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The Impact of Research and Development on Income and Employment in Utah

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THE IMPACT OF RESEARCH AND DEVELOPMENT ON INCOME AND EMPLOYMENT IN UTAH

by

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TABLE OF CONTENTS

Chapter		Page
I.	INTRODUCTION	1
	Purpose of Study	1
	Selection of a Study Area	1
	Time Period	4
	R&D as an "Industry"	5
	Definition of Terms	5
	Preview of Following Chapters	6
II.	RESEARCH AND DEVELOPMENT IN THE UNITED STATES	8
	Growth of R&D in the United States	8
	R&D in America Today	12
	Impact of R&D on the American Economy	19
III.	R&D IN UTAH	24
	The Economy of Utah	24
	R&D Population	28
	R&D by Utah Enterprises	32
	Federal Funds for Utah R&D	42
	Expenditures for R&D in Utah	44
IV.	INCOME AND EMPLOYMENT MODELS	45
	Economic Models	45
	The Multiplier	50
	Income Model and Multiplier for R&D	53
	Determination of Parameters	55
V.	THE IMPACT OF R&D ON UTAH'S ECONOMY	65
	Comparison of Sectors	65
	Income Generated	65
	Total Income Multiplier	66
	APPENDIX	69
	BIBLIOGRAPHY	76

LIST OF TABLES

Table | Page

1. Employment in Utah 26
2. Percentages of total personal income from major industrial sources in Utah and the United States 28
3. Utah's R&D population 32
4. Expenditures for R&D in Utah 44
5. Hypothetical industry-income multiplier for a closed economy . . . 52
6. Hypothetical industry-income multiplier for an open economy . . . 52
7. Income generated by Utah R&D 66

LIST OF ILLUSTRATIONS

Figure | Page

1. Fund for performance of R&D by industry and source, 1963 13

2. Trends in funds for industrial R&D performance, by sector, 1953-1963 18

3. Flow of R&D funds in Utah 53

CHAPTER I

INTRODUCTION

Purpose of Study

Research and development (R&D) play an increasingly important role in the economy of the United States. Total expenditures for R&D during the decade of the 1950's were greater than in the entire history of the United States previous to that time. As a percent of gross national product, R&D has grown from 0.2 percent in 1921, to 0.4 and 0.6 percent in the 1930's and 1940's, and is now more than 3 percent.[1]

Much has been said of the impact that the growth of R&D has on the general economy. R&D had also had a significant economic and sociocultural impact on the local areas of R&D concentration--an aspect of R&D which is difficult to measure and frequently ignored. Although a general view of R&D in the United States as whole is given, the present study is mainly concerned with the economic impact of R&D on a local area. Although not exhaustive, this study represents an attempt to gain information in a vitally important area of the economy which has generally been ignored.

Selection of a Study Area

The main justification for examining a local area is the fact that most of the economic impact take place within the local area, more so

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[1]Nestor E. Terleckyj, Research and Development: Its Growth and Composition (New York: Industrial Conference Board, Inc., 1963), p. 21. Figure for present date estimated by the author.

than in the general economy. The direct impact of a wage increase for automobile workers will have a greater impact in Detroit, Michigan, than it will have for all employees in the United States. This is true, if for no other reason, than most of the payrolls are spent where they are earned. Because of the relatively high income of scientists and engineers, R&D would logically have a greater impact in the local area than most industries. In addition to this direct impact on employment and income, there is a socio-cultural impact resulting from the geographic concentration of highly-trained R&D personnel.

In selecting an area for the study of R&D's economic impact, the purposes for which the area is selected should be kept in mind. These purposes consist of (1) data collection, (2) analysis and comparison of data with national trends, and (3) study of the local impact in depth.

Data available from government agencies are generally collected on a political basis depending on the governmental level at which the information is gathered. Data are available for counties, states, and Standard Metropolitan Statistical Areas (SMSA). The latter is a combination of the other two. The availability as well as the accuracy of this data is generally greater for states than for counties. Quite often data for a particular industry are withheld for a country to prevent disclosing information on a particular firm, but this rarely occurs in data for an entire state.

Economic areas rarely correspond to state and county boundaries. An economic area is generally the same as a trading or market area and usually encompasses all or parts of several counties and even states. What is a market area for one good or service is not the same for all goods and services and makes it difficult to determine exactly what constitutes an economic area. A closer correspondence between economic and political areas is that of the SMSA, but this often cuts off the fringe areas because the boundary of the SMSA is the boundary of the county or counties.

Since this study is concerned with the economic impact of R&D, the study area should be one in which R&D employees spend their payrolls. It can be seen that the determination of the economic area is a function of distance. The proportion of total payrolls spent diminishes as the distance from the place of employment increases until a point is reached when the impact would be greater from an area other than the one under consideration. It is at these points of discontinuity that the boundaries of economic areas exist. The area should not be so large that it encompasses several areas of apparent discontinuity, nor so small that it does not cover the entire area.

For purposes of this thesis, since the author is a student at Utah State University, the most feasible area of study was within or in the vicinity of the State of Utah. Most of the economic activity of the State is concentrated in the north-central part, in the vicinity of Salt Lake City and Ogden. Possible areas of study were the Ogden, Salt Lake City and Provo-Orem SMSA's. To limit the study area to (a county, group of counties, or one of the SMSA's) would have limited the study considerably, and would not have been justified on the basis of economic boundaries as discussed in the previous paragraph, since all three SMSA's border each other.

To include the three SMSA's which embrace Weber, Davis, Salt Lake and Utah counties (the "Wasatch Front") seemed logical. However this excluded substantial R&D performed in Cache and Box Elder counties, and the impact in the neighboring counties whose residents were employed in R&D facilities in the Wasatch Front.

An important factor influencing the choice of a study area was the fact that more data were available for the entire state than for any of the other areas mentioned above. Clearly the best areas of study was the entire State of Utah.

The State of Utah is a good approximation of a true economic area because of the concentration of business in the Wasatch Front, which is due to the geography of the State. Almost all business in Utah is geographically segregated from the business of other states. The only areas which might have considerable state interaction would be in the St. George area of southeastern Utah, and in Box Elder and Cache counties in the north. The evidence seemed to indicate that the number of R&D personnel working in Utah who were residents of other states was small. This was due to the fact that the only close R&D facility to a state boundary was Utah State University, which employed very few people, who lived in another state. There is also the possibility that some employees of Thiokol Chemical Corporation in Box Elder County live in Idaho, but this in turn seemed insignificant. Granted that in general, states are not a very good approximation of an economic area, the "isolated" State of Utah appeared to be a very good one.

Time Period

In establishing the bench mark year for historical analysis, it was desirable to start at a time preceding or coincident with the initiation of extensive R&D in the State, without going so far back in history that data becomes immeasurable.

The period selected covers the ten-year period from 1954 to 1964. Virtually all defense-oriented installations as well as the major increases in R&D expenditures at the universities and manufacturing facilities in the State have occurred during this period.

R&D and "Industry"

An industry is defined as a distinct group of productive enterprises, the "distinctness" between one industry and another being determined by either its inputs or its outputs.

From the standpoint of output R&D might be considered an industry because it product is distinct--new products and processes or new scientific or technological information. In the conventional meaning of industry it would not be classified as such. For example, research to produce new uses of transistors would be classified as part of the electronics industry rather than part of an R&D "industry." However, using the concept of "new products or processes" this type of activity could be classified as part of the same industry as that of finding better applications of nitrogen as ferterlizer.

From the input side R&D might be considered an industry because of its employment of so any scientists and engineers. Although some other industries are extensive employers of technical personnel a larger percent are employed in R&D than in most industries.

Even though R&D is not considered to be an industry in the usual meaning of the term, it will be considered as such for convenience, and will be referred to as the "R&D industry."

Definition of Terms

To determine just what is involved in the R&D industry it is necessary to have precise definitions of terms. The National Science Foundation uses the following definitions:

> Research and Development include basic and applied research in the sciences and engineering, and the design and development of prototypes and processes. Excluded from this definition are routine product testing, market research, sales promotion, sales service, research in the social sciences or psychology, or other non-technological activities or technical services.
>
> Basic Research includes original investigations for the advancement of scientific knowledge that do not have specific commercial objectives, although such investigations may be in fields of present or potential interest to the reporting company.
>
> Applied Research includes investigations directed to the discovery of new scientific knowledge that have specific commercial objectives with respect to products or processes. This definition of applied research differs from the definition of basic research chiefly in terms of the objectives of the reporting company.
>
> Development includes technical activities of a non-routine nature concerned with translating research findings or other scientific knowledge into products or processes. Development does not include routine technical services to customers or other activities excluded from the above definition of research and development.[2]

The R&D industry in Utah consists of the universities and their associated enterprises; manufacturing concerns, mainly those oriented to missiles, electronics, and basic metal; government defense installations; and a few research, development, and testing laboratories. These will be discussed in detail in a later chapter.

Review of Following Chapters

Chapter II is a historical review of R&D in the United States and gives the general view of the impact of R&D on the economy.

Chapter III gives the setting of the study area and a description of the economy of Utah. It also describes Utah's R&D population, the major performers of R&D, and the types of research performed.

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[2]U.S., National Science Foundation, Research and Development in Industry, 1961 (Washington, D. C.: U. S. Government Printing Office, 1964), p. 95.

The analysis of the data is in Chapter IV. The impact of R&D on employment and income is determined through the use of an income multiplier. The methodology and models uses in the analysis are discussed and the various parameters of the models determined.

In the final chapter the models are applied to the different sectors of R&D performance. Through this method of analysis the impact of R&D expenditures on income and employment in Utah are exhibited.

CHAPTER II

RESEARCH AND DEVELOPMENT IN THE UNITED STATES

Growth of R&D in the United States

Science in colonial America

Early America was not scientifically oriented in comparison with the countries of Europe. It was many years after its settlement that America attained prominence in scientific endeavors and achievements comparable with that of the Old World. The conditions which existed in the Colonies were conducive to neither scientific thinking nor invention. To be able to invent, a person must take time to cogitate and reason. A farmer or soldier generally has "more important" things on his mind.

> Americans fought and worked to live and prosper--fought the Indians, conquered a continental wilderness, and built a Nation from a turbulent and traditionless society. Techniques and knowledge which helped in this struggle were welcomed. The frontierman had no time for refinements or subtleties. . . . The pioneer nation did not have the reserves of labor, wealth, and time for a long-range view.[1]

When America started to show some promise in industry, manufacturing was restricted by England. The American culture differed from the European culture in other ways; the colonies did not have the libraries, universities, or "conversation of the learned that graced the centers of Old World Culture."[2]

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[1]U.S., National Science Foundation, Basic Research: A National Resource (Washington, D.C.: U.S. Government Printing Office, 1957), p. 10.

[2]Brooke Hindle, The Pursuit of Science in Revolutionary America, quoted by Alan T. Waterman, "Basic Research in the United States," Dael Wolfle, ed., Symposium on Basic Research (Washington, D.C.: The American Association for the Advancement of Science, 1959), p. 21.

The United States relied heavily on Europe for scientific and technical knowledge. A direct and powerful influence was exerted on the new nation as scientists, books, and knowledge were imported. Of 90 scientific journals published before 1815, more than 50 were German, 35 French, English, and Italian, and but 1 of American origin.[3]

The beginnings of American science

The situation started to change in the middle of the nineteenth century. Scientific schools were organized at Harvard, Yale, and other universities; the Massachusetts Institute of Technology and other similar institutions were established. The first American Doctor of Philosophy degree in science was awarded by Yale University in 1861. Fifteen years later the Johns Hopkins University was established placing major emphasis on scientific research and graduate study. Other school followed this practice.[4]

Most of the inventions during the 1800's were the results of indivdual thinking and effort. The more important inventions often resulted in the establishments of new firms and products. Engineering and technical personnel were employed to amke the changes and improvements in the basic products, but did not participate in what would be called organized research.[5]

Organized R&D

This pattern changed at the turn of the century when the electrical

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[3]U.S., National Science Foundation, Basic Research: A National Resource p. 11.

[4]Ibid., p. 12; William Miller, A History of the United States (New York: Dell Publishing Co., Inc., 1958), p. 322.

[5]Ross M. Robertson, History of American Economy (end ed.; New York Charles Scribner's Sons, 1964), p. 416.

industry, which virtually consisted of Westinghouse and General Electric, developed engineering staffs. Both companies began R&D programs as business strategy to improve equipment and processes in the electric power industry and keep ahead of the other firm. Through organized R&D new products were created, thus increasing the demand for electricity and the profits of both firms.[6]

R&D became an integral part of the expenditures of these two companies and spurred the growth of an industry which has continued to maintain a prominent position in the American economy. R&D are an integral part of the electrical industry today, and the latter remains one of the primary users of R&D funds and personnel.[7]

The first World War exerted considerable influence on science in the United States. Prior to the war the nation purchased most of its chemicals and scientific instruments from Germany.[8] From this and other nations the United States borrowed scientific ideas and entire technologies.[9]

> Forced to develop new laboratories and plants and processes, American industry began investing increasingly in applied research and development--and became more nearly self-sufficient in devising and providing the instruments and equipment it needed. The demand for scientists and engineers increased accordingly. At the same time devastation and impoverishment abroard took an inevitable toll of European science, so that the relative progress of the United States was even more marked.[10]

The principla effects of the war on science were: (1) The introduct-

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[6] Ibid., pp. 416-417.

[7] See Review of Data on Science Resources, "Research and Development in the Electric Equipment and Communication Industry, 1956-62," I (3) (January 1965).

[8] U.S., National Science Foundation, Basic Research, p. 12.

[9] A. Hunter Dupree, Science in the Federal Government: A History of Policies and Activities to 1940 (Cambridge, Massachusetts: The Belknap Press of Harvard University Press, 1957), p. 323.

[10] U. S., National Science Foundation, Basic Research, p. 12.

ion of science into society, especially into production to the extent that "industrial research as a branch of the county's scientific establishment dates its rise to eminence almost entirely to the war period." (2) Cooperative research on a large scale was incorporated as many specialists worked with others in their own and related fields for the first time.[11]

After the war the electrical, chemical, and rubber industries made large outlays for R&D. The petroleum, farm equipment, and automobile industries began to build large R&D organizations during the 1920's and 1930's. During this period three-fourths of the personnel in organized industrail research were employed in these six industries. Such important industries as the steel, nonferrous metals, paper, textiles, and the food industries used less than one-fourth of the personnel.[12]

The second World War, like the first, had an impact on science and technology. "Spectacular achievements such as radar and the atom bomb from large-scale directed effort gave new prestige to scientific research for both military and commercial purposes."[13] The war also brought the federal government into prominence as a major supplier of R&D funds.

The distribution of industrial R&D performers has changed little since the end of World War II. The reasons for this are apparent. Research is not important in industries producing simple mechanical products such as potato mashers and pocket knives. Recognizing the need to perform research, companies face the question of how much.

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[11]Dupree, Science in the Federal Government, p. 323.

[12]Robertson, History of the American Economy, p. 564.

[13]Arthur Cecil Bining and Tomas C. Cochran, The Rise of American Economic Life (4th ed.; New York: Charles Scribner's Sons, 1964, p. 556.

> Especially is this true for industries whose technology is still in an early stage of development or for whom the factor of technological obsolescence is decisive. This may explain why two-thirds of all industrial scientists and engineers are employed in industries which have had the greatest growth in the past 30 years--chemicals and drugs, electrical and electronic equipment, petroleum, automobiles, aircraft, rubber, and precision instruments.[14]

Science in this country has grown from the condition in which the United States was a major importer of science and technology to one in which it is a major exporter. This is evidenced by the number of Nobel prizes in science awarded to Americans. The first prize was awarded in 1901, the first to an American in a scientific field in 1907. Of the 63 individuals to receive prizes in physics, chemistry, or physiology and medicine between 1901 and 1920, only 2 were to Americans, a mere 3 percent. Of the 67 awarded from 1921 to 1939, 13, or 19 percent, were to Americans; and of the 108 since 1943, 48, or 44 percent, have been to Americans![15] The application of science and technology discovered through research and development is one of the most dynamic forces in the economy today.

R&D in America Today

R&D performers

The performers of R&D can be classified into four groups.

(1) Private business. Private business supplies 33 percent of the funds for R&D and uses 76 percent. The primary reason for business's participation in R&D is to develop new products or processes and increase its profits.

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[14]John T. Connor, "The Responsibilities of Industry," Gerald W. Elbers and Paul Duncan (eds.), The Scientific Revolution: Challenge and Promise (Washington, D.C.: Public Affairs Press, 1951), pp. 103-111.

[15]"Nobel Prize," The World Book Encyclopedia, 1965 ed., vol. 14; "Nobel Prize," The 1965 World Book, Reviewing Events of 1964; pp. 333-348; Year Book. p. 441.

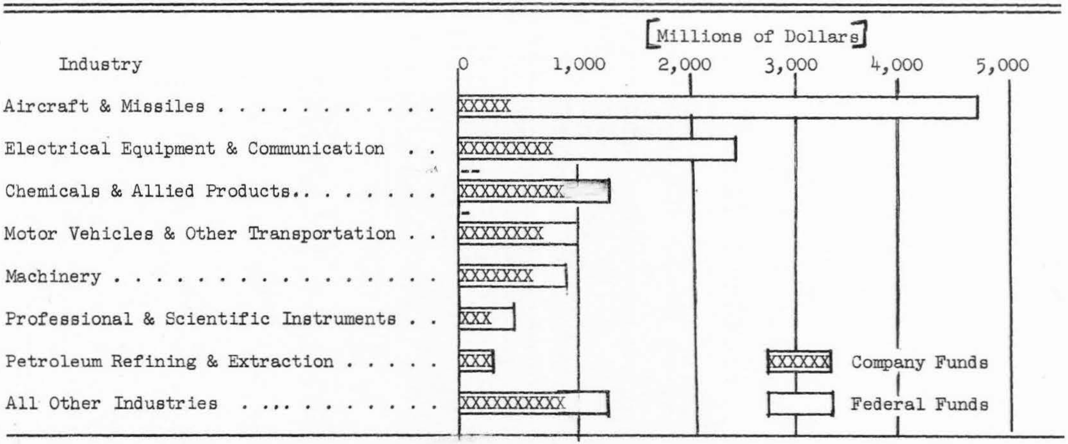

Figure 1. Funds for performance of R&D, by industry and source, 1963.

Source: U. S., National Science Foundation, "Research and Development in American Industry, 1963," Reviews of Data on Science Resources, I (1) (December 1964), 8.

(2) Federal government. The federal government provides 65 percent of the funds and uses 14 percent. The government supports projects beneficial to society, which usually are not profitable to private firms.

(3) Educational institutions. Colleges, universities, and professional schools, with their associated research institutions, hospitals, and agricultural experiment stations, provide 2 percent of the funds and use 8 percent. Educational institutions play a vital role in training most of the scientists and engineers performing R&D. R&D is considered by many to be an important function of a university, and although they perform a small part of the total research, they account for about half of the basic research.

(4) Other non-profit organizations. Other organizations supply 1 percent of the funds and use 2 percent. The quantity of R&D performed in this sector is small, but they given support to many pioneer projects.[16]

R&D by private business

The major motivating factor in business decisions is profit.[17] A firm makes a decision because it expects the results of that decision to increase its profits. This is just as valid for a decision concerning R&D. If the expected revenue from the new product or process exceeds the expected costs of the project a firm will engage in research, but if the

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[16]Jacob Perlman, "Introduction to Proceedings," U.S. National Science Foundation, Proceedings of a Conference on Research and Development and Its Impact on the Economy (Washington, D.C.: U.S. Government Printing Office, 1958), pp. 1-28; figures for sources and uses of funds are averages of the 1957-1961 fiscal years, U.S., Bureau of the Census, Statistical Abstract of the United States: 1963 (84th ed.; Washington, D.C.: U.S Government Printing Office, 1963), p. 543.

[17]Most of the ideas for this section are from Richard R. Nelson, "The Simple Economics of Basic Scientific Research," Journal of Political Economy, LXVII (June 1959), 297-306.

expected costs exceed the expected revenue a firm will not engage in the project.

Even though the technology needed to produce a new product or process is limited, if the demand is large enough a firm will engage in research to find the required know-how because it will be profitable in the long run. However, if the present knowledge is small and the costs of producing the needed knowledge cannot be estimated with any degree of accuracy the firm usually will not engage in research until additional information is known.

The two determining factors of whether a particular research project is incorporated are (1) the estimation of the incremental costs and revenue, and (2) the relative size of each.

If these can be estimated accurately, the firm will be able to collect the value of the new product or process to society through the market and the resources will be properly allocated. If the costs and revenue cannot be estimated accurately, the resources could be misallocated.

Two important factors which limit a firm's participation in R&D are risk and time. Because of the unpredictability of costs and revenue, a risk-avoiding firm will not perform borderline projects. A large firm can engaged in several research projects at a time and spread the chances of loss. Hence a large firm is more likely to support R&D on a large scale than a small firm. This is one reason why the major portion of R&D in the United States is performed by large corporations.

The length of the pay-off period also limits the performance of R&D. It might take a long time to perform the necessary research, and even after achieving success in the discovery of a new product or process, it might be considerable time before the product can be marketed.

One further point should be mentioned to explain business's support of applied as opposed to basic research. Private business does not generally engage in basic research because of the external economies of scale assoicated with it. These economies arise from two factors: (1) Quite often the results of basic research are of more value to firm other than the one performing the research. (2) It is difficult or impossible to obtain a patent on the results because fundamental knowledge cannot be patented.

Because of the reasons mentioned above resources are often misall-cated, being diverted to applied research when basic research is of more value to society. This is not to say that firms do research only when it appears profitable. There are other reasons for the performance of R&D (to improve the public image or as a social obligation or perhaps an ex-excutive desires to further science) and so there are private businesses performing basic research which might be of no economic worth to a particular firm.

Government R&D

Private business will not devote the resources to basic research which society deems necessary. As in other areas, there are benefits accruing to society which will not be produced by the profit motive. Government's objective should be to provide the R&D of value to society, but which will not be accomplsihed by competitive business because of the lack of profit and other reasons. Additional justification for the performance of R&D is to increase the store of knowledge about the world in which we live. Although this is a worthwhile endeavor, it is easy to see that it has no commercial application and would not be performed by a profit seeking firm.

A more practical justification for performing basic research is the fact that today's applied research is productive because of the knowledge obtained from yesterday's basic research. The development of new and improved products and processes tomorrow depends, to a great extent, on the basic research of today.

This justifies participation of the federal government in basic research. The government also participates in applied research such as defense and space research--areas in which the majority of federal funds for R&D are expended--agricultural and health research, and the collection of data. "This financing of scientific work may be regarded as an investment in the Nation's future defense, resource development, and material welfare."[18]

Effect of government R&D on industrial R&D

There are three views of the impact of federal research on private research.[19] One is that competition exists between government and industry the same as between different industries or firms. Thus, the entry of government into a field of interest to business in beneficial because it provides more competition to make the important discoveries. This augments the research effort, increases the probability of success, and quickens the rate of growth.

Another opinion is that when the government enters a field, private interests are lessened and industry is discouraged from entering it

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[18]Forest G. Hill, "Federal Expenditure Policy for Research and Development," U.S., Congress, Joint Economic Committee, Federal Expenditure Policy for Economic Growth and Stability, 85th Cong., 1st Sess., 1957, p. 1170.

[19]Ralph E. Burgess, "Federal Research Expenditure Policy and Its Relation to Economic Growth and Stability," Ibid., p. 1144.

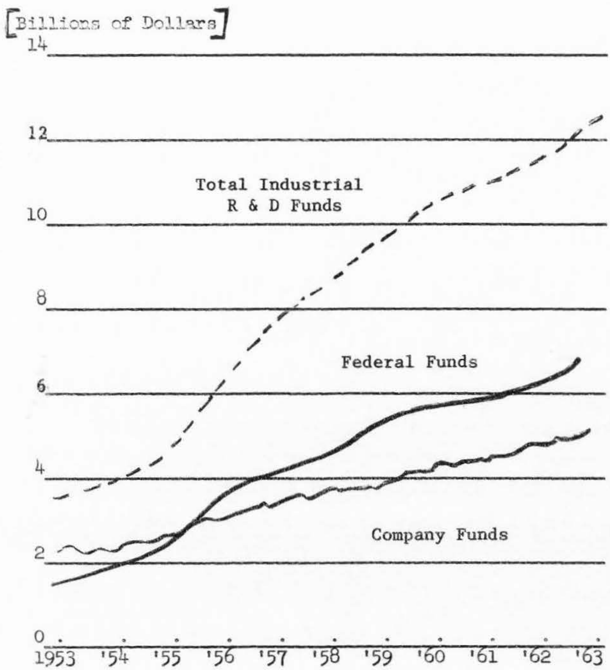

Figure 2. Trends in funds for industrial R&D performance, by sector, 1953-1963.

Source: U.S., National Science Foundation, "Research and Development in American Industry, 1963," Reviews of Data on Science Resources, I (December 1964), 4.

because any findings by the government are made public and no advantages accrue to the private firm. If this is true, there would be less private research activity in fields in which government participates than in fields in which they do not. This would lead to fewer research attempts, reducing the chances of success and retarding economic progress.

However, since discoveries of government research are made public, this could be benefical to some private firms by allowing them to capitalize on the new discovery. There is also the possibility that the new knowledge will open further areas of research with even greater possible rewards to private firms.

Still another arguement might be that they are independent so that government research neither stimulates nor retards private research.

Impact of R&D on the American Economy

One of the best ways to determine the impact of R&D on the American economy is to examine its impact on the economic goals of the United States. The various economic goals are affected to different degrees, and rather than consider several aspects on which R&D has had little effect, the two in which R&D have had their greatest impact will be considered--economic freedom and economic growth.

Economic freedom

One of the important goals of the United States is to maintain economic freedom. It is generally conceded that all citizens and businesses should have the right to make their own decisions without interference from the government or anyone else.

An important aspect in maintaining economic freedom is national security. R&D have helped the nation achieve this goal. Since World War II the federal government has had expenditures averaging more than $4 billion per year on defense and space-related R&D projects. Actually, 90 percent of the government R&D budget has been expended in this area.

Since 1960 the average has been more than $10 billion a year.[20]

Few people will doubt that these expenditures have had an influence in maintaining peace at home and abroad. But, although these expenditures have accomplished this and perhaps bolstered our prestige abroad, they have not been of direct benefit to the consumer. The majority of the projects associated with defense or space research have little commercial application.

> The defense effort and the research effort connected with it do not contribute per se to the material well being of the people and, inasmuch as goods are not destined for ultimate consumption (if strictly defined military spending amounts to economic waste) the impact of such outlays is inflationary in a period of full employment such as we enjoy today.[21]

Another influence on economic freedom is the relationship between business and government. If the government is exercising more control over business by supporting R&D, this would tend to diminish business's economic freedom. To avoid this problem the government has followed the policy of using contracts and grants for the major portion of its R&D expenditures. If the government-financed R&D on 1963, 80 percent was performed by "extramural" performers, i. e. business, educational and other institutions out side the federal complex. Government agencies performed the remaining 20 percent.[22]

Another possible outcome of government R&D is the formation of a new industry creating new inter-industry competition. New discoveries bringing forth added information or a completely new product could make new

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[20]U.S., National Science Foundation, Federal Funds for Research, Development, and Other Scientific Activities (Washington, D.C.: U.S. Government Printing Office, 1964), pp. 150-151.

[21]Burgess, "Federal Research Expenditure Policy," p. 1142.

[22]U.S., National Science Foundation, Federal Funds for Research, pp. 14, 18.

commercial application feasible, making possible a new industry and creating competition which did not exist before.

An example would be the automobile industry. Because of control of the market by large oligopolies, it would be virtually impossible for a new firm to enter the industry and attain a profitable position. But if a new firm had a good marketable substitute for the automobile, it could complete with the present automobile industry and attain a profitable position.

The possibility of new discoveries, as well as their actual application seems to bolster competition in a capitalistic system.

Economic growth

Another of the important goals of the American economy is economic growth--growth in real national product and a rising level of living. There are many factors which affect the growth of an economy. Unquestionably, one of the most important for a highly developed economy such as the United States is R&D. Alvin Hansen, noted Harvard economist, emphasized its importance in the following way:

> What now are the real bases of long-term growth? The answer, I believe, is not capital accumulation though this plays a necessary albeit restricted role. The answer, I suggest, is rather scientific research and invention. If these can be made to grow at a more rapid rate than in the past, then we shall in the usual case be able to open up deeper and broader outlets for investments, and thereby accelerate the rate of long-term growth.[23]

The chain of events leading from research to growth are: (1) research, (2) invention, (3) innovation, and (4) economic growth. How does

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[23]Alvin H. Hansen, "Federal Tax Policy for Economic Growth and Stability," papers submitted by panelist before the Subcommittee on Tax Policy, Joint Committee on the Economic Report, November 9, 1955, pp. 15-16, cited in U.S., National Science Foundation, Proceedings of a Conference on Research and Development and its Impact on the Economy (Washington, D.C.: U.S. Government Printing Office, 1958), p. 5.

R&D have this impact? The instruments of this impact can be traced to increased productivity and increased demand.[24]

New methods of production lead to greater productivity and allow more efficient use of capital and resources. Studies have shown that companies performing "intensive" R&D have increased their productivity and profits at a faster rate than companies not performing R&D.[25]

In the United States about half of the economic growth is attributed to increases in productivity, which can be attributed mostly to technological change through organized research and organizational change by management. (Education undoubtedly plays a strategic role in both phases.)[26]

Increases in productivity make it possible for growth to be attained, but the implemental factor is the level of aggregate demand. Only as R&D increases demand will it have a noticeable effect on growth.[27]

R&D affect demand by creating new or improved products which cause an increase in demand directly in the consumer market and indirectly in the capital market. If the result of research is a new production process or technique, the demand in the capital market will increase as firms implement the more efficient methods.

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[24]See Sumner H. Slichter, "Technological Research as Related to the Growth and Stability of the Economy," U.S., National Science Foundation, Proceedings of a conference . . ., pp. 108-109; John T. Connor, "Research: The New Dynamo for Economic Growth," address before the Federal Wholesale Druggists' Association Inc., White Sulphur Springs, West Virginia, September 19, 1960, unpaged.

[25]Nestor E. Terleckyj, Research and Development: Its Growth and Composition (New York: National Industrial Conference Board, Inc., 1963), pp. 55-56.

[26]Ibid., p. 7.

[27]See Irving H. Siegel, "The Role of Scientific Research in Stimulating Economic Progress," in "Investing in Education and Research," American Economic Review, L (May 1960), 343-344.

By these two methods, R&D quicken

> the pace of scientific and technological progress, which in turn increases the rate of economic growth. This dynamic process yields new and improved commodities, new industires, increased interindustry competition, and new and cheaper processes and methods of production. In consequence, new investment opportunities appear, labor and capital become more productive, and the gross national product rises.[28]

American history is replete with examples of how this has taken place. In earlier times an invention often caused the birth of a new industry, which sometimes had an impact on the entire economy. Examples include the railroad, electrical, and automobile industries.

In more recent imes most inventions have had a less significant general impact, but have undoubtedly had an influence on growth. Such inventions as television, the transistor, and the electronic computer have changed our society and helped cause more rapid growth and a faster rising standard of living.

Because of the impact on the economy of generating economic growth, R&D have "become the most dynamic economic force of the decade."[29]

28Hill, "Federal Expenditure Policy," p. 1165.

29Connor, "Research: The New Dynamo . . ."

CHAPTER III

R&D IN UTAH

The Economy in Utah

Population

In the latter part of 1964 the population of Utah reached the one million mark. The 1960 census listed the population of Utah at 890,627, slightly less than 0.5 percent of the nation's population.

Utah ranks 38th with other states in population, and 11th in land area.[1] Although these figures do not indicate it, Utah is an urbanized state. Of Utah's residents, 75 percent are classified as urban compared to a national average of 70 percent. It is the tenth most urbanized state in the nation and ranks above Michigan, Pennsylvania, and Indiana, and all eleven Western states with the exception of California. Urbanization is a relatively recent occurence in Utah, rising from 65 percent to 75 percent during the 1950's.

The high urbanization is mainly a result of the topography and climate. Much of the State is barren wasteland or mountainous. Because of scanty rainfall there is only sparse vegetation in nine-tenths of the State.[3]

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[1]"United States", The World Book Encyclopedia (Chicago" Field Enterprises Educational Corp., 1965 ed), vol. 18, p. 52.

[2]Leonard J. Arrington and George Jensen, "Utah's Emerging Metropolis: The Wasatch Front", Utah's Urban-Rural Revolution, Sixth Annaul Agricultural and Industry Conference, Utah State University, Logan, Utah, Feb. 6, 1962 (Logan, Utah: Utah State University, 1962), pp. 9, 22.

[3]"Utah", The World Book Encyclopedia, vol. 18.

Because of the environmental conditions the population and industry are concentrated in the valleys of the Wasatch Mountains, east of the Great Salt Lake. The four-county "Wasatch Front" (consisting of Weber, Davis, Salt Lake, and Utah counties) while comprising only 4.2 percent of the land area, accounts for 75 percent of the population.[4] Businesses in this area accounted for 80 percent of the payrolls, production workers, and value added of the manufacturing industries,[5] and an equal percentage of total employment in the State in 1963.[6]

Employment

Utah's labor force has not been growing as fast as its' population, but non-agricultural employment has been gorwing faster. This has been caused by a shift of employment from agriculture to industry. During the 1950's the population increased 29 percent, the labor force 27 percent, and non-agricultural employment 39 percent while agricultural employment decreased 24 percent.[7] The distribution of the labor force in 1953 and 1963 is given in table 1 and shows the change in each sector for that period.

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[4] Ibid.

[5] U.S., Department of Commerce, 1963 Census of Manufactures, Area Series/Utah, preliminary report, (Washington, D.C.: U.S. Government Printing Office, 1965), p. 5.

[6] Utah Department of Employment Security, Utah Annual Report Supplement, 1963 (Salt Lake City, Utah: Utah Department of Employment Security, 1964), p. S-29.

[7] Ibid., pp. S-5 to S-8.

Table 1. Employment in Utah

Industry	Percent of Total 1953	Percent of Total 1963	Employment[b] 1963	% Change
Agriculture	20.0	14.8	51.4	-5.5%
Manufacturing	12.4	15.9	54.8	63.0%
Mining	5.0	3.4	11.9	-13.3%
Construction	4.1	5.1	17.5	56.8%
Transportation & Communication	8.6	6.3	21.7	-6.8%
Trade	17.8	19.0	65.6	34.8%
Finance, Insurance & Real Estate	2.8	3.6	12.5	61.5%
Service & Miscellaneous	8.6	11.2	38.9	65.3%
Government	20.7	20.7	71.6	27.2%
Labor Force			363.7	28.9%

Source: Utah Department of Employment Security, Utah Annual Report Supplement, 1963 (Salt Lake City, Utah: Utah Department of Employment Security, 1964), pp. S-8 to S-9.

The largest employers in the State are the various levels of government, employing 72,000 people. The percentage of the total employment at the federal level, almost half of total government employment, actually decreased during the last ten years, but this was offset by a 65 percent increase at the other two levels.

The largest private employment is in wholesale and retail trade, with employment of 66,000, followed by manufacturing with 55,000. Manufacturing employment has been increasing in importance annually except for the recession of 1958. The most significant change is the manufacturing sector has been in durables, which more than doubled its employment during the ten-year period. This has occurred primarily because of the advent of the missiles industry. The relative importance of primary metals and good and kindred products had a considerable decrease during the decade.

Income

Personal income reached the $2 billion mark for the first time in 1963. It has grown at the rate of 7 percent a year for the past decade, slightly faster than the United States figure.[8]

Real per capita disposable income was $1,648, almost nine-tenths of the United States figure in 1963.[9] This smaller than average figure is caused by the employment of a smaller percentage of the population and a larger proportion of the population being under the age of 21. On a family income basis the State is generally the national norm.[10]

The sources of personal income differ considerably from that of the nation, but not to the extent that it did ten years ago. Utah derives a larger part of its income from mining, government, contract construction, and utilities and transportation than the nation as a whole, but less from manufacturing, agriculture, services, and finance, and insurance.[11]

In comparison with the other Rocky Mountain states, Utah receives more of her income from mining, manufacturing, and government, but less from agriculture, services, and communications.[12]

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[8]U.S., Department of Commerce, Survey of Current Business, XLV, (April 1965), 13-24.

[9]Ibid.

[10]ElRoy Nelson and Osmond Harline, Utah's Changing Economic Patterns, 1964 (Salt Lake City, Utah: University of Utah Press, 1964), pp. 4-5.

[11]See table on following page.

[12]U.S., Department of Commerce, Survey of Current Business, XLIV, (August 1964), 23.

Table 2. Percentages of total personal income from major industrial sources in Utah and the United States.

Industry	Utah 1957	Utah 1963	U.S. 1963
Basic Physical Production			
Agriculture	6.4	3.0	4.4
Mining	7.8	4.8	1.2
Manufacturing	15.9	19.7	29.2
Utilities and Transportation	10.0	8.3	7.4
Contract Construction	9.2	8.8	6.4
Sub Total Production	49.2	44.6	48.6
Trade	19.4	19.7	19.1
Finance and Insurance	4.1	4.3	5.2
Services	9.4	10.2	13.5
Government	17.7	21.1	13.2
Other and Miscellaneous	0.1	0.1	0.4
Sub Total Service	50.7	55.4	51.4

Source: U.S., Survey of Current Business, XLV (August 1964), pp. 18, 22, XLI (August 1958), p. 20.

R&D Population

The performers of R&D in Utah can be classified into four main groups: (1) manufacturing firms, (2) universities and their associated enterprises, (3) federal defense installations, and (4) research, development, and testing laboratories. One of the purposes of this study was to determine the extent of R&D within there groups, and the resulting impact on Utah's economy.

Manufacturing firms

There are 1,130 manufacturing firms in Utah. Since most of the R&D in the State is performed by the larger firms, it seemed logical to assume that any R&D performed by a single small firm, if ignored, would be of little consequence. For purposes of this study only those firms with more than 25 employees in the following industries were considered to be important potential performers of R&D. Aircraft and missiles, electric equipment and communication, chemicals and allied products, professional and scientific instruments, and petroleum refining and extraction. Firms in these industries, because of the nature of their products, were considered to be more likely to perform R&D than firms in other industry classifications. In all other manufacturing classifications only those firms which had more than 100 employees were considered. With these restrictions, the number of possible performers of R&D in Utah's manufacturing sector were reduced to 120.

To determine whether or not a particular form performed R&D a questionnaire (Appendix A) was sent which required only "yes" or "no" answer. The questionnaire was made simple with the hope of obtaining a high response. All firms which did not reply were contacted personally to determine if they performed R&D. Of the 120 manufacturers, 25 performed organized R&D.

A second questionnaire (Appendix B) was sent to the 30 firms to determine the extent of R&D by the particular company as well as to acquire information which would reduce the essential information to be obtained by personal interviews. All firms were to be interviewed, but gathering data by mailed questionnaires saved time.

In view of the heavy concentration of Utah R&D in a few large firms and institutions, it did not seem to be a wise use of resources to study the economics of R&D performed on a small basis. To consider firms which employed less than five R&D scientists or engineers in comparison with firms which hired hundreds of such persons seemed impractical. The elimination of firms which employed less than five scientists and engineers on R&D limited the sample in this category to 15 firms. The 10 firms excluded from intensive study only employed 34 persons in R&D. The 15 firms and the R&D performed are:

1. Atlantic Research Corporation -- missiles, chemicals
2. Bennett's -- paints and varnishes
3. Christensen Diamond Products Company -- oil field machinery
4. Combined Metals Reduction Company -- metals, plastics
5. The Eimco Corporation -- mining, machinery, steel
6. Hercules Powder Company -- missiles
7. Kennecott Copper Corporation -- copper, chemicals
8. Litton Systems, Inc. -- electronics
9. The marquardt Corporation -- missiles, aircraft engines
10. McGraw-Edison Company (Ajax Presses) -- laundry and dry cleaning machinery
11. Model Engineering & Manufacturing Company (Montek) -- electronics
12. Sperry Utah Company -- missiles, electronics
13. Thiokol Chemical Corporation -- missiles, transportation equipment
14. United States Steel Corporation -- steel, chemicals
15. Utah-Idaho Sugar Company -- beet sugar

Universities

There are three major universities in the project area: Utah State University, Brigham Young University, and the University of Utah. The universities have long been employers of persons in R&D.

Federal defense installations

Utah has eight major Department of Defense installations. Six of these perform R&D:

1. Deseret Test Center -- chemistry, biology, public health
2. Dugway Proving Grounds -- chemistry, biology, radiology
3. Green River Missiles Test Complex -- missiles
4. Ogden Air Materials Area at Hill Air Force Base -- missiles
5. Tooele Army Depot -- munitions
6. Vernal Air Force Seismological Site -- nuclear detection

Research, development, and testing laboratories

This sector of R&D establishments includes Standard Industrial Classification 9391 -- research, development, and testing laboratories; and medical laboratories performing R&D. There are 12 firms in this category in Utah not associated with universities. Most of these are national firms with small branches in Utah. Four perform significant R&D:

1. Avco Corporation -- aerospace, chemicals
2. C-E-I-RR-- statistical
3. Intermountain Research & Engineering -- metallurgy
4. Utah Research and development Company -- aerospace

The eight firms which were included 19 persons in R&D.

Final sample

The final sample of Utah R&D performers includes the following firms and enterprises:

Table 3. Utah's R&D population

Category	Number
Manufacturing firms	15
Universities and Associated enterprises	3
Federal Defense installations	6
Research, development & Testing Laboratories	4
Total	28

Although several small performers of R&D are eliminated, this sample includes virtually all of the R&D performed in Utah.

R&D by Utah Enterprises

Traditional manufacturing firms

The two firms in this category which are the most significant performers of R&D are the Kennecott Copper Corporation and United States Steel Corporation. Kennecott Copper Corporation is the largest producer of copper in the world and one of the 100 largest manufacturing concerns in the United States.[13] The Utah Copper Division's facilities include two ore concentrators, a smelter, and electrolytic refinery, and a large steam electric generating plant, in addition to a large open pit mine.[14] Kennecott employs more than 5,000 persons in Utah and pays in excess of $35 million in payrols annually. Their Bingham Mine has produced $5

13"Kennecott Copper Corporation," The World Book Encyclopedia, v. 10, p. 213.

14Leonard J. Arrington and Gary B. Hansen, "The Richest Hole on Earth:" A History of the Bingham Copper Mine, Utah State University Monograph Series, XI (October 1963), pp. 1-13, 67-82.

billion worth of copper and more than $1 billion in other metals. It is the world's second largest producer of copper and molybdenite, and the second largest producer of gold in the Western Hemisphere. More metal has been produced from this mine than from any other single mine in the world.

Extracting the value from the earth has not been an easy task and has become more difficult as time has progressed. It has required the removal of more than 2.2 billion tons of overburden, more than for the Panama Canal. Ore containing as little as 0.4 percent copper is shipped to the smelter for refining.

> A profusion of new techniques and equipment has appeared on the scene--new techniques of gravity concentration and the development of the flotation process of dressing ore. For it was at Bingham that mining engineers perfected the technique of mass production of minerals--atechnological breakthrough which bears resemblance in basic importance to the development of the factory system in industry.[15]

Research and innovation have been indispensable to the success of Kennecott. To further R&D, a research laboratory was established on the campus of the University of Utah. In 1954 a $1,250,000 facility was built to house the research center.

> This laboratory functions to coordinate and expand the research of Kennecott's four Western mining divisions--Utah Copper, Nevada Mines, Ray Mines, and Chino Mines. In addition to improvements in the recovery of molybdenite, research staff members have developed a method for recovering rhenium, and more efficient methods of recovering by-product metals from the electrolytic refining process. Today, the output of the Utah Division includes platinum, palladium tellurium, selenium rhenium, and nickel sulphate.[16]

The Geneva Works of the Columbia- Geneva Steel Division of United States Steel Corporation was constructed for the government during World War II as a precautionary measure to assure adequate steel sources for

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[15] Ibid. p. 8.

[16] Ibid. p. 78.

the pacific Coast users in case the Panama Canal was attacked.[17] It was purchased by U.S. Steel in 1946. The capacity of the plant was increased from 1.2 million ingots annually to more than 2 million ingots in 1958. One of the largest and most modern integrated steel plants in the nation, it employs almost 5,000 persons and has an annual payroll of more than $40 million. Because of competition and other factors, the division has stepped up its research activity by establishing a laboratory adjacent to the factory. Improvements in both the final product and production techniques have helped lower costs and expand markets.

Missiles and electronics

Prior to 1956 this industry was essentially non-existent in Utah; since then it has grown and become the largest single industry (in terms of payroll and employment) in the State.[18]

The first appearance of missiles in the State was the establishment, in 1956, of the Sperry Utah Engineering Laboratories by the Spery Rand Corporation of New York City. Sperry is located in Utah because of the relative proximity to its Sergeant missile co-contractor, Jet Propulsion Laboratories in Pasadena. California, and the White Sands Proving Grounds in New Mexico. The purpose of the Utah laboratory, with 500,000 square feet of floor space, was research and production of the Sergeant medium range ballistic missile. Payrolls of the firm since 1957 have averaged

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[17]Information on W.S. Steel from Growth of the Iron and Steel Industry in Utah (Columbia-Geneva Steel Division, United State Steel Corporation, Geneva Works); "U.S. Steel Shows Big Gain, " The Salt Lake Tribune, January 15, 1958.

[18]Information on the missiles industry from Leonard J. Arrington and George Jensen, The Defense Industry of Utah (Logan, Utah: Utah State University, 1965), pp. 16-22, 28; Nelson and Harline, Utah's Changing Economic Patterns, 1964, pp. 60-62.

$20 million per year, with a high of $23 million and a present rate of $18 million per year. In addition to extensive work on the Sergeant missile, Sperry has engaged in many R&D projects. These have included studies of advanced weapons systems, missile and fire control applications for ground and airborne limited war weapons, radar, and process control, and the application of computers to commercial activities.

The largest R&D facility in Utah is that of the Thiokol Chemical Corporation. Constructed on an 11,000-acre site in Box Elder County, west of Brigham City, this $15 million plant was built partly by the Air Force and partly by private financing. The choice of location was based upon the need of room for expansion as well as a suitable place for the testing of rocket engines. In the early 1960's Air Force Plant 78 was constructed near the R&D complex, bringing the investment of Thiokol and the Air Force in Box Elder County to more than $80 million. Employment by Thiokol's Wasatch Division reached a peak of 6,100 in 1962 but has dropped to a present level (August 1965) of 2,700. R&D expenditures on the Minuteman missile from 1957 to 1959 were $77 million. In addition to the first stage of Minuteman, R&D has included probes in the upper atmosphere and the response of parachute system to high-altitude winds. Thiokol research resulted in new processes including propellants, metals, plastics for rocket motor cases, and insulation materials; new designs for rocket motors and nozzles have also been developed.

The Hercules Powder Company has been in Utah since 1914. Employment was small until 1955 when the awarding of defense contracts made possible the construction of extensive R&D facilities at Bacchus, 20 miles southwest of Salt Lake City. A large expansion program was started in 1958, and with the construction of Air Force Plant 81 in the early 1960's the total investment at the Bacchus reached $47 million.

Employment by Hercules reached 5,900 in 1963, but dropped to 3,500 by the summer of 1965. Most of the activities at the Bacchus works are for the production of the third-stage Minuteman motor, and the Navy's Polaris missile. Important recent contracts have had to do with the Poseidon missile. Minuteman contracts have totaled $300 million and Polaris contracts $100 million. The company has also produced smaller solid-fuel motors.

The Marquardt Corporation located in Ogden in close proximity to Hill Air Force Base and also because of adequate testing facilities in the vicinity. The main purpose of the Utah complex was the production and testing of ramjet engines for the Bomarc ground-to-air missile.

> As the production of Bomarc was phased out, Marquardt actively bid on subcontract work with other missiles and aerospace manufacturers and continued its active program of research. Marquardt has been involved with advanced space research, and weapons system support and manufacturing.[19]

Federal defense installations

The largest single employer in Utah is Hill Air Force Base, south of Ogden.[20] The base was established in 1942 as a repair and maintenance base and for the storage of material. Since 1952 the command, which was renamed the Ogden Air Material Area, has become the "Missile Center of the West." It assembles, repairs, and maintains several missiles including the Minuteman. In 1964 the $7.5 million Hill Air Force Range was completed in the northeast section of the Wendover Range Complex in western Utah. It was established to study and test missile motors, mostly Minuteman.

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19 Arrington and Jensen, The Defense Industry of Utah, p. 22.

20 Information on Government installation from Ibid., pp. 3-6, 23-24.

The dugway Proving Ground, 85 miles southwest of Salt Lake City, was activated in 1942 as a proving ground for the Chemical Warfare Service. It was established to conduct large-scale testing of chemical munitions, but also performed other biological research. In addition, incendiary weapons and protective equipment which was used during the war were developed. The installation was deactivated after the war.

> During the Korean Conflict the reactivated base carried on a stepped-up program of testing material and equipment for the Army Chemical Corps, working on flame throwers, smoke generators, and both Napalm and incendiary bombs. In addition to toxic gas tests, meterological test, and bacteriological tests, recent activities have included ecological systems surveys, radiation tests, and a Chemical Biological and Radiological Weapons Orientation course for key Department of Defense civilian and military personnel. For such purposes it is the major proving ground in the nation. The ecological systems survey includes biological inventories of various areas and the study of diseases endemic in animals -- the relations of various animals to vegetation, animal disease pathways, and the control of diseases. These are studied as pertinent aspects of basic epidemiological transmission cycles.[21]

The entire facilities, including 500 buildings, are valued at $52,4 million and utilize approximately 2,000 military and civilian personnel. Dugway is operated by the U.S. Army Test and Evaluation Command.

The Deseret Test Center, with headquarters at Fort Douglas, east of Salt Lake City, carries out an active research program at Dugway. Under the jurisdiction of the United States Army Material Command, it was established in 1962 to "coordinate service and public health interests in defensive chemical and biological testing."[22] The Center employs 63 military and 113 civilian personnel.

The United States Air Force constructed the Green River Test Complex in 1963 to study payload re-entry problems. The main purpose of the

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[21] Ibid., p. 12.

[22] Ibid., p. 3.

complex is to fire missiles which impact at White Sands Missile Range in Arizona. Employment at the site is 450, mostly by private contractors.

R&D at universities and associated enterprises

With just over one million residents, Utah is the home of thre universities and six colleges and junior colleges, with a total enrollment of 37,893 students in 1963, of whom 38 percent were non-residents. This does not include enrollment at the State's two trade technical institutions of 1,412, and evening school enrollment of 1,700.[23] The universities in Utah have not only performed research, but have influenced the location of research-oriented industries in the State by providing a scientifically able and technologically capable labor force.

Utah State University. Organized research began in Utah with the establishment of the Utah Agricultural Experiment Station in conjunction with the founding of the Agricultural College of Utah (now Utah State University).[24] The college was founded as a Land Grant College under the Federal Hatch Act of 1887, and an act of the Utah Territorial Legislature in 1888. In 1890 the first president and director was appointed and money appropriated for a chemical laboratory and farm house. Before the year had passed, two bulletins had been published, giving evidence of early research work at the station. Most of the research work, including that of the Engineering Experiment Station organized in 1918, was directly or indirectly associated with agriculture until after World War II.[25]

23Nelson and Harline, Utah's Changing Economic Patterns, 1964, p. 2.

24The name was changed to Utah State Agricultural College and in 1955 to Utah State University.

25Utah State University, Pioneering in Western Agriculture, A Resume of the First Half-Century of Research, 1888-1938, at the Utah Agricultural Experiment Station, (Utah Agricultural Experiment Station Bulletin No. 282; Logan, Utah: Utah State University, 1938), pp. 10, 13-14, 123

Even as late as 1955, 98 percent of the research funds[26] were assigned to the Agricultural Experiment Station. (All of this would not be classified as agricultural research, but most of it would.) Associated with USU since 1942 is the Utah Scientific Research Foundation, now owned by the University. The Division of Research was organized in 1955; funds were established to pay staff members to do research during the academic and summer quarters; and in 1965 the Director of the Division of Research was appointed to the position of Vice President for Research. This shows the change in scope and emphasis of research at Utah State University during the past decade.

The distribution of research funds in 1963-1964 was 40 percent to the College of Engineering, 32 percent to Agriculture, 18 percent to Science, and 10 percent to the remaining colleges. The funds were utilized in four main areas: 26 percent for natural resources, 24 percent for aerospace, 23 percent for food, and 15 percent for basic biology, with other areas of research receiving 12 percent. The amount of research performed at Utah State University has grown from $1.0 million in 1955 to $5.7 for the 1963-1964 fiscal year. The Federal government supplies 64 percent of the funds; 16 percent from State appropriations; 11 percent from Utah's Uniform School Fund; and 6 percent from private and other sources.[27]

In addition to the development of wheat and other grains, tomatoes, onions, and other corps and improved breeding animals, Utah State

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[26]Research in this section includes research in the social sciences and psychology, literary studies, and other areas which do not correspond to the previous definition of research.

[27]Utah State University, Division of Research, Biennial Report, 1962-1964, (Logan, Utah: Utah State University, 1964) p. 7.

University research has attracted world-wide attention in water resource and water management studies, snow surveys for predicting stream flows, soil-water relations, and drainage.[28]

The University of Utah. Although a predecessor of the University of Utah (University of Deseret), was organized forty years before the founding of the Utah Agricultural College, it did not attain a prominent status in research until recent years. Organized research started in 1909 with the establishment of the Engineering Experiment Station. Four years later the Department of Mining and Metallurgical Research was organized. Research during the early part of the twentieth century was generally restricted to this area. It was permitted in the University as a whole only if its cost was minimal interms of money or time from undergraduate instruction. The Biological Survey of Utah and the Geological Survey of Utah were established in 1919 with hopeful planning for research, but lack of funds presented action until the 1930's.

> In the thirties when the atmosphere of university life was relatively complacent, research was conducted for the most part in a leisurely manner as an adjunct to teaching, under little pressure and with little or not special financial support.[29]

With the upsurge of R&D during World War II and realization of its importance by Washington and the public, research took on a new outlook at the University and the faculty recognized the importance of research and established programs to implement it. A research council was organ-

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[28]Utah State University, To the Commission of Higher Schools of the Northwest Association of Secondary and Higher Schools, Self-Evaluation Report No. 1 (Logan, Utah: Utah State University, 1958), pp. 95-96.

[29]Ralph V. Chamberlin, The University of Utah, A History of Its First Hundred Year--1850-1950 (Salt Lake City, Utah: University of Utah Press, 1960), p. 527.

ized, and in 1945 the first research fellowships and assistantships were made available. In 1947 a further boost was given to research when faculty members were hired for four quarters instead of three. One of the quarters was required to be devoted to research work or some other form of "self-improvement."[30]

Total expenditures for research[31] grew from $84,000 in 1945 to $2.1 million in 1955. Total research expenditures in 1963-64 were $6.1 million. Most of this is medicine and related areas. Of the total grants received by the University during the 1960's, 43 percent were in medicine, 28 percent in the biological sciences, 23 percent in the physical sciences, 5 percent in the social sciences, and 1 percent in humanities.[32]

Brigham Young University.[33] Organized research is a recent addition to Bragham Young University. Before the fall of 1952 there were no formal means of attaining financial help for research, nor were there any University funds set aside for the purpose. There are only two grants on record before that time, one to the Chemistry Department from Kennecott Copper Corporation and one to the Botany Department from the Utah-Idaho Sugar Company. In the fall of 1952, Dr. Harvey Fletcher, who has been

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30 Ibid., pp. 270-271, 437, 499, 529.

31 Research expenditures here include research in the social sciences and psychology, as well as training programs, fellowships, and other areas which do not correspond to research as previously defined.

32 University of Utah "Report to the President from Cooperative Research for the Fiscal Year 1964," Salt Lake City, Utah, 1964.

33 All information on research at Brigham Young University taken from "Eleven-Year Report of the President (1950-51 to 1960-61) of Brigham Young University and Eight-Year Report of the Administrator (1953-54 to 1960-61) of other areas of the Unified Church School System," Brigham Young University, Provo, Utah, 1961, pp. 127-129. The figures for research in the social sciences, as well as poetry, and musical composition.

nationally recognized for his pioneer work in acoustics, was appointed Director of the newly formed Research Division. By the end of 1952 he had obtained two grants and laid the foundation for others. He also helped establish a summer salary program to enable faculty members to perform research.

In 1956 the University made an agreement with Research Corporation of New York City to market its inventions. Under this agreement proceeds of discoveries made at Brigham Young University are divided so that 15 percent goes to the inventor, and the remainder is divided approximately equal between Research Corporation and the University, whose share is devoted to research. Further incentive for faculty research was provided by the Faculty Research Program established in 1961.

Research expenditures grew from $32,650 in 1952-1953 to more than $327,000 in 1961.

Federal Funds for Utah R&D

By far the largest supplier of R&D funds in Utah is the Federal government.[34] Utah received 1.1 percent of total Federal government R&D obligations in 1963 and 0.5 percent in 1964 -- $135,8 million and $65.1 million respectively. Most of the government R&D obligations in Utah are made by the Department of Defense -- 84 percent in 1964 and 93 percent in 1963. If the National Aeronautics and Space Administration and the Atomic Energy Commission are added to the Department of Defense figures, the

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[34]Information for this section is from U.S., National Science Foundation, Obligations for Research and Development, and R&D Plant, by Geographic Divisions and States, by Selected Federal Agencies, Fiscal Year 1961-64, a report to the Subcommittee on Science, Research, and Development of the Committee on Science and Astronautics, U.S. House of Representatives.

figures are raised to 86 percent and 94 percent, respectively. (See Appendix) Other major suppliers of R&D funds are the Department of Health, Education, and Welfare, with 6.2 percent of the funds, and the departments of Interior and Agriculture with 3.6 percent and 2.5 percent, respectively.

On a per capita basis, Utah received and equal portion, in comparison with other states, of total R&D funds in 1964. Utah received more than her share of Agriculture, Defense, and Interior funds, a fair share of Health, Education, and Welfare and National Science Foundation funds, and less than her share of funds from the Department of Commerce, the Atomic Energy Commission, and the National Aeronautics and Space Administration.

More federally-financed R&D is performed by government agencies in Utah than in the nation as a whole -- 31 percent compared to 19 percent. Profit organizations performed 54 percent of the R&D in Utah and 66 percent in the nation. The proportion performed in educational institutions is 14 percent in Utah compared to 12 percent in the nation.

Much of the distribution of government-supported R&D is a result of the relatively high concentration of the missiles industry in the State. Utah ranked first with the highest concentration in one category of military prime contract awarded in fiscal year 1962. Missiles were responsible for 87 percent of the prime contract awards in the State, opposed to a national average of 27 percent. Experimental, developmental, test, and research work accounted for 40 percent of these awards.[35]

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[35]U.S., Department of Defense, Five-Year Trends in Defense Procurement, 1958-1962 (Washington, D.C.: Office of the Secretary of Defense, 1962), pp. 11, 62.

Although the activities of the missiles industry in Utah has tapered off, it is still the most prominent performer of industrial R&D in the State.

Expenditures for R&D in Utah

The amount of R&D performed in the State of Utah has been growing in the State as it has been in the nation. This growth and its impact are indicated by the following table comparing R&D expenditures in 1964 and 1958.

Table 4. Expenditures for R&D in Utah

	1964	1958
Total R&D Employment	2,467	1,220
R&D Employment of Scientists and Engineers	871	214
Total R&D Expenditures	$60,890,146	$26,815,894
R&D Payroll	26,329,673	12,497,788
Investment in R&D Facilities	6,353,286	4,738,603

CHAPTER IV

INCOME AND EMPLOYMENT MODELS

Economic Models[1]

Very little is gained in economic analysis with simple qualitative statements of tendencies which in and of themselves often mean very little. For example, the statement that R&D expenditures in Utah create income for Utah residents is tautological and contributes nothing to understanding: for the impact may be great or meager. As Lord Kelvin stated:

> When you can measure what you are speaking about, and express it in numbers, you know something about it; when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of sc science. . . .[2]

This is one reason for the use of theories and models in economic analysis. A theory is an abstraction or generalization of phenomena which has been observed or experienced.

A model is a statement of economic theory, put in a form which is intended to give better understanding or meaning to the relationships among the variables involved. A model "uses what we know or think we know about economic behavior patterns, technology, or institution to

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[1]See Gardner Ackley, Macroeconomic Theory (New York: The Macmillan Company, 1961), pp. 8-14; Campbell R. McConnell, Economics: Principles, Problems, and Policies (New York: McGraw-Hill Book Company, Inc., 1963), 2nd ed., pp. 4-10.

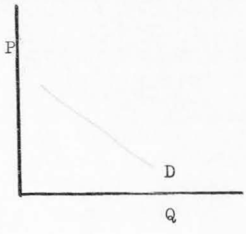
[2]Cited in Paul A. Samuelson, Economics: An Introductory Analysis (6th ed.; New York: McGraw-Hill Book Company, 1964), p. 721.

permit us to make predictions -- more or less specific depending on how much or little we know."[3] The application of a theory or model in the real world depends on the accuracy of the data used in deriving it and on the relevance of the assumptions.

A better understanding of the relationships among variables in a model is often made when the model is exhibited graphically or in the form of a methematical equation. Where it is not possible to establish a definite relationship, the variables are often stated as being functionally related. This can be expressed graphically or as a mathematical function. Hence, the relationship between quantity demanded and price of the product is usually stated as

$$D = f(p)$$

meaning that demand is a function of price. Equivalent, but more meaningful, is the downsloping demand curve:



where P is price per unit and Q the quantity which will be purchased during a period of time at the various prices. In this case, it is impossible to determine a definite relationship, and so the relationship cannot be expressed as an equation. Even if this were possible, it would be desirable to do so only if this would give a more meaningful understand-

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[3]Ackley, Macroeconomic Theory, pp. 13-14.

ing of the relationships.

Income model

Income is a given area or region is determined by many different factors, but mainly the expenditures of society for consumption and investment, purchases by governments, and net exports of goods and services. As the volume of each of these items increases, barring other drastic changes in the economy, so will income.

Part of government expenditures and expenditures by private business is for R&D. The total amount of R&D compared to all other expenditures would be minor, and the contribution of R&D expenditures in determining income will be small; however, it will be something. In a local area where extensive expenditures are made for R&D, it could have a significant impact. In an segment of the economy an additional dollar spent for R&D will have about the same impact on income as will a dollar spent for another purpose.

The model showing the relationship between R&D expenditures and income can be written.

$$Y = F(r,o)$$

where Y is income, r is total expenditures for R&D, and o is the other factors (technology, consumption, investment, government expenditures, net exports, etc.) affecting the level of income.

Since this study is concerned with R&D and its direct impact on income, the R&D income model can be simplified, ceteris paribus, to

$$Y_r = f(r)$$

where Y_r is the income generated as a result of R&D expenditures.

Multiplier analysis is mainly concerned with the effect of changes in rates of expenditures on income, or the change in income generated by a change in R&D expenditures. This is expressed as

$$Y = f(\Delta r)$$

where Δ represents a change.

Logically, the relationship between the two varibles Y and r is direct; increases in R&D will induce increases in income, and vice versa.

An assumption which makes the analysis considerably more simple is that of a linear and homogeneous relationship between Y and r. This is to say that the function $Y = f(r)$ increases or decreases in the same proportion as r. This means that

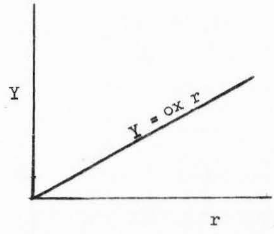
$$f(hr) = hf(r)$$

for any value of h.

The effects of these assumptions on the income model are twofold: (1) Graphically it forces the equation representing the relationship through the origin. It means that no R&D will induce zero income. (A logical assumption!) This is not to say that if there is not R&D, there will be no income, but that if there are no expenditures for R&D, no income will be induced by it. (2) The assumption of linerity indicates that equal changes in R&D, at all levels, will indice proportional changes in income. If expenditures for R&D of $100 induce income of $50 to residents of the State, the $50 will be induced whether the change in total R&D expenditures is from $10,000 to $10,100, or from $1,000,000 to $1,000,100.

Both of these assumptions are logical, a priori. If sufficient data were available their accuracy or validity could be tested emperically. Incorporating these assumptions into the income model reduces it to a simple equation:

where ox is the parameter to be estimated by this study. It can be depicted graphically as:



Employment model

Wages are generally fixed to an individual firm, so the level of employment in a particular firm is determined mainly by the amount of its expenditures going to employees in the form of payrolls. Employment in the short run for a particular form or even an industry would in many cases be a function of its output, given the wage rate.

In the R&D industry in Utah, the number employed depends on the level of R&D expenditures as the wage rate is given. In this sense it could be said that

$$N = g(r)$$

where N is the level of employment in the R&D industry and r is the total expenditures for R&D as defined above.

Since expenditures on R&D determine income, and income originating as payrolls determines the amount of employment for given expenditures for R&D, employment in R&D is a function of the expenditures for R&D and the wage rate of R&D personnel. It can be expressed as:

$$N = Y'/w$$

where Y' is the income originating as payrolls and w is the average annual wage rate.

The Multiplier

The multiplier is the term used in economics to show the relationship between changes in total income and changes in one kind of income or particular type of expenditure. It is the result of two factors: (1) The repetitive process of transactions -- a payment to one person is a receipt to another, and subsequently becomes, in part, a payment to someone else. (2) The expenditures are some portion of the receipts, other portions being held as savings or lost through leakages. For example, an individual is paid for working in a manufacturing establishment. His weekly check is net of taxes and a savings deduction by the local credit union (both leakages). The money received for his work is spent for food, clothing and other items. The retail store where he makes his purchase uses the money to buy other goods and to pay wages to its employees, as well as supplying profits to the businessman. The payments of the retail store to its employees in turn becomes income and the chain of events repeats itself.

The expenditure cycle consists of a "round" of the multiplier. A round occurs whenever an expenditure by one individual or form is received and spent by the next individual or firm. A round is not a time period and should not be considered as such. Some rounds are longer than others, and there is no even pattern or cycle in the series of rounds making the complete multiplier. The first one or two rounds can be measured but to go beyond this would be very difficult if not impossible.

In a closed economy where all business transactions are in a certain locality, the leakages, exclusive of savings, will be zero, since by definition all payments are within the area. In an open economy, such as the State of Utah, many payments are made to "foreigners" outside the State and are included in leakages as the income is not respent in the locality.

As an hypothetical example, assume a closed economy, where o.1 of the receipts of a firm is saved, o.3 is paid out as payrolls, of which 0.8 is spent as consumption, and the remainder paid to other firms which have an identical pattern of expenditures and payroll. If $100 of expenditures were made to a firm, the following income would be generated at the different rounds of expenditure:[4]

The income multiplier is 1.98, and only 15.2 percent of the total income was generated in the first round of expenditures.

By contrast, assume a hypothetical open economy in which the same fraction is saved (0.1), the same fraction paid to employees (0.3), and the same fraction spent on consumption (0.8). The same percentage is spent for purchases from other firms, but two-thirds of the expenditures are made outside of the area and are leakages. This leaves 0.2 of the total cost as purchases from firms in the local area. With these assumption, the following situation exists.[5]

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[4]A mathematical expression of this model is:

$$X_t = (0.6)S_{t-1} \quad (0.8)Y_t$$
$$= (0.6)S_{t-1} \quad (0.8)(0.3)S_{5-1}$$
$$= (0.84)S_{t-1}$$

where X_t is business expenditures in round t and Y_t is payrolls in round t.

[5]A mathematical expression for this model is:

$$X_t = (0.2)X_{t-1} \quad (0.8)y_t$$
$$= (0.2)X_{t-1} \quad (0.8)(0.3)S_{5-1}$$
$$= (0.44)X_{t-1}$$

Table 5. Hypothetical industry-income miltilplier for a closed economy

Round	Expenditures in Area (0.6)	Payrolls (0.3)	% of Total Impact	Cumulative Income
	$100.00	-	-	-
1	84.00	$30.00	15.2	$30.00
2	70.56	25.20	12.8	55.20
3	59.67	21.17	10.7	76.37
4	49.92	17.90	9.1	94.27
5	41.94	14.98	7.6	109.25
	Total			197.50

Table 6. Hypothetical industry income multiplier for an open economy

Round	Expenditures in Area (0.2)	Payrolls (0.3)	% of Total Income	Cumulative Income
-	$100.00	-	-	-
1	44.00	$30.00	56.0	$30.00
2	19.36	13.20	24.6	43.20
3	8.52	5.81	10.9	49.01
4	3.75	2.56	4.8	51.57
5	1.65	1002	1.9	52.59
	Total			53.57

There are significant differences in the two economies. The open economy generated income of only 0.54 of the original expenditure compared to 1.98 for the closed economy. The difference is a result of the leakages to the outside.

Another significant difference is in the relative importance of the first round of the multiplier. In the closed economy the first round accounted for only 15 percent of the total generated income, but in the open economy in accounted for 56 percent. The second, third, and ensuing rounds of the multiplier in the closed economy plays a relatively more significant part than in the open economy.

Thus, a large portion of the multiplier's effect is in the first round of expenditures. Because of the relatively large impact in the first round in a local area, this would be the main concern of local area economics analysis. This greatly facilitates the accomplishment of the study, as it would be difficult to determine the impact beyond the first round with any degree of confidence. For these reasons the analysis in the present study is mainly concerned with the first round. Only an estimate will be made of the complete industry-income multiplier.

Income Model & Multiplier for R&D

The model of the simple first-round industry-income multiplier can be expressed as a flow chart:

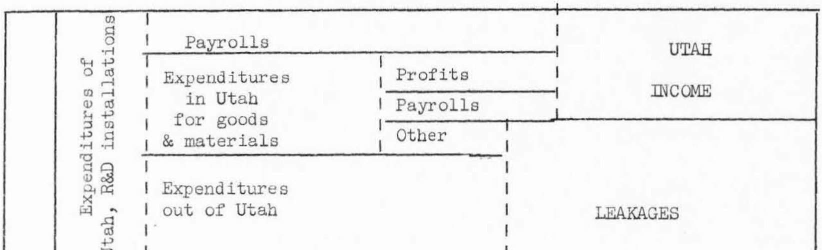

Figure 3. Flow of R&D funds in Utah.

It is essential to consider not only the direct income flow to the residents of the State from R&D payrolls, but also the expenditures made to Utah firms and the profits and payrolls generated by those expenditures. The income model for a sector performing R&D can be expressed as

$$Y_r = ai \quad b_i(T_p \quad T_w) \quad c_i(M_p \quad M_w) \quad d_i(S_p \quad S_w) \quad r$$

where:

r = total expenditures on R&D

a_i = percent of total R&D expenditures for payrolls in sector i

b_i = percent of total R&Dexpenditures going to Utah trade in sector i

c_i = percent of total R&D expenditures going to Utah manufacturing firms in sector i

d_i = percent of total R&D expenditures going to Utah service firms in sector i

T_p = profit margin for trade industry

T_w = payroll-sales ratio for trade industry

M_p = profit margin for manufacturing firms

M_w = payroll-sales ratio for manufacturing firms

S_p = profit margin for service industry

S_w = payroll-sales ration for service industry

The above equation states that income generated by R&D expenditures is a function not only of R&D, but of the pattern of expenditures of the R&D facility. Income generated depends on how much of total expenditures are made to Utah firms and the industry to which they belong. Income also depends on profit margins and payroll-sales ratios in the industries whom payments are made. It is necessary to use only three broad industry classifications, since virtually all purchases by Utah R&D facilities are made from the trade, manufacturing and service industries.

The multiplier can be expressed as

$$k = \Delta Y_r / \Delta r$$

Since the model is assumed to be a linear homogeneous equation, the ratio of the change in income to changes in R&D is the same at all levels and the first round multiplier can be expressed in the following manner:

$$k = Y_r / r$$

or equivalently

$$k = a_i + b_i(T_p + T_w) + c_i(M_p + M_w) + d_i(S_p + S_w)$$

The amount of employment generated by a given amount of R&D expenditures can be determined by the following equation:

$$N = \left[a_i/W_i + b_i T_w/W_b + c_i M_w/W_m + d_i S_w/W_s\right] r$$

where: N = number of people employed or jobs created

W = wage level for the different sectors and industries

The amount of R&D expenditures necessary for each additional job can be determined in the following way:

$$L = r/N$$

$$= a_i/W_i + b_i T_w/W + c_i M_w/W_m + d_i S_w/W_s$$

Determination of Parameters

Parameters

In the sector model

$$Y_r = \left[a_i + b_1(T_p + Tw) + c_i(M_p + M_w) + d_i(S_p + S_w)\right] r$$

there are several parameters to be estimated. The industry parameters T_p, T_w, M_p, M_w, S_p, and S_w (defined above) have the same values for all sectors of R&D performance, whether in a profit-making or non-profit-making sector of the economy. This means the same prices are charged to the differnet performers of R&D as are charged to the industires' other customers, and since total purchases of the R&D installations are a minor part of their total sales R&D purchases have little if any effect on the firms' pricing policies.

The parameters a_i, b_i, c_i and d_i are not the same for all sectors of R&D performance (manufacturing firms, universities, federal defense installations, and research development and testing laboratories); but vary from one sector to another. Their values are the proportions of total R&D expenditure going directly to payroll or to Utah trade, manufacturing, or service. They are assumed constant for each particular sector in which R&D is performed. The industry parameters will be estimated first, and then a_i, b_i, c_i and d_i, for the different sectors of R&D performers. After all parameters for the industries and the particular sector have been determined, they can be summed and a simple model produced

$$Y_r = ox_i\ r$$

While the value of ox_i will be different for different sectors, a weighted average can be made to determine the total impact of R&D on income in Utah, thus giving the even more simple model

$$Y_r = Ox\ r$$

Parameters of industries

Trade. Profit margins for the trade industry are not available at the state level, so national figures must be used. The trade industry had a 2.0 percent markup on sales for 1964.[6] Employment and sales figures were available from the 1963 Census of Manufactures. The purchases by these firms were generally made at the wholesale level. The census reported payrolls

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[6]First National City Bank, New York, "Review of Corporate Profits in 1964," Monthly Economic Letter, April 1965, p. 41.

$88,678,000 in wholesale trade and sales of $1,478,427,000. This gave a payroll-sales ration of 610 percent.[7]

Although wage levels are not available at the local level for 1964, employment and wage totals are. Wholesale trade in Utah and payrolls of $105,849,208 and employed 17,722 persons, which gave and average annual wage of $5,973.[8] From these figures in the following parameters were derived:

$$T_p = .020$$

$$T_W = .060$$

$$W_t = \$5,973$$

<u>Manufacturing</u>. The profit margins and the payroll-sales ratio are greater in the manufacturing industry than in trade. Profit margins for manufacturing corporations in the United States for 1964 were 6.1 percent.[9] The payroll-sales ration was estimated from the current statistics found in the Survey of Current Business. Since most of the goods used in R&D were durable goods data for this sector of industry were used. The statistics showed average monthly sales of $17,989 million for 1964 and average monthly employment of 9,848,000. Weekly gross earnings for the same period were $112.19. Annual gross earnings of employees were $43,609 million and total sales were $230,772 million. This gave a payroll-sales ration of 25.0 percent ($43,609 million/$230,772 million).[10] The annual wage of Utah's non-durable goods manufacturing employees was calculated

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[7]U.S Department of Commerce, <u>1963 Census of Business, Wholesale Trade, Utah</u> (Washington, D.C.: U.S. Government Printing Office, 1965), p. 3.

[8]Utah Department of Employment Security, <u>Utah Labor Market Quarterly</u>, (Salt Lake City, Utah: Utah Department of Employment Security, 1964-1965), 1964, 1-4.

[9]"Review of Corporate Profits in 1964," p. 41.

[10]<u>Survey of Current Business</u> XLV (April 1965), S-r, S-13, S-14.

in the same way as that for the trade firms. The Uath Department of Employment Security reported employment in this sector of 33,595, and payrolls of $232,279,474 in 1964, giving an average annual wage of $6,914.[11] This above figures give the following parameters:

$$M_p = .061$$

$$M_w = .250$$

$$W_m = \$6,914$$

Service. Service corporations in the United States realized a profit margin of 5.2 percent.[12] The 1963 Census of Business reported that the Utah service industry received $173,092,000 and paid payrolls of $43,656,000. This gives a payroll-sales ratio for service industries of 25.2 percent.[13] The service industry in Utah employed 37,655 persons in 1964 and paid wages of $128,681,521, giving an annual wage of $3,416.[14] This gives the following parameters:

$$S_p = .052$$

$$S_w = .252$$ [14a]

$$W_s = \$3,416$$

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[11] Utah Labor Market Quarterly, 1964.

[12] "Review of Corporate Profits in 1964," p. 41.

[13] U.S. Department of Commerce, 1963 Census of Business, Selected Services, Utah (Washington, D.C.: U.S. Government Printing Office, 1965), p. 46.

[14] Utah Labor Market Quarterly, 1964, Nos. 1-4.

[14a] It may seem illogical that wages as a percent of sales would be identical, or nearly the identical in the manufacturing and service industires. Since the manufacturing industry paid higher wages ($6,914) than the service industry ($3,416), the number employed per dollar of sale would be higher in the service industry.

Sector models

The above parameters hold true for all performers of R&D, whether a private firm, a government agency, or a university facility. These parameters reduce the models to the following:

$$Y = a_i \quad 0.080\ b_i \quad 0.311\ c_i \quad 0.304\ d_i \quad r$$

$$K = a_i \quad 0.080\ b_i \quad 0.311\ c_i \quad 0.304\ d_i$$

$$N = a_i/W_a \quad 0.000010\ b_i \quad 0.000035\ c_i \quad 0.000074\ d_i \quad r$$

$$L = a_i/W_a \quad 0.000010\ b_i \quad 0.000035\ c_i \quad 0.000074\ d_i$$

The remaining parameters a_i, b_i, c_i and d_i are different for the different sectors. These parameters will not be determined from the data gathered by the mailed questionnaires and interviews.

Manufacturing sector parameters. The R&D considered in the estimation of the parameters in the manufacturing sector do not cover the entire R&D performed. The sample was limited by excluding small R&D performers and certain others for which it was impossible to obtain data. Some of the data received was inaccurate because of poor estimation or difficulty in determining where purchases were made and to which industries. Often only a very rough estimate was given, and rather than use these rough estimates, the parameters were estimated from the data which were accurate and the same ration applied for other firms.

Payroll and employment data were more easily obtained, so that payroll and employment data are more reliable than other data in the study. The local income impact will not be affected very much by this expenditires which were made in Utah was small.

Of the $40,321,300 of R&D performed by Utah manufacturing firms which were considered to be accurate, $18,520,700 was for payrolls. This gives a ration of 45.9 percent.

Of the total cost of R&D reported, \$2,115,000 was considered valid. Of this cost 3.3 percent was to Utah trade, 1.0 percent to Utah manufacturing, and 0.2 percent to Utah service industries. This provides the following parameters for the manufacturing sector:

$$a = 0.459$$

$$b = 0.023$$

$$c = 0.010$$

$$d = 0.002$$

By incorporting these parameters into the model, we have

$$X_r = 0.459 \quad 0.023(0.080) \quad 0.010(0.311) \quad 0.002(0.304) \quad r$$

$$= (0.465)(r)$$

The direct employment in manufacturing concerns is responsible for 99 percent of the impact of R&D expenditures on income.

Parameters of research, development, and testing laboratories. Most of the firms in this sector were small and had little employment in R&D. The four firms which answered the questionnaire reported total expenditures of \$890,000 and payrolls of \$221,000. As was the case with the government installations, the industry parameters were not considered because of their insignificance as well as in accurate data. Although very little accurate data was obtained, that which was available indicated very few expenditures to Utah firms, the same as in the manufacturing sector.

This gives the following model for R&D performed in research, development, and testing laboratories:

$$Y_r = (0.248)(r)$$

Federal government sector parameters. The government installations reported total R&D expenditures of \$16,341,000 for 1964, of which \$3,809 or 23.3 percent was for employment. Because of the difficulty of determining the portion of total puchases which were made to Utah firms and also because of their insignificance, they were not considered. This will have an insignificant effect on the model.

This gives a model for the R&D performed by the federal government in Utah of:

$$Y_r = (0.233)(r)$$

Utah State University. Because it is possible to segregate and present separate data for the two State universities, separate parameters were calculated for each. The 1964 Annual Financial Report of Utah State University reported total R&D expenditures of $3,422,987, of which $1,946,132 was in the form of payrolls. In addition, federal collaborators at the University had total expenditures of $969,478, of which $710,939 was for payrolls. This meant that 63.4 percent of the total cost of R&D was for payrolls. A sampling of the records of R&D purchasing over an eight-month period (13 percent of all R&D purchases) showed that the University's sector expenditure pattern was as follows:

Out-of-state	50.0 percent
Utah trade	36.4 "
Utah manufacturing	9.4 "
Utah Service	4.2 "
Total	100.0 percent

As an percentage of total R&D expenditure, the percentages would be 23.3 percent of out-of-state firms, 17.0 percent of Utah trade, 4.4 percent to Utah manufacturing, and 1.9 percent to Utah service. These figures provide the following parameters for Utah State University R&D:

$$a = 0.634$$
$$b = 0.157$$
$$c = 0.041$$
$$d = 0.018$$

Incorporating the above parameters into the sector model reduces the equation to a very simple form:

$$Y = \left[0.634 + 0.157(0.80) + 0.041(0.311) + 0.018(0.304)\right] r$$
$$= (0.665)(r)$$

Approximately 95 percent of the impact of Utah State University R&D on Utah income is through direct payments to the University's employees. The expenditures made to industries in the State play a relatively insignificant role.

Determining the average wage of all persons employed on R&D at Utah State University was not as easy as in the different industries where extensive employment data were available. A recent study made by the University auditor for the National Science Foundation listed all professionals, technicians, and graduate students engaged in teaching and research. The report indicated that 113 scientists and engineers were working full-time on R&D during 1964. While the payroll of this group cannot be isolated, the average wage of scientists and engineers employed in R&D similar to that done at Utah State University was recently reported to be $11,000.[15] This meant that scientists and engineers received approximately $1,243,000 in salaries. The report showed 66 graduate students and 16 technicians engaged in R&D. With an average salary of $5,000 they absorbed $410,000 of the total University R&D payroll, leaving $406,132 for the

[15]See U.S. National Science Foundation, Reviews of Data on Science Resources, "Salaries and Professional Characteristics of U.S. Scientists, 1964", I(January 1965), p. 8.

remaining R&D personnel. At the average University wage, the employment could be calculated at 110 ($410,000/$3,733). The 100 federal collaborators were paid $710,939. Thus total employment on R&D at Utah State University in 1964 was 405. The average annual salary of all Utah State University R&D personnel was $6,561 ($2,657,071/405).

University of Utah parameters. The University of Utah expended $6,136,293 for R&D during the 1964 fiscal year. Of these expenditures $3,134,576 or 51.1 percent were paid as payrolls to individuals. As with Utah State University, a sample was taken of the R&D purchasing records at the University of Utah purchasing office. The sample indicated that 63.4 percent of the expenditures for R&D other than payroll was to firms outside the State. Utah trade received 29.8 percent of the expenditures; manufacturing, 2.9 percent; and service, 3.9 percent. These figures gave the following parameters for R&D at the University of Utah:

$$a = 0.511$$

$$b = 0.146$$

$$c = 0.014$$

$$d = 0.019$$

Incorporation of the above parameters into the R&D sector model, reduced the model to a much simpler equation:

$$Y = 0.511 \quad 0.146(0.080) \quad 0.014(0.311) \quad 0.019(0304) \quad r$$

$$= (0.533)(r)$$

Some 96 percent of the total impact on income of University of Utah R&D comes from direct payrolls to R&D personnel. As was the case with Utah State University, other expenditures play a relatively insignificant role.

Total R&D employment at the University of Utah was determined by assuming a distribution similar to that at Utah State University; i.e., 37 percent of total R&D employees were professionals; 27 percent, graduate students and technicians; and 36 percent, supporting personnel. Because of the high relative importance of medical research, the annual wage of professionals doing research at the University of Utah was greater than at Utah State University.[16] An average salary of $13,000 was assumed. The salary of graduate students and technicians was assumed to be the same as at Utah State University. The average wage of all employees at the University of Utah was $4,062. With the assumed relationships and wages, a total of 419 were employed in research at the University of Utah--155 professionals, 113 graduate students and technicians, and 51 other supporting personnel. This gave an average salary of $7,515 for all R&D personnel at the University of Utah.

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[16] See Reviews of Data on Science Resources, pp. 5-8.

CHAPTER V

THE IMPACT OF R&D ON UTAH'S ECONOMY

Comparison of Sectors

An average of 44.0 percent of the total R&D expenditure in Utah during 1964 was for employment. A comparison of the different sectors indicates the first round income generating impact of one dollar of R&D expenditures in each of the various sectors of the State:

Utah State University	$.67
University of Utah	.53
Manufacturing concerns	.46
Research, development and testing laboratories	.25
Government installations	.23

Income Generated

The income generated by R&D expenditures can be determined by applying the various sector models to the R&D performed by the different types of enterprises. The total expenditures of R&D as well as the income generated in the first round is indicated in Table 7.

Table 7. Income generated by Utah R&D (in thousands)

	R&D Expenditures	Generated Income
Utah State University	$ 4,392	$ 2,921
University of Utah	6,136	3,270
Manufacturing firms	43,977	20,229
Government installations	30,341	6,978
Research and testing labs	86,330	371
Total	$86,330	$33,769

Total Income Multiplier

Although the first round is more important than other rounds in its economic impact, it should be kept in mind that the impact does not in fact end with the first round. The impact beyond the first round is difficult to measure and would involve a study much beyond the scope of the present one. An estimate of the total impact will be made, but it should be emphasized that this is only a rough approximation.

If the "average" Utahan had an expenditures pattern similar to the "average" American, and if the average propensity to consume is equal to, or differs little from the marginal propensity to consume, it is possible to extrapolate from national income data and estimate the total income generated by R&D in Utah. The estimate of the total income miltiplier depends on the validity of these assumptions.

During 1964 Americans spent an average of 81.2 percent of their income on consumption and the remaining 18.8 percent was spent for taxes or was saved (i.e. spent for something other than consumption such as paying off a debt, adding to a savings account, or investing in stocks or bonds). His consumption expenditures were such that 47.6 percent of his income was for durable and non-durable goods and 33.6 percent was for services.[1]

From the above figures the total income generated can be estimated in the same manner as was done for the different industries in a previous chapter. Sales in the trade sector for durable and non-durable goods generated income of 11.7 percent through wages[2] and 2.4 percent through profits.[3] Sales of services generated income of 25.2 percent through wages[4] and 4.6 percent through profits.[5] These figures indicate 16.7 percent of consumption expenditures create income each round. Assuming that all wholesale purchases are made from out-of-state firms, this would give an income multiplier of 1.2 (100/(100-16.7) = 100.83.3). Since 42.0 percent of the original R&D expenditures become income the total multiplier for R&D in Utah is 0.5 (0.42 x 1.2).

This indicates that R&D expenditures for 1964 generated $43,165,000 of income in 1964. This is 2.0 percent of Utah's $2.14 billion personal income for that year.[6]

An additional dollar of Utah income is generated by R&D expenditures

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[1]Calculated from figures reported in U.S., President, Economic Report fo the President, January 1965 (Washington, D.C.: U.S. Government Printing Office, 1965), pp. 201, 206.

[2]U.S., Department of Commerce, 1963 Census of Business, Retail Trade, Utah (Washington, D.C.L. U.S. Government Printing Office, 1965), p. 46-9.

[3]First National City Bank, New York, "Review of Corporate Profits in 1964", Monthly Economic Letter, April 1965, p. 41.

[4]U.S. Department of Commerce, 1963 Census of Business, Selected Services, Utah (Washington, D.C., U.S. Government Printing Office, 1963), p. 46-6.

[5]"Review of Corporated Proftis in 1964," p.41.

[6]Survey of Current Business, XLV (July 1965), 16.

of \$2.00. A new job is created for an increase in R&D expenditures of \$21,120. R&D accounted for 4,087 jobs in Utah in 1964.

APPENDIX

U T A H   S T A T E   U N I V E R S I T Y

Economics Research Institute
Division of Industrial and Historical Research

Logan, Utah 84321

May 21, 1965

Dear Sir:

The newly-created Economics Research Institute at Utah State University is undertaking a study of the impact of industrial research and development on the economy of Utah. This inquiry will seek to measure the importance of research and devlopment in the various industries in the state. It will also reveal the ways in which the substantial expenditures on R & D in recent years have affected different sectors of the state's economy.

We would be pleased if you would check below whether or not your firm does any R & D in Utah. A self-addressed envelope is enclosed for returning this form; no postage is required.

Research and Development (R&D) includes research in the sciences, in engineering, and in designing and developing prototypes and processes. It includes activities carried on by persons trained, either formally or by experience, in the physical and biological sciences, engineering, or medicine. It does not include quality control, routine product testing, market research, sales promotion, sales service, or other non-technological activities or technical services.

Sincerely,

Leonard J. Arrington
Professor

LJA:jw

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1. Name of your firm:

2. Is your firm engaged in R & D in Utah?

YES ☐

NO ☐

E C O N O M I C S   R E S E A R C H   I N S T I T U T E

Utah State University
Logan, Utah

June 9, 1965

Dear Sir:

Your firm is among those asked to participate in a study of the impact of research and development (R&D) and research-based manufacturing on the economy of Utah. The information you provide on your firm is of vital importance to the success of this study.

The information obtained from this survey will give an indication of the importance of industrial R&D and research-based manufacturing in the state. The information required for this evaluation is not available in published form, its only source being the individual producing and employing units in Utah.

Our interest is only in aggregates, and we are requesting data concerning your firm to develop these aggregates. Any information we receive concerning any individual form will be held strictly confidential and will not be released from our files to any individual or organization for any reason.

Some of the information requested may not apply to your firm or installation. If it does not apply, please so indicate. For that which does apply, we would appreciate as complete and accurate information as is possible. If some of the information is not known, an estimate would be most valuable to us. Estimates by knowledgeable persons are certainly better than no information at all!

A self-addressed, stamped envelope is enclosed for your reply.

Your cooperation in this survey is appreciated. Copies of any published reports based on the study will be made available upon request.

Sincerely,

Leonard J. Arrington
Professor of Economics

LJA:jw

INSTRUCTIONS FOR FILLING OUT QUESTIONNAIRE:

1. For items which are not applicable, write "NA."

2. If actual figures are not known, please estimate. Reliable estimates are better than no information at all.

3. Please Record dollar figures in thousands.

DEFINITIONS OF TERMS

Employment: The employment figure should be the average for the year to fulltime employees plus fulltime equivalent of part-time employees.

R&D: Research and devlopment includes basic and applied research in the sciences (including medicine) and in engineering, and design and development of prototypes and processes. It does not include quality control, routine product testing, market research, sales promotion, sales service, research in the social sciences or psychology, or other nontechnological activities or technical service.

Scientists and Engineers: Scientists and engineers are all persons engaged in scientific or engineering work at a level which requires a knowledge of physical, life, engineering, or mathematical science equivalent at least to that acquired through completion of a four-year college course with a major in these fields.

Supporting Technical Personnel: Technicians are those doing technical work which requires a skill acquired through schooling or "on the job" training, which cannot ordinarily be performed by an ordinary laborer. This does not include secretaries, clerks, or other administrative workers.

Total Expenditures in Utah on Subcontracts and/or Materials: Total payments to Utah firms for all goods and services (excluding payrolls and general utilities).

Cost of R&D Performed by Your Firm in Utah: All costs incurred within the company for wages and salaries, direct material costs, services and supporting costs, and an appropriate share of company overhead to conduct research and development activities. If you did R&D for others, include the total amount charged for such work. Do not include payments for R&D performed by others.

R&D Expenditures in Utah on Subcontracts and/or Materials: Payments to Utah firms for all goods and services (excluding payrolls and general utilities) used in R&D operations.

U T A H   S T A T E   U N I V E R S I T Y

Economics Research Institute

SURVEY OF R&D IN UTAH MANUFACTURING FIRMS

Sales of All Products or Services to:

Federal Government . . . . ____%

Defense ____%

Non-Defense ____%

100%

Other . . . . ____%

Year	1954	1958	1959	1960	1961	1962	1963	1964
Total Employment								
R&D Employment								
a. Scientists & Engineers								
b. Supporting Technical Personnel.								
Total Payroll (in thousands)	$	$	$	$	$	$	$	$
R&D Payroll (in thousands)	$	$	$	$	$	$	$	$
Cost of R&D Performed by your Firm in Utah (in thousands)	$	$	$	$	$	$	$	$
R&D Expenditures in Utah on Subcontracts and/or Material (in thousands).	$	$	$	$	$	$	$	$

State briefly the nature of your R&D work:

ECONOMICS RESEARCH INSTITUTE

Utah State University
Logan, Utah 84321

Dear Sir:

We recently sent your company a questionnaire in conjunction with our study of research and development in Utah. We have not yet received a reply. If we could be of any assistance in filling out the questionnaire, we would be happy to come to your office and do so. If so, would you inform us of a time which would be convenient for you.

We hate to appear impatient, yet the data from each firm is of vital importance to the success of the study.

We are enclosing a business-reply envelope, as well as a new questionnaire and would be grateful for your immediate response. If your reply is already in the mail, please excuse this letter.

Sincerely,

Leonard J. Arrington
Professor of Economics

LJA:jw

Table 8. Research and development obligations of the federal government in Utah Fiscal Year 1964 (in thousands)

Agency	Total	Agric.	Commerce	Defense	H.E.W.	Interior	A.E.C.	N.A.S.A.	N.S.F.
All Performers	$65,180	$1,626	$33	$55,041	$4,018	$2,352	·793	504	813
Intramural	20,427	1,124	33	17,089		2,181			
Extramural	44,753[a]	502		37,952	4,018	171	793[a]	504	813
Educational Inst.	8,960[a]	502		2,607	3,867	49	793[a]	329	813
Profit Organizations	35,420			35,245				175	
Other Nonprofit Org.	213			100	113				
Other	160				38	122			
R&D Plant	2,062	45		1,017	503	57	95		345
Federal Install.	1,062	45		1,017					
Educational Inst.	901				503	20	95		283

Source: U.S., National Science Foundation, Obligations for Research and Development, and R&D Plant by, Geographic Divisions and States, by Selected Federal Agencies, Fiscal Years 1961-64. A report to the U.S. House of Representative (Washington, D.C.: National Science Foundation, 1965).

[a]Includes obligation of $530 in Federal Contract Research Center.

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