# The Industry of Discovery

The part of research that is pursued for profit contributes to the growth and stability of the economy.

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The best way to indicate the significance of technological research for the growth and stability of the economy is to point out that technological research had developed sufficiently by 1937 to make Keynes' theory of employment obsolete on the day of its publication—in spite of invaluable concepts and tools of analysis contained in the work. The reason why his theory of employment itself was out of date on the day of its publication was that Keynes ignored completely the impact of technological research upon the economy. Hence, his theory of employment rested upon a theory of consumption and upon a theory of investment that were seriously in error. In addition, Keynes was led to the mistaken practical conclusion that economic progress inevitably creates a chronic deficiency of demand.

Today it is unthinkable that anyone should attempt to construct a theory of employment or a theory of growth without taking account of technological research. Within the last 30 years technological research has become a large activity that introduces fundamental changes into the operation of the economy. Measured in terms of the number of scientists and engineers devoting full time to technological research, this activity is more than five times as large as it was in 1930, and measured by the ratio of research expenditures to the gross national product, it is about 13 times as large. In 1956, the annual budget of technological research, according to estimates of the National Science Foundation, was about $9 billion a year. Research is growing right through the recession of early 1958 (as it grew steadily during the much deeper depression of the 1930's), and in 1958 research outlays will undoubtedly be well above $10 billion.

My remarks fall into four principal parts. In the first place, I wish to point out briefly some fundamental characteristics of technological research that give it far-reaching economic significance. In the second place, I wish to discuss more specifically the effect of technological research upon the capacity of the economy to grow—and particularly to point out some of the changes required by technological research in the theory of consumption and in the theory of investment. In the third place, I have a few observations to make concerning the relationship of technological research to economic stability. In the fourth place, I wish to discuss a few selected questions of general economic interest that are brought into being by technological research.

## Characteristics of Technological Research

Technological research has three characteristics that give it far-reaching economic significance. The first of these characteristics is that it greatly increases the capacity of the economy to raise the demand for goods. It is obvious that technological research increases the capacity of the economy to raise productivity. Less obvious, and indeed generally overlooked, is the fact that research gives the economy the capacity to bring about planned increases in the demand for goods, both by creating new demands for consumption goods and by creating new investment opportunities. Naturally these capacities are fatal to the stagnation thesis expounded with such brilliant error by Keynes. I deal with this point more specifically below, where I discuss the effect of research on the theory of consumption and on the theory of investment.

A second characteristic that gives technological research far-reaching significance is the fact that much of it is a profitable activity as well as a useful activity. There are, of course, research areas of the greatest usefulness that cannot be investigated for profit and that must be handled either by nonprofit institutions, or by the government, or by private industry under government contract. Within the last half century, however, the fund of technological understanding has become sufficient so that many projects, particularly at the development level, can be pursued for gain. This means that many research programs can be determined by the economic calculus—by the balancing of expected gains against expected costs. The importance of this fact is that it draws into research far greater resources than would otherwise be available for it.

The part of technological research that can be carried on for profit should be regarded as an industry—the industry of discovery. Its product is knowledge. Slightly more than half of the research and development work now being conducted in private laboratories is financed by private funds for the purpose of making a profit. Thus, the National Science Foundation estimates that, in 1956, $3.4 billion of the $6.5-billion research budget of private laboratories was financed by industry's own funds, and $3.1 billion by the federal government.

A third significant characteristic of research is the fact that an increase in its output does not tend to reduce the marginal value of its product; on the contrary, it tends to increase the marginal value. Hence, the greater the output of research, the stronger tends to be the demand for still more output.

This peculiarity of research is a result of the fact that its output is knowledge. One may think of knowledge as consisting of a body of tested propositions. When two things are known, there is a possibility of seeing significant relationships between them which will yield practical applications. The larger the number of tested propositions, the more numerous are the cases in which the addition of a new tested proposition to old propositions will yield new useful applications and, in addition, will suggest hypotheses useful in adding still more

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tested propositions to the body of knowledge. Thus, the greater the body of existing knowledge, the greater is likely to be the value of the new discoveries.

All of this is particularly important for that part of research that is pursued for profit—the industry of discovery. Unlike other industries, the industry of discovery produces against a rising schedule of marginal utility, not a diminishing schedule.

## Demand for Consumer Goods

The most important effects of technological research upon the capacity of the economy to grow stem from its effects upon the demand for goods, not from its effects upon the capacity of the economy to produce goods, though the latter effects are obviously of great importance. Once demand exists, efforts to raise output will be stepped up. In the absence of sufficient demand, however, efforts to raise capacity will be limited. Hence, it is better on the whole that demand have a slight tendency to outrun productive capacity than that productive capacity tend to outrun demand.

Technological research affects both the demand for consumer goods and the demand for capital goods. It affects the demand for consumer goods by developing new kinds and varieties of consumer goods that people desire to incorporate into their standard of consumption. People acquire these additional goods by going into debt, by drawing on accumulated savings, or simply by saving a smaller proportion out of any given income. As a result, rising per capita incomes in the United States have not produced a drop in the ratio of incomes that have been saved. In the American economy, personal consumption expenditures have always been an important income-determining influence, contrary to the theory of Keynes, who held that consumption expenditures are a stable function of real per capita national income. If the view of Keynes were correct, consumption expenditures would be merely income-determined, not income-determining.

It would be a mistake to ascribe dynamic standards of consumption solely to the attractive products made possible by technological research, though in recent years this source of dynamic consumption standards has been growing rapidly. But specialized technological research, as I have pointed out, had very limited importance until about 25 years ago, and consumers have been a dynamic influence in the United States since time immemorial. Most of the population has been motivated by strong desires to get ahead, and this ambition has made all aspects of life in the United States, including consumption, strongly competitive. Various features of the American environment have stimulated ambition and competition: the absence of tradition and social stratification, the rapid growth of population (especially up until the end of the 19th century), and the abundance of economic opportunities created by the immense resources awaiting development. But, as the rate of population growth has dropped and as natural resources have become more fully developed, technological change has become a more important source of opportunity, keeping vigorous the strong ambitions and competitive spirit of early days.

A little more than half a century ago, there was widespread belief that, with the filling up of the continent and with the passing of the frontier, the United States would become like Europe with a stratified society in which a class struggle would emerge. But this has not happened, largely because of the accelerating rate of technological change beginning about the middle of the 19th century. Of course, the accelerating rate of technological change did not depend to a large extent upon full-time, specialized research workers until about the second quarter of the 20th century. In earlier days, much important research was done by brilliant self-trained men ("inventors") and much more work of great importance was done by technically trained operating men. But though many of the operating men did excellent research, they were unable to give full time to research problems. The recent development of full-time, specialized research must be regarded simply as a far more efficient method of doing what industry had previously been doing on a fairly substantial scale.

I do not assert that the rise in technological research is attributable to the decline in the rate of population growth or to the fact that natural resources had become rather well developed. Perhaps there was a causal relationship between these developments, and perhaps there was not. Until these matters are better understood, it is preferable to regard the timing of the rise of technological research as a happy accident of history.

No one, of course, knows what would have happened had technological progress made much smaller additions to the number of products of industry. Suppose that the automobile, the radio, television, a host of household electrical appliances, home movie cameras, and other things had not been invented and developed. Everyday living would obviously have been very different from what it is now. Perhaps we should have had a civilization superior to our present one—one in which men would be more interested in ideas and less interested in things. An attempt to argue the pros and cons of such issues would take me far afield. It is reasonable to suppose, however, that a much smaller variety of things to buy and to use would have led men to be more interested in leisure and less interested in income than they are today. The working week would have fallen faster. The present eager desire for more income stems largely from the facts that industry, through technological research, is able to offer the people a much wider variety of goods than they are able to purchase and that new and improved goods are constantly being offered for sale.

Thus, technological research has had two offsetting effects on the length of the working week. By developing efficient machinery, it has tended to reduce the value of goods relative to leisure and to bring about a reduction in the length of the work week. By increasing the variety of goods, it has tended to raise the value of goods relative to leisure and to retard the drop in the length of the work week. Between 1929 and 1956 the proportion of disposable income spent on user-operated transportation, household appliances, boats, pleasure craft, sporting equipment, radio and television receivers, and radio and television repairs increased from 9.13 percent to 12.7 percent. Much of the success of these parts of industry in getting a larger share of incomes after taxes must be explained by the development of products and services for which specialized technological research is responsible. Thus, technological development has helped to hold down personal savings in the face of rising per capita real incomes.

## Demand for Capital Goods

Technological research affects the demand for capital goods in two ways: by developing new consumer goods that require new plants and equipment for their manufacture, and by the developing of new processes and new equipment

that represent opportunities for investment.

The capacity of technological research to create investment opportunities reminds us of how unsatisfactory have been the economists' theories of investment. Economists have pretty much taken the volume of investment opportunities as given and have had little to say about the determinants of the volume of investment opportunities. There have been a few observations about the effects of undeveloped natural resources and the growth of population upon the supply of investment opportunities. Keynes has a chapter on the state of long-term expectations in which he discusses "some of the factors which determine the expected yield of an asset" (*1*, p. 147). Among the factors determining the prospective yield, Keynes mentions "future changes in the type and quantity of the stock of capital assets." This is about as near to technological research as he gets at any point in his book.

It did not occur to Keynes, any more than it has occurred to most other economists, that special efforts directed toward the specific purpose of creating investment opportunities might be fruitful and highly profitable and might, indeed, be the basis for a large and growing industry. So low was Keynes's estimate of the capacity of the economy to create investment opportunities that he ventured the opinion that in a highly developed community in which population is not increasing, the increase in the stock of capital might bring down the marginal return on capital to approximately zero within a single generation (*1*, p. 220). Keynes conceded that the changes in technique could in theory postpone this result, but his views of practical policy indicated plainly that he did not expect technological change to avert stagnation. According to his view, only a chronic government deficit would do the trick.

At this point we must consider the significance of the part of technological research that I have called the industry of discovery. I have described the product of the industry as knowledge. But let us be more specific about this. The product of the industry consists in large part of investment opportunities. In other words, here we have a large and rapidly growing industry which is devoted largely to discovering or creating investment opportunities. Obviously, from now on, economists, in constructing a theory of investment, must put the industry of discovery at the top of the list of investment determinants. In an age of research the capacity of the economy to discover investment opportunities depends in the main upon (i) the fund of knowledge that has been accumulated and is available to be drawn on, and (ii) the volume of resources devoted to the industry of discovery.

Of crucial importance is the question of how much larger the industry of discovery is likely to grow relative to the gross national product. Space does not permit a rounded discussion of this question, and my limited knowledge of the problem restricts me to a few scattered observations. The value of the current product of the industry of discovery, to the community as a whole at least, may be expected to grow for the reason that I have already mentioned, namely, the fact that the greater the population of existing truths, the better is the prospect that any addition to this population will produce useful relationships between propositions. But the extent to which the industry of discovery can profitably grow depends upon (i) the extent to which the makers of discoveries can appropriate the gains from them, and (ii) the cost of making discoveries. The time may come within a few decades when a further expansion of the industry of discovery relative to the gross national product is not profitable to private industry. Certainly, the scale of research that private industry can afford is bound to be far less than the amount that would be justified by balancing gains to the entire community against costs to the entire community. But the day when the marginal returns of research to private enterprises merely balance the marginal costs is undoubtedly some decades away, at least in most industries—especially in many industries which have not as yet made much of a start on specialized research.

## Stability of the Economy

How will the rise of specialized, technological research affect the stability of the economy? In general, technological research will contribute to stability, though it cannot be depended upon alone to produce stability.

The growth of specialized, technological research will promote stability in two principal ways. In the first place, research tends to introduce into many parts of industry the sort of technology that must be financed by long-range plans which ignore the business cycle. In the second place, technological research greatly increases the number of industries in the economy, and this, in itself, is a stabilizing influence. It is difficult, if not impossible, to eliminate fluctuations in the spending of individual industries on plant, equipment, and inventories. Hence, each industry has cycles more or less of its own, depending upon the value of the accelerator and the multiplier in the particular industry and upon the sensitivity of the investment plans of the industry to outside events. The important point is that no two industries have the same cyclical patterns or the same sensitivity to outside events. The larger the number of industries in the economy, the greater is the chance that the upward and downward movements of the economy will be sluggish resultants of averages derived from the nonsynchronized cycles of the many industries in the economy. Hence, by adding to the number of industries, technological research tends to moderate the cyclical movements of the economy as a whole.

A special word should be added about the possibility of technological research's helping industries adapt their current production to market changes. The present plight of the automobile industry serves to illustrate the point. The technology of the automobile industry is of such a nature that the industry is from two to three years away from its market; that is, important changes in models need to be frozen anywhere from 2 to 3 years in advance of the models' being put on sale. In spite of this fact, the industry has attempted to develop the automobile as a style good, placing great emphasis upon year-to-year model changes. The industry needs to put its engineers hard at work to change its technology in ways that will permit prompter changes in its models when, as in 1958, it misjudges the tastes of consumers. There are many other industries which could advantageously use their engineers to modify their technology to make possible a quicker adaptation of the industry's product to changes in consumer preferences, and also to make possible greater variety in product lines at any given moment to meet the preferences of minority groups of consumers.

The rise of specialized, technological research raises important economic questions that are interesting, alike from the standpoint of practical policy and economic theory. Let me discuss briefly a few of these questions.

1) May technological research be ex-

pected to maintain full employment fairly steadily by helping the economy keep the proper relationship between the volume of investment-seeking funds and the volume of investment opportunities?

Will not technological research, by raising per capita incomes, create a propensity to save that is too large in relation to the rate of discovery of new investment opportunities? One can say that this result is extremely unlikely, although one cannot assert that as a matter of economic theory it is impossible. A chronic excessive propensity to save could be maintained only through a growing desire to hold liquid assets. Technological discovery is itself a powerful enemy of liquidity preference, because it is constantly offering people new and more attractive goods and services to buy and new and more attractive ways to use their leisure. Powerful and special circumstances would be necessary to permit the preference for liquidity to prevent people from buying the new and more attractive goods and services which technological research makes possible. Furthermore, the larger the stock of automobiles, houses, and household appliances, and the greater the use of the various services (airplane travel, for example) that technological research has made possible, the greater becomes the advantage in spending money on research designed to make the existing stocks of goods or existing processes obsolete. And what applies to consumer goods applies also to industrial equipment: the larger the existing supplies, the more advantageous it is to expand research in order to make these stocks obsolete.

2) In view of the fact that the period since 1929 has seen an enormous rise in technological research, why have the rate of interest and the rate of profit been falling? The proportion of gross savings to the gross national product was about the same in 1956 and 1957 as in 1929: about 16.0 percent in 1929, 15.8 percent in 1956, and 15.0 percent in 1957. Nevertheless, both interest rates and corporate profits were considerably lower in 1956 than in 1929. For example, the return on AAA bonds dropped from 4.73 percent in 1929 to 3.36 percent in 1956, and 3.89 percent in 1957. Corporate profits, after corporate income tax liability and after inventory valuation adjustment, dropped from 6.1 percent of corporate sales in 1929 to 2.7 percent in 1956.

The explanation of the drop in interest and profits is found, I believe, in a cost-profit squeeze resulting partly from higher corporate profits taxes and partly from higher wages. In 1929 corporate profits tax liability was 3 percent of all income originating in corporate business, and in 1956 it was 11.6 percent. And the compensation of employees as a percentage of income originating in corporate business, less corporate profits tax, was 76.9 in 1929 and 89.4 in 1956. In a nutshell, government and labor just increased their shares a little too fast for the engineers and scientists, reducing the proportion of income available for profits.

3) Is there a close relationship between the parts of the economy where discoveries are made and those where increases in productivity occur? There is not, and there is no reason why there should be. Many of the most important technological advances are made in order to sell more goods—by the suppliers of the industry that experiences the gain in productivity. The printing industry plays only a limited role in developing printing presses; the railroads did not develop the diesel locomotive (in fact, they almost had to be forced to try these locomotives); the coal industry does not develop the mining machinery that it uses. The part of the economy that has been gaining most rapidly in productivity in recent years has been agriculture, but the sources of this gain are not on the farms.

4) How great is the need for the support of technological research outside the industry of discovery, that is, for the support of research that has to be justified by benefits to the entire community rather than by profits to the discoverer of knowledge? The answer to this question is fairly plain, and I ask it mainly to remind you of its importance. The discovery that an enormous amount of research can be carried on for profit is surely one of the most revolutionary economic discoveries of the last century, and, as I have pointed out, it has enabled research to command far greater resources than would otherwise be available for it, and has led to the spectacular boom in research. But the rapid rise of the industry of discovery does not alter the fact that the community as a whole can afford research on a far larger scale than the sum total of the research projects that private industry can afford.

By and large, the government has shown a grossly inadequate appreciation of the importance of research to the community. Government research expenditures, it is true, are large and have been growing rapidly, but they have been forced mainly by military considerations. The crimes, first of Hitler and later of Russia, have forced our government to do research that it had lacked the initiative and imagination to attempt. Fortunately, much of the military research has civilian applications.

But outside the field of military research, government support of research is only a small fraction of the amount that would yield enormous returns to the community. Indeed, it is safe to say that there is no field where larger government expenditures would produce as rich a return as greater outlays on research—and also on the necessary foundations for research, the education of talented people. Perhaps it is unreasonable to expect the members of Congress and the members of legislatures to see this fact clearly without assistance from the scientists themselves. To help the government policy-makers appreciate the nation's need for greatly enlarged government research outlays outside the military field is one of the responsibilities of the National Science Foundation. It is a great national asset that the country has this Foundation to help the country make wise use of its resources.

### Reference

1. J. M. Keynes, *General Theory of Employment, Interest, and Money* (Harcourt, Brace, New York, 1936).