Programs for Innovative Technology Research in State Strategies for Economic Development

National Governors' Association
Center for Policy Research and Analysis

PROGRAMS FOR INNOVATIVE TECHNOLOGY RESEARCH
IN
STATE STRATEGIES FOR ECONOMIC DEVELOPMENT

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Center for Policy Research and Analysis

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FOREWORD

The National Governors' Association (NGA) wishes to thank the many individuals who contributed time and information for the development of this paper. The paper was authored by Dr. Charles Watkins, Chairman and Professor of Mechanical Engineering at the Howard University School of Engineering. Dr. Watkins served as an American Society of Mechanical Engineering Fellow at NGA from March 1984 through February 1985.

Every attempt has been made to ensure the accuracy and timeliness of the data presented. Descriptions of individual state programs were reviewed by appropriate state officials. Given the speed with which technology development programs are being implemented and expanded, many developments occurred between the time the information was collected and the time the project was completed. This was particularly true of those programs which were just getting under way at the time of the initial data collection.

In those cases where states provided information updating the data contained in the program description, this information has been included in a section entitled Update and Comments. Also included are comments made by the state in response to assessments or comments made by the author. The Update and Comment section immediately follows each individual program description.

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Joan L. Wills
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ABSTRACT

The role of basic and applied research in state strategies for economic development through technological innovation is reviewed in relation to current research results on the job creation ability of technology-based firms. With this background, the policy implications of various state strategies, including those involving recruitment of high-technology firms, are examined. The programmatic components of state strategic initiatives are then discussed and conclusions are formed regarding optimal individual state strategies based on the state's economic and demographic profiles. Within this framework, tentative assessments of the strategic research initiatives of ten states are offered.

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BACKGROUND

Introduction

The recent and rather dramatic structural and cyclical changes in the national economy have focused the attention of federal, state, and local government policy-makers on programs to stimulate economic growth. The geographic heterogeneity of the nation's economic activity results in these economic changes having an especially profound effect on some local and regional economies. The disparate impacts of the waves of worker dislocations which accompany these changes are particularly troublesome for state and local officials. They create the need for state or local initiatives to stabilize regional economies as well as to ensure long-term prosperity. At the same time, the visible success of foreign technological enterprises and domestic technology-oriented regional economies point to technology as a key ingredient in any strategic formula for economic revitalization. State government, in particular, has assumed a leadership role in encouraging economic development through technological innovation. Most states have already begun to implement program initiatives in economic development based on the exploitation of innovative technologies.

In view of the many new state program initiatives for technology-based economic development, it is useful to place them in a common analytical framework to facilitate comparison and discussion. Having accomplished this, one can review in this context some representative case-study examples of state programs and tentatively assess the relative potential of these programs for achieving development goals. The present report attempts such an analysis, concentrating on programs which promote the research phase of research and development, the first stage of the technological innovation process. In doing this, the report provides background information on the rationale for state technology-based economic development strategies in relation to the results of recent research on the job creation potential of technology-based firms. To provide additional background, the technological innovation process is described. After these preliminaries, the policy implications of state strategies based on technological innovation, including recruitment of technology-based industry, are examined. The

High Technology, Jobs and Public Policy

National, state, and local policymakers have been devoting increasing attention to programs to encourage economic growth. At the state level, much of this attention has been directed toward the notion of the high-technology industrial sector in general and new, small high-technology firms in particular as being a solution for declining levels of employment. The press has popularized this notion and perhaps contributed to inflated expectations regarding its potential contribution.

Current research results and thoughtful, informed opinion indicate that technology may indeed be a panacea for the nation's economic woes, but not by creating jobs within the high-technology sector. Some have criticized the term "high technology" itself as contributing to inflated expectations regarding its promise. Some of these critics suggest that the terminology "new technology" and/or "advanced technology" is more descriptive and relevant, while others favor "innovative technology" as the descriptive term. It has been shown that, although the role of the small high-technology firm in job creation is undeniably important, high-technology firms of all sizes are creating new jobs. Large high-technology firms are creating the larger share. Since initiatives targeted toward high-technology industry, traditional industry, large firms, small firms, new firms, or existing firms may represent divergent policy alternatives and compete for scarce resources, the design of an optimal strategy for technology-based economic development is a complex undertaking. Assessment of individual state strategies as well as state and sub-state programs must be viewed in the context of optimal strategy design. Interstate comparison of programs and/or strategies are only meaningful to the extent that development objectives coincide and resource bases are homogeneous.

The thrust for much of the recent enthusiasm directed toward small business is found in the work of Birch (1978) in which he attributes two-thirds of all new job creation between 1969 and 1976 to businesses with fewer than twenty employees. More recently, Armington and Odle (1982) reported that between 1978 and 1980, firms employing fewer than 100 people were responsible for only two-fifths of net new jobs. Armington and Odle's work, which utilized a different data base than Birch's, tends to raise questions about development strategies centered around small business alone, while confirming the dynamism of the small firm sector's contribution to job creation.

Technology and the Innovation Process

Most persons with an interest in the potential of technology for stimulating economic development have an intuitive understanding of what is meant by the terminology commonly used in discussing this subject. But if asked to articulate their conceptions, few would give the same definition for terms such as "high technology," "technological innovation" or some of the other frequently used terms. It is, therefore, appropriate to review briefly the most widely accepted relevant definitions and conceptualizations of persons who have given some formal attention to the subject.

Riche, et al. (1983) give three alternative definitions of high technology industries which differ in the relative importance placed on a high proportion of technology-oriented workers as opposed to a high ratio of research and development expenditures to sales. Emphasis on the latter index tends to limit the definition to the few industries that most lay persons would agree with, such as drugs, computers, electronics, communications equipment, and aerospace. Unfortunately, reliance on any single definition of the many that various persons have given (Malecki 1984) is probably overly restrictive. A more useful operational definition is that of an industry, either manufacturing or service, with a strong dependence on science and engineering, i.e., wherein new technologies and their applications are a major driving force influencing the marketplace economics of supply and demand.

Similarly, there is little common agreement on the exact elements of the technological innovation process which feeds these industries. It is in itself a complex field of study (Rosegger 1980; U.S. Congress Joint Economic Committee 1980; Tornatzky et al. 1983). A simple-minded view is that the process proceeds from an invention to its initial commercial application as an innovation and then is spread by means of a diffusion-like phenomenon into the marketplace, eventually saturating it and ultimately disappearing as it is supplanted by new technology. Udell and Baker (1982) have depicted the business aspects of the process as shown in Figure 1. Figure 2, which is reproduced from the work of Rorke, et al. (1983), depicts the process in matrix form to illustrate the participants involved in some of the activities at various stages of the process.

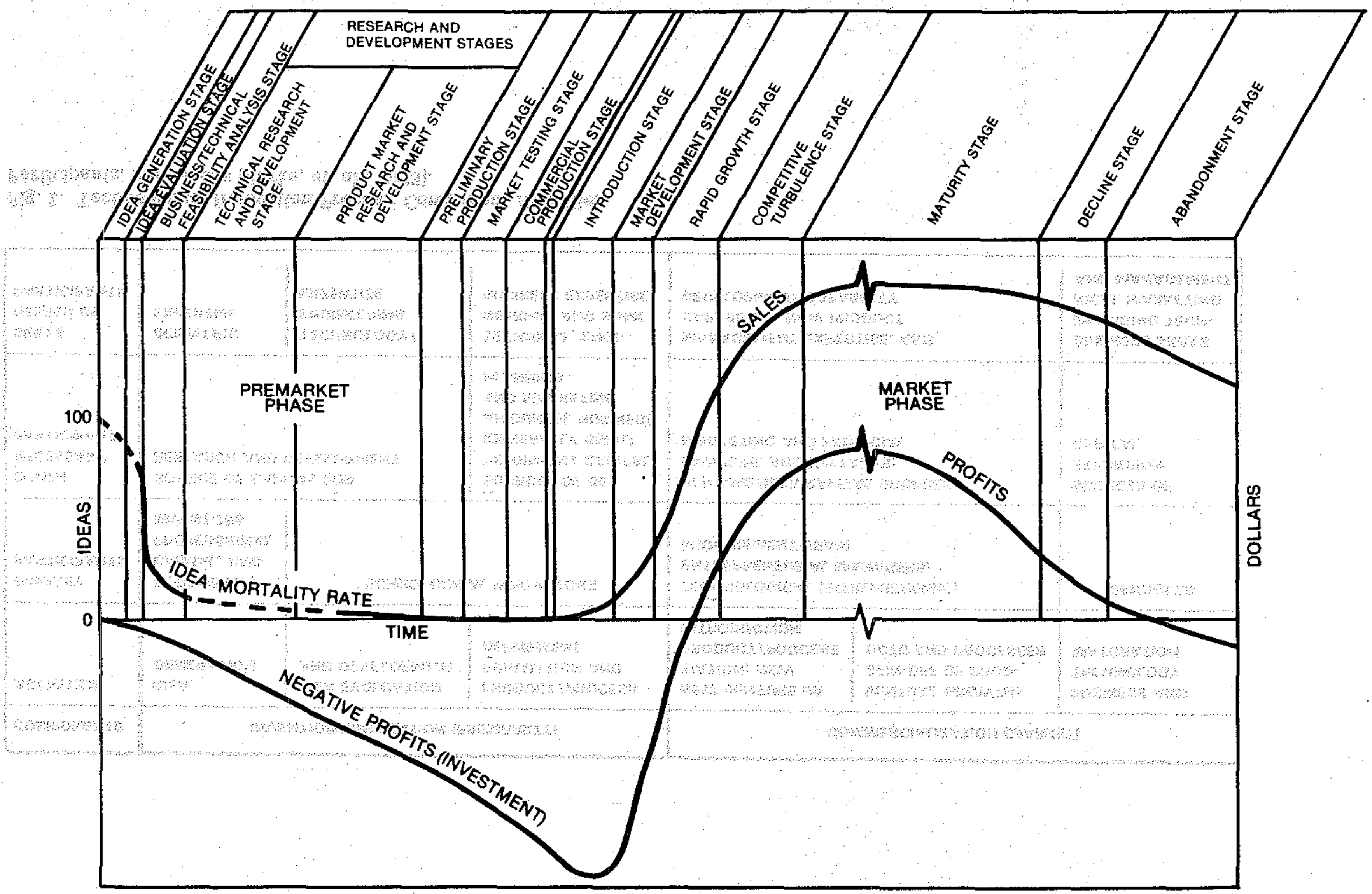

Fig. 1. The technological innovation process: a sequence of events through which new products, processes, and services normally pass (Udell and Baker, 1982).

Here, the term "invention" refers to the discovery of a new or improved process or product and the resolution of associated technical problems through research and development. The stage or pipeline model of research and development describes an orderly progression of activities beginning with basic research, progressing through an applied research stage, and culminating in the development of a process or product. A successful development stage would conceptually be followed by extensive market-oriented research, testing, and evaluation. The model is overly simplistic; but it is easily conceptualized and is adequate for most purposes.

It is generally agreed that basic research is distinguished from applied research by the former being pursued (often at universities) primarily for the advancement of scientific or engineering knowledge while the latter (often in industry) is directed toward useful objectives with respect to ultimate creation of a product or process. The distinction is sometimes nebulous, particularly when it is recognized that frequently, much of the justification that scientists and engineers must give to obtain funding for "basic" research is its ultimate connection to some useful objective. Furthermore, some basic research, especially in industry, is characterized as "directed." Development consists of those technical activities undertaken to transform research knowledge into a product or process.

The simple linear pipeline model is not inconsistent with the business-oriented model of Figure 1 or the participant-oriented model of Figure 2, but the figures require some interpretation to clarify the connection. For a product based on a sophisticated new technology, idea generation is usually the result of basic research. Applied research would be involved in evaluation and demonstrating technical feasibility. "Technical Research and Development" and "Product Research and Development" in Figure 1 or alternatively, "Product/Process Evaluation and Refinement" in Figure 2 are all primarily associated with the "development" activities of research and development. These activities are the engineering analysis, design, and testing required to evolve and test a full-scale production prototype from demonstration of technical feasibility using "breadboard" or laboratory components. The culmination of the first stage of this process or the "Technical Research and Development" stage in Figure 1 would be the creation of a demonstration prototype.

and Stanford Research Institute (SRI) (1984b). Many others have been established since these reports were published. State and local programs are generally designed to either attract industry from outside the region, promote the stabilization, expansion, and retention of existing industry, or encourage the formation of indigenous technology-based firms through technological entrepreneurship. In many cases, these efforts seek to emulate such successful models as California's Silicon Valley, Massachusetts' Route 128, or North Carolina's Research Triangle Park. These names have become synonymous with desirable high-technology growth. Hence, it is useful to examine the phenomenon of high-technology growth and the factors that influence it to determine which localities may realistically aspire to achieve it and what alternatives may exist.

The concensus view of OTA (1984b), Birch and MacCracken (1984), Malecki (1984), and Shanklin and Ryans (1984) as well as others, is that most localities do not have the technological or financial infrastructure to incubate or accommodate technology-based industry on the scale necessary to replicate the growth of Silicon Valley, Route 128 or even Research Triangle Park. This view is reinforced by the revealing statistic that during World War II, the federal government injected over $35 billion (NGA 1983) into the California economy. Likewise, Massachusetts also benefited from large defense-related expenditures during the 1940s and early 1950s. However, it is important not to misinterpret these facts. The flow of government funds to these areas may only be incidental in the sense that the defense contracting firms simply happened to be located in those regions (Malecki 1983) and development was actually the result of a process of industrial evolution (Dorfman 1983). The most important impact of federal government research and development activity is the agglomeration of technical employees and resulting employment generation through new firm formation, spin-offs, and corporate innovative activity (Malecki 1983).

The pessimistic view of the development potential of most localities as a center for technology-based industry is reinforced by quantitative statistical research as well as more subjective studies and informed opinion. Harris (1984b) investigated statistically the factors influencing branch formation of high-technology firms and new independent high-technology establishments in metropolitan areas. These findings indicated that both types of businesses were most sensitive to the availability of scientific and technical workers. Agglomeration economies resulting from the presence of a significant amount

It is generally agreed that there are many limitations involved in short-term strategies aimed solely at recruiting technology-based industrial firms. Moreover, from a national perspective, such efforts tend to cancel each other, producing a "zero-sum game." However, as pointed out by OTA (1984) and NGA (1983), such recruiting may be an important component of state technological innovation strategy. According to OTA (1984b), this is particularly important for states lacking indigenous technological infrastructure which can then utilize the technological impact of a major branch plant as part of a bootstrap strategy to develop their own infrastructure to the point where significant technological entrepreneurship is feasible. This view is disputed by Malecki (1983), who argues that production facilities have little impact and that research and development is the key. Unfortunately, as indicated previously, industrial research and development facilities are less mobile than branch production facilities.

In spite of the foregoing, technological innovation need not be abandoned as a component of economic development strategies for areas which are less-developed technologically for these localities. OTA (1984b) and Birch (1984) advocate emphasis on employing technology, perhaps developed elsewhere, to create jobs. Shanklin and Ryan (1983) as well as Birch and MacCracken (1984) emphasize entrepreneurship per se, encompassing also the low-technology and service sectors. NGA (1983) stresses the use of new and advanced technologies to revitalize older smokestack industries as a medium-term strategy, particularly in heavily industrialized states. Malecki (1984) points out that encouragement of local research and development activity, using universities as the foundation for growth, is important even if few high-technology jobs emerge. This is because these localities will thereby improve their attractiveness as sites for economic activities that grow less spectacularly than high technology, but that use human skills in non-routine ways.

State Role in Technology-Based Economic Development

Fostering economic growth and employment is emerging as a critical leadership function of state governments (NGA 1983; SRI 1984b). State and local governments are, because of their decentralized nature, often in a more appropriate position than the federal government to leverage or provide the cooperation and partnership involvement necessary (NGA 1983; SRI 1984b; Peltz and Weiss 1984). States perform key functions

(6) technology and information transfer; and

(7) research and high-technology industrial parks and incubator facilities.

Although these seven functional categories provide sufficient operational classifications to cover most of the state initiatives, a broader perspective is needed in terms of policy variables for an analysis of state technological innovation strategies. Figure 3 is a matrix representation of the policy tools that state governments possess and the target areas in which these tools can have an impact. Broadly speaking, the raw materials for the technological innovation process are technology resources, human resources and commercialization resources. They constitute the region's technological infrastructure. State government can have a major influence on the availability of these resources through the fulfillment of its responsibilities and the exercise of its authority. There are, however, real resource and wealth constraints which obviously limit a state's ability to utilize the tools at its disposal to effect change.

Figure 3
State Policy Tools and Targets for Technological Innovation

TARGETS	STATE POLICY TOOLS: Planning, Coordination and Policy Development	Semi-Autonomous Public Enterprise	Direct R&D Support	Education and Training	Direct/ Indirect Debt and Equity Financing	Information/ Technology Transfer	Brokering	Taxation	Regulation	Public Works Infrastructure	Quality of Life
Technology Resources											
1. University/Industry R&D	X	X	X			X	X	X	X		
2. Federal R&D	X									X	
3. University/Federal R&D	X	X	X				X				
4. University/State R&D	X		X								
5. Industry/Small Bus. R&D	X	X	X			X		X		X	X
Human Resources											
1. Scientists and Engineers	X			X						X	X
2. Technicians & Technologists	X			X							X
3. Skilled Workers	X			X							
4. Entrepreneurs	X			X						X	X
Commercialization Resources											
1. Technical Assistance	X	X				X					
2. Managerial Assistance	X	X				X					
3. Seed/Venture Capital	X	X			X		X	X	X		
4. Marketing	X						X				
5. Production	X				X					X	
Catalysts/ Agglomeration Factors											
1. Customers	X					X	X	X		X	X
2. Suppliers	X					X		X		X	X
3. Competitors	X					X		X		X	X
4. Role Models	X					X		X		X	X

Technology Resources and Development Priorities

As discussed by OTA (1984b), a threshold amount of technological infrastructure is a prerequisite for significant high-technology growth. In addition to human, financial and technology resources, this infrastructure provides the catalytic ingredients needed to stimulate technological innovation such as proximity to customers, suppliers, competitors, and role models. The technological infrastructure of a state is perhaps best characterized by the existing amount or concentration of technology-based industry. The geographic distribution of employment in three alternatively defined high-technology industry groups is given in Tables 1 and 2. The data are given in terms of absolute employment in Table 1 and as a percentage of total nonagricultural employment in Table 2. The data were supplied by the Bureau of Labor Statistics. The Group I definition is linked to a high percentage of technical workers. Group II consists of industries with high ratios of research and development expenditures to sales. Group III is a composite based on a definition combining the two measures.

The data in Tables 1 and 2 contain certain deceptions. The most important of these is that service industries are excluded and that employment in manufacturing facilities of technology-based firms, facilities which contribute little to a region's technological infrastructure, is included. Further, the existence of local or regional technological infrastructure sufficient to incubate or attract technology-based industry can be diluted when examining aggregate state statistics. Farrell (1983) lists twenty-two "developing high-tech centers" as local areas having a significant potential for development; these are in addition to the "mature high-tech centers" in California, Massachusetts, and North Carolina. Therefore, the data presented here are only useful in a relative sense and even then, a great deal of care must be exercised in drawing any firm conclusions. For example, if the stringent Group II definition is applied, the only states appearing in the top ten in both tables are California, Massachusetts, Connecticut, and New Jersey. At the other extreme, the bottom ten in both tables include Hawaii, Alaska, Montana, Wyoming, North Dakota, West Virginia, and Delaware. Delaware, paradoxically, because the chemical industry is excluded from the strict Group II definition and included in Group I and III, tops these latter lists in Table 2.

Table 2

High Technology Employment as a Percent of Total Nonagricultural Employment in All States, the District of Columbia, Puerto Rico, and the Virgin Islands, 1983 Annual Averages (1)

GROUP I		GROUP II		GROUP III	
Delaware	21.1	New Hampshire	7.1	Delaware	14.2
Michigan	19.7	Connecticut	6.8	Connecticut	12.2
Connecticut	18.8	Arizona	6.4	Massachusetts	11.5
New Hampshire	18.0	California	6.3	New Hampshire	11.1
Massachusetts	16.6	Massachusetts	6.3	New Jersey	10.0
Indiana	16.2	Vermont	6.3	California	9.7
New Jersey	16.1	Washington	4.9	Vermont	9.6
Texas	15.7	Puerto Rico	4.3	Arizona	8.1
California	15.5	Utah	4.2	Puerto Rico	8.1
Ohio	15.5	Kansas	4.1	Indiana	7.4
Vermont	14.7	New Jersey	3.8	Washington	7.2
Kansas	14.6	Colorado	3.3	Minnesota	7.0
Oklahoma	14.6	Minnesota	3.2	Colorado	6.7
Colorado	14.1	Missouri	3.1	Kansas	6.5
Illinois	13.7	Indiana	2.9	Missouri	6.5
Missouri	13.6	United States	2.8	New York	6.5
Wisconsin	13.6	Florida	2.8	United States	6.3
Arizona	13.5	New York	2.8	Utah	6.3
United States	13.4	Texas	2.5	Tennessee	6.1
Minnesota	13.0	Maryland	2.2	South Carolina	5.9
Louisiana	12.7	North Carolina	2.0	Texas	5.9
Pennsylvania	12.6	Pennsylvania	2.0	Illinois	5.8
Tennessee	12.6	Rhode Island	2.0	Ohio	5.7
Iowa	12.4	Alabama	1.9	Pennsylvania	5.7
South Carolina	12.3	Illinois	1.9	Maryland	5.4
New York	12.1	Maine	1.9	Wisconsin	5.3
Utah	12.0	Oklahoma	1.9	North Carolina	5.1
Washington	11.9	Idaho	1.7	Virginia	4.8
Arkansas	11.8	Nebraska	1.7	Idaho	4.7
Kentucky	11.7	New Mexico	1.7	Arkansas	4.5
Maryland	11.5	Ohio	1.7	New Mexico	4.5
North Carolina	11.0	Oregon	1.6	Virgin Islands	4.5
Puerto Rico	10.9	South Dakota	1.4	Florida	4.4
New Mexico	10.7	Georgia	1.3	West Virginia	4.4
Virginia	10.7	Iowa	1.2	Rhode Island	4.2
Alabama	10.6	South Carolina	1.2	Oregon	4.1
Mississippi	10.5	Virginia	1.2	Alabama	3.9
West Virginia	10.0	Arkansas	0.9	Louisiana	3.8
Georgia	9.9	Michigan	0.9	Kentucky	3.7
Idaho	9.8	Tennessee	0.9	Michigan	3.7
North Dakota	9.7	Kentucky	0.8	Mississippi	3.6
Wyoming	9.6	Mississippi	0.8	Oklahoma	3.6
Florida	9.5	Louisiana	0.6	Nebraska	3.4
Rhode Island	9.2	Nevada	0.6	Georgia	3.3
Oregon	9.0	Wisconsin	0.6	Iowa	3.1
Nebraska	8.8	Delaware	0.5	Maine	3.0
Alaska	8.5	North Dakota	0.2	Nevada	2.8
South Dakota	7.9	West Virginia	0.2	South Dakota	2.6
Virgin Islands	7.4	District of Columbia	0.1	Wyoming	1.1
Montana	7.3	Montana	0.1	Montana	0.9
Maine	6.8	Wyoming	0.1	District of Columbia	0.6
Nevada	6.8	Alaska	(2)	Alaska	0.5
District of Columbia	5.2	Hawaii	(2)	Hawaii	0.5
Hawaii	4.1	Virgin Islands	(2)	North Dakota	0.5

[1]Source: Bureau of Labor Statistics, U.S. Department of Labor

[2]Employment of less than 100 workers

Table 3

FY 82 R&D Expenditures and Personal Income
(billions)

STATE	FEDERAL R&D SUPPORT	INDUSTRY* R&D SUPPORT (EST)	UNIVERSITY PERFORMED R&D	FED. LAB.** PERFORMED R&D	TOTAL*** R&D (EST)	PERSONAL INCOME
Alabama	0.562	0.034	0.071	0.322	0.616	33.47
Alaska	0.040	--	0.038	0.021	--	6.66
Arizona	0.264	0.548	0.101	0.079	0.851	28.48
Arkansas	0.043	0.056	0.036	0.026	0.121	19.12
California	8.888	2.992	0.947	2.353	12.431	304.65
Colorado	0.557	0.421	0.137	0.167	1.003	36.66
Connecticut	0.440	0.888	0.152	0.015	1.363	42.22
Delaware	0.035	--	0.018	0.023	--	6.90
District of Columbia	0.955	--	0.063	0.716	--	9.29
Florida	1.776	0.931	0.168	0.769	2.778	111.31
Georgia	0.217	0.178	0.170	0.070	0.463	52.41
Hawaii	0.045	--	0.043	0.011	--	11.30
Idaho	0.127	--	0.018	0.113	--	8.57
Illinois	0.543	2.153	0.283	0.284	2.782	136.15
Indiana	0.186	0.908	0.123	0.044	1.125	53.86
Iowa	0.136	0.335	0.111	0.027	0.522	30.89
Kansas	0.638	--	0.056	0.007	--	28.07
Kentucky	0.097	0.118	0.048	0.016	0.243	32.52
Louisiana	0.237	0.142	0.098	0.038	0.435	44.41
Maine	0.024	--	0.019	0.004	--	9.86
Maryland	2.850	--	0.351	1.997	--	50.66
Michigan	0.377	4.265	0.226	0.045	4.724	98.09
Massachusetts	2.775	1.170	0.470	0.465	4.018	67.82
Minnesota	0.379	0.800	0.147	0.024	1.243	45.56
Mississippi	0.126	--	0.050	0.088	--	19.49
Missouri	0.911	0.389	0.130	0.030	1.346	49.38
Montana	0.043	--	0.020	0.179	--	7.50
Nebraska	0.032	0.025	0.053	0.013	0.089	16.95
Nevada	0.376	--	0.018	0.063	--	10.38

Table 4
FY 82 R&D Expenditures as a Percentage of Personal Income

STATE	FEDERAL R&D SUPPORT	INDUSTRY* R&D SUPPORT (EST)	UNIVERSITY PERFORMED R&D	FED. LAB.** PERFORMED R&D	TOTAL*** R&D (EST)
Alabama	1.679	0.102	0.212	0.962	1.840
Alaska	0.601	—	0.571	0.315	—
Arizona	0.927	1.924	0.355	0.277	2.988
Arkansas	0.225	0.293	0.188	0.136	0.633
California	2.917	0.982	0.311	0.772	4.080
Colorado	1.519	1.148	0.374	0.456	2.736
Connecticut	1.035	2.103	0.366	0.035	3.228
Delaware	0.507	—	0.261	0.319	—
District of Columbia	10.280	—	0.678	7.707	—
Florida	1.596	0.836	0.151	0.691	2.496
Georgia	0.414	0.340	0.324	0.134	0.883
Hawaii	0.398	—	0.389	0.097	—
Idaho	1.482	—	0.210	1.318	—
Illinois	0.399	1.581	0.208	0.208	2.043
Indiana	0.345	1.686	0.228	0.082	2.089
Iowa	0.440	1.084	0.359	0.087	1.690
Kansas	2.273	—	0.200	0.025	—
Kentucky	0.298	0.363	0.148	0.049	0.747
Louisiana	0.534	0.320	0.221	0.086	0.980
Maine	0.243	—	0.193	0.041	—
Maryland	5.626	—	0.693	3.942	—
Michigan	0.384	4.348	0.230	0.046	4.816
Massachusetts	4.092	1.725	0.693	0.684	5.924
Minnesota	0.832	1.756	0.323	0.053	2.728
Mississippi	0.646	—	0.256	0.452	—
Missouri	1.845	0.787	0.263	0.061	2.726
Montana	0.573	—	0.267	2.387	—
Nebraska	0.189	0.147	0.313	0.077	0.525
Nevada	3.622	—	0.173	0.607	—

These data illustrate an obvious existing pattern of the agglomeration of government, industry, and university research and development in certain states. Clearly, those localities in which it is already concentrated have the inside track on its further exploitation for economic development. The recognized high-technology states of California and Massachusetts tend to rank higher than the others in the absolute levels of research and development but tend, because of their relatively large populations, to drop in rank when compared on the basis of expenditures as a fraction of personal income. Economies of scale in converting research and development to innovation may be possible.

It is also important to recognize that in several states, such as Maryland, New Mexico, Florida, and Virginia, a large component of their enormous federal research and development expeditures are due to the presence of federal laboratories. The ability to exploit these federal technology resources could be a critical factor in determining the success of technology-based economic development in the few states which are rich in them.

Due to the importance of the university in various technology-based economic development scenarios, research and development expenditures at the universities within a state are of particular interest. These expenditure totals in Table 3 are a measure of the collective capacity and capabilities for performing research and for training research personnel within the universities in a state and an indication of the ability of the universities to compete on a national level for research funding. The range of university research and development expenditures as a fraction of state personal income given in Table 4 ranges from a high of 0.693 percent in Massachusetts to a low of 0.110 percent in New Jersey. The statistics in Table 4 are more meaningful as a basis for interstate comparison than raw expenditure totals since they account for differences in population and tax base. States at the lower end of the range will need to consider placing more emphasis on the development of research capability in their university systems if technological innovation is pursued as an economic development strategy.

Since funding of university research is dominated by the federal government, research and development expenditures indicate only the existence of the potential for performing research likely to produce technological innovation within a state. Industry-

Table 5

University Patents Granted
During Period of 01/63 - 12/83

State	Patents	State	Patents
Total U.S.	3,643	Rhode Island	12
California	747	Arizona	9
Massachusetts	689	Tennessee	9
Iowa	230	Connecticut	8
Wisconsin	214	South Carolina	8
Illinois	188	New Mexico	7
Indiana	185	Colorado	6
Michigan	152	Hawaii	4
New York	149	Minnesota	4
Ohio	135	Mississippi	4
Utah	130	Arkansas	3
Maryland	96	Louisiana	3
*Pennsylvania	87	Oregon	3
Georgia	54	District of Columbia	2
Kansas	52	Alaska	0
Missouri	49	Delaware	0
Texas	49	Indiana	0
Virginia	48	Maine	0
Kentucky	46	Montana	0
Florida	39	Nevada	0
Washington	32	New Hampshire	0
North Carolina	24	North Dakota	0
Alabama	22	South Dakota	0
Oklahoma	20	Vermont	0
Nebraska	20	West Virginia	0
New Jersey	16	Wyoming	0

*Known to be incomplete.

Source of institutional data: Science Indicators Unit, NSF
Unpublished data, 1984.

Table 6 (continued)
Manufacturing Employment

STATE	% CHANGE IN MANUFACTURING EMPLMT 1976-81	% OF WKRS EMPLOYED IN MANUFACTURING, 1984
Wisconsin	4.6	22.2
Delaware	4.1	22.3
Rhode Island	3.9	26.3
New Jersey	1.9	20.4
Idaho	1.3	12.3
Iowa	1.1	15.4
Mississippi	0.6	22.0
Missouri	0.6	18.7
Maryland	-0.3	10.1
New York	-0.4	17.7
Kentucky	-1.1	15.9
Hawaii	-1.7	5.0
Montana	-2.1	5.5
Pennsylvania	-2.7	22.1
Indiana	-4.7	25.2
Ohio	-4.8	23.8
North Dakota	-5.6	4.7
Illinois	-6.9	19.0
West Virginia	-7.2	14.1
Michigan	-7.8	23.9
U.S. Total	6.9	18.3

Source: Bureau of Labor Statistcs, U.S. Department of Labor education and training are almost universal and lie outside the scope of the present discussion. After education and training, program initiatives aimed at increasing the technological research base for innovation are the most numerous and are the focus of much of the present work. From 1978 through the end of fiscal year 1984, $369 million in state funds had been committed for research-related programs. Table 7 lists the contributions to this total from individual state programs, ranging from support for basic research to non-remunerative grants for product development. At the close of calendar year 1984, this total had reached nearly $450 million, including a new $57 million initiative in New Jersey.

Programs which fund product development through equity or royalty participation are excluded. Entries in this table may include support for programmatic initiatives other than research in cases where disaggregation from umbrella program funding was difficult.

Many state programs that support the research phase of research and development for economic development are university-based or connected (Cornell University 1984), and most devote a significant fraction of their resources to sponsorship of joint university/industry research. A few programs also sponsor innovative applied research by small firms. Other programs promote interaction between universities and industry by campus research parks and incubator facilities.

A comprehensive study of university/industry research relationships has been conducted by the National Science Board (NSB) (NSB 1982a; 1982b), while the General Accounting Office (GAO) (GAO 1983) examined the federal role in university/industry cooperation. Numerous fora have been held to discuss university/industry relationships and the topic has been examined in contributions to the permanent literature as well (see Lynn and Long 1982; Azaroff 1982; Hutt 1983). This literature contains useful facts and informative discussions of the philosophical issues involved, but little to assist in optimal program design. For example, GAO (1983) touts research parks as being the most effective model of university/industry cooperation, whereas NSB (NSB 1982a) claims that they are relatively ineffective.

Table 7

Recent State Research Program Initiatives --
Cumulative Funding Commitments through Fiscal 1984

STATE	FUNDING (millions)	RESEARCH PROJECT GRANT	TECHNOLOGY RESEARCH CENTER	OTHER
Alabama	1.0	X		
Alaska	0.8	X		
Arizona	19.5		X	
Arkansas	--			
California	6.4	X		X
Colorado	*	X	X	
Connecticut	--			
Delaware	--			
Florida	13.9	X	X	X
Georgia	21.0	X	X	X
Hawaii	1.7	X		
Idaho	--			
Illinois	18.0	X		X
Indiana	20.0	X		
Iowa	2.0	X		
Kansas	1.0	X	X	
Kentucky	--			
Louisiana	6.2	X		
Maine	--			
Maryland	1.9		X	
Michigan	23.0	X	X	
Massachusetts	26.4	X	X	
Minnesota	5.0	X	X	
Mississippi	4.0			X
Missouri	1.4	X		
Montana	*	X	X	X
Nebraska	--			
Nevada	--			

More recent studies by the National Science Foundation (NSF) have contributed somewhat more substantive information. Three reports by NSF personnel (Johnson and Tornatzky 1984; Johnson, et al. 1984; Eveland, et al. 1984) have dissected the NSF University/Industry Cooperative Research Centers and University/Industry Cooperative Research Grant programs. These findings of these studies, among other things, illustrate the fact that university/industry cooperation in basic research will not necessarily lead immediately to tangible products of technological innovation for the participating firms. In a complementary, externally contracted study (Abt Associates 1984), the factors affecting university spin-off firm establishment were identified. These results confirmed the crucial role of an extensive base of high-quality research in technological areas relevant to industry. Other factors identified as important were faculty entrepreneurism and consulting, and to a lesser extent, external technological infrastructure.

The two most prevalent modes of state sponsorship of research related to economic development are the university affiliated technology research center and the applied research project grant. Both types of programs usually require matching support from non-state sources. In their implementation by states, these programs often resemble the two aforementioned NSF programs. The distinction between the two types of state programs is sometimes blurred. Programs which are primarily research project grant programs have been used to establish technology research centers; technology research centers can operate as a funding umbrella for aggregated individual projects supported by a research project grant program. Further, a few newly established "Centers" are little more than a name, and there is no attempt at focused research on a significant scale.

The university technology research center is generally conceived as a vehicle for conducting research in some specific important technological area. Such centers frequently focus on technologies that are interdisciplinary or cross-disciplinary, such as manufacturing systems and biotechnology. The center concept improves research productivity and makes possible broad-based, cohesive approaches to solving complex problems. It should also enhance the quality and quantity of the scientific and engineering instruction at the university. Often, the research conducted by a center is directed basic or applied research of interest to a wide constituency of the center's commercialization and exploitation by the private sector. Many states have implemented technology transfer and commercialization assistance programs to facilitate this process in various ways.

The role of state government in enhancing technology transfer has been discussed by Bearse (1984). For purposes of the present discussion, state technology transfer programs are generally of four types. The first two types of programs involve the development of new technologies and are targeted at the creation of new firms. One such program type actively seeks to exploit new technology developed at a university (or in some cases, government laboratories) for commerical development. The other assists in the commercialization of new technology by providing technical and managerial support services to inventors and entrepreneurs for product and process development, often by means of a university-based innovation center. The final two program types exist principally to accelerate the diffusion of existing advanced "off-the-shelf" technology to industry for stabilization or expansion. These programs accomplish this either by providing, in one type, information or in the other type, field extension services to existing firms.

Other commercialization assistance programs seek to provide managerial and technical (in the broad sense) assistance to small firms and may or may not be only targeted to technology-based firms. They may also provide seed or second-stage risk-capital financing of entrepreneurial efforts or simply provide linkages to external sources of risk capital. Their primary role is the support of small and, often, new firms.

Figure 4 illustrates the relationship of some program types to development objectives.

FIGURE 4
RELATIONSHIP OF PROGRAM TYPES TO DEVELOPMENT OBJECTIVES

	OBJECTIVES			
PROGRAM	INDUSTRIAL RECRUITMENT	INDUSTRIAL EXPANSION AND RETENTION	INDUSTRIAL STABILIZATION	INDUSTRIAL FORMATION
Education and Training	H	M	L	M
University Technology Research Centers	H	H	M	M
Applied Research Project Grants	L	H	H	H
Technology Transfer (Technology Development)	L	H	H	H
Technology Transfer (Technology Application)	L	M	H	L
Commercialization Assistance (other than Technology Transfer)	L	M	L	H

H = High degree of effectiveness

M = Moderate degree of effectiveness

L = Low degree of effectiveness

Assessment of State Programs - Discussion

The preceding discussion provides some background for the primary task of the present work, the critical review of selected state research programs for technology-based economic development. As pointed out by OTA (1984b) and Peltz and Weiss (1984), there are many difficulties associated with an objective evaluation of such programs. First, the goals of state programs differ from one state to another. Although employment growth is perhaps the most common ultimate objective, various states place different emphasis on it in relation to other possible goals, such as increased incomes, business development and retention, economic diversification, increased industrial productivity, and creating or retaining competitive advantages in certain industrial sectors. The difficulty of the assessment task is exacerbated by lack of comparability between programs, their integration into strategies, and state resources for program implementation. In addition, there are numerous technical difficulties associated with the newness of most programs, the absence of standardization of effectiveness measures, the lack of data collection on program impact, and the difficulty of attributing causality in such data. The newness of the programs poses special difficulties, since the ultimate success of an invention or idea derived from research cannot actually be determined until it reaches the marketplace. The average time lag for such innovation to occur has been estimated to be anywhere from three to ten years (Joint Economic Committee 1980).

Because of these difficulties and because of the limited time and manpower resources available for the present study, the ten tentative program assessments contained in the next section are at best superficial and subjective. They are presented more to raise questions than to provide answers. Hopefully, they will provide a starting point for more in-depth study. In any case, the symbolic and psychological value of these programs, even those which are successful in promoting technological innovation, may be at least as important for demonstrating a state's economic vitality as for resulting in substantive and tangible economic outcomes. The ten states selected were chosen either because of the relative maturity of their programs or for some novel characteristic feature of their program. They are fairly representative in terms of their geographic location, economic profiles, program size, scope, and content.

ASSESSMENTS

PROGRAM SUMMARY DESCRIPTION

ARIZONA

Program:	Engineering Excellence Center
Year Begun:	1979
Current Annual Funding:	Incremental start-up funding plus an estimated $3.9 million in continuing costs to the state in appropriations.
Cumulative Funding:	(1983-84)
a. State appropriations	$19.5 million
b. Industry	$15.0 million
c. Other	$3.5 million
Program Goals:	To place Arizona State University's College of Engineering and Applied Science among the nation's foremost education and research centers; to contribute to and improve economic growth in the state.
Administrative Structure:	University-administered program.
Program Elements:	Facilities improvement, faculty enlargement, federal and industrial-sponsored research and development.
Benefits/Outcomes Claimed:	Five-fold increase in college research expenditures over four-year period, 50 percent increase in engineering enrollments over six years. Several major new high-technology business expansions and relocations have located recently in the area.

fold during the first four years. It reached more than $8 million in awards during 1983-84. Most of this research is federally funded, as is typical of conventional basic research at most universities. Engineering enrollment at ASU has increased 50 percent over a six-year period.

The economic development goals of the Center for Engineering Excellence program have not yet been fully articulated, except that the center is expected to contribute to and improve the economic growth of the state through providing support to engineering-related industry. A research park, which will include a small-firm incubator, is under development on university-owned property in Tempe. There is anecdotal evidence of successful industrial recruiting efforts which may have been aided by the development of the center; several major new high-technology businesses have recently located in the Phoenix area.

In view of Arizona's success in attracting technology-based industry and its boom in manufacturing, there is little incentive to put in place a university/industry applied research project grant program, especially one focusing on applied research. The Center for Excellence program, as it exists is probably the best type of program for stimulating increased economic development through industrial recruitment, even if it falls short of its optimistic national leadership goals. In the interest of balance, perhaps more emphasis should be placed on new firm creation from spin-off of university research. In addition, a formal university/industry matching grant program leaning toward basic research, like the MICRO program in neighboring high-tech California, might be considered. Such a program could also involve the University of Arizona in Tucson. Although an Optical Technology Center is being enhanced at the University of Arizona, and a large federal government biotechnology research grant was awarded to them, there is no large state-sponsored program of development comparable to the ASU Center for Engineering Excellence to encourage growth in the Tucson area where the U.S. Conference of Mayors has established a federal laboratory technology transfer. Finally, the absence of a significant effort related to biotechnology at ASU, an area which will be of increasing technological and economic importance in the future, is notable, although the relative proximity of Tempe and Tucson may mitigate against the duplication of large programs.

PROGRAM SUMMARY DESCRIPTION
CALIFORNIA

Program:	MICRO Program
Year Begun:	1981
Current Annual Funding:	(1983-84)
a. State appropriations	$1.7 million
b. Non-state sources	$2.2 million
Cumulative Funding:	(1983-84)
a. State appropriations	$4.2 million
b. Non-State sources	$6.8 million
Program Goals:	To help California electronics and computer industries maintain leadership by expanding relevant university research and training.
Administrative Structure:	Policy board with university, industry, and state representation.
Program Elements:	Joint funding with industry of directed basic and applied research leading to products in mid- to long- term.
Benefits/Outcomes Claimed:	Increased university/industry interaction.

There are at least one or two "world class" research universities in the UC system. The bulk of the MICRO funds are devoted to projects at UCLA, Berkeley, and Santa Barbara. Because of the quality and quantity of the California microelectronic research enterprise, many of the MICRO projects are eventually likely to pay economic dividends. However, the private universities, including "world class" Stanford, are not included in the program nor is the separate system of California State Universities. In light of the financial resources available in California, the program funding is modest. There is little attention given to technology transfer through university spin-off, where industry would allow the universities to exercise this option. The program is geared toward the economic development goals of expansion and retention of Silicon Valley-type firms. While that is a goal consistent with the state's high-technology economic profile, it probably does not exploit the full potential of university research and development in microelectronics. Moreover, technologies which are on the verge of commercializable breakthroughs, such as biotechnology, are ignored even though California public and private universities have significant resources to be exploited in such technologies.

Update and Comments

Annual state funding for the MICRO Program doubled in the 1984-85 fiscal year to $4.2 million. In addition, during the current fiscal year (85-86) the MICRO program will receive more than $4.4 million in state aid. This amounts to a 110 percent increase in funding over the last two years.

PROGRAM SUMMARY DESCRIPTION

INDIANA

<u>Program:</u> Corporation for Science and Technology

<u>Year Begun:</u> 1983

<u>Current Annual Funding:</u>

	(1983-85)
a. State appropriations	$20 million
b. Industry	N/A

<u>Cumulative Funding:</u> Same as Current Funding.

<u>Program Goals:</u> To strengthen the state economy through development of scientific and technological-based research and development ventures.

<u>Administrative Structure:</u> Private, not-for-profit corporation.

<u>Program Elements:</u> Interim funding support for applied research and development projects to transfer technology from the universities and industrial research and development laboratories into commercially viable products, processes, and services. The Corporation also provides technology advice and counseling and business/financial advice and counseling.

<u>Benefits/Outcomes Claimed:</u> No specific benefits claimed.

- o Biotechnology;
- o Control Systems;
- o Energy Development;
- o Industrial Byproducts;
- o Information Processing;
- o Integrated Optics;
- o Manufacturing Technologies;
- o Medical Technology;
- o Microelectronics; and
- o Telecommunications.

Initial bienniel funding for the corporation is $20 million.

The corporation's emphasis on applied research grants places its program into the applied research project grant classification; grants have been made to universities, non-profit organizations and business firms for technology-oriented projects. Industrial matching funds for university research projects are not required, but project proposals are supposed to "demonstrate a clear path to a commercial process or product." However, several of the projects which have been funded do not seem to quite meet this test. In one case, partial support was provided for a university technology research center with the anticipation that the center's research projects would be tied directly to a commercial opportunity.

The corporation's program is too new to evaluate meaningfully its likely impact. It does not plan to quantitatively monitor the impact of its grants on job creation or retention in the state. This may be an oversight insofar as projects tend to be of an applied nature, and job creation data would not be extraordinarily difficult to obtain. The level of state funding for the corporation is good, but an explicit requirement for industrial matching funds would likely provide more leverage for state funding and permit funding of additional projects.

In a state with a declining industrial base, the corporation's emphasis on applied research grants is probably the right choice. The relatively modest total research and development expenditures at the state's research universities suggest that, in spite of the

PROGRAM SUMMARY DESCRIPTION
KANSAS

Program(s):	Centers of Excellence and Research Matching Grant Program
Year Begun:	1983

Current Annual Funding:

	(1983-84)	(1984-85)
a. State appropriations	$1.0 million	$1.3 million
b. Industry	$1.4 million	$1.4 million

Cumulative Funding:	Same as current funding.
Program Goals:	Utilization of advanced research capabilities to stimulate economic development and to stimulate research and technological innovation in order to create jobs, induce investment, and improve production efficiency of Kansas firms.
Administrative Structure:	Advanced Technology Commission, staffed within the Department of Economic Development.
Program Elements:	Facilities improvement; federal and industrial sponsored research and development; joint funding with industry of applied research leading to economic growth.
Benefits/Outcomes Claimed:	A significant number of new jobs have been or will be created due to expansion of existing firms and recruitment of new firms.

The 1983 session of the Kansas legislature allocated $130,000 each for three "Centers of Excellence." The Centers are: a Center for Bioanalytical Research at the University of Kansas, a Center for Artificial Intelligence and Automated Control Systems at Kansas State University, and a Center for Productivity Enhancement at Wichita State University. Grants to the centers must be matched at least 150 percent by non-state sources. Funding for the 1984-85 year provided a $140,000 enhancement for each center for a total investment of $290,000 per center. It is questionable whether these totals are sufficient to achieve "world class" research status for these schools or to make significant new technological breakthroughs likely. A further concentration of resources would allow them to more fully exploit the potential for interaction with the defense-oriented federal research and development in the state and to fully exploit the potential for biotechnological research benefiting the agricultural industry in the state. The centers will serve to enhance the level of university technical expertise to facilitate the application of advanced technologies to existing industry and to portray a favorable image of Kansas as a location for innovative activity. The possibility of appropriating additional funds to develop these or additional centers, promote inter-university linkages, and transfer technology to spin-off firms, might be investigated.

The Research Matching Grant Program is a program of grants for matching industrial funding of applied university research on projects likely to lead to commercial application of the research results and economic ventures in the state. The matching requirement for this program is also 150 percent. State funds in the amount of $610,000 were allocated for this program during the 1983 session and $855,000 will be requested for the second year of program operations. The average size of the grant awards was approximately $40,000. The impact of the Matching Grant Program as of March 1, 1984, was that the addition of fifty employees each was foreseen by two participating firms, while another two firms anticipated opening up new markets in the $50-$75 million range. Two other firms were considering relocating to Kansas as a result of program funding for specific research. This type of near-term effect shows promise for adequate returns on continued investment in this program. The level of investment appears to be close to that required for a meaningful program. Increased funding may be indicated if quality proposals are not being funded.

PROGRAM SUMMARY DESCRIPTION
MARYLAND

<u>Program(s):</u> Engineering Research Center (ERC), Center for Advanced Research in Biotechnology (CARB), and Maryland Biotechnology Institute (MBI)

<u>Year Begun:</u> 1983 (ERC and MBI); 1984 (CARB)

<u>Current Annual Funding:</u>

	(1983-84)	(1984-85)
a. State appropriations (ERC only)	$1.3 million	$1.8 million

<u>Cumulative Funding:</u>

	(1983-84)
a. State appropriations (ERC only)	$1.9 million

<u>Program Goals:</u> ERC seeks to contribute to the state's leadership in high-technology evolution through education, by generating new knowledge and through increased service to industry and business in the state and in the region. CARB and MBI aim to consolidate expertise at the university, work in partnership with the state's high-technology industry, and serve as a magnet for attracting new industries, thus providing the state with the scientific component to its commitment to high-technology industries.

<u>Administrative Structure:</u> University of Maryland-based programs. ERC in College of Engineering; CARB and MBI are separate units.

<u>Program Elements:</u> University/industry cooperative research (proposed). ERC currently supports generic technology development and technology transfer efforts.

<u>Benefits/Outcomes Claimed:</u> N/A

ERC is an organization created within the UMd College of Engineering to extend the technical experience and expertise of the University of Maryland to businesses throughout the state. The Center received an initial appropriation of $600,000 for its first fiscal year of operation and $1.3 million and $1.8 million for the second and third years, respectively. The major thrusts of the ERC are support for a technology transfer/extension program, a planned incubator facility, support for capability expansion in relevant generic technology areas, and support for research partnerships. The research and development programs are not yet fully under way; however, the objective is to build on existing capabilities. Traditional engineering generic technology areas, such as CAD/CAM, robotics, and manufacturing systems, are supported, as well as an effort to couple chemcial engineering to the proposed UMd biotechnology research emphasis through research on fermentation processes. The ERC is neither a technology research center program nor is it an applied research project grant program. It is distinct from the technology research center model in that there is only an incidental concentration on basic and applied research in focused technological areas. ERC does, however, support technology initiatives within existing departments of the University.

A weakness of the present ERC program is the lack of substantial financial commitment from industry as compared with similar programs in other states. There is no formal non-state source matching requirement. Furthermore, it can be questioned whether the present state funding levels and patterns are sufficient to catapult the generic technology programs supported into national leadership stature. The program may be adequate to serve the needs of Maryland's existing traditional manufacturing industry, if the proper linkages are established. It is doubtful if it is large enough to be useful in recruiting new industry or in establishing substantial spin-off activity. The possibility of ERC establishing joint research programs in areas of commercializable technologies with the several federal laboratories in the state is in need of further exploration. The present policy of seeking federal research and development funds only if they facilitate university/industry interaction may be short-sighted. The exploitation of one federal laboratory's resources (the National Bureau of Standards) is the basis for the formation of CARB, and there may also be unexplored opportunities for ERC to also involve itself with a Maryland federal laboratory. The recent announcement of a $16.7 million NSF Engineering Research Center award may overshadow the perceived weaknesses of the ERC program and greatly enhance ERC's stature and potential for success.

development over time of a leading biotechnology research institution. Early indications are that industry is enthusiastic. One rather obvious shortcoming of the UMd concept from an economic development point of view is the lack of active involvement by Johns Hopkins University in Baltimore, which is considered by many to be "world-class" in its reputation for research in the life sciences. This may be due, in part, to the lack of early state government participation in evolving the concept and committing state resources.

Update and Comments

The Engineering Research Center's incubator has been established. Two companies presently reside in the on-campus facility, and negotiations are under way with four more companies. To date, forty-seven applications have been received, thirty for on-campus status and seventeen for affiliate status.

As regards mechanisms to link ERC to Maryland's existing industries, regional technology extension offices are operated in Baltimore, College Park, Gaithersburg, and Frostburg. Each of these offices is staffed by one or more industrially experienced engineers who serve the companies in the region. These engineers respond to companies by providing individual technical advice and problem solving. If the problem requires additional support, then the involvement of a University of Maryland faculty member will be arranged. The ERC will fund up to five days of support per problem. In the short time the program has been operating, over fifty firms have been helped in this manner.

Finally, it should be noted that Johns Hopkins University offers a number of innovative programs and acts as both a resource to industry and a source of continuing technological development. The Johns Hopkins Applied Physics Laboratory, with its 2,700 scientists, engineers, and support staff, engages in applied and basic research related to national defense, space exploration and civilian needs. The Space Telescope Science Institute located on the Homewood Campus of Johns Hopkins will receive and analyze data received from NASA's 95-inch Space Telescope, which will be launched in 1986. Finally, the Francis Scott Key Medical Center under development will include a 40-50 acre biotechnology research park and an upgraded acute care hospital facility. The first tenant in the park dedicated a 33,000 square foot research lab in 1984.

PROGRAM SUMMARY DESCRIPTION
NEW YORK

Program(s):	Centers for Advanced Technology and Research and Development Grants Program
Year Begun:	1981

Current Annual Funding:

	(1983-84)	(1984-85)
a. State appropriations	$2.6 million	$7.5 million
b. Other sources (est.)	$4.6 million	N/A

Cumulative Funding:

	(1983-84)
a. State appropriations	$2.9 million
b. Other sources (est.)	$4.7 million

Program Goals:	To increase and make available to the people of the state the benefits derived from new advances in science, technology and innovation; to strengthen the state's leadership position in technical research and development; to develop an effective and efficient process of technology transfer; and to improve the state's overall economy through the development and strengthening of its advanced technology industrial base.
Administrative Structure:	Science and Technology Foundation, a public corporation
Program Elements:	University/industry/government cooperative research centers and applied research and development grants for university/industry research.
Benefits/Outcomes Claimed:	University/industry interrelationships have developed and some of the projects supported are entering the commercialization phase.

- Columbia University - Computers and Information Systems.
- Cornell University - Biotechnology in Agriculture.
- Polytechnic Institute of New York - Telecommunications.
- SUNY Buffalo - Health Care Instruments and Devices.
- SUNY Stony Brook - Medical Biotechnology.
- Syracuse University - Computer Applications and Software Engineering.
- University of Rochester - Advanced Optical Technology.

All except one CAT center has met or exceeded the goal of obtaining matching external funds equal to its state appropriation. The CAT which did not attain this goal is being restructured with new leadership. The \$2.5 million first-year state appropriation for the CATs has effectively leveraged \$4.5 million in external funding. Basic state funding has been provided for equipment, faculty, research staff, and graduate students. The earmarked appropriation is used for development of capabilities and for project support.

The program's economic development goal is long-term and essentially "plants the seeds for the future growth of technology-based industries in New York State." As was true of the similar technology center programs in other states, it is impossible to assess the likely impact in New York of state expenditures in terms of job or wealth creation for a cost/benefit comparison. The level of individual center funding is such that it is likely to improve significantly the research and training capabilities of the universities involved; it will not elevate them to the "world class" status necessary for significant spin-off activity if they are not already at least marginally there, as are Cornell and Columbia. Moreover, there is some question as to whether or not targeted expenditures alone can accomplish this objective. However, the leveraging of external funding has so far been encouraging and the tangible evidence of the state's commitment to technology-based industry and the visible research activity is a positive influence on the business climate.

PROGRAM SUMMARY DESCRIPTION
NORTH CAROLINA

Program(s): Biotechnology Center, Microelectronics Center, Innovation Research Fund

Year Begun: 1981

Current Annual Funding:

	(1983-84)	(1984-85)
a. State appropriations	$7.9 million	$10.5 million
b. Other sources	N/A	N/A

Cumulative Funding:

	(1983-84)
a. State appropriations	$ 48.2 million
b. Other sources	$ 7.7 million

Program Goals: Part of strategy for: recruitment and expansion of new technology firms, fostering innovation in traditional industries, and start-up of new small business.

Administrative Structure: Separately administered organizations, each with board with representatives from academia and business; overall coordination by North Carolina Board of Science and Technology.

Program Elements: Basic research, applied research, and small amount of product-development funding.

Benefits/Outcomes Claimed: Over 1,800 new jobs created by high-technology manufacturing firms attracted to state during the two-year period, 1983-84. Some research and development firms have also been attracted.

North Carolina's approach to research and development programs has been to strengthen research and development in areas perceived to be important to the state's economy at the flagship state research universities, the University of North Carolina at Chapel Hill and North Carolina State University (Raleigh). The state has also set up independent research centers in microelectronics and biotechnology at RTP which will coordinate and promote research in these technologies within the state.

The microelectronics effort is centered around the Microelectronics Center for North Carolina (MCNC). MCNC both operates its own applied research facilities and works with five participating universities and the Research Triangle Institute to support their educational and/or basic research programs in microelectronics. From its inception in 1981 and through the 1985 fiscal year, MCNC will have received a total of $47 million in state funds and $7.7 million from non-state sources. Non-state sources include contractual research from the Semiconductor Research Consortium and support from membership fees paid by six industrial affiliates. MCNC's state funds represent only a portion of what is the largest financial commitment by any state to a single technology. Related state investments in university capital facilities exceed $20 million. As of December 1984, the MCNC device fabrication facilities had not been completed, pending equipment deliveries, and the in-house research program was not fully operational.

The North Carolina Biotechnology Center, established in 1981, emphasizes coordination, collaboration, and cooperation in research between industry and the state's universities. It also promotes the development of new and existing biotechnology firms. The Biotechnology Center is funded at a much lower level than MCNC; total funding through 1984-85 is $1.2 million. There is a requirement for funding from non-state sources to equally match the $500,000 per year state allocation. The Center funds seed grants for university research and provides support for university education and research in much the same way as MCNC. But unlike MCNC, there is no intramural research program. The Biotechnology Center is designed primarily to exploit the existing strengths of North Carolina universities in this field. A recent survey by the National Academy of Sciences rated the graduate programs in the biological sciences at several North Carolina universities among the most effective in the nation. The funding level for the Biotechnology Center is, however, less than that of several other states with biotechnology economic development program initiatives.

about the long-term effectiveness of this strategy as opposed to alternative strategies based on the revitalization of declining industries or development of capabilities in a broader range of technologies.

Update and Comments

The biennial appropriation figures from the 1985 session of the North Carolina state legislature are:

- Microelectronics Center of North Carolina

Fiscal Year 1985-1986:	$16.8 million
Fiscal year 1986-1987:	$12.2 million

- North Carolina Biotechnology Center

Fiscal year 1985-1986	$ 7.7 million
Fiscal year 1986-1987	$ 1.5 million (With $5.0 million pending in program funding.)

- Technological Development Authority

Fiscal year 1985-1986	$ 1.35 million (of which $500,000 is allocated for the Innovation Research fund.)

Where it may appear that the state has made a greater investment in microelectronics than in biotechnology, the difference in appropriations is due primarily to the capital expenditures involved in MCNC's in-house research capability. In general, commitments to the two initiatives are comparable.

While it is true that both MCNC and NCBC support North Carolina's industrial recruitment efforts, it should be noted that the TDA is intended to foster the development of "native" or indigenous technical or research-based start-up companies. Toward that end, the Innovation Research Fund investments are limited strictly to applied research by private companies which produce proprietary information and marketable products. Sales of the product then provide a royalty back to the IRF for reinvestment.

PROGRAM SUMMARY DESCRIPTION
OHIO

Program: Thomas Edison Program

Year Begun: 1983

Current Annual Funding: (1983-85 biennial)

a. State appropriation $32.4 million

b. Non-state $78 million

Cumulative Funding: Same as Current Funding

Program Goals: To encourage state economic development through technological innovation by fostering cooperative research and development efforts involving businesses and educational institutions that will lead to job creation in Ohio.

Administrative Structure: Ohio Department of Development with award funding by advisory board composed of representatives from academic, business, and legislative communities.

Program Elements: Advanced technology application centers of "excellence" involving joint industry/academic research, technology transfer to mature industry, entrepreneurial assistance, and education and training; applied research and development matching grants.

Benefits/Outcomes Claimed: Commitment from non-state sources of funds conservatively estimated to be $78 million.

Through the ATACs program, the state is providing $23.6 million in matching support for the formation and growth of several technology research, development, and implementation centers located around the state. Six centers were awarded to universities in a proposal competition judged according to criteria that were, in principle, free from political considerations. These centers conform to the technology research center generic model. They are supposed to attain national or international leadership status in their respective technology areas. However, they are also required to strongly emphasize technology transfer to the private sector and to demonstrate how jobs will be created in Ohio. The centers, their affiliations, and their initial funding allocations are:

o Institute of Advanced Manufacturing Sciences - University of Cincinnati	$ 4.1 million
o Ohio Welding Research and Development Institute - Ohio State University	$ 4.1 million
o Cleveland Advanced Manufacturing Program - Cleveland State University, Case Western Reserve Universities, Cuyahoga Community College	$ 4.1 million
o Advanced Technology Application Center in Polymers - Case Western Reserve, University of Akron	$ 4.1 million
o Recombinant Animal Biotechnology Center - Ohio State University, Case Western Reserve University	$ 3.1 million
o Applied Information Technologies Research Center - Ohio State University	$ 4.1 million

Estimates of the total matching fund commitment from non-state sources for these centers range from $127 million by the centers themselves to a more conservative $75 million by the Ohio Department of Development. Matching funds span the gamut of possibilities, including research support, equipment donations, and membership fees. The individual centers plan to become self-supporting over time. As an aside, it is interesting that there is no focus in the ATACs on microelectronics except in an incidental way in the Information Technologies Center at Ohio State.

technology transfer has been stressed. In the near-term, there may be some symbolic value to the program's presence for recruitment and retention of industry. However, the IRFP program can be a useful complement to the ATACs program and can perhaps interact with small business to create jobs in a shorter time frame than the ATACs if it is administered flexibly and promoted with this in mind.

Update and Comments

The State appropriation for the 1985-87 biennial is $34.8 million.

PROGRAM SUMMARY DESCRIPTION
PENNSYLVANIA

Program: Ben Franklin Partnership Program

Year Begun: 1982

Current Annual Funding:

	(1983-84)	(1984-85)
a. State appropriations	$10 million	$18 million
b. Industry	$16 million	$33 million
c. Other	$12 million	$22 million

Cumulative Funding:

	(1983-84)	(1984-85)
a. State appropriations	$11 million	$29 million
b. Industry	$19 million	$86 million

Program Goals: To link private and academic resources to make traditional industry more competitive in the international market place and to spin-off new, small businesses on the leading edge of technological innovation.

Administrative Structure: Regional, non-profit corporations with university ties and with consortia of representatives from academia, business, and labor.

Program Elements: Joint funding with industry of applied research, education and training, entrepreneurial assistance programs, and seed capital.

Benefits/Outcomes Claimed:

(1983-84)

Number of projects - 219
Number of new firms - 62
Number of new jobs - 352
Number of jobs retained - 72
Number of jobs recruited - 1,150

- o Western Pennsylvania Advanced Technology Center - based at Carnegie-Mellon University and the University of Pittsburgh; and
- o Advanced Technology Center of Central Northern Pennsylvania - based at the Pennsylvania State University.

In its research and development programs, each Center emphasizes applied research in three or four marketable technology areas related to the perceived strengths and capabilities of its participating universities. Each center has three or four Centers of Excellence such as robotics and computers, CAD/CAM, and sensors. Projects are funded through each Center with identifiable private firms and higher education institutions. The mode of program operation is closest to the applied research project grant model. However, in the present case, projects are administered by the Regional Centers under "umbrella" funding and Centers of Excellence are established under umbrella funding. The projects are packaged by the Center for consideration by the Ben Franklin Board. The Board allocates state funding to the Centers based on the quality of the projects submitted, the amount of matching funds committed, and past performance of each Center in creating jobs, attracting venture capital, and other measures related to job generation.

State funding for the Ben Franklin Partnership began with a 1982-83 start-up allocation of $1 million, increased to $10 million for 1983-84, and is $18 million for 1984-85. The latest appropriation of $18 million in state funds resulted in a match of over $55 million from non-state sources for a total of over $73 million, which is claimed to be the largest total program on an annual basis in the United States. It is also claimed to be the largest leveraged program with its 1:3 state to non-state funding ratio. The governor's budget projections show a steady increase in state funds to $25 million. If the matching ratio continues to hold, this will result in over a $100 million annual program when funding levels off. This is an amount equivalent to approximately one-fourth of total university research and development expenditures in the state or, to place it in a national perspective, more than two-thirds of the total budget for engineering research of the National Science Foundation.

From the beginning of the program in March 1983 through May 1984, it is reported that the Centers assisted sixty-seven firms to start-up and forty-three firms to expand, together creating 663 new jobs. This is an encouraging result considering the youth of the program.

Update and Comments

As concerns program outcomes, the following data covers the first 26 months of the program from March 1983 through April 30, 1985.

Number of Projects - 302
Number of new firms - 184
Number of new jobs - 860
Number of firms expanding - 121
Number of job created by expansion - 789

Pennsylvania indicated that the above numbers are not based on projections but are actual figures obtained from individual businesses. Staff of the Ben Franklin Partnership program contact firms directly to validate the numbers.

As regards funding allocation between the four centers, it was noted that their allocations are not influenced by a desire for regional balance.

PROGRAM SUMMARY DESCRIPTION

VIRGINIA

Program:	Center for Innovative Technology
Year Begun:	1984
Current Annual Funding:	(1983-85)
a. State appropriations	$30.3 million
Cumulative Funding:	Same as Current Funding
Program Goals:	To enhance the research capabilities of many of Virginia's universities and colleges, stimulate these capabilities to be relevant and applied to the technical needs of private industry, and market these capabilities to stimulate increased industry participation in university research in Virginia.
Administrative Structure:	Non-profit, non-stock corporation with board appointed by governor. Real property held by a state authority.
Program Elements:	Research institutes consisting of consortia of universities; a headquarters with research facilities, incubator space and graduate education.
Benefits/Outcomes Claimed:	Seeks to make state attractive as a home for high-technology enterprise. No effectiveness measures.

The CIT is not yet fully operational and therefore an assessment of its likely impact on economic development is highly tentative. Nevertheless, it is an interesting and novel approach and the concept itself is worthy of scrutiny.

Although the CIT is a novel approach overall, certain specific features resemble North Carolina's Biotechnology Research Center and Microelectronics Center of North Carolina (MCNC) discussed earlier in this report. Like the Biotechnology Center and MCNC, emphasis is placed on a consortium of universities engaged in research. The organizational difference is that, in theory, CIT works through a more structured (on the university-side), multi-institutional "Research Institute" in each of the four targeted technologies while the Biotechnology Research Center and MCNC operate their own facilities and work informally with participating universities. Each Institute has a resident research director on the campus of the lead institution for that technology. Another distinct difference is that, unlike MCNC, the on-site CIT research facilities will be staffed by persons with permanent faculty (or industrial) connections. The CIT will, therefore, be brokering university expertise, not its own.

The CIT has been funded by the Virginia General Assembly at $30 million for its first biennium. Approximately $9 million of this total is provided for the capital facilities of the CIT's headquarters. Most of the remaining funds will be utilized in support of on-campus research, including equipment, laboratory renovation, and Institute administration. The intent is for private sector funds to supplement the operations.

The CIT headquarters will be located in Northern Virginia on the fringe of the Washington, DC, metropolitan area, close to the high-technology firms which have gravitated to that area. The universities will be linked to the CIT through the latest in communications technology. The CIT will market its technological resources to out-of-state firms as well as in-state industry.

The primary stated rationale for the development of the CIT is to make the state more attractive as a home for high-technology enterprise. It is acknowledged that, while strong, Virginia universities are currently not "world class" research institutions and that only in Northern Virginia is there the critical mass of technological infrastructure. As is typical with technology-center type programs, there are no articulated, quantitative

Since the Center for Innovative Technology was just getting under way at the time the data for this project was collected, major advances have since been made. Thus far, three Research Institutes have been created at the Univeristy of Virginia (UVA), Virginia Polytechnic Institute and State University (VPI&SU), and Virginia Commonwealth University. During its first year of operation, CIT has attracted $3.9 million in industrial matching funds received from forty corporations located throughout Virginia to supplement its own $3 million appropriation for university research.

In April 1985, the Software Productivity Consortium (SPC), comprised of thirteen of the nation's leading aerospace corporations, announced it intends to co-locate its new facility in Northern Virginia at the Center for Innovative Technology. The Consortium will develop state-of-the-art software and software development techniques to help give the United States long-term superiority in the software field. The technology developed by this private sector venture will serve the defense and intelligence communities.

While Northern Virginia is the only region of the state with a critical mass of technological infrastructure, other areas of Virginia are showing signs of potential growth in the high technology field. The recent selection of Newport News by the U.S. Department of Energy as the site for the Continuous Electron Beam Accelerators Facility (CEBAF) is expected to greatly enhance Southeastern Virginia's high-technology potential. It is anticipated that CEBAF will be instrumental in research in the field of nuclear science, attracting leading scientists from all over the world and providing superior training to graduate students.

CONCLUSIONS

This report has attempted to provide an overview of state programs to encourage technological innovation through fostering basic and applied research in relevant technological areas. Many states have incorporated such progams into their economic development strategies. However, it is generally agreed that most localities do not have the technological infrastructure to incubate or accommodate technology-oriented industry on a large scale. Further, such industry will not be the dominant source of jobs nationwide for the forseeable future. Nevertheless, promoting local research and development activity through state initiatives will improve the image of technologically less-developed regions as sites for other innovative economic activity, even if few high-technology jobs are created.

The two most common types of state research program initiatives are the applied research grant program and the technology research center. These two program types differ in their ability to achieve various economic development objectives. A state's technology-based economic development objectives must be formulated in relation to its individual economic and demographic characteristics as well as its existing technological infrastructure.

The ten assessments of state research initiatives presented herein indicate that these programs fall generally into two categories. Whether the programs contribute to economic development primarily through their symbolic presence or directly create jobs through the technological innovation process, they are likely to improve the quality and the quantity of scientific and engineering manpower training in state universities.

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APPENDIX

Table A-1
Employment of Technological Workers, 1980

State	Employed Persons (16 & over non-agri.)	Engineers and Natural Scientists	Engineers	Technicians and Technologists	Precision Production Occupations
Alabama	1,511,928	26,752	17,739	24,975	67,754
Alaska	164,874	5,197	2,344	5,802	3,784
Arkansas	875,733	9,683	6,114	10,395	38,760
Arizona	1,113,270	27,185	17,209	27,709	40,033
California	10,640,405	312,406	213,232	261,012	469,828
Delaware	262,809	8,053	4,974	8,725	10,306
Colorado	1,362,017	44,036	24,798	38,985	48,202
Connecticut	1,482,309	47,306	31,838	34,413	81,774
Florida	4,002,330	68,272	43,906	78,799	129,705
Georgia	2,335,835	35,961	21,497	42,856	93,161
Hawaii	415,181	7,309	3,992	8,597	10,992
Idaho	383,652	8,475	4,829	7,153	11,391
Illinois	5,068,428	104,699	68,692	97,183	237,746
Indiana	2,366,263	41,952	29,920	39,942	125,465
Iowa	1,304,638	17,558	11,678	18,687	54,818
Kansas	1,078,741	19,898	13,414	18,950	53,800
Kentucky	1,388,046	19,065	13,286	18,153	52,418
Louisiana	1,639,394	31,671	20,861	31,931	64,108
Maine	459,522	6,817	4,330	6,389	22,647
Maryland	1,946,612	68,044	35,482	59,414	66,051
Massachusetts	2,674,275	78,298	51,510	64,850	126,207
Michigan	3,750,732	88,320	63,867	68,913	199,908
Minnesota	1,885,521	36,064	22,509	43,592	71,784
Mississippi	937,206	13,180	8,129	13,137	39,550
Missouri	2,103,907	38,579	25,860	37,658	85,255
Montana	328,316	5,352	2,452	5,032	8,038
Nebraska	716,633	8,923	4,822	10,733	26,460
Nevada	398,566	6,167	3,183	7,540	8,930
New Hampshire	432,622	12,200	8,604	11,026	24,929
New Jersey	3,288,302	92,222	55,846	75,223	143,743

Table A-2
Technological Workers as a Percentage of Total Employment, 1980

State	Engineers and Natural Scientists	Engineers	Technicians and Technologists	Precision Production Occupations
Alabama	1.769	1.173	1.651	4.481
Alaska	3.152	1.421	3.519	2.295
Arkansas	1.105	.701	1.187	4.426
Arizona	2.441	1.545	2.488	3.595
California	2.936	2.003	2.453	4.415
Colorado	3.233	1.820	2.862	3.539
Connecticut	3.191	2.147	2.321	5.516
Delaware	3.064	1.892	3.319	3.921
Florida	1.705	1.097	1.968	3.240
Georgia	1.539	.920	1.834	3.988
Hawaii	1.760	.961	2.070	2.647
Idaho	2.209	1.258	1.864	2.969
Illinois	2.065	1.355	1.917	4.690
Indiana	1.772	1.264	1.687	5.302
Iowa	1.345	.895	1.432	4.201
Kansas	1.844	1.243	1.756	4.987
Kentucky	1.373	.957	1.307	3.776
Louisiana	1.931	1.272	1.947	3.910
Maine	1.483	.942	1.390	4.928
Maryland	3.495	1.822	3.052	3.393
Massachusetts	2.927	1.926	2.424	4.719
Michigan	2.354	1.702	1.837	5.329
Minnesota	1.912	1.193	2.311	3.807
Mississippi	1.406	.867	1.401	4.219
Missouri	1.833	1.229	1.789	4.052
Montana	1.630	.746	1.532	2.448
Nebraska	1.245	.672	1.497	3.692
Nevada	1.547	.798	1.891	2.240
New Hampshire	2.820	1.988	2.548	5.762

Table A-2 (continued)
Technological Workers as a Percentage of Total Employment, 1980

State	Engineers and Natural Scientists	Engineers	Technicians and Technologists	Precision Production Occupations
New Jersey	2.804	1.698	2.287	4.371
New Mexico	2.969	1.576	3.009	3.194
New York	2.064	1.257	1.939	4.096
North Carolina	1.366	.855	1.636	4.811
North Dakota	1.179	.599	1.482	2.329
Ohio	2.148	1.526	1.889	5.301
Oklahoma	1.898	1.135	1.923	4.252
Oregon	1.952	1.102	1.882	3.819
Pennsylvania	2.050	1.371	1.993	4.953
Rhode Island	1.691	1.123	1.656	6.413
South Carolina	1.458	.950	1.911	4.684
South Dakota	.909	.512	1.100	3.032
Tennessee	1.699	1.119	1.842	4.568
Texas	2.341	1.520	2.264	4.437
Utah	2.356	1.437	2.622	3.988
Vermont	2.365	1.681	2.063	4.290
Virginia	2.716	1.415	2.543	3.588
Washington	3.242	2.185	2.371	4.320
West Virginia	1.503	1.040	1.577	3.942
Wisconsin	1.575	1.043	1.777	4.784
Wyoming	2.458	1.339	2.031	2.780

Table A-1 (continued)
Employment of Technological Workers, 1980

State	Employed Persons (16 & over non-agri.)	Engineers and Natural Scientists	Engineers	Technicians and Technologists	Precision Production Occupations
New Mexico	508,238	15,090	8,011	15,293	16,238
New York	7,440,768	153,621	93,602	144,310	304,822
North Carolina	2,607,925	35,632	22,310	42,691	125,488
North Dakota	272,620	3,216	1,633	4,041	6,351
Ohio	4,558,442	97,929	69,584	86,133	241,656
Oklahoma	1,287,857	24,448	14,630	24,771	45,772
Oregon	1,138,425	22,231	12,553	21,429	43,479
Pennsylvania	4,961,501	101,734	68,046	98,910	245,779
Rhode Island	426,812	7,219	4,795	7,070	27,373
South Carolina	1,319,970	19,250	12,547	25,225	61,835
South Dakota	296,679	2,698	1,519	3,265	8,996
Tennessee	1,914,920	32,538	21,447	35,284	87,487
Texas	6,311,845	147,818	95,967	142,950	280,090
Utah	585,921	13,810	8,425	15,366	23,370
Vermont	227,195	5,374	3,821	4,689	9,748
Virginia	2,348,401	63,785	33,239	59,730	84,267
Washington	1,794,354	58,183	39,219	42,547	77,524
West Virginia	689,461	10,366	7,177	10,877	27,182
Wisconsin	2,114,473	33,313	22,070	37,581	11,176
Wyoming	217,374	5,345	2,912	4,416	6,044

Source: U.S. Department of Commerce, Bureau of the Census

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economic development goals associated with the CIT's formation and no established evaluation procedure for determining its impact.

If the problem of geographical remoteness from potential sponsors of research can be overcome, CIT will probably fulfill its primary purpose of assisting industrial recruitment and retention in Virginia. This impact will most likely be confined to Northern Virginia because of its attractiveness to technology-based industry as compared to the areas in which the universities are located, and this is the principal weakness of the concept. Small business interaction and new firm creation beyond the incubator facilities planned initially at the headquarters and, later, on the university campuses, as well as significant involvement with the federal research and development installations in the state are important challenges facing the CIT and will require attention. The chief advantage of the CIT concept over approaches used in some other states is that it provides a means to collect and focus university strengths in several generic technology areas.

Update and Comments

Although Virginia's manufacturing employment increased by 6.8 percent from 1976 -1981 versus a national rate of 6.9 percent, this relationship is not upheld when other time periods are used. According to the Virginia Department of Economic Development, Virginia has traditionally outpaced the national average. From 1970-1984 Virginia's manufacturing employment increased 14.8 percent compared to a U.S. figure of .2 percent.

In addition, while the State of Virginia ranks twenty-sixth in terms of high technology employment as a fraction of total non-agricultural employment, the Northern Virginia area was ranked by Forbes magazine in June 1984 as having the third largest concentration of high technology companies and plants in the nation behind Silicon Valley, California, and Route 128, Boston.

PROGRAM ASSESSMENT
VIRGINIA

Virginia's ranking ranges from sixteenth to twenty-fourth in the number of workers employed in high-technology industry, depending on the definition of these industries used. It ranks twenty-sixth when high-technology employment as a fraction of total non-agricultural employment is calculated. It ranks seventh in the amount of federal research and development expenditures, with about half of this amount attributed to the federal laboratories in the state. University research as a fraction of personal income is below the national average. Virginia is only moderately industrialized with 15 percent of its workers employed in manufacturing. Manufacturing employment increased 6.8 percent during the 1976-81 base reference period, very close to the national average of 6.9 percent.

In 1984, as a result of a gubernatorial initiative, Virginia formed the Center for Innovative Technology (CIT), a non-profit, non-stock corporation which is primarily concerned with organizing on-campus research programs between Virginia's universities and industry. The CIT Board of Directors is appointed by the governor, and its real property is held by a new state authority with the power to issue tax-exempt bonds.

The research mission of the CIT is to enhance the research capabilities of Virginia's research universities and to stimulate these capabilities to be relevant to the technical needs of private industry. As such, it essentially follows the technology center model of state program initiatives. The center also seeks to market the research capabilities of the state's universities to foster increased industry participation in university research. Initially, the CIT will focus on research in biotechnology, computer-aided engineering, information technology and material sciences. The primary institutions involved are the University of Virginia (UVA), Virginia Polytechnic Institute and State University (VPI& SU), Virginia Commonwealth University (VCU), George Mason University (GMU), and the College of William and Mary. The CIT will have as its secondary missions assisting the development of emerging technology-based firms and meeting the part-time graduate education needs of industry.

Technology Center claims that, based on its projections, the projects supported during the 1983-84 year will in four years create eighty companies, create 5,600 jobs, and save 2,200 jobs. It is difficult to assess the validity of these kinds of claims; moreover, it is not in the short-term self-interest of the Center to provide conservative estimates. In fact, the casual connection between a job or firm created or saved and the existence of a Center's programs is often impossible to determine with any degree of certainty. However, even if the estimates are somewhat inflated, they remain impressive. Funding allocations between the four Centers are not equal, and some have suggested that they would be even less equal if there was not some unacknowledged attempt at regional balance.

The Advanced Technology Centers exploit the existing strengths of the state's universities for applied research in the various emphasized technology areas by stimulating interaction with the private sector. The research universities associated with each Center are already among the nation's leaders in key technologies. At least one (Carnegie-Mellon) and possibly others have a world class reputation for basic research in technological areas that are readily exploitable. To enhance the capabilities of its research universities, Pennsylvania has established technology centers of excellence, supported through identified private sector/university projects within each center of excellence. The program differs from the applied research project grant programs in other states not only in scale but, in most cases, in the degree of emphasis on applied research directly leading to jobs. Pennsylvania's approach is both near- and long-term and geared to accountability and the bottom line. Overall, the Ben Franklin Partnership Advanced Technology Centers program has what seems to be the proper scope, objectives, and organizational implementation for a state with an established technological infrastructure, strong universities, and a diversified, but declining industrial base. The funding level is large enough to have a significant impact on economic development. The Pennsylvania program rightly serves as a model for imitation by states with similar characteristics. As long as basic research in the state's universities retains its vitality, there is no reason to be concerned over its near-term focus.

PROGRAM ASSESSMENT
PENNSYLVANIA

Pennsylvania ranks eighth in employment in high-technology industry under the stringent, Group II definition and seventh under the Group I and III definitions. Due to the diluting effect of its relatively large population, it sinks to twenty-first for Group I, twentieth for Group II, and twenty-second for Group III when employment as a fraction of total non-agricultural employment is considered. Pennsylvania ranks fourth in industrial research and development and eighth in total federal research and development spending (about half of the industrial amount). Its university research and development spending as a fraction of personal income is close to the national average. Manufacturing, which accounts for about 22 percent of total employment in this highly industrialized state, declined almost 3 percent during the 1976-81 base reference period. The declining industrial economy of the Western Pennsylvania/Pittsburgh area was one of the mid-American regional economies studied by SRI for Ameritrust (SRI 1984a).

The major thrust of Pennsylvania's technology-based economic development strategy is provided by the Ben Franklin Partnership Advanced Technology Initiatives Program begun in March 1983. The Partnership is managed by the 15-member Ben Franklin Board, which includes private sector, small business, education, labor, and legislative representation. The Board approves all grants made under the programs.

The largest of the Ben Franklin programs is the Challenge Grants/Advanced Technology Centers program. Four regional centers have been established under this program, representing consortia of research universities and other higher education institutions, and private sector, labor, and economic development groups. Each Center administers a number of joint research and development project efforts. Matching of state funds on a one-to-one basis from non-state sources is required. The Centers are:

- o Northeast Tier Advanced Technology Center - based at Lehigh University;
- o Advanced Technology Center of South Eastern Pennsylvania - based at the University Science Center, which includes the University of Pennsylvania, Drexel University and Temple University;

If targeted money alone will accomplish it, the handsome level of funding for the ATACs will elevate those participating institutions, which already have a credible level of activity, into international prominence for targeted technology. The real question is whether funds targeted to specific areas can generate the overall institutional prestige to attract the personnel to achieve world class status in the specific areas. To give some idea of the likely impact of funding levels on the order of $10 million per center, the Ohio Welding Research and Development Institute ATAC can be used as a benchmark. The Institute is an outgrowth of its predecessor, the Center for Welding Research which was founded in 1980 with an NSF grant from the University-Industry Cooperative Research Centers program. The Center for Welding Research had some success, but its funding level was quite modest compared to its ATAC successor. The original Center had first-year NSF funding of $265,000 and industrial contributions (from membership fees) of $330,000, less than one-tenth of the present center's two-year budget. The funding of individual ATACs averaged more than three times the funding for New York's individual Centers for Advanced Technology, which they closely resemble.

The other major Edison research and development initiative, the IRFP program, consists of two programs. One is a program of university/industry directed basic or applied research grants with a $50,000 ceiling. The remaining program is a seed capital program of "advanced applied research" which leans toward the "D" in research and development. Both programs require at least a 1:1 match from industrial sponsors that are Ohio firms. The potential resource pool for these programs is close to $18 million for the 1983-85 biennium. As of December 1984, $1.4 million in state funds had been committed to grants with industrial matching fund commitments of $2.6 million.

Ohio's program is too new to meaningfully evaluate in terms of the output measures that Pennsylvania uses, but the state and matching funds committed are encouraging. Ohio has elected to strike a balance between technology centers, applied research project grants and technology transfer activities. A technology research center approach on the scale of Ohio's can strengthen the universities, but there may be danger in placing excessive emphasis on it in a state with a declining industrial base. There is an immediate need in Ohio to create and retain jobs through applied research and to train workers for them. The tangible benefits in terms of products in the marketplace and job creation from the Edison ATACs are likely to be mid- to long-term, even though

PROGRAM ASSESSMENT
OHIO

Ohio is ranked eleventh in high-technology industry under the strict Group II definition. Its ranking increases to fourth and eighth for the Group I and Group III definitions, respectively. In terms of fraction of non-agricultural workers employed in these industries, Ohio drops to twenty-ninth using the Group I definition and to tenth and twenty-first using the Group I and III definitions. The lower ranking in these relative terms is due to the diluting effect of a large population. The fraction of workers employed in manufacturing industries is almost 24 percent, and during the 1976-81 base reference period Ohio suffered a 4.8 percent decline in such employment, second only to Michigan and Illinois among industrialized states. Ohio can be considered almost a classic example of an industrial state with a declining traditional industrial base. Its economy is profiled in the SRI Ameritrust report (SRI 1984a). Ohio ranks eleventh in federal research and development expenditures. Industrial research and development is about one and one-half times federal research and development. University research and development as a fraction of state personal income is less than the national average.

Ohio's economy is similar to that of its neighbor, Pennsylvania, although Ohio's decline is somewhat more severe. In 1983, Ohio initiated a program dubbed the "Thomas Alva Edison Partnership Program" that at first glance seems imitative of Pennsylvania's Ben Franklin Partnership Program. In fact, although there are similarities, there is little imitation beyond use of a famous name. The major component of Ohio's program, the Advanced Technology Application Centers (ATACs), shares more in common with New York's Centers for Advanced Technology than with Pennsylvania's Advanced Technology Centers.

The Edison program operates through the Ohio Department of Development and has an advisory board appointed by the governor. The program is comprised of three separate initiatives. In addition to the ATACs, there is an Innovative Research Financing Program (IRFP) and a Search for Innovative Technology Program (Search). The ATACs and IRFP programs are research and development programs while the Search program is a technology brokering/transfer activity. Total funding for the Edison Program for its first biennium of operation, ending in June 1985, is $32.4 million.

In addition to MCNC and the Biotechnology Center, which both could be classified as variants of the technology research center generic program type, North Carolina has a host of other programs related to technology-based economic development. One other noteworthy effort is the North Carolina Technological Development Authority which seeks to create new jobs by stimulating the development of new and existing small businesses through seed capital and incubator facilities. There is, in North Carolina, no program which could accurately be described as an applied research project grant program, although such applied research could, in principle, be carried out under the auspices of any of the aforementioned programs. It would seem that establishing a program with this dedicated thrust could prove to be a valuable addition to the present efforts, especially if the technology transfer aspects were emphasized.

Theoretically, the overall coordination of the existing programs from an economic development strategy viewpoint is masterminded by the North Carolina Board of Science and Technology, but in reality, this body does not seem to have the resources or authority to assume full command. Hence, the implementation of an optimal grand strategy based on concepts of maximizing return on investment with fixed resources has not been given serious attention.

The MCNC and the Biotechnology Center programs are too new to meaningfully evaluate their impact in terms of tangible benefits to the state. However, the list of firms recently attracted to North Carolina includes several with potentially close ties to the two centers' research programs. During 1983, high-technology relocations yielded 1,800 new jobs. It is obvious that the glamour and prestige associated with the launching of an enterprise of the magnitude of MCNC will attract at least a few firms. The ultimate success of MCNC and the Biotechnology Center hinges on their university research relationships. The states research universities enjoy excellent reputations in selected areas of science and technology. A few are perhaps on the threshold of being considered "world class," but some knowledgeable persons have expressed reservations about the likelihood of technological breakthroughs (as opposed to incremental improvements) leading to significant spin-off activity from either the university research efforts or those of MCNC. If these opinions are correct, then huge investments in state-sponsored research, particularly in microelectronics, could be regarded as an activity whose most useful purpose is to bolster recruitment efforts. This raises some questions

PROGRAM ASSESSMENT
NORTH CAROLINA

Research Triangle Park (RTP) in North Carolina has received considerable attention for its increasing concentration of technology-based industry and research and development laboratories. In spite of the concentration of technology in the Research Triangle Park area, the state as a whole has yet to approach the level of technology-related industry in the more established technology areas. North Carolina's ranking in absolute level of high-technology employment ranges from fourteenth to sixteenth depending on the definition of "high technology" used. When compared to other states based on the fraction of employment in technology-based industry, its ranking ranges from nineteenth to thirty-first. Federal research and development expenditures in this tenth most populous state are twenty-fourth in the nation; university research and development expenditures are one-sixth of those in California (although approximately the same as California when compared relative to personal income) but one-half of the relative amount in Massachusetts. North Carolina's percentage of workers employed in manufacturing is 28 percent, the highest in the nation. Manufacturing employment increased almost 9 percent during the 1976-1981 base reference period, somewhat above the national average of 7 percent. It is commonly acknowledged, however, that the textile industry, which remains the largest single source of manufacturing employment in the state, is in decline.

North Carolina's strategy for technology-based economic development and for increasing the research and development portion of the technological infrastructure needed to make it possible is one of the most ambitious of any state. The motivation behind this effort has however, been questioned, and these questions have been raised in at least one formal article (Luger 1984). The basis for this criticism is that in spite of the fact that North Carolina's stated development goals involve a balanced strategy of industrial recruitment, retention, expansion and stabilization, and of new firm creation, industrial recruitment is seemingly the most heavily emphasized. It is further alleged (Luger 1984) that recruitment is the only area in which there has been much success, and that this has resulted in an overdependence on branch plant relocation. The rate of growth from this source has begun to slow, and the cost effectiveness of this strategy is now questionable. In addition, there are concerns about long-term stability, regional disparities and manpower shortages.

The CAT's might also be criticized for the lack of inter-institutional linkages between research universities. Only one Center emphasizes this kind of research cooperation as an important element of its program. Only limited attention has been given to spin-off type technology transfer activities, a sharp contrast to the activities at Rensselaer Polytechnic Institute, also in New York State. At Rensselaer, the state is participating in the support of a Center for Industrial Innovation.

The Research and Development Grants Program has funded twenty-one projects in the $20,000 to $50,000 range. These projects were selected from seventy-four full proposals after a preliminary submission of 450 pre-proposals. During the most recent grant period, eight of the nine projects funded had an industrial match. Of the twelve projects funded in the previous period, three have been commercialized and six others show promise. The program attempts to refer unsuccessful applicants to industrial funding sources. There are no available statistics of the program's impact on job creation. This program is more closely tied to near-term economic development objectives than the CAT program, and as such, it is more directly comparable to the Ben Franklin Partnership Challenge Grant program in Pennsylvania which channels joint university/industry applied research and development through regional "Advanced Technology Centers." Compared to Pennsylvania, New York's Research and Development Grants program appears smaller than desirable to achieve significant economic impact especially since New York, like Pennsylvania, has seen a decline in manufacturing employment.

PROGRAM ASSESSMENT
NEW YORK

New York ranks second in high-technology employment under the Group II and Group III definitions and third under the Group I definition. However, its ranking ranges from fifteenth to twenty-fifth when high-technology employment relative to total non-agricultural employment is considered. It is fifth in federal research and development expenditures, third in industry-funded research and development (about twice the federal expenditures) and second in university research and development. These rankings drop severely when considered as a fraction of personal income. Therefore, New York's relatively high ranking in absolute statistics is primarily due to its large population base. Manufacturing, which employs 18 percent of its workers, declined slightly in employment levels during the 1976-81 base reference period. It would appear that the state has a large technological infrastructure which is diluted by its large population and that its traditional industrial base is declining. An optimal, research and development-based, technological innovation development strategy should take these factors into consideration.

State research and development-related programs in New York State include the Centers for Advanced Technology Program (CAT), a program for support of cooperative research and development centers formed by a partnership among universities, private industry, and government, and the Research and Development Grants program, a program for support of university and not-for-profit organization applied research projects with commercialization potential conducted in cooperation with industry. These programs are essentially a technology research center program and an applied research grant type program, respectively. Both are administered by the New York State Science and Technology Foundation. A seed capital financing program is also administered by the Foundation.

The Centers for Advanced Technology program is the recipient of by far the largest share of the funding, a total of $9.5 million through fiscal year 1984. Seven CAT grants were awarded to public and private universities in the state on the basis of an RFP solicitation to develop a center in one of seven targeted technology areas. The CATs, all of which were placed in operation by February 1984, are as follows:

In addition to these independent programs, Johns Hopkins has established a Center for Advanced Studies at the Shady Grove Life Sciences Center. The center is designed primarily to serve the graduate, postgraduate, and professional educational needs of Montgomery County's high-technology population. Educational offerings at the Center will include masters degree programs, and credit and non-credit courses, programs, seminars, and colloquia in areas such as health policy, materials sciences, and engineering, molecular genetics, occupational stress, environmental engineering, communications technology, and toxicology.

CARB was formed by the University in partnership with the National Bureau of Standards (NBS) and Montgomery County. It is located along the I-270 corridor where many of the county's 100 major biotech research and development facilities are located, the highest concentration of such facilities in the nation. The CARB will be located on a site donated by the county in the corridor's Shady Grove Life Science Center. The new center will combine the unique technical resources of NBS and UMd to meet corporate needs in biotechnology, biomolecular engineering, analytical chemistry and other related fields. Participation from industrial firms, as well as other universities and organizations, will be encouraged. CARB will involve all of the University's campuses and NBS in an attempt to develop a world-class center for the determination and analysis of macromolecules. CARB as a technology center will complement and be a sister organization to the University's three campus technology centers organized as the Maryland Biotechnology Institute and will be located at the College Park, Baltimore, and Baltimore County campuses.

The University has committed its internal resources to the CARB projects and has received a commitment of state funding at an initial level of $4.5 million per year (primarily for staff) for all four Centers. CARB will be administered under the aegis of a board appointed by NBS and UMd and will include one or more representatives from business and county government. CARB will be staffed by permanent scientific professionals, UMd personnel with joint appointments, and NBS employees. Many of the details concerning CARB's implementation have yet to be resolved. CARB, like the other Centers, will be administratively distinct from the University academic units permitting "arm's length" arrangements. Construction of a building planned to house state-of-the-art research equipment and facilities and an incubator will begin in 1985. The building will be financed by a bond issue; CARB will lease and eventually purchase it.

The University of Maryland is not currently ranked among the nation's top fifty universities in terms of research and development expenditures in areas related to biotechnology, although it has attained prominence in certain specialized areas. In the past, there has not been a strong entrepreneurial culture at the University, and there has been negligible spin-off activity. The unique partnership of CARB and the establishment of the campus Centers can, together with strong state and industrial support, permit the

PROGRAM ASSESSMENT
MARYLAND

Maryland's rankings in level of high-technology employment range from nineteenth to twenty-second, depending upon which "Group" definition of high-technology employment is applied. Considering high-technology employment as a percentage of total non-agricultural employment has a slight negative impact on Maryland's rankings. In these relative terms, the state ranks from eighteenth to thirtieth. Federal research and development expenditures in Maryland are the second highest in the nation. This is primarily because of the federal research and development laboratories located there. Maryland is tied with Massachusetts for first place in university research and development as a fraction of personal income. The state's economy is not heavily industrialized; only 12 percent of Maryland workers are employed in the manufacturing sector. Manufacturing employment declined moderately during the 1976-81 base reference period.

Maryland's research and development programs with significant economic development implications are centered around the University of Maryland (UMd). These programs are the Engineering Research Center (ERC) and the Maryland Biotechnology Institute (MBI) of which the Center for Advanced Research in Biotechnology or CARB is the centerpiece. ERC is administered through the UMd College of Engineering; MBI and CARB are separate administrative units. These programs are all fairly new; ERC and MBI were established in 1983 and CARB was announced in early 1984. The University is also involved in the development of a new research park near its suburban Washington, D.C., College Park main campus. Due to the newness of these programs, it is difficult to evaluate anything but their potential contribution to economic development. The research park, however, has recently attracted a major new federally funded computer research activity, and was seriously considered although not chosen for a significant software research center, which was subsequently awarded to Carnegie-Mellon University in Pennsylvania. The focus of the present assessment is on ERC and CARB because they are novel in concept and may have some features worthy of replication in other states.

Update and Comments

The matching requirement for the research matching grant program was changed from 150 percent to 100 percent in 1984-1985.

PROGRAM ASSESSMENT

KANSAS

Kansas ranks eighteenth among the states in high-technology employment using the stringent Group II definition. However, using the same definition, its ranking increases to ninth in high-technology employment as a fraction of total non-agricultural employment. Manufacturing employment in Kansas increased almost 14 percent during the five-year base reference period ending in 1981. Kansas ranks sixteenth in the percentage of workers employed in manufacturing. In federal research and development expenditures (mostly from defense) as a fraction of personal income it ranks eighth, but its university research expenditures relative to personal income are well below the national average.

Based on the above economic profile, the optimum high-technology development strategy for Kansas would appear to be a vigorous one, emphasizing strengthening of university research and development and attempting to exploit the infrastructure created by the federal research and development. Kansas has put into place a technology-based economic development program, but it may not be taking full advantage of the potential offered by the state's resources.

The Kansas technology-based economic development programs are the Centers of Excellence Program and the Research Matching Grant program. The names convey their obvious relationships to the generic program types described in this report. Both programs were begun in 1983 and are administered by the Kansas Advanced Technology Commission. They are viewed as investments in university/industry research which will yield a dividend of several hundred new jobs within the first two to three years. It is planned that the jobs will be primarily in the areas of agricultural machinery, aviation, electronics, pharmaceuticals, robotics, telecommunications, and oil recovery. These jobs will, according to development officials, be created through industrial expansion, relocation, and new firm creation. The Centers of Excellence will, in concept, have an impact on existing industry through the application of new technologies; other projects will expand the demand for Kansas produced goods.

excellent reputations of institutions like Purdue and the presence of established university technology centers, the creation of additional technology centers might be considered. The absence of significant federal research and development investment makes this even more important as a source of basic research in new technologies.

Update and Comments

Funding for the corporation reached $40 million in 1985.

As regards efforts to evaluate performance, the corporation is actively monitoring each of its projects to assure that adequate resources are being devoted to research and development and the transition of the output products, processes, and services to the marketplace. This monitoring also includes a comprehensive analysis of the impact of 1) the leveraging of state funds with private funds and 2) the number of jobs created within the state.

Early figures gathered in this monitoring effort reveal that present planning by the principal investigators of the funded projects to date exhibits a leveraging ratio of CST funds to other fund expenditures in excess of 20-1 during the next three to five years. Although specific external/internal fund matching ratios are not mandated in this program, every effort is made to achieve a proper balance in each program at the earliest possible time, and experience to date indicates that this has been effective.

PROGRAM ASSESSMENT
INDIANA

Indiana's ranking in the number of workers employed in high-technology industry ranges from eleventh to thirteenth according to the various high-technology group definitions adopted in this report. Its moderately high ranking does not drastically change when considered on the basis of the high-technology fraction of total non-agricultural employment; these relative rankings range from sixth to fourteenth. Federal research and development expenditures in Indiana are twenty-fourth in the nation; industrial expenditures are somewhat larger than average and are approximately five times federal research and development expenditures. University research and development as a fraction of personal income is slightly below the national average. Indiana is highly industrialized with approximately 25 percent of its workers employed in manufacturing, the fifth highest percentage total in the nation. However, manufacturing employment declined almost 5 percent during the 1976-81 base reference period. Indiana was one of the midwestern states studied by SRI for the Ameritrust Corporation (SRI 1984), and some further insights into its economy can be found in their report.

Indiana's program to promote economic development through technological innovation is conducted under the auspices of the Corporation for Science and Technology (CST), a private, not-for-profit corporation. CST was formed in 1983 to strengthen Indiana's economy through the promotion of research and development ventures involving technology transfer from research and development labs into commercially viable products, processes, or services. It was established to identify scientific and technological problems and opportunities, and to fund proposals addressing them. Funding emphasis is given to applied projects rather than to basic research. The corporation provides grants, enters into contracts, and engages in joint ventures, surveys, seminars, workshops, and other activities. The corporation's professional staff is supplemented by several advisory committees for targeted technologies. These targeted technologies are:

- o Advanced Materials;
- o Artifical Intelligence;
- o Agricultural Genetics and Technology;
- o Automated Manufacturing;

PROGRAM ASSESSMENT
CALIFORNIA

California is the nation's high-tech leader. It ranks first in total employment in high-technology industry under all three high-tech definitions. On the basis of percentage of non-agricultural employment in each of these three groups of industries, its rankings are all among the top ten. It is first in federal research and development expenditures, federal laboratory research and development expenditures, total research and development expenditures and university research and development expenditures. It is second in industrial research and development expenditures. Manufacturing employment increased almost 32 percent during the 1976-81 reference period to a moderately high 17 percent of all workers.

The primary state research and development program in California is the MICRO program of applied research project grants, established in 1981. The program provides state matching funds for industry support of University of California (UC) projects in microelectronics and related technologies "that will be at the cutting edge of technology and may lead to products several years in the future." Fellowships for graduate students are also available in addition to student research support budgeted in the projects. The MICRO program has a policy advisory board which includes representation from industry, state government, and the University. An executive committee with representatives from five of the UC campuses administers the program.

During the 1983-84 year, approximately $4.2 million in state funds attracted $6.8 million in industrial funding, a positive outcome. The aims of the program in terms of economic development objectives are long term; immediate job creation has not been an issue and no statistics relating to the impact of this relatively new program on jobs is available. The success stories from the university side tend to relate to establishment of closer ties with industry, improved facilities, and better training of students. This program probably fits most easily into the applied research project grant program category, but the research goals and time frame approach those of basic research; the projects tend to be oriented in that direction.

Update and Comments

Cumulative funding for the Engineering Excellence Center reached $54 million in 1984-85, with $27.8 million in state appropriations, $18.4 million in industry contributions, and $7.8 million in other contributions. Externally funded research in the ASU College of Engineering thus increased ten-fold during the first five years. It reached more than $10 million in awards during 1984-1985.

PROGRAM ASSESSMENT
ARIZONA

Arizona ranks twelfth in employment in high-technology industry under the Group II strict definition of these industries. It drops to twenty-fourth when the definition is more liberal, encompassing industries with a high proportion of scientific and technical workers (as opposed to high research and development expenditures). When based on the percentage of non-agricultural workers employed in these fields, its ranking rises to third under the strict definition and eighteenth under the liberal definition. Arizona's high-technology growth rate as a percentage of total employment growth under the strict definition is the nation's fourth most rapid. The percentage increase in manufacturing employment for the 1976-81 base reference period is 52 percent, highest in the nation, although the percentage of workers employed in manufacturing is still fairly low at 13 percent. Arizona ranks twenty-fourth among the states in federal research and development expenditures but its university research and development expenditures as a percentage of personal income is well above the national average. Clearly, Arizona is an emerging high-technology state.

Arizona was one of the first states to put into place a research and development-based high-technology economic development plan. Its five-year plan was to create a Center for Engineering Excellence at Arizona State University (ASU) in Tempe, Arizona, outside of Phoenix. The plan called for a total of $32 million to be invested over a five-year period. The program, as it was originally planned, required approximately $19.5 million from state appropriation (primarily for buildings), $8.5 million from private sources, and $3 million from federally-sponsored research programs. The purpose of the center was to assist ASU in achieving national leadership in solid-state electronics, computers and computer science, and computer-aided processes. National prominence was sought in energy systems, transportation systems, and thermosciences. This can best be described as a plan to create technology centers for basic research in several areas.

Actual funding for the center through the first four years of the program totaled $38 million. Private funds in excess of $15 million exceeded the original goal of $8.5 million. Externally funded research in the ASU College of Engineering increased five-

industrial sponsors or of interest to a federal government sponsor. As a result, this kind of research is generally further from commercialization and its accompanying economic impact than research in an applied research project grant program where the sponsors tend to be a single firm. Hence, the chief advantage of establishing a technology research center is to create a reservoir of basic technological knowledge and human expertise that will be needed for future industrial vitality. This translates into the notion that this type of program is perhaps most effective as an instrument for promotion of state strategies based on recruitment and retention of research and development-oriented industry and on new firm formation through university spin-off. Establishment of such programs as centers of excellence would be particularly important for states without exceptionally strong universities. Technology research centers can also play an important role in industrial stabilization where a single technology is crucial to declining industry in the state.

The applied research project grant program is generally a program of matching grants for research conducted at universities with industrial support. In some states, small businesses are also eligible to receive the grants. The programs usually require some demonstrable potential for commercialization as a prerequisite for funding. The research and development typically supported ranges from basic research to development, with most of it falling into the applied research portion of the spectrum. Since these grants are frequently linked to matching sponsorship by a single firm, there is often a more direct path to ultimate commercialization than through technology research centers where several firms may be involved. Applied research matching grants are likely to have an immediate impact on expansion and stabilization of existing industry, including small technology-based firms. These programs should seemingly receive the most near-term emphasis for areas of rapid industrial decline where they can begin to create jobs almost immediately.

University technology research center programs and applied research project grant programs each have unique roles to play as components of state research and development-based economic development strategies. For most states, the optimal strategy will include both types of programs and they should be viewed as complementary initiatives. The effectiveness of state sponsorship of research using either of these models ultimately depends on the efficiency of its ultimate

Table 7 (continued)

Recent State Research Program Initiatives --
Cumulative Funding Commitments through Fiscal 1984

STATE	FUNDING (millions)	RESEARCH PROJECT GRANT	TECHNOLOGY RESEARCH CENTER	OTHER
New Hampshire	--			
New Jersey	*		X	
New Mexico	20.0		X	
New York	2.9	X	X	
North Carolina	48.2		X	
North Dakota	--			
Ohio	32.4	X	X	
Oklahoma	*			
Oregon	--			
Pennsylvania	11.0	X		
Rhode Island	1.5	X	X	
South Carolina	*			
South Dakota	--			
Tennessee	3.5			X
Texas	32.0 (from State University trust)			X
Utah	--			
Vermont	--			
Virginia	30.3		X	
Washington	1.6	X	X	
West Virginia	1.0			X
Wisconsin	2.0	X		
Wyoming	--			
Total U.S.	369.6			

*Proposed

Table 6
Manufacturing Employment

STATE	% CHANGE IN MANUFACTURING EMPLMT 1976-81	% OF WKRS EMPLOYED IN MANUFACTURING, 1984
Nevada	54.6	4.4
Arizona	52.1	12.8
Florida	33.4	10.6
Texas	29.3	13.0
Colorado	28.8	11.4
Oklahoma	28.2	11.8
Utah	26.7	14.3
Vermont	25.1	19.3
New Hampshire	23.4	24.1
Washington	22.6	15.2
California	22.5	17.1
Alaska	20.8	0.6
Wyoming	17.9	3.2
South Dakota	16.7	8.4
Louisiana	13.6	20.5
Kansas	13.2	15.4
Minnesota	13.2	17.1
New Mexico	13.2	6.2
Massachusetts	12.8	21.9
Maine	10.7	20.5
Connecticut	10.6	25.9
Georgia	10.1	20.3
North Carolina	8.5	28.3
Nebraska	8.0	4.4
Arkansas	7.5	21.7
Virginia	6.8	15.1
Alabama	6.4	22.1
South Carolina	5.1	26.4
Oregon	4.6	11.8
Tennessee	4.6	24.5

funded research and development expenditures in the universities may be a better indicator of actual relevant research and are available from the National Science Foundation (NSF) (NSF 1984). An even better indicator of performance as an innovator may be the number of patents granted. The number of patented applications from universities in each state for the period 1963 through 1983 is given in Table 5. Three caveats are necessary regarding Table 5. First, the data appear to be incomplete for some states. Further, the data reflect not only the propensity for invention and the presence of an entrepreneurial culture in a state's universities, but also the institutional patent policies and procedures as well. Finally, legislation passed in 1980 facilitating university ownership of patents resulting from their federal research and development has resulted in a significant increase in the rate of invention disclosure.

Many industrialized states have suffered recent structural declines in manufacturing employment. In addition to encouraging job creation through formation of new high-technology establishments, they seek to retain jobs and stabilize their traditional industries through the infusion of advanced technologies. Some idea of the extent of the problem (or of its converse, industrialization) in each state is given in Table 6. The table contains the state-by-state percentage changes in manufacturing employment during the five-year reference period, 1976-81. This base period was selected because, except for a five-month recessional period during 1981, it is relatively free of cyclical effects. Table 6 also gives the percentage of all workers employed in manufacturing in each state as of June 1984. This statistic is an indication of the importance of manufacturing to the state's economy.

Research and Development Program Design and Development Objectives

The optimal translation of state technology-based development policies into programs should depend on a set of strategic priorities that are uniquely determined by state resources and planning goals. Certain generic program types within the seven basic categories described earlier are rather commonplace. Unfortunately, in some states their raison d'etre as an element of a rational strategy is unclear.

Program initiatives designed specifically to increase the quality and quantity of the human resources for technological innovation through both technical and non-technical

Table 4 (continued)
FY 82 R&D Expenditures as a Percentage of Personal Income

STATE	FEDERAL R&D SUPPORT	INDUSTRY* R&D SUPPORT (EST)	UNIVERSITY PERFORMED R&D	FED. LAB.** PERFORMED R&D	TOTAL*** R&D (EST)
New Hampshire	0.518	--	0.285	0.152	--
New Jersey	0.933	3.119	0.110	0.389	4.094
New Mexico	10.818	0.564	0.605	8.732	11.521
New York	0.799	1.739	0.349	0.190	2.635
North Carolina	0.514	1.035	0.312	0.214	1.635
North Dakota	0.494	--	0.357	0.234	--
Ohio	0.908	1.440	0.181	0.432	2.392
Oklahoma	0.184	0.967	0.198	0.073	1.266
Oregon	0.393	--	0.333	0.122	--
Pennsylvania	0.887	1.834	0.271	0.383	2.787
Rhode Island	2.430	--	0.442	1.777	--
South Carolina	0.371	--	0.180	0.158	--
South Dakota	0.287	--	0.182	0.197	--
Tennessee	1.735	--	0.195	0.717	--
Texas	0.612	--	0.252	0.135	--
Utah	2.138	0.705	0.609	0.371	3.014
Vermont	0.750	--	0.396	0.021	--
Virginia	2.155	0.416	0.180	0.938	2.616
Washington	2.150	--	0.352	0.478	--
West Virginia	0.533	--	0.129	0.316	--
Wisconsin	0.257	1.153	0.376	0.040	1.546
Wyoming	0.402	--	0.241	0.209	--
Total U.S.	1.403	1.472	0.288	0.500	2.975

*Data not available for certain states due to sensitivity of data for proprietary information

**Federal Intramural plus federally funded R&D Centers

***Excludes state and local R&D outside of universities

Table 3 (continued)

FY 82 R&D Expenditures and Personal Income
(billions)

STATE	FEDERAL R&D SUPPORT	INDUSTRY* R&D SUPPORT (EST)	UNIVERSITY PERFORMED R&D	FED. LAB.** PERFORMED R&D	TOTAL*** R&D (EST)	PERSONAL INCOME
New Hampshire	0.051	--	0.028	0.015	--	9.84
New Jersey	0.888	2.967	0.105	0.370	3.895	95.13
New Mexico	1.323	0.069	0.074	1.069	1.409	12.23
New York	1.692	3.686	0.740	0.402	5.585	211.98
North Carolina	0.273	0.550	0.166	0.114	0.869	53.15
North Dakota	0.036	--	0.026	0.017	--	7.28
Ohio	1.025	1.626	0.204	0.489	2.701	112.94
Oklahoma	0.066	0.346	0.071	0.026	0.453	35.79
Oregon	0.106	--	0.090	0.033	--	27.01
Pennsylvania	1.131	2.345	0.345	0.488	3.553	127.49
Rhode Island	0.242	--	0.044	0.177	--	9.96
South Carolina	0.099	--	0.048	0.042	--	26.66
South Dakota	0.019	--	0.012	0.013	--	6.61
Tennessee	0.702	--	0.079	0.290	--	40.46
Texas	1.054	--	0.433	0.233	--	172.09
Utah	0.288	0.095	0.082	0.050	0.406	13.47
Vermont	0.036	--	0.019	0.001	--	4.80
Virginia	1.268	0.245	0.106	0.552	1.540	58.86
Washington	1.039	--	0.170	0.231	--	48.33
West Virginia	0.091	--	0.022	0.054	--	17.07
Wisconsin	0.129	0.579	0.189	0.020	0.776	50.20
Wyoming	0.025	--	0.015	0.013	--	6.22
Total U.S.	35.361	37.091	7.261	12.601	74.963	2520.17

*Data not available for certain states due to sensitivity of data for proprietary information

**Federal Intramural plus federally funded R&D Centers

***Excludes state and local R&D outside of universities

Sources: National Science Foundation, U.S. Department of Commerce

Human resources are an important part of the technological infrastructure of a region and the lack of them may be a major impediment to technology-based development of many localities. Past experience indicates that a cadre of "world-class" scientific and engineering talent (preferably with a university connection) together with a pool of workers with more routine technical skills is essential for the establishment of a high-growth rate regional high-technology center. An adequate base of routine skills is also essential for state strategies involving recruitment of branch plants.

It is difficult to garner any single set of statistics which will be an adequate measure of the human resources of a state. A picture begins to emerge, however, from looking at the geographic distribution by state of a few basic statistics. A state-by-state table of data compiled from the 1980 Census of the numbers and percentages of engineers and natural scientists, technicians and technologists, and precision production workers is included in the Appendix. The demographics are, to a great extent, reflective of the distribution of Group I high-technology industry.

In addition to the human resources required as the raw material for technological innovation, the work product and spin-off ideas of technical personnel employed in research and development are necessary for major innovations to occur. An indirect measure of these technology resources are research and development expenditures by various institutional performers. The nature of the dependence of regional economic growth on research and development expenditures is reviewed by Malecki (1983a). The connection is tenuous, and its causal relationship is elusive, but nevertheless, the phenomenon of growth stimulated by research and development activity is quite real. Table 3 gives state-by-state research and development expenditures by various performers and supporters. Table 4 shows these data as a percentage of state personal income as an alternative to per capita percentages. Personal income is a proxy for gross state product, and percentages based on this output measure should give a good indication of the significance of the level of investment in research and development to states' economies for purposes of interstate comparisons, much as gross national product research and development percentages are used for international comparisons.

Table 1
Employment in Three Groups of High Technology Industries for All States, the District of Columbia, Puerto Rico, and the Virgin Islands, 1981 and 1982 Annual Averages
(States are ranked by 1982 Employment.) (1)

(In thousands)

	GROUP I			GROUP II			GROUP III	
	ANNUAL AVERAGE			ANNUAL AVERAGE			ANNUAL AVERAGE	
	1981	1982		1981	1982		1981	1982
US	12876.5	12413.0	US	2562.5	2555.6	US	5859.9	5736.5
CA	1534.8	1522.9	CA	592.7	609.3	CA	929.1	940.1
TX	1055.6	1039.8	NY	201.8	202.4	NY	491.7	489.3
NY	917.5	905.4	MA	158.3	158.5	TX	375.8	366.8
OH	722.1	660.3	TX	160.5	155.0	NJ	316.9	312.6
IL	716.0	652.7	NJ	113.3	115.4	MA	300.9	299.9
MI	691.4	631.4	FL	102.0	106.3	IL	287.0	269.7
PA	628.6	598.5	CT	99.0	97.0	PA	285.5	269.4
NJ	511.4	506.5	IL	98.4	93.7	OH	258.0	239.5
MA	441.9	435.3	PA	94.6	90.8	CT	182.4	178.5
FL	359.2	362.7	WA	90.5	87.6	FL	164.0	167.6
IN	367.2	336.5	OH	73.5	70.1	IN	169.1	153.2
CT	285.7	276.1	AZ	68.1	68.3	MO	128.3	125.1
MO	274.3	263.2	IN	65.9	61.7	WA	129.3	121.7
NC	265.1	262.3	MO	61.8	59.4	MI	128.4	121.2
WI	283.1	260.8	MN	53.3	54.7	NC	120.6	119.5
MN	233.2	224.4	NC	44.8	44.9	MN	119.5	119.0
VA	222.3	224.3	CO	39.5	42.8	TN	109.3	106.2
TN	233.3	219.3	KS	50.9	40.4	WI	110.9	103.3
GA	212.1	215.5	MD	33.7	36.0	VA	97.7	99.8
LA	219.4	209.2	MI	30.4	28.8	CO	81.4	87.1
WA	213.6	201.1	GA	25.7	27.4	MD	85.9	87.0
MD	191.6	191.0	NH	26.6	26.8	AZ	86.5	86.5
CO	180.5	189.0	PR	25.9	26.3	SC	70.4	70.6
OK	192.6	187.3	OK	23.6	22.3	GA	68.1	70.2
AZ	150.1	144.3	UT	21.1	22.2	LA	66.4	64.3
SC	146.7	144.2	AL	19.9	21.8	KS	76.3	64.3
KY	152.9	139.6	VA	20.2	21.7	PR	54.0	51.9
KS	153.8	138.1	TN	17.9	16.4	AL	49.2	50.2
IA	153.8	134.8	OR	14.5	15.3	OK	45.9	44.8
AL	137.7	134.6	SC	14.0	14.8	NH	44.2	44.1
OR	96.4	89.4	IA	14.0	13.5	KY	48.5	43.4
AR	90.9	85.2	VT	13.2	13.2	OR	42.0	40.8
MS	87.5	83.7	WI	12.1	11.6	DE	38.6	38.4
NH	70.2	72.6	NE	11.5	10.6	IA	36.6	34.3
PR	73.5	69.8	LA	9.7	10.1	UT	32.2	33.5
UT	65.4	66.9	KY	10.7	9.4	AR	34.8	32.3
WV	63.9	61.9	ME	7.8	7.9	WV	28.1	27.4
DE	56.7	55.8	RI	7.8	7.8	MS	28.5	26.3
NE	58.9	55.1	NM	6.7	7.7	NM	19.2	20.6
NM	49.7	51.8	MS	5.9	5.6	NE	21.2	20.2
RI	38.4	36.3	AR	5.4	5.3	VT	19.8	19.9
DC	33.1	31.4	ID	4.4	4.7	RI	17.9	17.4
ID	32.7	31.3	SD	3.5	3.0	ID	13.9	14.1
VT	32.3	31.2	NV	2.7	2.8	ME	13.6	12.9
ME	29.8	29.3	DE	1.8	1.3	NV	10.6	11.1
NV	26.2	26.4	WV	1.3	1.1	SD	6.1	5.8
WY	25.4	25.2	ND	0.6	0.6	DC	3.8	3.4
ND	22.8	23.6	DC	0.3	0.3	WY	2.7	2.5
MT	20.0	20.6	MT	0.3	0.3	MT	2.4	2.3
SD	20.1	18.2	WY	0.2	0.2	HI	2.3	2.1
HI	17.1	16.7	AK	(2)	(2)	VI	2.0	1.9
AK	14.5	16.4	HI	(2)	(2)	ND	1.4	1.3
VI	3.4	2.9	VI	(2)	(2)	AK	0.9	1.1

[1]Source: Bureau of Labor Statistics, U.S. Department of Labor

[2]Employment of less than 100 workers

that are of instrumental importance to the promotion of national economic development, such as education and training, infrastructure provision and maintenance, business management and technical assistance, and export financing. The involvement of state government is especially critical in the stimulation of national economic growth through technological innovation, and the nation's governors have been at the forefront in promoting initiatives designed to encourage technological innovation (NGA 1983).

The previously-mentioned reports by NGA (1983), OTA (1983; 1984a; 1984b) and SRI (1984b) delineate the state role in technological innovation for economic development. The NGA report lists five key functional categories into which state program initiatives fall. Peltz and Weiss (1984) restate these categories in a somewhat more general categorization and give their notion of the type of activities they encompass. Their categories are: policy development, education and training, basic and applied research, technical and management assistance to innovating firms, and financial assistance to innovating firms. OTA (1984b) lists a similar group of functional categories: research, development, and technology transfer; human capital, including education and training; entrepreneurship training and assistance; financial capital; physical capital; and information gathering and dissemination. SRI's (1984b) categories are: advocacy, policymaking and oversight; technical centers, institutions and research consortia; developmental facilities; and direct technical assistance programs.

None of these lists appears adequate for a complete generic description of state initiatives. Both NGA (1983) and Pletz and Weiss (1984) force certain activities into categories in which they do not appear to fit. On the other hand, the OTA (1984b) and SRI (1984b) categories are too broad.

A list that both includes a sufficient number of generic groupings and is specific enough to avoid the generalities of the broader approaches might be:

(1) policy development;
(2) education and training;
(3) research and development;
(4) entrepreneurship training and assistance;
(5) financial assistance to innovating firms;

of similar activity were far more important for new technology-based enterprise development than for branch formation.

In quantitative research findings summarized by OTA (1984b), Glasmeier, et al., identified airport access, a large labor force, high defense spending and major universities to be important influences in high-technology growth of metropolitan areas. A more subjective study by Premus conducted for the U.S. Congressional Joint Economic Committee (1982), using survey interview methodology, highlights additional factors, such as business cost, climate factors, and quality of life as also being important.

NGA (1983) attributes to Robert Ady of the Fantus Corporation a description of different requirements for technology-based businesses at different stages of product development. According to Ady, location criteria are different depending on whether the product is in the theory-driven stage, the product-driven stage, or the market-driven stage. In the initial or theory-driven stage of an embryonic firm with an embryonic product, the necessary ingredients are high-risk venture capital, close contact with university research and other technology-based enterprises, and reasonably priced natural or artificial incubator facilities for feasibility testing and developmental research. In the second stage, where the product is proven viable but is still unique, a supply of trained technicians and skilled workers becomes essential as well as access to research and development facilities, attractive living conditions, and a favorable business climate. Finally, in the market-driven stage, which is characterized by price competition and mass production, traditional industrial location variables such as labor and energy costs, tax exemptions, and other incentives become important.

Malecki (1983) summarizes most of the existing knowledge about high-technology growth in citing regional industrial mix, product cycle mix, university research, infrastructure, capital availability, history of new firm formation, and government research and development and procurement as being the most important ingredients in the generation of new economic activity. He also points out that the location of a firm's research and development activity is most often based on proximity to corporate headquarters and on the locality's attractiveness to research personnel. Therefore, this activity is unlikely to be relocated, particularly to areas lacking in appeal to culturally sophisticated professionals.

The involvement of government in the innovation process has been studied extensively (see Rothwell and Zequeld 1981); however, from a policy standpoint, it is unclear where the various levels of government can most appropriately and effectively intervene in the innovation process to stimulate it. Intervention is possible at any stage in the innovation process and the potential is made clear when the innovation process is described in terms of the product cycle. The process in this context is (Office of Technology Assessment (OTA) 1983): (1) research and development of innovative products and processes; (2) commercial application of innovation and the associated creation of new firms; (3) attraction, expansion, or standardization of production among producers of innovations; and (4) application of new technologies by established users of innovations.

The federal government has supported all phases of research and development in areas related to national defense and aerospace and basic research in all areas. The support for basic research is justifiable on the grounds that the social rate of return is high and that industry tends to underinvest in basic research because of its low financial rate of return and the difficulty in capturing its results for exclusive exploitation by the sponsoring firm. On the other hand, government has traditionally left commercialization of technology and its subsequent adoption to the private sector. The effectiveness of the federal government's traditional strategy is the essence of the discussions involving technology in the national industrial policy debate. A recent report by the Congressional Budget Office (1984) contains an excellent discussion of federal support for research and development.

Technology-Based Regional Economic Development

Many localities have initiated programs to promote technological innovation as an economic development strategy. They perceive that these strategies will lead to some combination of desirable outcomes such as increased employment and job quality or higher personal income levels. Such strategies should be pursued judiciously since they can also have negative economic consequences (Wiewel, et al. 1984).

A number of state and local efforts have been catalogued in a series of reports from OTA (1983; 1984a; 1984b), the National Governors' Association (NGA) (NGA 1983),

COMPONENTS	INVENTION/INNOVATION (PREMARKET)			COMMERCIALIZATION (MARKET)		
ACTIVITIES	IDEA GENERATION	IDEA EVALUATION AND DEVELOPMENT	PRODUCT/PROCESS EVALUATION AND REFINEMENT	NEW VENTURE INITIATION; NEW PRODUCT/PROCESS INTRODUCTION	VENTURE GROWTH; SPIN-OFF OF PRODUCTS AND PROCESSES	BUSINESS AND TECHNOLOGY MATURATION
PRIMARY PARTICIPANTS	CORPORATE, CASUAL, AND PROFESSIONAL INVENTORS	TECHNOLOGICAL INNOVATORS		TECHNOLOGICAL ENTREPRENEURS; ENTREPRENEURIAL MANAGERS; MANAGEMENT TEAM		MANAGERS
OTHER NECESSARY PARTICIPANTS	SOURCE OF CAPITAL FOR RESEARCH AND DEVELOPMENT		SOURCES OF DEVELOPMENT CAPITAL (GENERALLY SMALL AMOUNTS); BUSINESS AND MARKETING PLANNING	VENTURE/RISK CAPITAL SOURCES; LAWYERS; ACCOUNTANTS; MARKETING AND FINANCIAL		SOURCES OF EXPANSION CAPITAL
SKILLS NEEDED BY PARTICIPANTS	SCIENTIFIC EXPERTISE	TECHNOLOGY/ENGINEERING EXPERTISE	TECHNICAL, ENGINEERING, AND SOME BUSINESS EXPERTISE	MANAGEMENT EXPERTISE; R&D CAPABILITY; NEW PRODUCT DEVELOPMENT CAPABILITY		BUSINESS SKILLS INCLUDING TECHNICAL MARKETING AND MANAGEMENT

Fig. 2. Technological Innovation Process: Component Activities, Participants, and Needs (Rorke, et. al., 1983).

A still more recent estimate by Birch (1983) for the 1977-81 period attributes 51 percent of new jobs to businesses with fewer than twenty employees. However, both the original Birch (1978) and the Armington and Odle (1982a; 1982b) studies report that new establishments, both large and small, contribute one-half or more of net new jobs. An excellent discussion of both studies is contained in Vaughan (1983).

Harris (1984a; 1984b) recently studied the phenomenon of job creation in high-technology industry. This study revealed the following facts about the high-technology industry sector: (1) under Harris' definition of high-technology, in 1980 the sector employed less than 10 percent of the total work force and 60 percent of this employment was in large firms of more than 10,000 employees; (2) between 1976 and 1980, high-technology employment growth of 19.4 percent was 1.7 times the percentage growth in other manufacturing plus business services; and (3) within the sector, small firms of less than 500 employees grew twice as fast as larger firms and contributed 40 percent of net new jobs, although their share of total sector employment was only 20 percent.

It would appear, then, that the potential of small high-technology firms for job creation within the sector itself is significant but these firms are not at this time the dominant source of jobs. Moreover, the entire sector will contribute only a small fraction of new jobs created. The Bureau of Labor Statistics (Riche, et al. 1983) estimates that between 1982 and 1995, high technology industry will account for between 3 percent and 17 percent of net new jobs, depending on whether a narrow or broad definition of "high technology" is adopted.

There may, however, be an indirect effect of the innovative activity to which these firms contribute that is far more important than their employment statistics. Birch and MacCracken (1984) have advanced the concept of a "high innovation" sector of which the high-technology sector is a subset. They hypothesize that the principal benefit of the innovative activity in the high innovation sector is the creation of jobs in smaller businesses in the low technology sector. This is accomplished through innovative activity spawned by the primary and secondary impacts of technology transfer to the traditional business sector.

programmatic components of state development strategies involving research are then discussed and general conclusions are formed regarding optimal individual state strategies based on relevant state economic and demographic characteristics. Finally, a research and development-based economic development research program initiatives of selected states are assessed within the analysis framework presented. A companion report (Watkins 1985) discusses state program initiatives which focus on the commercialization of ideas derived from basic and applied research.