the development of *per se* doctrines, trade regulation rules, and the like.

We cannot have it both ways. It may, however, be possible to resolve the dilemma, partially at least, by two means. First, by defining those circumstances and practices that push so *predominantly* toward a given result as to justify a conclusion that they should be deemed, at least presumptively, permissible or prohibited. Second, by suggesting criteria and procedures (within existing procedural frameworks, to the extent possible) for resolving the more uncertain and debatable issues in a manner that promotes the public interest and is reasonably satisfactory to the affected parties.

The achievement of these goals will be no easy task. In few, if any, of the gray areas under discussion does our present knowledge and understanding provide a basis for firm answers. *To suggest significant judgmentive changes of policy in the absence of the empirical data and analysis needed to support such changes, would therefore be irresponsible.*

RECOMMENDATION 12

We recommend, at this time, no legislative changes in the antitrust and regulatory laws. However, we do recommend that in the interpretation and administration of these laws, the effect on innovation, as well as on competition, be taken into account.

4. AN ANALYTICAL AND ADVISORY RESOURCE FOR THE ANTITRUST AND REGULATORY AGENCIES

We need empirical data. How are we to get them? How are we then to arrive at sound interpretations of the facts? While there can be no assurances of certain success, we suggest certain premises and considerations for the satisfactory performance of these tasks:

(1) To avoid unnecessary injury to either competition or innovation, those responsible for making and carrying out policy in these fields must have

condoned, but affirmatively encouraged in the public interest. Such activity poses no antitrust problem in the restraint-of-trade sense. Monopoly problems can arise, but they rarely do. Even if they do, both judicial and statutory law tend to accept this in the interests of encouraging individual effort. The policy seems to have worked reasonably well.

Similarly, there is no problem with respect to cooperative innovative activities, *as such*. The attack upon a given problem by two or more minds, instead of one, or through two or more sets of resources (know-how, assets, managerial skills, equipment, and the like) instead of one, seems as likely in most instances to produce beneficial results in this as it does in other fields of cooperative endeavor. The same is generally true of cooperation in removing legal and other impediments to innovation through the licensing of patents, the release of secret processes and know-how, and other transfers of technological property.

Restrictive agreements involving the use or non-use of technological property are more of a problem. Here, conflicts between our innovative and competitive goals do arise. Such agreements may restrain trade, create monopolies or otherwise distort the competitive balance.

These restrictive agreements may take various forms:

—Parties may agree not to compete with each other or with third parties. They may do this directly by means of patent licenses and other agreements containing price, geographic, field-of-use or other restrictions, or indirectly by royalty arrangements that impede or discourage competition.

—They may boycott or otherwise injure third persons, or obstruct channels of distribution, and at the same time adversely affect innovation by means of closed pools, tie-in arrangements, discriminatory conditions as between different licensees, and so on.

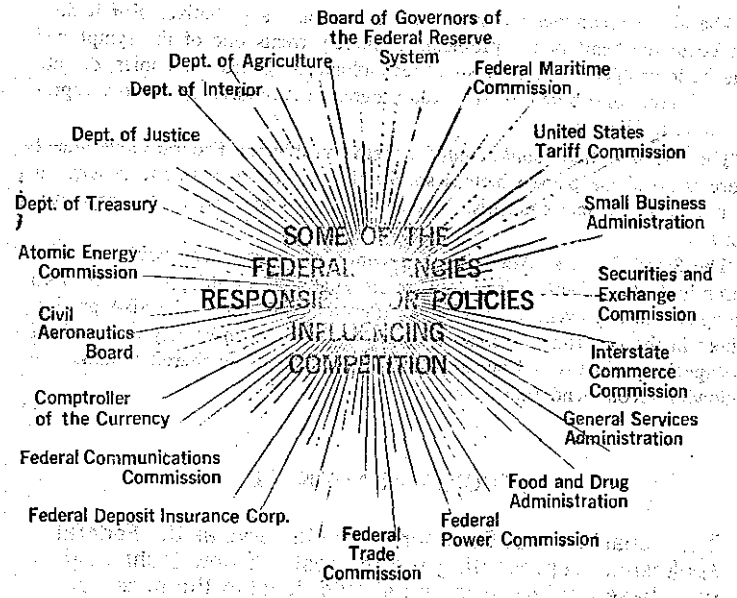
—They may lessen the incentive to engage in competitive innovation by imposing limitations upon the use of new technology developed or acquired by the licensee or upon methods of distribution.

—They may cause competitive imbalance through excessive acquisition of technological property by purchase, merger or grant-back.

Arrangements such as those we have noted above may be quite ambivalent from the standpoint of both innovation and competition. They may stimulate innovation or they may retard it. They may strengthen competition or weaken it. It may be extraordinarily difficult, in short, to reach firm conclusions as to the extent to which a given practice promotes or retards innovation, on the one hand, and competition on the other.

It may be even more difficult to assess the *relative* merits or demerits of such arrangements in terms of the respective objectives, or to determine where, on balance, the public interest lies. In the formulation of policy, the difficulties in defining and measuring the nature and extent of benefit or detriment in terms of innovative and competitive effects are compounded when one attempts to balance the one against the other. This is so whether the

CHART 20



The purpose of this chapter is to examine an important facet of this complex system. What we hope to do is clarify some of the issues concerning the interfaces between competition, antitrust, regulation and technological innovation.

1. THE NEED FOR CLARIFICATION

The necessity for our examination is perhaps obvious: Our central concern is innovation and its stimulus and promotion. Such promotion requires appropriate attention and adjustment to *other* public policies—among them, antitrust and regulatory policies, which we lump, for convenience, into what we call "competitive policy." Hence, it becomes necessary to examine the interrelationship between innovation and competition, understand their interaction, lay bare the apparent or hidden conflicts between them, and suggest means for resolving or minimizing these conflicts.

We subscribe to both of the public policies involved here: (1) the preservation of a satisfactorily balanced, competitive enterprise system, and (2) the promotion of invention and innovation. The former is reflected in our laws on restraint of trade, monopolization, regulation and unfair methods of competition. The latter includes both technological and commercial activities, and both private and governmental actions.

2. GOVERNMENT CONTRACTING AND THE SMALL FIRM

In the past, government contracts have been one of the most important sources of business for the initiation of new technologically based enterprises. Nevertheless, the small business "set-aside" program, which purports to set aside contracting opportunities for small businesses, does not provide them with any real hope for success in the highly competitive research and development business associated with today's defense and space programs. It should be noted, also, that the total percentage of Federal work performed by small companies has decreased in the last five years.

Current Department of Defense (DOD) and National Aeronautics and Space Administration (NASA) contracting trends, the rapidly increasing costs of doing R&D, and the increased critical size required for a successful business operation, all work against the interests of small technologically oriented ventures. In addition, increasing competition from in-house government laboratories and "nonprofit" firms that are DOD and NASA captives, and the greatly increased costs of preparing proposals for government R&D contracts and of private representation in Washington, have all substantially reduced the prospects for success by the small company.

The large technologically based company (which, as we have noted, probably had small beginnings itself) can bid a fixed price under the current fixed-price R&D contracting procedures that may clearly be a losing proposition—in the short term. In the long term, however, the bid may be a winner in terms of lodgement in the technological field involved. For example, assume a large company bids $300,000 below the estimated cost of a contract. Generally, a small firm cannot compete in this way. If it loses $300,000, it has probably committed suicide; it is out of business. As Professor Corwin Edwards of the University of Oregon expresses the problem, a large economically powerful firm ". . . can outbid, outspend, and *outlose* a small firm. . . . If it overdoes its expenditures, it can absorb losses that would bankrupt a small rival." [11]

As an important first step in bringing these problems to the attention of government contracting agencies, we make the following recommendation.

RECOMMENDATION 10

An interdepartmental ad hoc review of current contracting policies and procedures of such agencies as the Department of Defense, the National Aeronautics and Space Administration, the Atomic Energy Commission, and the National Institutes of Health, to ensure that these policies are conducive to the long-range growth of small enterprises.

[11] *Testimony in hearings on Economic Concentration before U.S. Senate Antitrust Subcommittee, 88th Cong., Part I* Overall and Conglomerate Aspects *(Government Printing Office, 1964), p. 42.*

2. VENTURE CAPITAL AND JOBS

A recent study conducted by the Sloan School of Management at the Massachusetts Institute of Technology, examined the job-creating power of venture capital. We have tabulated the data developed in that study in the following chart.

CHART 19

VENTURE CAPITAL DOLLARS PER JOB: AN ILLUSTRATION

No. of Companies	21
Average Time Period	4.2 Years
Increase in Sales - Average	$ 3,657,000
Increase in Sales - Total	$76,806,000
Increase in Employment - Average	147
Increase in Employment - Total	3,096
Initial Venture Capital - Average	$ 225,000
Initial Venture Capital - Total	$ 4,720,000
Initial Venture Capital Requirement	$ 1,525 Per Job

This does not take into account the additional, derivative employment resulting from these primary jobs.

Source: Sloan School, Massachusetts Institute of Technology.

There were twenty-one companies in the survey. All were private, technological ventures. In an average period of a little over four years, the average increase in sales for these companies was approximately $3½ million; the total increase in sales was roughly $75 million. The average increase in employment over that period was 147 jobs; the total increase for all of the companies was 3,096 jobs. The average venture capital investment in these companies was $225,000, the total venture capital investment having been almost $5 million.

We note from the above data that roughly $1500 of venture-capital investment resulted in one primary job. We realize that there may be objections with respect to the adequacy of these data—for example, the sample was limited to the Boston area. Nevertheless, despite the deficiencies that purists may find in these data, they do illustrate the significant contribution of technological ventures to employment. For whether the amount of venture capital per job was $1500 or $2500 or, indeed, $3500 (which allows for a substantial margin of error), this still represents a very powerful job-creating capacity per risk-dollar utilized. Moreover, it should be understood that the data in Chart

were had with a number of Small Business Investment Companies (SBIC's), investment trust firms, wealthy individuals, and investment bankers engaged in organized venture capital investment activities. We heard testimony from a number of successful entrepreneurs and individual inventors who depend upon securing venture capital in their present business operations.

On the basis of these discussions we have made some rough estimates of the amounts of potentially available venture capital from various sources. Our estimates indicate that more than $3 billion of potentially available capital exists in this country. This by no means indicates that all of the holders of such capital are actively seeking investment opportunities or that the techniques and communication mechanisms for approaching capital sources are necessarily known to individuals with worthwhile projects requiring financial support. The potential availability of such an amount of money, however, indicates that factors other than money alone determine the rate of new-enterprise funding.

Let us discuss, for a moment, some of the sources of venture capital in the United States.

a. Personal Wealth—This country now has over 65,000 individuals each with a net worth in excess of $1,000,000. In addition, there are a large number of family fortunes which, in the aggregate, exceed several billions of dollars. We have also identified as a separate category, successful entrepreneurs who have prior experience in the field, and are in a position to assume the role of venture capitalists. For example, some twenty experienced and successful technical entrepreneurs in the Boston Route 128 complex alone, currently have a total *personal* net worth in excess of $500,000,000.

b. Insurance Companies, Investment Funds, Trusts—A number of less conservative insurance companies are engaged in financing speculative ventures—at least the "Second Stage" businesses we identified in our discussion of the small company environment (See Chapter III). In addition, publicly owned investment funds, such as American Research and Development, and organized, family-owned venture capital operations, represent a sizeable source of venture capital. These organizations have a high degree of sophistication and appraisal experience with respect to technological opportunities.

c. Corporate Sources—Within the past few years a number of large corporations have entered the venture capital business and have initiated the financing of new technological ventures. Although it is too early to appraise the impact of this development, the potential capital availability is obviously large. An important factor with respect to corporate sources of funds is that they may also provide knowledge of markets, management skills, and other aids that are, as we saw, essential to the success of a beginning firm. On the other hand, conflicts of interest and the frequent lack of knowledge on the part of the large corporation of the unique problems of small companies may present major difficulties.

d. Investment Bankers and Underwriters—The investing public becomes, through underwriters, a source of venture capital. For example, we found that in 1961 it was common to finance a wide variety of highly speculative electronic ventures through this public source of financing. Increased public interest in such schemes occurs from time to time, depending upon investment

In the case of any capitalized expenditure, a deduction for the cost is written off over the estimated useful life of the asset acquired, provided that its useful life is determinable with reasonable accuracy. For example, in the case of a secret formula, generally no deduction is allowable for its cost against the income earned therefrom, until such time as the process becomes completely worthless. This result is premised on the assumption that a secret process has an indefinite life, an assumption made doubtful in many cases by the rapid changes in modern technology. Moreover, the advantage of the current deduction for self-developed innovations over purchased innovations tends to discourage the acquisition by purchase rather than development, especially in light of uncertainty as to the proper write-off period, and this may operate to the disadvantage of the small innovator seeking to sell his innovation.

The Treasury Department's concern over any step that might tend to erode the principle of no tax write-offs for "good will" is understandable. Yet, the equally legitimate concern over the rate of technological diffusion suggests serious consideration be given to that portion of "good will" that can logically be attributed to technological assets. The ability to write off patents but not technology creates a distinction that is neither logical nor meaningful.

We do not propose that a general assault be made on the "good will" principle. Rather, we seek to encourage the spread of innovation by permitting the depreciation of purchased technological assets in certain limited cases. Accordingly, we make the following recommendation.

RECOMMENDATION 7

Companies making taxable purchases of technological assets should be permitted some depreciation and tax write-off of these assets in excess of the value of tangible assets.

Such treatment could be limited in the following ways:

(1) Only taxable purchases (for example, in cash) would qualify; tax-free acquisitions in exchange for stock would not be entitled to such treatment.

(2) Purchasers would be required to distinguish the technological components of the intangible assets—e.g., know-how—from "good will" elements, such as trade names and marks.

(3) To remove some of the ambiguity, the purchaser of such qualifying technological assets could be assured that he could write off a certain minimum portion (say, 50%) of the excess of the purchase price over the value of the tangible assets (including cash and accounts receivable).

(4) The burden of proof would be on the purchaser to validate the values of technological assets above the level of tangible assets—for example, by estimating costs of duplicating know-how, if the company had developed it internally.

RECOMMENDATION 5

Research and development expenditures incurred to develop new products or processes should not be disallowed as a business deduction merely because they are unrelated to a taxpayer company's current products or processes.

5. THE PROFESSIONAL INVENTOR

Under present law, an individual patent owner receiving compensation for the sale or use of his patent may be entitled to capital gains treatment under two separate but overlapping provisions of the Internal Revenue Code. If he is an *"amateur"* inventor, he may be entitled to capital gains treatment under the general provisions of the Law (Internal Revenue Code Section 1222). These provisions are applicable to capital transactions in general and not just to patents. He is an "amateur" if he is not holding the patent for sale to customers in the ordinary course of his business. If he is a "professional" inventor, however, he must look to Section 1235 of the Internal Revenue Code, which permits the capital gains treatment to an inventor if he transfers substantially all of his rights in the patent.

Under the Treasury Regulations,[7] the requirements to qualify under Section 1235 are more stringent than the requirements developed by some courts with respect to the general provisions of the Code.[8] Thus, under these general provisions, an amateur inventor may realize a capital gain on a grant of rights in a patent limited to a specific field of use (for example, the field of radio and television), while retaining the rights to other fields (for example, computers or telephone equipment). Or he may limit a patent license to a particular geographical area of a country (for example, the West Coast), while retaining all rights in the remainder of the country. But a professional inventor loses the capital gains advantage if he imposes either of these limitations in a license of his patent, for Section 1235, as interpreted, does not permit such limitations.

These more stringent requirements imposed under Section 1235 can operate as a disincentive to the diffusion of technology. Requiring a professional inventor who seeks to comply with Section 1235 to forego, in effect, possible applications of his invention is, it seems to us, against the public interest. For there are inventions which have diverse applications, and in these instances no *single* licensee or purchaser may be able to pursue all of the invention's possibilities.

In effect, we ask the inventor to make a complete commitment to a particular company or person who will presumably exploit the invention. Because of this complete commitment, it is no surprise the inventor's asking price is high. It is high because (1) he realizes that this is "his only chance" to receive the capital gains treatment and (2) he tries at the outset to be assured of a subs[illegible]

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[7] *Treas. Reg. Sec. 1.1235–2(b)(1)(1965); Treas. Reg. Sec. 1.1235–2(c)(1)*

[8] *See, for example,* Dairy Queen, Inc. v Commissioner, *250 F.2d 50 (1957);* Thornton G. Graham, *26 T.C. 730(1956);* Gowdey v. Commissioner, *F.2d 816(4th Cir. 1962);* Molberg v. Commissioner, *305 F.2d 800 (5th Cir.*

a net, national gain in industrial innovation if these small technological based companies could attract more skilled, *managerial* talent from the *larg* companies. Liberalized stock options for these small companies could be a important incentive.

RECOMMENDATION 2

We recommend a liberalization of the stock option rules for small technologically based companies by (1) extending the permissible option period from a maximum of five years to ten years, and (2) reducing the holding period required to receive capital gains treatment to less than three years, preferably to six months.

4. CRITERIA FOR R&D DEDUCTIBILITY

a. Casual Inventors and Innovators Judicial decisions under Section 17 relating to the allowance of a current deduction for research and developm expenses, *disallow* such a deduction to "casual" inventors and innovators w are not engaged in a trade or business at the time the expenditure is incurr We cite, for example, the following cases:

—T. R. Ewart, Tax court Memo (1966) (deduction disallowed to a pub relations executive who sought to promote a novel candy-dispensing to

—John F. Koons, 35 T.C. 1092 (1961) (deduction disallowed to a vertising executive for payments to develop an invention unrelated to advertising business);

—Charles H. Schafer, P–H T.C. Memo P64, 156 (1964) (deduct denied lumber salesman on the ground that his invention did not consti a separate going trade or business);

—William S. Scull II, P–H T.C. Memo P64, 224 (1964) (deduct denied president of instant coffee corporation on the ground that he w not personally engaged in the coffee business).

We recognize that appropriate safeguards are necessary to protect aga deductions for "hobby" expenditures, and feel that such safeguards can erected without denying a deduction to bona fide inventors and innova who incur out-of-pocket expenses for the *purpose of ultimately producing come*. Among the safeguarding factors which, in various combinations, tend to show bona fide inventive activity, are the filing of an application patent; diligent prosecution of the application; the borrowing of capital finance the inventive activity in question; a contingent fee arrangement the inventor's attorney; efforts to license, assign or otherwise exploit patent or prospective patent.

We are aware of the Treasury Department's reluctance to draw a generous line between the "casual inventor" and the "inventor-busine and are also aware that it is not easy to differentiate between a hobby an inventor who intends to go into business. But the answer to this d is not to draw the line at the point where the inventor is already in b before these expenses can qualify as deductible expenses, for to do s

RECOMMENDATION 1

We recommend that losses of small, technologically based companies, meeting criteria along the lines we have suggested, be allowed as a carry-forward against profits of the succeeding ten years instead of only five years.

This would assure those businesses which contemplate a longer than five year period of development that the Government would bear an equitable share of the losses, as it does in the case of the large profitable enterprises. Such an extension of the loss carry-forward period for small technologically-based companies would certainly help to equalize their treatment with that of the larger profitable organizations.

And yet, conceptually, it is clear that our recommendation is really only a *partial* equalization of treatment. The large corporation is often a conglomerate of a number of different businesses, some profitable and others not. In particular, the new and innovative businesses are often not profitable, at least for some time. The Government shares *currently* these losses of large profitable companies.

On the other hand, the small, technologically based company, as we have seen, often has its total commitment in one or a very limited number of product lines. Thus, its losses from its new product lines may often be unaccompanied by offsetting profits from profitable product lines.

We have explored the concept of suggesting that the Government share *annually* in the losses of these small, technologically based companies through a *tax credit*—a negative tax, as it were. It has been suggested that the concept of the Government's sharing in the losses (they share in the gains) makes good economic sense—particularly since this kind of firm contributes significantly to invention and innovation. Nevertheless, we are aware of the political and philosophical objections to such a proposal. We are not inclined to favor a tax recommendation as far-reaching as this at a time when even the most "conservative" and "modest" proposals for tax incentives are likely to be viewed with great caution, both by the makers of fiscal policy and respected commentators in the field.[4] However, we would be remiss if we did not point out that we seriously debated the merits of such a proposal and there is something to be said for it conceptually.

3. A LIBERALIZED STOCK OPTION FOR THE SMALL FIRM

There are few subjects less popular and perhaps less likely to receive favorable consideration than any proposal for the liberalization of stock options.[5] And yet, our study of small technologically based companies indicates they and the pace of their innovation have probably been affected adversely by the tightened provisions of the 1964 tax revisions. We note the following chart three of the major stock option revisions that were enacted in 1964.

[4] *See, for example, Peckman,* Federal Tax Policy, *Brookings Institution.*
[5] *See, for example, Eisenstein,* The Ideologies of Taxation, *Ronald Press.*

appear from the study that Section 1244 (which allows an ordinary deduction, instead of a capital loss, for losses incurred in the stock transactions of certain small business corporations) did not have a substantial influence on many of these companies. Because a tax provision of such potential benefit is still apparently not widely appreciated and used, one is led to conclude that not enough is being done to provide better education for administrators, businesses, and individuals on the availability and meaning of *existing* tax provisions. One needs to ask, moreover, whether a given tax problem, such as that to which Section 1244 was directed, while noticed by sophisticated tax experts, really affects only a very small percentage of the potential innovators.

To propose that far-reaching, across-the-board tax benefits are the major requirement for higher levels of innovation requires an explanation of why, with existing tax benefits, some areas like Boston, Palo Alto, Pittsburgh, and northern New Jersey have produced many more technologically based innovative companies than have other major areas with equivalent or greater numbers of scientists. A study we have already alluded to suggests that other factors—attitudes of universities and banks, for example—play a major role.[3]

Thus, where we were not impressed that a *pervasive* and *important* need existed for a tax proposal, we were not persuaded to recommend it, however technically elegant the proposal may have been. On this basis, we eliminated a large number of specific, technical tax recommendations that may have made sense in their own terms, but which, in our view, were likely to have limited impact. In this process of selection, we have focused on the special problems of the inventor, the entrepreneur and the small technological enterprise. We turn now to our specific proposals.

2. MORE TIME FOR SMALL BUSINESS DEDUCTIONS

A large corporation engaged in research, development and innovation projects generally has profits against which losses incurred on these projects may be deducted. As a result, it may be said that the Government shares in the cost of these innovation losses to the extent of 48% of the cost. On the other hand, a small corporation that has no profits from which it may deduct R&D expenditures bears the entire cost of that expenditure. While those losses may be carried forward against profits of the succeeding five years, this places the unprofitable corporation in a disadvantageous position as compared with the large corporation, because (1) the Government's contribution is deferred until profits are realized, and (2) if profitable operations are postponed beyond the fifth year after the loss is incurred, the Government is never called upon to "contribute" its share of the loss. A similar result obtains in the case of the individually operated business, except that here the time limitation on the loss carry-over provisions also wipes out the deductions for personal exemptions and non-business income. Our review of several successful, technologically based companies indicates that it is not uncommon for even the successful ones to have lost money for at least five years. To recapitulate:

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[3] *Deutermann, Elizabeth P., "Seeding-Science Based Industry," Business Review, Federal Reserve Bank of Philadelphia (May 1966), pp. 3-10.*

V

PROBLEMS AND RECOMMENDATIONS

Having explored various aspects of incentives and barriers to technological change and having analyzed some of the salient features of small and large companies in the management of technological innovation, we are in a position now to present our recommendations. For reasons already stated, and which will be supplemented, they are aimed primarily at the problems encountered in the small company environment.

A. TAXATION [1]

1. THE PROCESS OF SELECTION

We have reviewed many tax proposals aimed at either (1) encouraging innovation in a positive way, or (2) eliminating disincentives or barriers to innovation. We are recommending only a few, having rejected most of the proposals we considered. It would please us to be able to say that our evaluation was made on the basis of clear, statistical evidence of the prevalence and importance of a given barrier to innovation, or on the basis of a sophisticated cost-benefit study of the impact of a given tax change on the amount of innovation or even on the level of tax revenues.

Unfortunately, there are few such data available. In fact, the lack of objective data, in or out of government, on the innovation process, in general, and the technologically based firm, in particular, is symptomatic of a very serious deficiency in our thinking regarding technological innovation. As we have said earlier, too few people in government, in industry, in banks, and in universities understand the special forces at work in the conception, appraisal and nurturing of the innovative, technological enterprise. Yet, even a casual reading of the business history of this country makes it clear these innovative

[1] *See Appendix D for provisions of the Internal Revenue Code discussed in this chapter.*

time we discussed in reference to the small company environment is not easily attainable here. The distance from the chief executive's office to the maintenance shop may be a long way. He is, in fact, often removed from the operational details of his company; surely, he is not familiar in detail with each new venture early in its lifetime. The complexity of the organization itself leads to certain problems.

There are the *"know-it-alls."* They explain that they have thought about similar new ideas many times before, and have concluded that there are many, many reasons why each new concept cannot succeed. Or, it will not work because it has never been done before. There are many other reasons why, in this experimental appraisal stage, prior experiences and predispositions rise up to block innovation. Often these take the form of an overly conservative estimate of *risk-versus-probable cost* for new ventures. It is easy to make such decisions because there is always the choice of *extending the present business* rather than taking the organization into unknown territory. As we have noted, the beginning small business has no analogous option.

These are different kinds of problems from those we discussed in reference to the small company environment. There, when the problem was to obtain initial financing for the incipient firm, the problems were largely external ("Can we get the capital?"). Here, we are concerned with what may be a lack of entrepreneurial spirit and commitment within a well-established, well-financed organization. In a complex organization the overriding problem often is maintaining an adequate commitment to a new idea in the face of internal obstacles to change. There is an understandable reluctance to depart from what has been a successful pattern of business. So we come back again to the need for *understanding,* within and outside the company, of the special problems of managing and exploiting technological change. These problems are no less formidable in a large organization than they are in a small firm. They are just different.

THE EMBRYO BUSINESS

The experimental appraisal is over and the idea has proved itself. An embryo business is formed within the framework of the corporation. Because of its ancestry, the business needs no major effort to establish a long-range R&D program. It has the tradition and the backing to fill in gaps in the R&D sector.

But the embryo business usually does *need outside inputs*—in the marketing area, for instance. Key management is also important. The established company can get these inputs more easily than can the small firm, for it can offer the *incentives* of high salaries, security, and other inducements already mentioned.

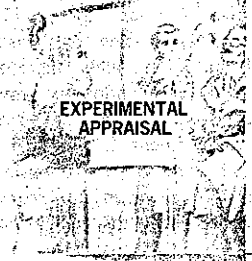
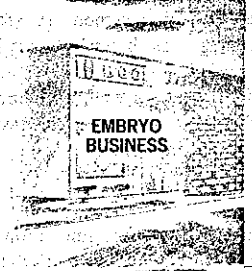
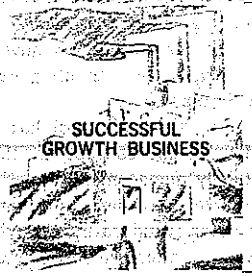
But sometimes the most effective strategy is to purchase the needed elements by acquiring assets from another company or merging with it. Here, again, *antitrust* considerations play an important role in limiting the company's course of action.

At an equivalent point in its growth pattern, a small company is in a "do or die" situation. The large company, however, may still elect to abandon the venture if it fails to show signs of measuring up. For example if, in the early

CHART 16

MANAGING TECHNOLOGICAL INNOVATION

LARGE COMPANY ENVIRONMENT

	CHARACTERISTICS	PROBLEMS
 BUSINESS PLANNING	**Venture analysis** Directional planning **Business objectives control**	**Not invented here** Time value of money **Inbreeding** Lack of specific market experience often kills good projects
 EXPERIMENTAL APPRAISAL	Complex enterprise **Has R/D organization** May lack certain technical skills	**Entrepreneurs missing** Know-it-alls **Risk vs. Cost emphasized** Extend present businesses
 EMBRYO BUSINESS	**Outside imputs needed** Incentives available **Continuing R&D effort**	**Failure to meet return on investment criteria in early years** Antitrust **Key management**
 SUCCESSFUL GROWTH BUSINESS	**Growth** Jobs **Products**	**Assimilation** Antitrust

UNDERSTANDING

IV

THE LARGE COMPANY ENVIRONMENT

The innovation process in a large company is, in many respects, similar to that in a small company. But the risk of any single venture to the future of a large company is nowhere near as great, for the large technologically based company can spread its risks by undertaking several innovation projects at once. Moreover, because a large company normally has profits against which it can offset costs, the government, in effect (through the corporate income tax), shares in 48% of the innovation project losses of the company. As we have seen, this is not true of a typical small company in its early stages.

THE PROBLEMS OF GROWTH

To illustrate the basic problem of the large company with growth objectives, let us consider the following hypothetical case.

CHART 15

GROWTH PROBLEM IN A SUCCESSFUL LARGE COMPANY

(Hypothetical Case)

Annual Sales	$1,000,000,000	
Sales Decline (Oldest Products)	5% Per Year	$70,000,000
Price Erosion	2% Per Year	
Typical Market Penetration	25%	
Growth Target	10% Per Year	$100,000,000
		$170,000,000

Such a company needs $170,000,000 of new sales from a combination of
(a) established products
(b) new products in established businesses
(c) new businesses

Ultimately this company must seek to enter completely new businesses or abandon its growth objective

all of the time; and to do this he has to have adequate appraisal resources at hand. One cannot overstate the pivotal importance of adequate appraisals. There truly are very few capital sources who understand equally well the nuances of convertible debentures and the intricacies of gas laser technology.

The "appraisal gap" is a rather specific example of our principal theme, that if any problem can be singled out as the central obstacle to the small technologically based enterprise, it is the need for *understanding*. Too few leaders in industry, government, the universities, and the financial community truly understand the business and human dynamics of the innovation process.

THE "GARAGE" OPERATION

The Company obtained the needed capital. It is now in business, but it is *losing money*. Let us put some rough dimensions on the firm at this stage. It is small, lean, proud, hard working. It is quartered, we may say, in a "garage"—in any case, very modest facilities. During this "garage" stage, it is typically less than five years old, has less than one hundred employees and less than $1 million in capital. Some of these firms may have one tenth of these resources.

The company is *technology oriented* and has a high ratio of technical to non-technical staff. Often, it is seeking government research and development contracts.

This kind of company has a *fast reaction time;* it is quick on its feet. It has to be: the distance from the front to the back of the garage or from smooth sailing to bankruptcy is very short, indeed. Each adversity is a major crisis for the fledgling enterprise.

It has limited marketing problems, because it typically has only a *few customers*. One dissatisfied customer, and the firm may face disaster, so it naturally tries a little harder to please. Because its market is limited, it often produces on a custom basis.

All of the above characteristics—high ratio of technical people, emphasis on know-how, a high-technology product or service, and so on—indicate that the firm's output probably has a *high value added*. This, in turn, means that if the company matures to a successful growth business, there will be a very high return on the *initial* investment.

But let us turn now to some of the problems. Management problems are foremost. They present the greatest frustrations. The typical inventor, prime mover, man with the idea, lacks managerial skills. The firm needs these skills, but how does it get them? The salaries, pensions, and other fringe benefits used by successful large firms to lure and hold key people cannot be offered by a struggling small company which is fighting for its survival. Other incentives must be found. To lure *key managers*, who are willing to share the *total commitment* of the company founders, the company must be able to point to a high return if the high risks are overcome. Our recommendation concerning stock options (Recommendation 2) is directed to this end.

Government procurement procedures may pose a problem to our new firm. Procurement regulations and policies do not take the peculiar problems of small, technological firms into account. For example, the summary cancellation of one government contract may he disastrous to a small firm. A large

CHART 14

MANAGING TECHNOLOGICAL INNOVATION

SMALL COMPANY ENVIRONMENT

	CHARACTERISTICS	PROBLEMS
IDEA	Individualists Technical Uncertainty No business experience Total commitment	Capital? In business?
MONEY	High risk requires high potential return Relatively small $ No technical experience	Appraisal Lack of understanding • Banks • Industry • Government • Universities
"GARAGE" OPERATIONS	Losing money Less than • 100 employees • $1 million capital • 5 years old Technology oriented High ratio technical men Government contracts Fast reaction time One or few customers Custom manufacture High return on investment High value added	Key management Motivation Fringe benefits Government procurement Total commitment
2nd STAGE BUSINESS	New kind of financing Dilution of equity Many impersonal customers Product oriented High volume manufacture More than • 100 employees • $1 million capital • 5 years old	Key functional staff Control techniques Market analysis World wide marketing Costs Competition
SUCCESSFUL GROWTH BUSINESS	Growth Jobs Products	Escape Merger Sell out Antitrust Timing

UNDERSTANDING

CHART 13

SOME IMPORTANT INVENTIVE CONTRIBUTIONS OF INDEPENDENT INVENTORS AND SMALL ORGANIZATIONS IN THE TWENTIETH CENTURY

Xerography Chester Carlson	**Shrink-proof Knitted Wear** Richard Walton	**Mercury Dry Cell** Samuel Ruben
DDT J. R. Geigy & Co.	**Dacron Polyester Fiber "Terylene"** J. R. Whinfield/J. T. Dickson	**Power Steering** Francis Davis
Insulin Frederick Banting	**Catalytic Cracking of Petroleum** Eugene Houdry	**Kodachrome** L. Mannes & L. Godowsky Jr.
Vacuum Tube Lee De Forest	**Zipper** Whitcomb Judson/Gideon Sundback	**Air Conditioning** Willis Carrier
Rockets Robert Goddard	**Automatic Transmissions** H. F. Hobbs	**Polaroid Camera** Edwin Land
Streptomycin Selman Waksman	**Gyrocompass** A. Haempfe/E. A. Sperry/S. G. Brown	**Heterodyne Radio** Reginald Fessenden
Penicillin Alexander Fleming	**Jet Engine** Frank Whittle/Hans Von Ohain	**Ball-Point Pen** Ladislao & Georg Biro
Titanium W. J. Kroll	**Frequency Modulation Radio** Edwin Armstrong	**Cellophane** Jacques Brandenberger
Shell Molding Johannes Croning	**Self-Winding Wristwatch** John Harwood	**Tungsten Carbide** Karl Schroeter
Cyclotron Ernest O. Lawrence	**Continuous Hot-Strip Rolling of Steel** John B. Tytus	**Bakelite** Leo Baekeland
Cotton Picker John & Mack Rust	**Helicopter** Juan De La Cierva/Heinrich Focke/Igor Sikorsky	**Oxygen Steelmaking Process** C. V. Schwarz/J. Miles/R. Durrer

It goes without saying that the United States could not depend solely on the innovative contributions of small firms. The large firms are indispensable to technological and economic progress. From a number of different points of view, however, we are persuaded that a unique cost-benefit opportunity exists in the provision of incentives aimed at encouraging independent inventors, inventor-entrepreneurs, and small technologically based businesses. The cost of special incentives to them is likely to be low. The benefits are likely to be high.

and managing technological change? What characterizes the relatively uninnovative industries? Are they this way because they failed to exploit innovative opportunities? Because they possess excessive built-in barriers to technological change? Is it that their managements have not learned the importance of utilizing technological opportunities and innovative skills?

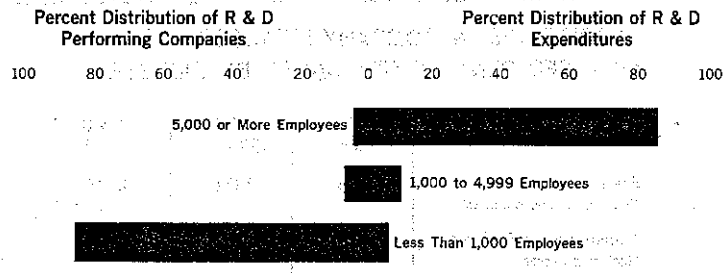
We find that we must answer each of these questions affirmatively. The major barrier is one of attitude and environment. It is primarily a problem of *education*—not of antitrust, taxation, or capital availability.

THE SIGNIFICANCE OF SIZE

We have examined variations in innovative performance between the public and private sectors, different regions, and different industries. We turn now to a consideration of innovative performance as a function of company size. Again, however—because we have no choice in the matter—we have been forced to resort to data concerning R&D, *not* the total innovative process.

CHART 10

VARIATIONS IN R & D, BY SIZE OF COMPANY



Source: Basic research, applied research, and development in industry, 1962, NSF 65-18, 1965.

The above data show that a handful of large companies (having 5000 or more employees) perform almost all of the R&D, although, as we have illustrated, this is not necessarily indicative of *innovative* performance.

It is important to distinguish between large and small sources of invention and innovation, for the resources available to them are different and, not surprisingly, the riskiness of a venture and the manner in which it is undertaken are generally a function of the available resources. We therefore analyzed several studies on the sources of invention and innovation. These studies were unusually consistent in indicating that independent inventors (including inventor-entrepreneurs) and small technologically-based companies are responsible for a remarkable percentage of the important inventions and innovations of this century—a much larger percentage than their relative investment in these activities would suggest.

—Professor John Jewkes, et al, showed that out of 61 important inventions

The author carefully and objectively selected several research-oriented firms in the Delaware Valley area and in the Boston area and asked the founders of these companies several questions, among which the following two are of greatest interest: (1) "Do local universities play any role in stimulating new science-based firms?" (2) "What is the attitude of local banks toward financing for the small, science-based firm?" The Boston entrepreneurs, in response to the first question, replied to a man that the universities play an important role. In striking contradistinction, the Philadelphia entrepreneurs were of the unanimous view that universities play a small role.

In response to the second question, the Boston entrepreneurs replied unanimously that the attitude of local banks to the financing of small science-based firms was "good" or "excellent." Again, in marked contrast, the Philadelphia entrepreneurs said, without exception, that the attitude of their local banks was "unreceptive," "poor," or "bad."

It is true that the number of firms interviewed by the author was small (there were 13 all together), but the likelihood of getting these completely disparate views with respect to the attitudes of banks and the importance of universities is so remote that the results are significant. There is at least some reason to believe that the apparent difference in attitudes among venture capital sources, technological entrepreneurs, and universities in these two areas bears upon their propensity to generate new technological enterprises.

THE TOTAL ENVIRONMENT

In our over-all deliberations, we came to some general conclusions about the kind of *total* environment that seems to encourage the creation of new technological enterprises. Included in this environment are:

a. Institutional and individual venture capital sources that are (i) "at home" with technologically oriented innovators and (ii) have the rare business appraisal capabilities necessary to diagnose the prospects of translating a technical idea into a profitable business.

b. Technologically oriented universities, located in an area with a business climate that encourages staff, faculty, and students to study and themselves generate technological ventures.

c. Entrepreneurs, who have been influenced by examples of entrepreneurship (for it is our contention that entrepreneurship *breeds* entrepreneurship).

d. Close, frequent consultations among technical people, entrepreneurs, universities, venture capital sources, and others essential to the innovative process.

Professor Cole has drawn an analogy between the elements of an entrepreneurial environment and the charges in an electric field. A beneficial environment requires, he has said, "a sympathetic alignment of institutions . . . pointing in the same direction, or charged with the same brand of electricity." [5]

[5] *Arthur H. Cole,* Business Enterprise and Its Social Setting, *Harvard University Press, 1959, p. 245.*

For example, the development of the automotive industry and the introduction of various forms of chemical processing have created conditions leading to the pollution of water and air. In this respect, private innovation has created environmental conditions which call for social innovation. New industrial innovations requiring additional supplies of fresh water and a substantial number of well-educated workers will depend, in turn, on social innovation. For without improvements in water supply and in our educational system, it would seem that future industrial innovation will be limited. On the other hand, improvements in the educational system are at least partially dependent upon innovation in teaching aids such as audio-visual instrumentation. There is a mutual interdependence between social and private innovation.

We have considered the possible sources of social innovation and the roles of government and industry with respect to its performance. Social innovation in the public sector must depend upon private as well as public resources. As an illustration, improvements in the control of water and air pollution must stem from private innovations producing changes in automobiles and in industrial processes such that the polluting elements which are discharged into the environment will be reduced or eliminated.

We believe it is incumbent upon government, both local and national, to provide the essential framework for social innovation. As a general principle, moreover, government should encourage the use of private resources for social innovation whenever possible. In this effort we conceive of governmental functions along the following lines:

a. Defining the social problems and the priorities for their solutions.
b. Intensifying the planning for such solutions.
c. Encouraging private enterprise to seek profit-making opportunities in the development of such solutions.
d. Developing regulatory and other mechanisms, such as government purchasing policies, to compel or encourage industries to modify productive processes and products in such ways that they will contribute to the betterment of the social sector (for example, regulations regarding water and air pollution).
e. Carrying on the necessary technological developments, when it is clear that private resources cannot be depended upon to undertake them satisfactorily.

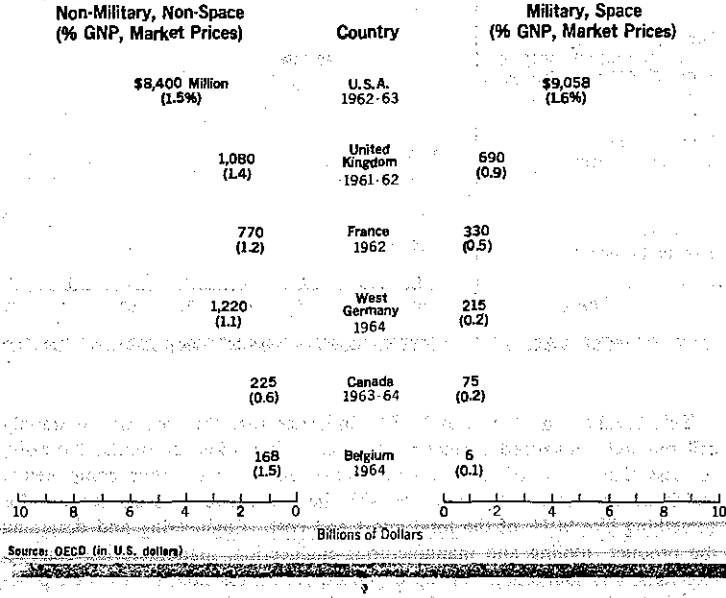
The prosecution of this program on the part of the government would call for careful, intensive analyses of each of the areas requiring social innovation. No pat formulas can indicate which paths would be more productive. Social problems may arise which are not susceptible to solution via the private sector of the economy, in which case the government would have to accept the primary or exclusive burden of performance. Again, however, we believe the only reasonable generalization which can be made in tackling these problems of social innovation is that the government should give careful consideration to the utilization of private industry for this purpose before it undertakes investment of public funds and resources.

get some indication of the ratio of R&D costs to the total costs of innovative activities, both successful and unsuccessful. As a very rough measure of this, we compared total company expenditures on R&D in the manufacturing sector with the total net sales of these companies.[1] The latest year for which such data are available is 1964. We make no pretense about the adequacy or relevancy of these data. The total net sales for 1964 amounted to $293 billion; company-financed R&D expenditures totaled $5.7 billion. The ratio of R&D costs to net sales was therefore approximately two per cent, which would indicate that R&D costs are a small part of the total effort in the manufacturing sector.

Another illustration of the need for careful study of the innovative process is the indiscriminate use of statistical aggregates purporting to show the comparative innovative performance of various countries—in particular, statistics comparing research and development expenditures as a percentage of gross national product. As a measure of our innovative performance as a nation, data such as in the following tabulation are occasionally cited. We believe such data to be an inappropriate index of innovative performance.

CHART 8

TOTAL EXPENDITURES ON RESEARCH AND DEVELOPMENT, SELECTED COUNTRIES.



Source: OECD (in U.S. dollars)

[1] *"Basic Research, Applied Research, and Development in American Industry, 1964,"* Reviews of Data on Science Resources, *No. 7, January 1966, National Science Foundation, Washington, D. C.*

II

INNOVATION IN CONTEXT

We have already noted that technological innovation, in the sense we have been asked to be concerned with it, is a complex process by which an invention is brought to commercial reality. It is our thesis that if we are interested in increasing our rate of economic growth and the vigor of competitive forces in our society, we need to remember that these goals cannot be satisfactorily achieved in the absence of technological progress—i.e., the bringing of new products, processes and services to market.

We need also to bear in mind that the path between an invention (or idea) and the market place is a hazardous venture, replete with obstacles and substantial risks. It is ordinarily a very costly, time-consuming, and difficult task that the innovator faces.

INNOVATION IS NOT SIMPLY R&D

Continuing the series of basic questions we put to ourselves, we asked what it is the Government should seek to promote. Should attention be focused on the total process of innovation or merely on the research and development phase of the total process?

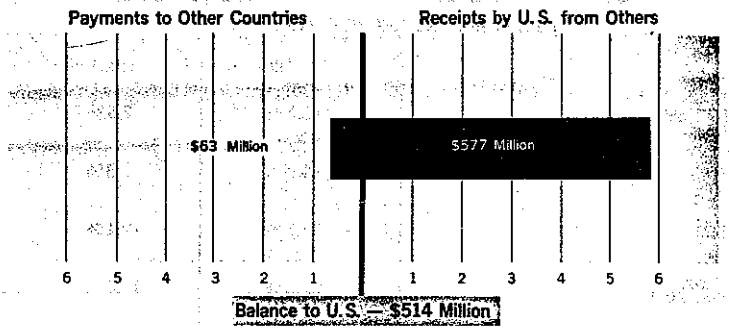
We came to realize early in our analysis how very little statistical evidence there is on the innovative process. Such data as are available primarily concern research and development, not the *total* innovation process, of which R&D is only a part. These data give us a reasonable indication of the investment in R&D, who is performing it and to what extent. But they are not reliable indications of *innovative* performance. They do not tell us, for example, what the total investment in innovation is in the United States. Such information would be very useful to have. Indeed, it would be highly desirable to encourage systematic studies of the innovative process in order to clarify the strategic elements which stimulate and further innovation.

We wish to make quite clear, therefore, that our analysis could not be based upon empirical data on the innovative process. Rather, we have had to rely on personal experience and knowledge and, where appropriate, data concerning R&D.

CHART 5

U. S. TECHNOLOGICAL BALANCE OF PAYMENTS

Payments for Technical Know-how, Patent Royalties, etc.



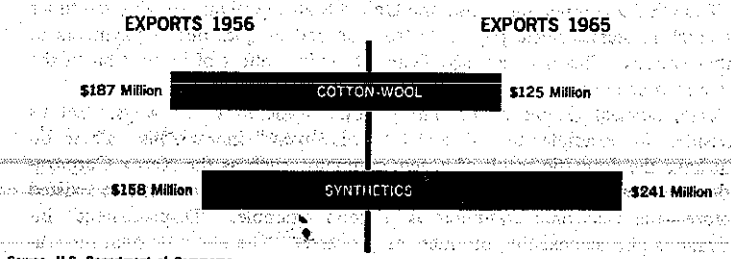
Source: OECD (1965) — Figures for 1961

It is very difficult to measure the full significance of "displacement" innovations in the United States, because such displacement is a *domestic* give and take. But if we look at the international picture, we can get a better feeling for the significance of these kinds of innovations. We chose as an example the yarns and fabrics industry and we compared synthetics with cotton and wool.

CHART 6

INNOVATION AND INTERNATIONAL TRADE

An Example: U.S. Exports of Yarns & Fabrics
Synthetics (High Technology)
Cotton & Wool (Low Technology)

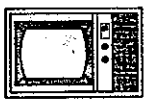


Source: U.S. Department of Commerce.

technological innovation played a major role. We realize that data such as the GNP are abstract statistical notions. By and large, they fail to excite the imagination, for they do not have the impact of specific examples. So we thought it would be instructive to look at the histories of three industries which were commercially non-existent in 1945, but over the past 20 years have contributed significantly to the nation's growth. We chose the television, jet aircraft, and digital computer industries.

CHART 3

ECONOMIC EFFECTS OF ONLY THREE TECHNOLOGICAL INDUSTRIES OUT OF MANY







In 1945, the TELEVISION, JET TRAVEL, and DIGITAL COMPUTER industries were commercially non-existent.

In 1965, these industries contributed more than $ 13 BILLION to our GNP and an estimated 900,000 jobs . . . and very important, affected the QUALITY of our lives.

We also thought it would be useful to compare the average annual growth of the Gross National Product over the period, 1945-1965, with that of some of the companies that have committed themselves to innovation as a way of life and have experienced most of their growth over the 20-year period (see Chart 4). We analyzed the growth histories of Polaroid, 3M, International Business Machines, Xerox, and Texas Instruments. While the average annual growth of the GNP over this period advanced at a rate of 2.5%, the average annual net-sales growth of these companies ranged from 13% to 29% and averaged, for the group, nearly 17%[3]. At the same time, the average yearly growth in jobs ranged from 7.5% to almost 18%.

Here we see some large, successful, innovative companies which grew from relatively small beginnings and have contributed very significantly to the GNP and employment opportunities. Many other companies have had similar experiences.

[3] *Texas Instruments, which had the highest growth rate and would have raised the over-all average, was nontheless excluded, since data for the company were not available for the year 1945.*

We began our investigation by asking ourselves some very basic questions. The climate for invention and innovation could be improved by providing reasonable incentives to these processes of technological change and by removing or lessening unreasonable barriers that impede or stifle them. But what is reasonable or unreasonable? The reasonableness of our proposals would depend upon an appreciation of other national goals upon which these proposals might impinge—for example, the preservation of competition and fiscal integrity. And incentives and barriers to what? What is the anatomy of invention and innovation in the American economy? We had to analyze illustrative cases, demonstrating some of the problems and characteristics associated with the processes of invention and innovation, before we could rationally weigh incentives and barriers. Our analysis had to tell us something about the people who power invention and innovation, for these are largely "people" processes.

We shall develop illustrative cases as we get to the specific recommendations of this report. In the meantime, however, we need to make some initial distinctions between the processes of invention and innovation, for incentives and barriers to one may not be to the other.

Very simply, the difference between the processes of invention and innovation is the difference between the verbs "to conceive" and "to use."

CHART 1

WHAT IS INVENTION? INNOVATION?

Invention . . . TO CONCEIVE . . . The idea.

Innovation . . . TO USE . . . The process by which an invention or idea is translated into the economy.

To be sure, innovation is not limited to technological products and processes in the business world. But that is the principal sense in which we were asked to be concerned with innovation. Much of what is said in these pages, however, applies as well to fields where non-technological innovation is of great importance—for example, social institutions and relationships. For invention and innovation encompass the totality of processes by which new ideas are conceived, nurtured, developed and finally introduced into the economy as new products and processes; or into an organization to change its internal and external relationships; or into a society to provide for its social needs and to adapt itself to the world or the world to itself.

INNOVATION AND ECONOMIC PROGRESS

The next basic question we asked ourselves was: Why should the government have an interest in invention and innovation?

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17. A White House Conference on Understanding and Improving the Environment for Technological Innovation, followed by regional conferences for mayors, governors and other key individuals ---- 57

* *The recommendations are recapitulated, in full, in Appendix E, page 79.*

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