An Economy at Risk: The Imperatives for a Science and Technology Policy for New Jersey

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Executive Summary

New Jersey has always been positioned at the leading technological edge of the American economy. This has long been the foundation of the state's prosperity, its high standard of living, and its attractive quality of life. Initially, New Jersey was preeminent in advanced technology-based manufacturing; but by the end of the 20th century, the state had evolved into a post-industrial, information-based, knowledge-driven economic dynamo. Only by being on the frontiers of economic innovation – only by continually moving "up-market" – has New Jersey maintained its enviable position.

However, recent years have seen signs of an erosion of New Jersey's key technology-based economic assets. Globalization, deregulation, and accelerating technological change have been the predominant force in the world economy of the new century. These forces, and aggressive investments in technology-based growth by other states and nations, have reshaped New Jersey's competitive economic environment. However, the sheer scale and momentum of New Jersey's past prosperity and of its core economy have obscured both relative and absolute deterioration of the state's competitiveness. The loss of national employment share in the following technology-based industries has been steep and dramatic.

New Jersey's Share of National Employment

	1990	2004
Pharmaceuticals and Medicine	20.2%	13.8%
Computer and Electronics Manufacturing	3.2	2.4
Telecommunications	5.8	3.9
Wired Telecommunications	7.8	4.7
Wireless Telecommunications	4.2	2.8
Internet Service Providers/Data Processing	6.1	3.5
Scientific Research and Development Services	6.6	5.1
Computer Systems Design and Related Services	6.4	4.3
Management, Scientific, and Technical Services	5.1	3.8
Architectural, Engineering and Related Services	3.6	3.3
Total	**5.2**	**4.1**

This startling erosion has been magnified in the current decade by a vast acceleration in the hemorrhaging of high-paying manufacturing jobs and the simultaneous loss of sophisticated high-paying services jobs in financial activities, information, and professional and business services. It was the expansion of the latter sectors during the 1990s that compensated for the losses of manufacturing jobs during that time, but this is no longer the case. Consequently, the state's income position relative to the nation has fallen every year during the current decade. The imperatives for a science and technology policy – and for technology-driven strategic investments in the economy of the future – are becoming increasingly apparent. Positive public policy responses are needed to halt the slippage in the state's core economic sectors. The longer this slippage remains unchallenged, the greater the probability it will not be reversible as other states and nations accelerate growth in this area. While there is no single silver economic bullet that will produce an immediate and effective reversal of the dynamics now in force, the following policies and strategies can put New Jersey on the long economic road back to a prosperous future.

- **Four Policy Principles.** New Jersey's science and technology policies should be guided by the following four principles:
    1) *Significant resources* should be committed to building research excellence.
    2) The magnitude of this commitment should be *sustained over time*.
    3) Resources should be invested in a *strategic and focused manner*.
    4) State investments should be based on a *peer-review process*. (See pp. 35.)

- **Three Policy Areas.** To foster economic growth, a comprehensive and coherent portfolio of science and technology policies should achieve three key goals pivotal to the development of New Jersey's science and technology industries. These are: to build the research and commercialization capacities of the state's universities; to improve the state's entrepreneurial environment; and to enhance the competitiveness and growth potential of the state's existing science and technology businesses. (See pp. 35-52.)

- **<u>Supporting Research University-Driven Economic Growth.</u>** New Jersey should seek to maximize the ability of its research universities to compete for federal research dollars and to generate economic growth through new discoveries and the commercialization of intellectual property. Strategies toward this end should include: investing in human and physical capital to build new centers of research excellence; providing matching grants for major federal research proposals; establishing cooperative partnerships among universities; making matching capital available for university-based startup firms; and expanding support for university incubators and university technology transfer functions. (See pp. 37-47.)

- **<u>Enhancing the State's Entrepreneurial Environment.</u>** The Commission on Science and Technology should develop additional technology incubators and increase support to improve the effectiveness of programs of existing incubators. In addition, the state should implement a set of "financial incubation" policies designed to help tech startups mature through the difficult, early stages of development and achieve successful commercialization of innovative technologies. The New Jersey Commission on Science and Technology and the New Jersey Economic Development Authority should work to expand the scope and availability of Techniuum financing, to increase the supply of venture capital funding available to startups, and to develop and encourage the use of tax incentives and credits for growing technology firms. (See pp. 47-51.)

- **<u>Assisting Existing Technology Businesses.</u>** To assist New Jersey's existing core of large- and mid-sized tech industry employers, the state should promote and, where appropriate, coordinate the establishment of university-operated research centers that provide applied research and technical services to science and technology industries. In addition, the state should identify obstacles to a competitive business climate and make appropriate changes, for example, revising how the state taxes capital gains from the sale of small technology-based businesses. In general the state should provide incentives for companies to remain and grow *in* the state. (See pp. 51-52 and pp. 55-56.)

Introduction

An increasingly popular perception is that New Jersey's 2005 economy is finally back on track, currently generating impressive rebounds in state tax revenues and maintaining an unemployment rate consistently below that of the nation. However, beneath an apparently smooth surface are troubling signs that suggest that the once unique core economic assets of the state are starting to erode. There have been subtle but significant shifts in New Jersey's employment growth patterns that are signaling that the positive economic advances of the past two decades are beginning to retreat. At the federal level, large deficit spending, financed by other countries, together with expansionary monetary policy, have stimulated consumer spending based on debt, raising serious questions about the sustainability of U.S. economic growth.

New Jersey's economy completely reinvented itself in the 1980s and 1990s, maintaining its leading technological edge in the nation's emerging postindustrial era. By 2000, New Jersey had achieved an advanced, high-paying, knowledge-dependent employment base. The state was seemingly well poised for the successful unfolding of the new decade, century, and millennium. However, the economic reality of the first half of the current decade has proven to be far different.

Obscured by the momentum of a vast statewide economy that now totals more than 4 million jobs has been an attrition of New Jersey's once preeminent technological position. Key parts of the core economy – including the state's unique concentrations of technology-based economic specializations – have not only stopped growing in the 2000s but, in a number of important areas, have started to contract. New Jersey has been losing high-paying technology-dependent jobs and has been mainly gaining low-paying lower-level jobs. The initial stages of relative economic erosion are evident not only in a deteriorating employment profile, but in a relative decline in the state's dominant income position as well.

New Jersey's long-term position at the nation's technological edge has been the foundation of the state's enviable affluence. This affluence, even as it erodes, will for a considerable time convey an image of economic health. But in the longer term, the standard of living in New Jersey, as well as economic opportunity, will surely diminish.

Analytical Framework

The employment structure of New Jersey's economy is detailed by the North American Industry Classification System (NAICS). The major economic supersectors (non-italicized) of this classification system are listed in Table 1. The **bold** supersectors are those that have the highest average annual pay and are the foundation of the state's high standard of living. They are also, with the exception of federal government and financial services, the supersectors that encompass the major science and technology industries of the state, which are set in ***bold italics*** in Table 1.

The manufacturing supersector has two major technology-based industries: pharmaceuticals and medicine, and computer and electronic products. The information supersector also has two major high-technology industries. The first is telecommunications, which itself has two subsectors – wired telecommunications and wireless telecommunications – and the second is Internet service providers, Web search portals, and data processing. Financial activities have the highest average annual pay of all the supersectors, led by the security and commodity contracts, intermediation and brokerage industry sector. While technically not a pure technology industry, it does depend heavily on advanced information technology and is one of the highest-paying employment specializations of the state. Finally, the professional and business services sector has four key technology-based industries: scientific research and development services (which includes biotechnology); computer systems design and related services; management, scientific, and technical consulting services; and architectural, engineering, and related services.

Table 1
High-Technology and High-Paying Industries and Employment Supersectors

TOTAL NONFARM

TOTAL PRIVATE SECTOR

GOODS PRODUCING
- Natural Resources and Mining
- Construction
- **Manufacturing**
  - ***Pharmaceuticals and Medicine****
  - ***Computer and Electronic Products****

PRIVATE SERVICE-PROVIDING
- Trade, Transportation, & Utilities
- **Information**
  - ***Telecommunications****
    - ***Wired Telecommunications****
    - ***Wireless Telecommunications****
  - ***Internet Service Providers, Web Search Portals, and Data Processing****
- **Financial Activities**
  - **Security and Commodity Contracts, Intermediation and Brokerage**
- **Professional and Business Services**
  - ***Scientific Research and Development Services****
  - ***Computer Systems Design and Related Services****
  - ***Management, Scientific, and Technical Consulting Services****
  - ***Architectural, Engineering and Related Services****
- Education and Health Services
- Leisure and Hospitality
- Other Services

GOVERNMENT
- **Federal**
- State
- Local

* High-technology industries.
Source: U.S. Bureau of Labor Statistics

The employment trends in these specific technology-based industries and the broader economic supersectors provide a conclusive and useful measure of the overall economic performance of the state and its science and technology components.

Thus, in the subsequent analyses, the key economic supersectors and technology-based/dependent industries are as follows:

High-Paying Supersectors and Industry Groups

Manufacturing
Information
Financial Activities
  Security and Commodity Contracts, Intermediation and Brokerage
Professional and Business Services
Federal Government

Technology-Based/Dependent Industry Groups

Pharmaceuticals and Medicine
Computer and Electronic Products
Telecommunications
  Wired
  Wireless
Internet Service Providers, Web Search Portals, and Data Processing
Scientific Research and Development Services
Computer Systems Design and Related Services
Management, Scientific, and Technical Consulting Services
Architectural, Engineering and Related Services

Low-Paying Supersectors

Natural Resources and Mining
Construction
Trade, Transportation, & Utilities
Education and Health Services
Leisure and Hospitality
Other Services

A Successful but Unplanned Past

Over the past 150 years, New Jersey experienced two major economic transformations and each time successfully reinvented itself – by itself. At the end of the nineteenth century, the state awoke to discover that an agricultural economy had become a powerful, technology-driven, urban-manufacturing economy. At the end of the twentieth century, the state awoke again to find that it had become a powerful, technology-driven, knowledge-based, information-age economy. These two monumental transformations took place in a virtual public policy vacuum, however. In fact, stimulating or shaping New Jersey's economic future has never been a state public policy priority, as long-term concerns usually have succumbed to immediate exigencies. While the state has often reacted quite successfully to specific economic crises or opportunities, sustained proactive efforts concentrating on investing in the long-term economic future of New Jersey have been sorely lacking. Despite this, economic success predominated. The New Jersey economy has always managed to maintain its leading-edge status – at least until now.

Perhaps luck, historical accident, entrepreneurial spirit and geography ruled. New Jersey may have been so well positioned with its business structures and location in relation to key national and global markets that it was virtually impossible not to succeed. However, economic success is not the state's birthright. New Jersey may no longer be able to count on these once-fortunate attributes to again lead it to future economic preeminence.

The new millennium has brought with it new dimensions of globalization that are reshaping the world economic order and are leading to a third monumental transformation – driven by globally wired supply and knowledge chains. It is essential for New Jersey's future that it remain on the leading technological edge of this transformation – as it has done twice before – and not be left behind.

The First Transformation

In the decades after the Civil War, the business of the Garden State economy was transformed from strictly "growing things" to primarily "making things." For more than a century, manufacturing was the state's primary economic locomotive. New Jersey's "big six" cities – Camden, Elizabeth, Jersey City, Newark, Paterson and Trenton – all thrived and developed in the nineteenth century as urban manufacturing centers. Paterson became know as “Silk City USA.” “Trenton Makes, the World Takes,” and “On Camden Supplies, the World Relies” were not merely slogans but economic reality. New Jersey was a technology-driven, urban manufacturing dynamo by the time the twentieth century unfolded and was at the leading technological edge of global industrialization. In the last part of the nineteenth century Menlo Park, New Jersey, was home to what could be called one of the nation’s first industrial research laboratories. There, Thomas Edison produced seminal innovations, such as the electric light and the phonograph, which transformed the nation and the world and generated enormous new industries and millions of jobs.

In the first half of the then new twentieth century, New Jersey could boast proudly of the mammoth Singer Sewing Machine plant in Elizabeth – the largest sewing machine manufacturing facility in the world that at its peak employed 10,000 workers; the RCA radio and Victrola factory in Camden – the largest of its type in the world; and Western Electric in Kearny – the world’s leading telephone manufacturing complex. All of these businesses, and many others, sold their outputs in national and world markets, bringing large revenue flows back to New Jersey. However, by the 1980s all these businesses were reduced to a historical memory.

The Second Transformation

But a second major technology-driven transformation was already well underway – the emergence of a postindustrial, knowledge-dependent, information-age economy. AT&T’s Long Lines complex in Bedminster, which opened in 1976, and its global headquarters in Basking Ridge, which opened in 1977, quickly became powerful symbols of the state’s postindustrial, high-technology future. New Jersey became nothing less than “global telecommunications central.” These advanced-stage “teleco” facilities also legitimized once frontier suburban sites as market-acceptable geographic locations for office development in New Jersey. The broader economy that emerged from the second major economic transformation was mainly housed in office buildings – postindustrial “factory floors.” By 1990, North-Central New Jersey had emerged as the fifth largest metropolitan office market in the country, with much of the new inventory located in freeway-oriented suburban growth corridors.[1] Occupying these buildings in the 1980s and 1990s were technology-dependent professional and business services, financial activities, and information services.[2] These economic sectors were at the heart of the new economy, and New Jersey found itself at the leading technological edge of a second global economic reordering. Once again, New Jersey's economy had successfully reinvented itself – by itself.

The Third Transformation

New Jersey's two industrial transformations left the state with not only an enviable economic position but also an unparalleled standard of living. However, a third transformation may well be at hand – one that may yield different consequences. Internet-dependent global supply chains have already spatially rearranged the global manufacturing order. Internet and information technology-dependent innovation chains are now threatening to spatially rearrange the world's knowledge and advanced-services economy. An international economy with an abundance of low-cost, globally wired, highly educated, high-technology, service-sector workers is a challenge of unprecedented complexity and implications. Low-cost factories and high-technology production are now being supplemented by low-cost laboratories and high-technology services at new emerging global locations. Will New Jersey's economy be able to successfully reinvent itself – by itself – a third time in the face of such unprecedented competitive forces?

Troubling Signs

The urgency of this question is further emphasized by a number of worrisome trends that emerged in the state in the post-2000 period – trends that suggest a loss of New Jersey's competitive position. The state has stopped gaining sophisticated, high-paying knowledge-based jobs; instead, employment growth has been clustered in low-

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[1] By 1990, 80 percent of all of the office space ever built in the history of New Jersey had gone up in the decade of the 1980s.

[2] Professional and business services include management of companies and enterprises (corporate headquarters), scientific and technical services, legal services, accounting services, engineering services, research and development services, and computer systems design and services, among others. Financial activities include finance, banking, securities investment and brokerage, and insurance as well as others. Key components of the information sector are telecommunications and Internet-related activities. All of these categories are specified by the North American Industry Classification System (NAICS).

paying sectors of the economy. At the same time, tax-supported state and local public-sector jobs have accounted for an unprecedented share of employment growth. Moreover, two of the state's crown economic jewels – the pharmaceutical and telecommunications industries – are starting to lose national employment share at a rapid rate, while the growth of sophisticated financial activities and professional services jobs – mainstay sectors of the 1980s and 1990s – has stalled. As a result, the state's once lofty income position is steadily eroding.

Employment Growth Trends: High Pay to Low Pay

Between 1980 and 2000, the state's employment increases were dominated by higher-paying industries. However, in the 2000s, it has been lower-paying industries that have accounted for much of the job growth. This and other employment-related statistics suggest that corporate America is concentrating its "high-end" economic expansion outside of New Jersey.

The average annual pay in New Jersey by industrial sector in 2004 is presented in Table 2. While the state still maintains an overall advantageous economic position, it is one that may be in jeopardy.

- *The state's average annual pay for all employment sectors was $48,042 in 2004, a level 22 percent higher than that of the nation ($39,348).*

This pay "premium" is due to the state's unique employment concentrations in financial activities, information, and professional and business services, three of the five highest-paying employment sectors in the state.[3] New Jersey is distinctly overrepresented in these three sectors.

[3] These are five of the 13 supersectors of the North American Industry Classification System (NAICS) detailed in Table 1.

Table 2
New Jersey Nonfarm Payroll Employment Change and Average Annual Pay
1990-2000 versus 2000-2004

	Employment Change		2004 Average Annual Pay
	1990-2000	**2000-2004**	
Total Nonfarm	359,400	7,500	$48,042
Total Private Sector	347,300	-37,700	$47,608
Goods Producing	-107,200	-66,600	$55,959
Natural Resources and Mining	-1,000	-400	$28,740
Construction	1,900	16,400	$51,320
Manufacturing	-107,900	-82,700	$59,134
Private Service-Providing	454,500	28,900	$46,066
Trade, Transportation, & Utilities	65,700	-23,500	$41,446
Information	**6,400**	**-28,300**	***$72,468***
Financial Activities	**32,600**	**10,900**	***$74,789***
Professional and Business Services	**160,300**	**-16,900**	***$58,018***
Education and Health Services	133,700	50,800	$41,065
Leisure and Hospitality	33,400	23,700	$20,065
Other Services	22,400	12,200	$30,565
Government	12,200	45,200	$50,412
Federal	-12,500	-6,000	$69,580
State	4,500	13,100	$59,296
Local	20,100	38,100	$46,997

Note: Numbers may not add due to rounding.
Sources: New Jersey Department of Labor and Workforce Development.
U.S. Bureau of Labor Statistics.

- *The five high paying sectors are financial activities ($74,789), information ($72,468), federal government ($69,580), manufacturing ($59,134), and professional and business services ($58,018).*

During the 1990s, New Jersey had significant employment gains in three of these high-paying sectors and losses in two, but positive new growth from the five sectors combined (Table 2).

- *While the state lost 107,900 jobs in the high-paying manufacturing sector between 1990 and 2000, this was more than compensated for by large employment* *increases in professional and business services (+160,300 jobs), financial activities (+32,600 jobs per year), and information (+6,400 jobs). The three sectors combined added 199,300 jobs during the entire decade.*

Thus, the state was adding approximately two high-paying private-sector service jobs for every manufacturing job loss. This strong growth also served to counterbalance the sustained hemorrhaging of federal government employment (-12,500 jobs), the highest-paying public-sector job.[4] On a net basis, however, the state added 78,900 jobs in the five high-paying sectors – the result of a gain of 199,300 private-sector service jobs and losses of 107,900 jobs in manufacturing and 12,500 in federal government. Still, it was a positive net gain, all due to the three high-paying private-service sectors.

- *Of the total 359,400 jobs gained by the state between 1990 and 2000, more than half (55.5 percent, or 199,300 jobs) were in professional and business services, financial activities, and information.*

This pattern of growth reflected the successful shift to the new knowledge-based economy, and it was the foundation of the robust economic health of New Jersey during the second half of the 1990s. But significant changes occurred after 2000. First, the New Jersey manufacturing employment hemorrhage actually accelerated.

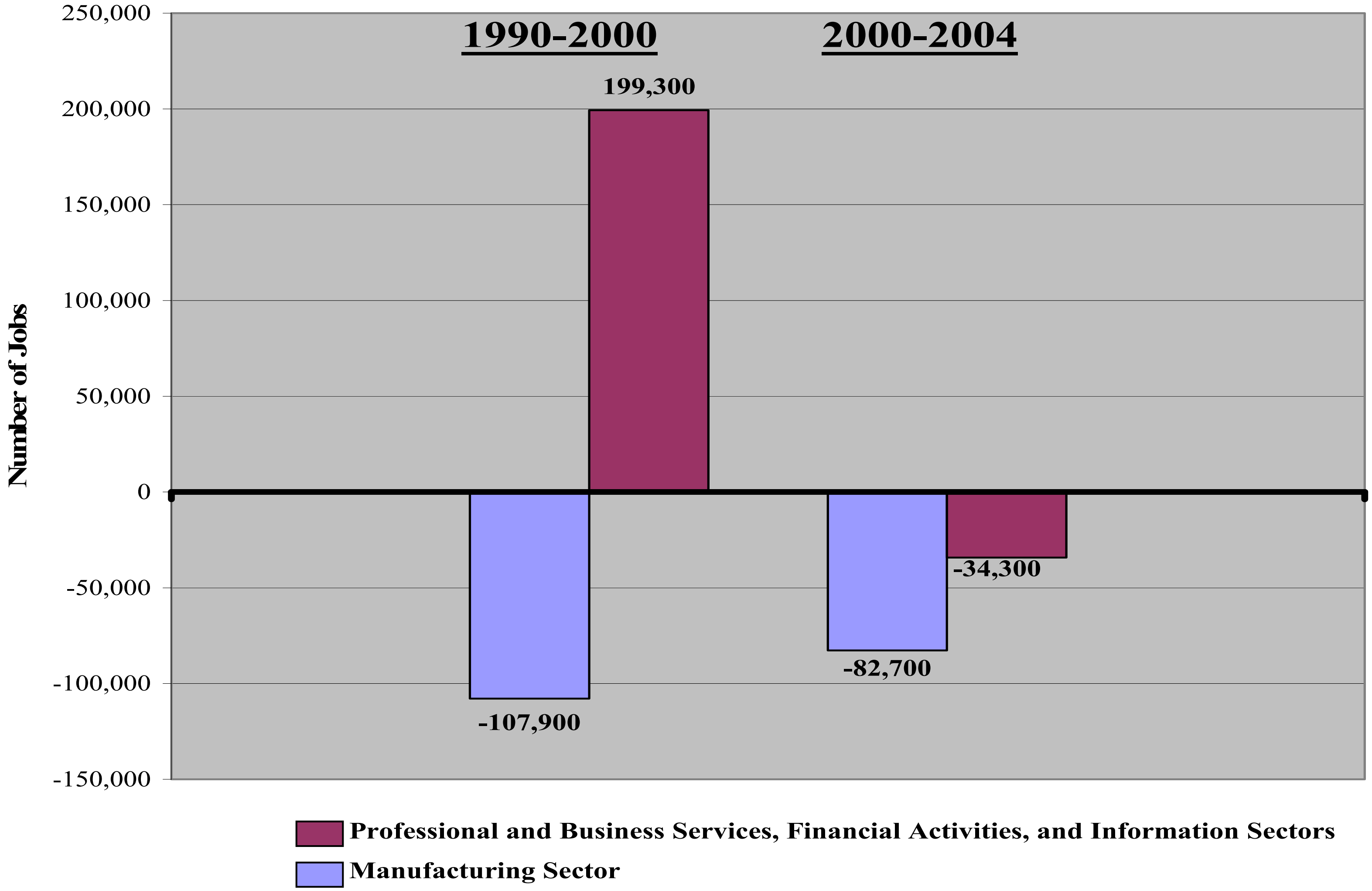
- *Manufacturing lost 82,700 jobs in the four years between 2000 and 2004 alone, compared to a loss of 107,900 jobs during the entire decade of the 1990s.*

However, this time these jobs were not replaced by high-paying service jobs. Instead, the prime private service-providing sectors were also buffeted by employment losses. Figure 1 demonstrates the dramatic shift from the net gains of high paying jobs in the 1990s as losses in manufacturing (-107 thousand jobs) were more than offset by gains in business services (199 thousand). From 2000 to 2004, job losses occurred in both categories.

- *Professional and business services lost 16,900 jobs between 2000 and 2004 and information lost 28,300 jobs, while financial activities gained only 10,900 jobs. These three high-paying private-service sectors together had aggregate employment losses of 34,300 jobs between 2000 and 2004. When combined with manufacturing (-82,700 jobs) and federal government (-6,000 jobs),*

[4] Federal government employment has an enormously important fiscal impact because it represents a flow of funds into New Jersey from the other 49 states. Other public-sector employment (state and local) is paid for largely by New Jersey taxpayers.

Figure 1
Change in High-Pay Employment Sectors



the five high-paying sectors had a total net employment loss of 123,000 jobs.

- *This net loss in the five high-paying sectors (-123,000 jobs) between 2000 and 2004 more than fully erased their net gain (+78,900 jobs) in the 1990 to 2000 period. So, by 2004, New Jersey had 44,100 fewer high-paying jobs that it had in 1990, 14 years earlier.*
- *The job growth sectors in the 2000-2004 period were education and health services (+50,800 jobs), government (+45,200 jobs) and leisure and hospitality (+23,700 jobs). However, leisure and hospitality had the lowest annual pay ($20,065) of the major economic sectors, while that of education and health services ($41,065) was considerably below the all-industry average ($48,042).*

Moreover, while government employment overall has above-average wages, all of the public-sector job gains since 2000 have been in state and local government. These are tax-supported positions dependent on local resources drawn from the state's private-sector economy and its property owners. Thus, as mid-decade approached, New Jersey was experiencing a contraction of high-paying, private-sector jobs, replaced by lower-paying, private-sector employment and expanding public-sector, tax-dependent jobs.

Part of this failure to generate high-wage jobs is due to the 2000-02 recession, the tendency during the early stages of a recovery to add lower-wage jobs, and a somewhat similar national job pattern. Nonetheless, employment in financial activities is now growing faster in the nation than in New Jersey, while the national rates of decline in professional and business services and information are far lower nationally than in New Jersey.[5] Although the state still maintains a leading-edge economy, these disparate growth rates may be signaling that the state is losing competitiveness.

[5] Between 2000 and 2004, employment in financial activities grew by 4.1 percent in New Jersey compared to 4.7 percent in the nation; professional and business services declined by 2.8 percent in New Jersey versus a 1.5 percent drop in the United States; and information declined by 22.3 percent in the state compared with 13.6 percent nationally.

New Economy Engines Slowing Down

Underlying this concern about a decline in New Jersey's competitive position are some troubling trends in specific economic sectors of key importance to the state's economy.

Pharmaceuticals

New Jersey has often been called the nation's medicine chest. But it is now a leaner and smaller one. Although New Jersey still retains a unique concentration of pharmaceutical activity, its share is rapidly eroding.

- *In 1990, the state accounted for 20.2 percent of the nation's total pharmaceutical employment (Table 3).*[6] *Thus, more that one of five "pharma" jobs in America was located in New Jersey – an impressive and unequalled concentration.*[7]
- *But by 2004, the state's pharmaceutical employment share declined to 13.8 percent.*
- *Between 1990 and 2004, the state lost 4.1 percent of its pharma jobs.*[8] *In contrast, pharma employment grew by 40.4 percent nationally.*
- *The 1990-2004 national increase in pharmaceutical employment (40.4 percent) was more than double the growth rate (20.1 percent) in overall employment in the United States.*

Since the average annual pay in pharmaceuticals in New Jersey in 2004 was $99,522, the economic ramifications of pharma employment losses in New Jersey are certainly significant. It is also significant that these losses occurred while employment in pharma nationally was soaring. So New Jersey's troubles were *not* due to a weak national pharmaceutical growth context. New Jersey – the nation's medicine chest – simply failed to participate in a strong national pharmaceutical expansion.

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[6] The specific NAICS subsector is pharmaceutical and medicine manufacturing. This sector captures approximately 80 percent of total pharmaceutical employment.
[7] Again, this compares to New Jersey's 3.0 percent share of the nation's total job base.
[8] Pharma employment declined from 41,900 jobs in 1990 to 40,200 jobs in 2004, a loss of 1,700 jobs. In contrast, the nation added 83,800 pharma jobs during the same 14 years, from 207,200 jobs in 1990 to 291,000 jobs in 2004.

Table 3
Total Manufacturing, Pharmaceuticals and Medicine Manufacturing, and Computer and Electronic Products Manufacturing
New Jersey versus United States: 1990-2004

	1990	2004	Change: 1990-2004 Number	Change: 1990-2004 Percent	2004 Average Annual Pay
Total Manufacturing					
United States	17,695,000	14,329,000	-3,366,000	-19.0%	
New Jersey	529,500	338,900	-190,600	-36.0	$59,135
NJ share of U.S.	*3.0%*	*2.4%*			
Pharmaceuticals and Medicine Manufacturing					
United States	207,200	291,000	83,800	40.4%	
New Jersey	41,900	40,200	-1,700	-4.1	$99,522
NJ share of U.S.	*20.2%*	*13.8%*			
Computer and Electronic Products Manufacturing					
United States	1,902,500	1,326,200	-576,300	-30.3%	
New Jersey	61,100	31,400	-29,700	-48.6	$66,558
NJ share of U.S.	*3.2%*	*2.4%*			

Sources: New Jersey Department of Labor and Workforce Development
U.S. Bureau of Labor Statistics

Computer and Electronic Products

Computer and electronic products manufacturing is the second major high-technology manufacturing industry (Table 3). Both the nation and New Jersey have experienced sustained employment losses, but those of the state are far more severe.

- *New Jersey lost nearly half (-48.6 percent) of its employment in consumer and electronic products manufacturing between 1990 and 2004, while the nation lost "only" 30.3 percent.*
- *As a result, the state's share of the nation's employment in this sector fell from 3.2 percent in 1990 to 2.4 percent in 2004.*

Telecommunications

The highly visible – and still highly lamented – great manufacturing hemorrhage in New Jersey began in earnest in 1969. It took 32 years, until 2001, for manufacturing employment to decline by one half.[9] Thus, manufacturing had a so-called half-life of 32 years. But virtually unnoticed, an employment decline of equal relative magnitude occurred in wired telecommunications in New Jersey – a subsector of information – in just nine years – a half-life of nine years![10] Moreover, this decline in New Jersey took place while wired telecommunications nationally grew modestly.

- *New Jersey accounts for 3.0 percent of the nation's total job base. In 1990, the state accounted for 7.5 percent of the nation's wired telecommunications employment (Table 4). At that time, this was a unique and powerful concentration and a key new economy locomotive for the state. But by 2004, the state's employment share in wired telecommunications fell markedly to 4.7 percent.*

This rapid and dramatic loss of relative position is even more troubling since the average annual pay in wired telecommunications was $94,078, a level nearly double the all-industries average ($48,042) in New Jersey (Table 2).

- *While wired telecommunications employment in New Jersey declined by 51 percent between 1990 and 2004, wireless telecommunications employment grew by almost 200 percent (Table 4). However, over the same time, wireless employment increased by 355 percent nationally – almost twice as fast. Thus, New Jersey lagged badly in this technology-driven frontier growth sector.*
- *Moreover, the increase in wireless employment in the state (3,499 jobs) was only 13 percent of the wired loss (-26,595 jobs) between 1990 and 2004. And while wireless annual pay ($78,789) is certainly above average, it still was below that of wired ($94,078). Thus, not only is wireless adding barely one job for every*

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[9] Based on the former Standard Industrial Classification (SIC) code, manufacturing employment declined from 892,500 jobs in 1969 to below 446,250 by the summer of 2001.

[10] Wired telecommunications employment in New Jersey totaled just above 50,000 jobs in the first half of 1995. By September 2004, it had slipped below 25,000 jobs.

eight wired job losses, each of those new job gains has an annual pay below that of the jobs being lost.[11]

New Jersey's transformation into an information-age economy was led by telecommunications and AT&T. The latter's demise should serve as a warning that other sectors of the state economy could experience similar reversals of fortune in very short periods of time.

Table 4
Selected Telecommunications Employment
New Jersey versus United States: 1990-2004

	1990	2004	Change: 1990-2004 Number	Change: 1990-2004 Percent	2004 Average Annual Pay
Total Telecommunications					
United States	994,093	1,028,206	34,113	3.4%	
New Jersey	57,738	39,747	-17,991	-31.2%	$84,120
NJ share of U.S.	*5.8%*	*3.9%*			
Wired Telecommunications					
United States	690,864	539,250	-151,614	-21.9%	
New Jersey	51,881	25,286	-26,595	-51.3%	$94,078
NJ share of U.S.	*7.5%*	*4.7%*			
Wireless Telecommunications					
United States	41,371	188,234	146,863	355.0%	
New Jersey	1,755	5,254	3,499	199.4%	$78,789
NJ share of U.S.	*4.2%*	*2.8%*			

Note: Subcategories will not add to total since other telecommunications industries are not included.
Source: Quarterly Census of Employment and Wages, U.S. Bureau of Labor Statistics

[11] Moreover, while wired telecommunications was formerly a highly-regulated, high-paying industry, wireless telecommunications is in a new, nonregulated, competitive, pay-constrained environment. This difference is likely to yield further pay constraints in the future.

Internet Services

Also telling is the experience of another important high-technology subsector of information: Internet service providers, web search portals and data processing.

- *While employment in this high-paying sector ($77,639) grew between 1990 and 2000 in New Jersey, its share of the nation's employment in Internet service providers, web search portals and data processing fell from 6.1 percent to 3.9 percent (Table 5). Thus, New Jersey was not a full participant in the Internet boom of the 1990s, when national employment in this sector doubled.*
- *Nonetheless, in the national bust that followed (2000-2004), New Jersey was, unfortunately, more than a full participant. It suffered disproportionate employment losses, and its share of national employment dropped to 3.5 percent. In 2004, the nation had about 50 percent more jobs in this sector than in 1990, while New Jersey had about 10 percent fewer.*

Table 5
Internet Service Providers, Web Search Portals and Data Processing
Total Employment Level and Share
New Jersey Versus United States: 1990, 2000, and 2004

	1990	2000	2004	2004 Average Annual Pay
United States	252,200	510,100	388,100	
New Jersey	15,500	19,900	13,700	$77,639
NJ share of U.S.	*6.1%*	*3.9%*	*3.5%*	

Source: U.S. Bureau of Labor Statistics

Financial Activities

The strong overall growth in financial activities masks divergent underlying trends in its subsectors (Table 6). Although financial activities is not included in the definition of high-technology industries, this sector is an important part of the high pay to low pay employment trend observed in the New Jersey economy. In the 1990s, lower-paying traditional banking jobs were sharply declining, while higher-paying "Wall Street-type" jobs were sharply increasing.[12] In the 2000s, just the reverse has been happening. Thus, a shift from high pay to low pay is also now evident in the financial sector.

- *Between 1990 and 2000, while total financial activities employment increased by 32,600 jobs (13.9 percent), traditional banking jobs declined by nearly one-third (-31.3 percent or -19,800 jobs). The average annual pay of these jobs was $49,477.*[13]

While these lower-paying financial jobs were shrinking in number during the 1990s, higher-paying ones were soaring.

- *Employment in "Wall Street-type" financial activities grew by 203.6 percent (28,500 jobs) between 1990 and 2000! This was nearly 15 times the rate of increase of total financial activities employment.*
- *In 1990, New Jersey accounted for 4.3 percent of the nation's "Wall-Street-type" jobs. Its share jumped to 6.5 percent by 2000.*
- *Most significantly, the average annual pay in this subsector was an extraordinary $131,422 compared to $49,477 in traditional banking.*

Thus, the movement of Wall Street activities to the western shore of the Hudson River proved to be a strong income stimulus for the New Jersey economy, and it made the state a significant player on the national financial scene. However, this trend stalled and then reversed in the post-2000 years.

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[12] The NAICS subsector that encompasses traditional banking is "depository credit intermediation." "Securities and commodity contracts intermediation and brokerage" encompasses "Wall Street-type" employment.

[13] While the average annual 2004 pay ($49,477) in this subsector is actually above the all-industry average ($48,042) in New Jersey, it is significantly below the average annual pay ($74,789) for all financial activities employment

Table 6
New Jersey Nonfarm Payroll Employment Change and Average Annual Pay
Selected Financial Activities
1990-2000 versus 2000-2004

	Employment Change		2004 Average Annual Pay
	1990-2000	**2000-2004**	
Financial Activities	***32,600***	***10,900***	***$74,789***
Depository Credit Intermediation *	***-19,800***	***5,600***	***$49,477***
Security & Commodity Contracts, Intermediation and Brokerage **	***28,500***	***-5,400***	***$131,422***
Real Estate and Rental and Leasing	***2,900***	***5,800***	***$47,621***

Notes: Numbers will not sum to total.
* Traditional banking-type jobs
** "Wall Street"-type jobs
Sources: New Jersey Department of Labor.
U.S. Bureau of Labor Statistics

- *Between 2000 and 2004, total financial activities jobs grew by a respectable 4.1 percent. However, "Wall Street-type" employment declined by 12.7 percent, exacerbated by a "bear market" during 2001-02, while traditional banking jobs grew by 12.9 percent.*
- *The state's share of the nation's "Wall Street-type" employment dropped from 6.5 percent in 2000 to 6.3 percent in 2004.*

Thus, the highest-paying financial jobs have been in retreat in the post-2000 period, while the lower-paying ones have experienced a rapid rate of increase. Is this a start of long-term erosion of a very recent concentration? With the New York Stock Exchange's hegemony threatened by electronic trading, with other global financial centers becoming more powerful with growing competition among financial institutions, and with back-office functions now as easily carried out in low-cost Asia as in Jersey City, the state's recently gained role as a significant national financial center may well be in jeopardy.

The real estate sector ($47,621) of financial activities has expanded in tandem with traditional banking in the 2000-04 period (Table 6). Growth in both of these sectors has been driven by the state's housing and consumption booms of the past five years. This reflects the enormous role that housing and consumption have been playing not only in financial activities during this period but also as an economic engine for the state and nation. This "dependency" could prove to be problematic if the current housing boom turns out to be a housing bubble, even if only a slowly deflating one.

High-Technology Professional and Business Services

Similar losses in share of national activity took place in the four key high-technology professional and business services (Table 7).

- *New Jersey accounted for 6.6 percent of the nation's employment in scientific research and development services (this includes biotechnology businesses) in 1990 (Table 6). By 2000, the state's share had actually increased slightly to 6.9 percent. But its share then plummeted to 5.1 percent four years later (2004), and actual employment fell by 7,100 jobs. The average annual pay in this sector is $105,013!*

The other three key subsectors lost market share not only in the 2000-04 period, but also lost relative position in the earlier 1990-2000 period. Two of the three actually lost jobs between 2000 and 2004.

- *Computer systems design and related services ($84,536) also lost national employment share, declining from 6.4 percent in 1990 to 4.8 percent in 2000 to 4.3 percent in 2004.*
- *Similarly, the share of national employment accounted for by New Jersey in management, scientific, and technical consulting services ($75,966) fell from 5.1 percent in 1990 to 4.3 percent in 2000 to 3.8 percent in 2004.*
- *New Jersey's share of the nation's employment in architectural, engineering, and related services ($69,132) declined from 3.6 percent in 1990 to 3.4 percent in 2000 to 3.3 percent in 2004.*

Table 7
Selected High-Technology Professional and Business Services Sectors
Total Employment Level and Share
New Jersey versus United States: 1990, 2000, and 2004

	1990	2000	2004	2004 Average Annual Pay
Professional and Business Services				
United States	10,848,000	16,666,000	16,414,000	
New Jersey	438,200	598,500	581,600	$58,018
NJ share of U.S.	*4.0%*	*3.6%*	*3.5%*	
Scientific Research and Development Services				
United States	493,600	515,000	547,700	
New Jersey	32,700	35,300	28,200	$105,013
NJ share of U.S.	*6.6%*	*6.9%*	*5.1%*	
Computer Systems Design and Related Services				
United States	409,700	1,254,300	1,147,400	
New Jersey	26,300	60,500	49,500	$84,536
NJ share of U.S.	*6.4%*	*4.8%*	*4.3%*	
Management, Scientific, and Technical Consulting Services				
United States	323,600	704,900	779,000	
New Jersey	16,400	30,600	29,300	$75,966
NJ share of U.S.	*5.1%*	*4.3%*	*3.8%*	
Architectural, Engineering and Related Services				
United States	941,500	1,237,900	1,260,800	
New Jersey	33,600	41,500	42,100	$69,132
NJ share of U.S.	*3.6%*	*3.4%*	*3.3%*	

Source: U.S. Bureau of Labor Statistics.

Moreover, in addition to these declines in competitive share, three of the four sectors had absolute employment declines in the 2000-04 period, led by scientific research and development. Employment in scientific research and development services did grow from 32,700 jobs in 1990 to 35,300 jobs in 2000. But it then plummeted to 28,200 jobs by 2004, 4,500 jobs fewer than 1990 and 7,100 jobs fewer (-20 percent) than in 2000. The net loss of the four subsectors was 18,800 jobs.

High-Technology Summary

New Jersey's total high-technology employment is the sum of the following industry groups.

NAICS Code	Business Sector
334	Computer and Electronic Products Manufacturing
3254	Pharmaceutical and Medicine Manufacturing
517	Telecommunications
518	Internet Service Providers, Web Search Portals, and Data Processing Services
5413	Architectural, Engineering, and Related Services
5415	Computer Systems Design and Related Services
5416	Management, Scientific, and Technical Consulting Services
5417	Scientific Research and Development Services

In 2004 these industry groups, in total, accounted for 275,500 jobs, or 6.9% of total employment in New Jersey. However, New Jersey's high-technology industries have experienced a loss in the share of the nation's total high-technology employment.

- *Between 1990 and 2000, New Jersey's high-technology employment increased from 285,300 jobs to 322,600 jobs (Table 8). However, the state's national share fell from 5.2 percent to 4.3 percent, a significant indication of relative slippage.*
- *And four years later (2004), New Jersey's high-technology employment (275,500 jobs) had fallen back below the 1990 total (285,300 jobs), and the state's national share fell further, to 4.1 percent. This was both absolute and relative slippage.*

Table 8
High-Technology Employment in New Jersey and the United States, 1990-2004

New Jersey Share of U.S. High-Technology Employment

	1990	2000	2004
New Jersey (000s)	285.3	322.6	275.5
United States (000s)	5,510.6	7,579.2	6,782.7
New Jersey Share of U.S. Employment (%)	**5.2**	**4.3**	**4.1**

Share of High-Technology Employment in New Jersey

	1990	2000	2004
Total High-Tech Employment (000s)	285.3	322.6	275.5
Total Nonfarm Employment (000s)	3,635.1	3,994.5	4,002.0
High-Tech Share of Total Nonfarm Employment (%)	**7.8**	**8.1**	**6.9**

Share of High-Technology Employment in the U.S.

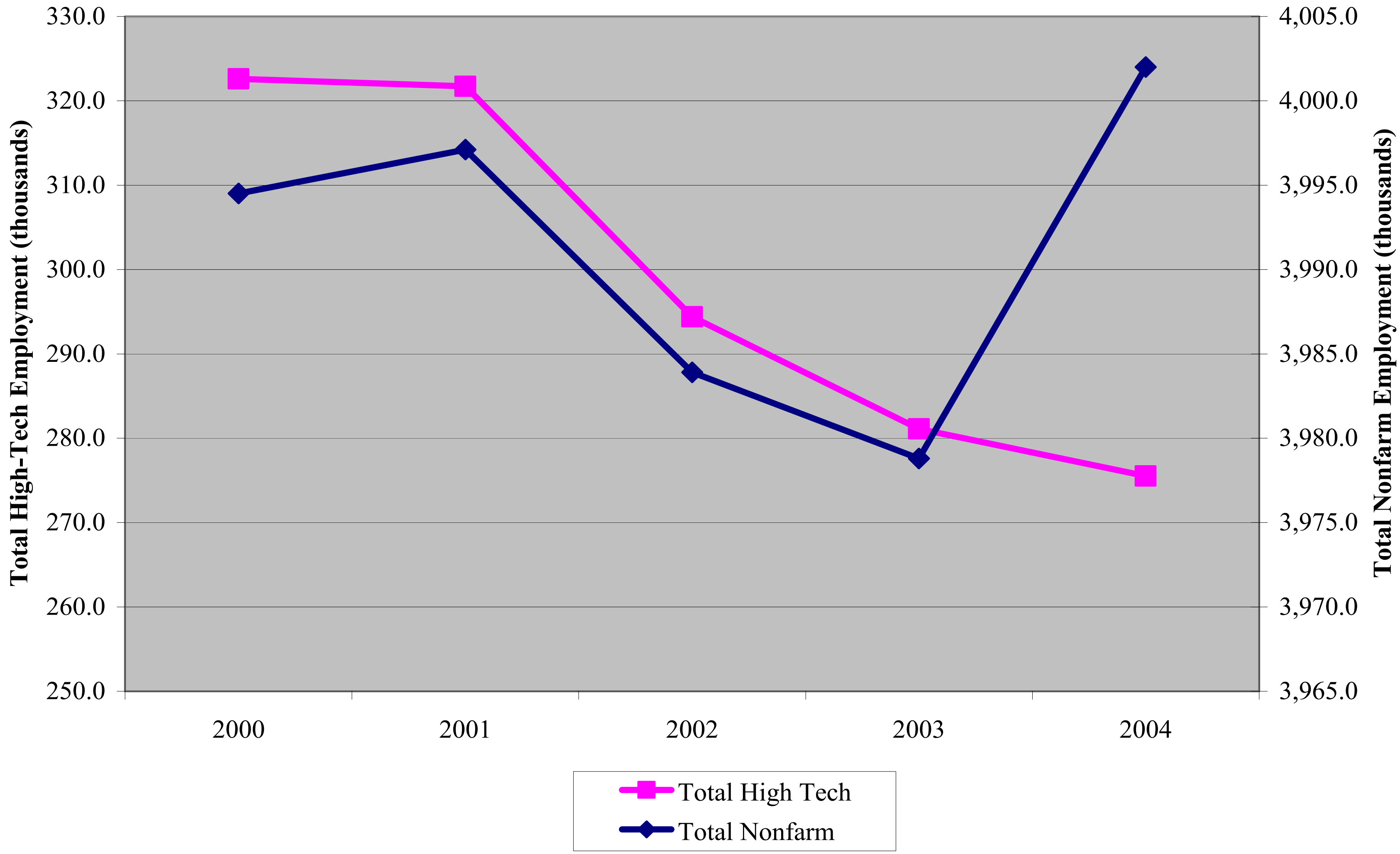
	1990	2000	2004
Total High-Tech Employment (000s)	5,510.6	7,579.2	6782.7
Total Nonfarm Employment (000s)	109,487.0	131,785.0	131480
High-Tech Share of Total Nonfarm Employment (%)	**5.0**	**5.8**	**5.2**

Source: U.S. Bureau of Labor Statistics.

In addition, high-technology's share of total employment in New Jersey experienced a similar pattern, increasing from 7.8 percent in 1990 to 8.1 percent in 2000 (Table 8). But post-2000, there was significant erosion, and high technology's share of total employment fell to 6.9 percent by 2004, continuing its sharp absolute decline even as total employment surpassed pre-recession levels (Figure 2). This 6.9 percent share of total state employment was significantly below the level of 14 years earlier, and the gains of the 1990s were fully erased. Moreover, the state has also been losing its relative edge in technology's share of the state's economy compared to technology's share of the nation's economy.

- *In 1990, technology's share (7.8 percent) in New Jersey was 56 percent higher than technology's share (5.0 percent) in the nation (Table 8). This relative advantage fell to 40 percent by 2000 (8.1 percent versus 5.8 percent) and to 33 percent by 2004 (6.9 percent versus 5.2 percent).*
- *While technology jobs now represent about 7 percent of the state's total employment, they comprise almost 12% of New Jersey's total salary base.*

Figure 2
New Jersey High-Tech and Nonfarm Employment Trends
2000-2004



- *Because these jobs have above average salaries, and given the progressive structure of the state's income tax, they pay a disproportionate share of New Jersey's gross income tax (i.e., disproportionate to their employment share).*

The conclusion of this analysis is that New Jersey still has a significant above-average concentration of high-technology employment, but the decline in the state's relative advantage has been sustained and substantial.[14]

Government Employment Dependencies

During the 1990s, expansion of government employment in New Jersey was highly disciplined. Job gains were concentrated predominantly in the private sector. This pattern was completely reversed in the post-2000 period, with public-sector employment soaring and private-sector employment contracting.

- *Private-sector employment growth totaled 347,300 jobs between 1990 and 2000, while government added a modest 12,200 jobs (Table 2). Between 2000 and 2004, government employment growth (45,200 jobs) surged, while private-sector employment declined (-37,700 jobs). A single year's average government employment growth in the 2000s (11,300 jobs) was nearly equal to the 10-year total of the entire 1990-2000 decade (12,200 jobs)!*
- *In addition, the rate of increase in government employment between 2000 and 2004 (7.7 percent) was nearly double that (4.0 percent) of the nation as a whole (Table 9). This is a complete reversal of the pattern of the 1990-2000 period, when government employment nationally grew more than six times faster than in New Jersey (12.9 percent versus 2.1 percent).*

[14] Other recent studies of the technology industry also note the recent change in employment growth. Using a different (but closely related) definition of technology industries, AEA – the American Electronics Association – ranked New Jersey forty-ninth among the states in employment change between 1998 and 2003 (-26,543 jobs). See *Cyberstates 2005*, American Electronics Association, Washington, D.C. The New Jersey Technology Council with another, again closely related, definition of technology industries has also tracked recent changes in employment. See G.M. Stoup, *NJTC State of the Technology Industry Report*, September 2005.

Table 9
Rate of Government Employment Change
New Jersey Versus the United States: 1990-2000 and 2000-2004

	Change: 1990-2000		Change: 2000-2004	
	NJ	**U.S.**	**NJ**	**U.S.**
Total Government	2.1%	12.9%	7.7%	4.0%
Federal	-15.5	-10.4	-8.8	-4.8
State	3.4	11.2	9.7	4.2
Local	5.5	20.4	9.9	5.8
Education	15.8	23.6	11.2	6.4

Sources: New Jersey Department of Labor and Workforce Development
U.S. Bureau of Labor Statistics

Thus, in the current decade, employment growth in the state has become heavily dependent on taxpayer-supported jobs.

Income Warning Signs

The final two decades of the twentieth century turned out to be a unique period of growing prosperity, following the economic malaise that gripped the state in the 1970s. However, does the growth of low-paying industries, and the lackluster performance of a number of key knowledge-based economic sectors, have a measurable impact on the economy? While no single overarching measure can capture the "bottom line," per capita income is a useful barometer of economic well-being. The ratio of New Jersey's per capita personal income to that of the nation is a valid measure of the state's relative economic performance.

- *Between 1970 and 1980, a period when manufacturing in New Jersey began its long-term hemorrhage, the state's per capita income fell from 18 percent higher (1.18) than that of the nation to 16 percent higher (1.16), as shown in Table 10.*

Table 10
Ratio of New Jersey's Per Capita Income to United States Per Capita Income
Selected Years: 1970 to 2004

		Ratio: NJ to U.S.	NJ Per Capita Income	US Per Capita Income
1970		**1.18**	$4,821	$4,085
1980		**1.16**	11,707	10,114
1990		**1.26**	24,572	19,447
2000		**1.29**	38,365	29,845
	2001	**1.28**	39,142	30,575
	2002	**1.27**	38,979	30,804
	2003	**1.26**	39,577	31,472
	2004	**1.25**	41,332	32,937

Source: U.S. Bureau of Economic Analysis.

This decline indicated a negative shift in relative economic position. The state's advanced service sectors failed to expand fast enough to fully compensate for manufacturing income losses. However, the knowledge-based economy soared during the 1980s and 1990s, and this resulted in a positive shift in the state's relative income.

- *The per capita income ratio improved dramatically, to 1.26 by 1990, and to 1.29 in 2000. Thus, per capita income in New Jersey moved from being 16 percent higher than that of the nation in 1980 to 29 percent higher by 2000.*

While averages mask distributional issues, this sharp gain certainly captures the overall success of the second major transformation in New Jersey: The broad economic position of the state was dramatically enhanced. But following the 2000 peak, this positive trend has now been reversed, replaced by a steady decline.

- *The state's per capita income fell to 28 percent higher in 2001, 27 percent higher in 2002, 26 percent higher in 2003, and 25 percent higher in 2004.*

This pattern appears to be more than a temporary soft patch, although it is possible that it could be a short-term aberrant. But it is entirely consistent with the low-paying service jobs dominating employment growth. New Jersey's relative economic well-being has been slowly but clearly eroding as the state lagged in the growth of advanced, high-paying service jobs.

Losing Our Technological Edge?

The unsettling economic trends of the current decade can be classified into three overlapping areas. The first is the loss of relative employment share in the leading-edge technology-dependent industries. These high-paying industries are important pillars of the state's high standard of living. The second is the declining significance of the state's once unique leading-edge technology/research facilities. Innovation "factories" or "genius factories" such as Bell Labs (telecommunications) and RCA's Sarnoff Labs (electronics) were once globally preeminent, drawing the world's "best and brightest" to New Jersey.[15] The third is the contraction of our export-based industrial "winners." The gold standard of state economic development is "growing" wealth-creating industrial sectors that sell their goods or services to the rest of the nation and the world. Such industries are thus supported by flows of dollars and resources into New Jersey, increasing the state's wealth position.[16] Most of the high-paying technology-based jobs specified above fall into this category, as do (or did) the jobs in our research crown jewels. The erosion that is taking place in all three of these areas suggests the need for a broad-based state economic development policy with a serious focus on science and technology. This concern is also present at the national level, and a recent National Academy of Sciences report has stressed the need to restore the nation's competitiveness in science and technology.[17]

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[15] In addition, the establishment of major new pharma research facilities in San Diego, California, and Cambridge, Massachusetts – not in New Jersey – has recently raised the specter of another loss of technological edge.

[16] For example, AT&T used to be the *sole* seller of long-distance telephone services to the nation. Since New Jersey accounts for approximately 3 percent of the nation's population and jobs, that meant that 97 percent of the revenues that supported AT&T's operations in New Jersey came from outside the state.

[17] See *Rising Above The Gathering Storm*, National Academy of Sciences, 2005 (available at http://books.nap.edu/catalog/11463.html).

Fort Monmouth: A Forthcoming Setback

Fort Monmouth is home to a partnership of five federal organizations whose mission is to develop, acquire, field, sustain, and integrate C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance) systems for the joint war-fighter. The installation is the military's key center for electronics and communications research and development. The federally funded interaction among researchers and engineers in New Jersey has helped revolutionize the field of communications and electronics. There are nearly 12,000 technology civilian jobs (direct and indirect) linked to Fort Monmouth.[18] The closing of the fort will mean that most of these jobs will relocate to Maryland, causing further deterioration in New Jersey's key technology service sectors. In addition, the closing will aggravate an already severe balance-of-payments deficit New Jersey has with the federal government, thus reducing externally-supported income flows into the state.[19]

New Business Research Models: Disadvantage New Jersey

Concurrent with the economic transitions stemming from globalization is a new business model for basic research and industrial laboratories in America. While foreign-based industrial giants are expanding large-scale corporate research facilities, an emerging trend in the United States is a shift in focus by the nation's industrial laboratories from basic leading-edge research – research that historically served as the basis for groundbreaking products and industries – to research directed at supporting their current business operations. Very simply, in a competitive global economy and in a deregulated national economy, U.S. businesses found that they could not afford to support their own extensive basic research undertakings.

The emerging paradigm is to shift leading-edge research to the nation's major research universities. These universities have broadened their traditional focus by

[18] Michael Lahr, "The Economic Impact of Military Bases in New Jersey," Center for Urban Policy Research, Edward J. Bloustein School of Planning and Public Policy, Rutgers University, 2004.
[19] New Jersey is, and has been for some time, last among the 50 states in terms of federal fiscal flows. In 2003, New Jersey received 57 cents in federal expenditures for each tax dollar it sent to Washington. (See S. Sagoo, *Federal Tax Burdens and Expenditures by State*, Tax Foundation Special Report No. 132, December 2004, available at www.taxfoundation.org.)

building alliances and partnerships with corporate America in order to undertake the types of advanced research that can spawn new business innovations and economic opportunities. This change became institutionalized by the Bayh-Dole Act that gave universities intellectual property rights stemming from research performed on federal grants, and by explicitly including industry connections/partnerships as criteria for awarding those grants. Many states have recognized the economic benefit of successfully competing for large federal grants that can then leverage activities spawning new businesses and support emerging science and technology business clusters. These states have made significant investments in increasing the quality and scale of the research capacity of their leading research universities.

This new model has worked to the detriment of New Jersey. Historically, the state has long been home to some of the world's leading large-scale corporate research operations. Leading-edge research activities have now shifted from such facilities in New Jersey to locations near the major national research universities outside of the state, with the attendant loss of high-paying jobs and the economic spin-offs that typically accompany that research. At the same time, New Jersey has not been nearly as competitive in supporting its research universities. Thus, New Jersey is losing at both ends of the shifting paradigm of industrial R&D.

These new industrial R&D facilities are going to such locations in part because of the access they provide to university-based research "stars" and facilities, and the resulting leveraging of corporate resources from the large federal grants awarded to universities. This adds another dimension to the state's economic losses stemming from the new business model. In general, new corporate research facilities are now being located outside of New Jersey.

The Policy Imperative

The incipient and relative slippage of the New Jersey economy has only recently become apparent. This erosion was initially obscured by the unprecedented national surge in information technology capital investment of the second half of the 1990s and the accompanying stock market bubble, then by the sheer momentum of the state's relative affluence through the severe 26-month-long national employment downturn (March 2001 to May 2003). It was subsequently masked by the positive statistics emanating from the current economic recovery and expansion. In addition, record-low interest rates and massive federal deficit spending sustained consumption and led to a national housing boom (and possible bubble), with New Jersey as one of its epicenters. But it is now becoming clear that New Jersey's once preeminent technology-based economic position is at serious risk.

Because of New Jersey's high relative income and wealth advantage, the state can live off its historic assets, even while they are eroding, with only minimal current near-term economic consequences. Thus, it may be tempting to give lip service to future economic imperatives while continuing to concentrate on more immediate short-term issues, problems, and demands. But at some point, without positive public policy responses, the slippage may not be reversible. The longer that the slippage is not challenged, the greater the probability that it will not be reversible.

What Is New Jersey To Do?

What will ensure the long-term prosperity of New Jersey? Can the state do anything to reinvent its economy a third time in order to replicate the sustained, better-than-national economic performance of the past? It was this ability of New Jersey to outperform the national economy that gave the state its current high income and high wealth status.

In an ever more competitive global economy there are no guarantees that this status will continue. The fundamental questions are: Do public decision makers and the broader population of the state understand that New Jersey has likely entered a new era of below-average economic growth? Does it matter to them, and if so, what can be done about it? While a number of effective business incentive programs exist, and several state agencies are dedicated to economic development, state policy has not given high priority to, or major, sustained investments for, growing the economy.[20] Instead, policy debates focus on such issues as property tax reform, ethics and pay-to-play, K-12 educational equity, and the inevitable myriad special interests that compete for support during each state budget cycle. More than 40 percent of the state budget is sent back to school districts and to municipal and county governments in the form of various state aid programs.

Essentially, the choice is whether New Jersey can continue to be production oriented with significant, externally supported industries (businesses that produce goods, services, and/or knowledge and innovations) that leverage out-of-state and out-of-nation resources into the state's economy. It is such externally generated resources that increase economic well-being and the quality of life within New Jersey. Or, will New Jersey continue, as it has over the last five years, to move toward a consumer-based economy? In such an economy, locally serving industries (e.g., retail trade, housing, leisure and recreation, transportation and warehousing, direct health care) are supported primarily from in-state income, thus limiting New Jersey's growth potential.[21] With such locally serving industries acting as engines of the economy, rather than externally supported industries, New Jersey's economic performance will lag that of the nation, and its relative economic advantages are likely to continue to erode.

Externally Supported Industries

One effective way New Jersey can avoid this outcome is to focus on those externally supported science and technology industries that can significantly increase income and build wealth. That is, the state's focus must be on creating, growing, and sustaining the high-value added, high-productivity businesses that generate external

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[20] The New Jersey Economic Development Authority, the New Jersey Commission on Science and Technology, the New Jersey Commerce, Economic Growth, and Tourism Commission, the New Jersey Treasury, and the New Jersey Department of Labor and Workforce Development have significant portfolios of programs, incentives, and policies to encourage economic development.

[21] It is certainly possible that externally supported industries outside of science and technology can also draw significant resources into New Jersey. Tourism and recreation are examples of such industries and a number of states use these to generate economic growth. In New Jersey, the casino industry is estimated to generate about half of its revenues from out-of-state customers. New Jersey's shore tourism industry also attracts significant external resources and is able to retain large amounts of New Jersey tourist dollars within the state. However, these industries are all characterized by below-average wages.

revenues. New Jersey cannot compete by producing less sophisticated goods or services for export to out-of-state buyers. The state's high relative costs of doing business and the proliferation of production capacity in these low-end industries elsewhere throughout the world make competition for these industries futile for New Jersey. Moreover, the global proliferation of capacity in the high-end industries of the present is a major cause of the current erosion of New Jersey's former economic advantages.

New Jersey needs to create and sustain an economic and entrepreneurial environment conducive to the growth of new, high-knowledge-content, high-value-added businesses. However, this strategy has also been the goal of many other states, and there have been numerous state efforts to promote science- and technology-driven economic growth. There is a vast literature of recommendations from myriad studies, commissions, task forces, and governmental offices across the nation that, in response to distress in their state economies and/or visions of the state economy of the future, have come to this same conclusion. Planning for the establishment of a state-based science and technology policy is heavily plowed ground, and many states have aggressively moved to identify effective policies and commit expertise and resources to implement them.

Policy Framework

In general, policy recommendations to support science and technology can be organized on a continuum from broad generic policies – improve the state's business climate, invest in education at all levels, provide for workforce development, build efficient transportation networks, reduce regulatory costs and barriers – to very specific policies that provide resources and/or incentives to create innovations and then assist their commercialization in targeted scientific activities. Such strategic policies would include, for example, making significant amounts of venture capital available at the various stages of new business development, making tax code changes that permit loss-carryover allowances for small technology-based businesses, establishing business incubators with specialized science and technology services, and making specific public investments (in equipment, facilities, personnel) in targeted scientific research areas aligned with research universities.

Another vital part of this policy spectrum is aimed at creating the pre-conditions necessary for the emergence of entrepreneurs and small start-up firms so that the pipeline of innovations and of potential new firms is continuously full and expanding. In addition to the policies mentioned above, this requires close cooperation with, and support of, university-based strategic research areas and university-generated technology transfer and commercialization processes. It also requires an awareness and commitment by the research universities of the importance of developing intellectual property from the work of their faculty and research centers and embracing economic growth as part of their institutional mission.

Implementing the full continuum of policies can be viewed as improving the overall business environment and ultimately the economic performance of all businesses within a state from established large firms (e.g., the pharmaceutical industry in New Jersey) to small life-science and technology-based start-up firms. With considerable support and nurturing, these later firms could develop into major externally supported businesses, either through their own growth or through collaborations with, or buyouts from, larger established firms.

In an ideal fiscal environment, a state could carefully design and commit the necessary resources to implement key elements across the entire continuum of best-practice policies that would support economic development in general, and science- and technology-driven economic growth in particular. However, limited resources and the accompanying need to make strategic decisions in the use of these resources is the prevailing condition in New Jersey.[22] Accordingly, the focus of a science and technology policy in New Jersey should be to complement New Jersey's economic strengths and to implement specific actions that improve the science and technology entrepreneurial environment and increase the probabilities of commercial success and growth. A key

[22] The New Jersey Commission on Science and Technology budget grew steadily during the 1990s and exceeded $20 million in FY 2001. It declined to $8.8 million in FY 2005 but has, encouragingly, increased to $15.2 million in FY 2006, mostly due to the stem cell research allocations.

element of this is the support of strategic components of research universities that generate subsequent economic innovation, private investment, and business growth.

Policy Principles

Before specific recommended policies are discussed, it is vital to understand that success in this highly competitive area of achieving science-based economic growth requires adherence to several general principles. First, the policy strategies discussed in this report will require *significant resources*, particularly for the strategy of building research excellence in a limited number of targeted areas of science and technology. Second, the commitment of these resources must be on a *scale that can make a threshold difference* and must be *sustained* over the inevitable pressures of the political cycle. Third, the seductive temptation of the political process to *spread resources, must, at all costs, be avoided.* For example, providing something for all geographic areas of the state, or for many small projects, or for a large number of scientific areas, are all approaches that are doomed to failure. Fourth, an impeccable and thorough *peer-review process* must be the basis for all allocations of investments in science and technology.

Three Policy Areas

A major effort to define a science and technology policy for the state was recently made by the Commission on Jobs, Growth, and Economic Development.[23] The report of this broadly constituted commission, completed in October 2004, provides a highly useful and carefully considered set of policy recommendations. Extensive supporting documents for the report reviewed the status of science and technology strategies across the United States and provided a detailed inventory and assessment of parallel efforts in many states. The report and a number of its recommendations are the best available and most current assessment of the status of high-technology industries in New Jersey and how the state can promote science and technology based economic growth. It further defines an important role for the New Jersey Commission on Science and Technology in

[23] Commission members were drawn from the business, public sector, academic, and science and technology communities of the state. See *Strengthening Our Innovation Triangle*, Report of the Commission on Jobs Growth and Economic Development, Submitted to Governor James E. McGreevey, October 2004.

both the process and the substance of developing and implementing a strategic policy of science-based economic growth.

A review of this thorough report, along with a large number of similar efforts from other states, together with the need to make prudent but effective recommendations recognizing New Jersey's fiscal realities, leads to a focus on three policy areas. The *first* is **to build the capacity of the research universities of New Jersey** in strategic areas that complement economic development. This encompasses a range of objectives from increasing the share of federal research awards to New Jersey to raising the rate of achieving commercial fruition of university intellectual property. The goal is to build the conditions that generate a large and expanding number of research discoveries that potentially can lead to commercial success.[24] Obviously, large amounts of research occur in existing, well-established firms, and this research is also aimed at successful commercialization. Ensuring that New Jersey has a supportive business environment for such firms and their research is also a critical part of a successful science and technology policy. These firms typically have the resources to conduct the research and provide the substantial, multidimensional, in-house expertise to evaluate, finance, develop, and manage the research into commercial fruition. Given limited state resources, however, the focus of the *first* set of recommendations is to significantly **raise the capacity of research universities** in order to increase the number of discoveries, and then to provide the critical and complex assistance such innovations require *before* they can become businesses and contribute to the economic growth of New Jersey.

The *second* policy focus is to build the **entrepreneurial environment** of the state so that the larger number of the new science and technology businesses resulting from the first set of policies and from other entrepreneurial activity can develop and mature at every phase of the business growth process. This is a vital component of a successful

[24] A familiar, and spectacular, example of the possibilities of a research university–generated idea developing into an enormous engine of economic growth is Google. Two Stanford University computer science graduate students, Larry Page and Sergey Brin, with an idea about search engines and a willingness to take risk, attracted early-stage investors and ultimately turned their idea into Google—now a publicly traded company with over 4,000 employees and a current capitalization (as of early November 2005) of $114 billion. The company has been a major source of externally supported growth for California. In 2004, Google's revenues were $3.2 billion, mostly from out-of-state customers!

strategy and requires, as the Jobs Commission Report notes, the collaborative action of the triangle of academic, business, and government sectors.

Finally, the *third* policy area focuses on limited, **specialized assistance to existing mid-sized and even large science and technology businesses**. The rationale is that these businesses already are contributing significantly to the state's economy. Ensuring their ongoing competitiveness is of vital importance. Promoting and supporting the development of new ideas and new firms through the first two policy areas is important, but this general approach cannot be the long-term, *sole* source of generating growth for the economy. Accordingly, some specialized assistance for the existing technology-based companies of New Jersey is also warranted and appropriate. More generally, discussions with individuals in these businesses indicate that such firms place priority on such factors as ensuring a competitive tax and regulatory environment, reducing restrictive land-use controls, raising the quality of educational systems, and improving workforce skills.

Research University–Driven Economic Growth

This section discusses the essential elements that comprise an integrated portfolio of policies to raise the level and effectiveness of the research universities to contribute significantly to science- and technology-based economic growth. While the focus is on the research function of universities, it is important to acknowledge the role of education at all levels and its importance in economic development. Improving the education and training of the national workforce is a fundamental factor in the ability of the American economy to compete given the increase in skills, technology, and education across the world. Beyond the issue of the amount of resources dedicated to education at all levels, a repeated theme heard from the business sector is the need to change what is taught and how it is taught as a prerequisite for economic success. Initiatives such as the Partnership for 21st Century Skills argue for such a systematic change in education in America.[25] New Jersey, with its very considerable public investment in education, particularly at the

[25] See "The Road to 21st Century Learning," Partnership for 21st Century Skills (www.21stcenturyskills.org).

K-12 level, should be a leader for changes that align with and complement the new economic realities.

At the more narrow focus of the research function of universities and as a first principle, the ability of research universities to compete for federal research dollars and increase their capacity to make new discoveries is derived from achieving excellence in the academic quality of their faculties, research facilities, and intellectual environments.[26] All else follows from this.

The stakes are very high. In 2003, the federal government awarded $24.4 billion to colleges and universities in grants for science and engineering research and development (see Table 11). Maryland (where Johns Hopkins University is located) has 1.9 percent of the nation's population but received 6.2 percent of these federal grants ($1.5 billion). California, with 12.2 percent of the nation's population, was awarded 13 percent of the total grants ($3.2 billion), the largest share of any state. Massachusetts, with 2.2 percent of the nation's population, received 5.6 percent of the grants. All these states received grants significantly in excess of their population shares. However, New Jersey, with 3 percent of the nation's population, received 1.5 percent of the federal research grants ($361 million), or only half of its population share.[27] Between 1998 and 2002, federal research funding increased by 64 percent from $14.9 billion to $24.4 billion. New Jersey's 1.5 percent share of total federal research grants was unchanged over this period. Thus, although New Jersey was able to increase the absolute amount of federal research funding it received, it increased this funding at approximately the same rate of increase in total federal funding, leaving the state's share of federal research awards to colleges and universities constant.[28]

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[26] Such increased capacity will also raise the ability of research universities to attract industry and foundation research support.

[27] A recent report by the New Jersey Commission on Higher Education called on the state to strive to increase its share of federal research grants by 0.1% a year for ten years. See "Target Areas for Enhanced Research Funding and Milestones Toward an Improved National Ranking," New Jersey Commission on Higher Education (Trenton), January 21, 2005 (www.nj.gov/highereducation/ResearchReport.htm).

[28] It is important to be totally clear that this report is *not* advocating an allocation formula for these grants based on population share. Peer review should be, and must remain, the prevailing protocol for the allocation of these federal resources.

Table 11
Federal R&D Funding for Colleges and Universities and Population Shares for the 50 States, 2003
Ranked by Share of Total R&D Funding

Rank	State	Federal R&D Funding		Population		Ratio of Federal Funds Share to Population Share
		Total Dollars (000s)	Share	Total	Share	
	United States	**24,447,196**	**100.0**	**290,231,356**	**100.0**	
1	California	3,183,762	13.0	35,462,712	12.2	1.1
2	New York	2,014,483	8.2	19,212,425	6.6	1.2
3	Texas	1,551,740	6.3	22,103,374	7.6	0.8
4	Maryland	1,503,759	6.2	5,512,310	1.9	3.2
5	Pennsylvania	1,444,109	5.9	12,370,761	4.3	1.4
6	Massachusetts	1,379,361	5.6	6,420,357	2.2	2.6
7	Illinois	963,582	3.9	12,649,087	4.4	0.9
8	North Carolina	838,312	3.4	8,421,190	2.9	1.2
9	Michigan	792,521	3.2	10,082,364	3.5	0.9
10	Ohio	742,798	3.0	11,437,680	3.9	0.8
11	Florida	667,688	2.7	16,999,181	5.9	0.5
12	Washington	642,216	2.6	6,131,298	2.1	1.2
13	Georgia	638,395	2.6	8,676,460	3.0	0.9
14	Colorado	534,716	2.2	4,547,633	1.6	1.4
15	Missouri	519,515	2.1	5,719,204	2.0	1.1
16	Wisconsin	504,352	2.1	5,474,290	1.9	1.1
17	Virginia	482,743	2.0	7,365,284	2.5	0.8
18	Connecticut	418,449	1.7	3,486,960	1.2	1.4
19	Alabama	409,919	1.7	4,503,726	1.6	1.1
20	Tennessee	382,619	1.6	5,845,208	2.0	0.8
21	New Jersey	361,046	1.5	8,642,412	3.0	0.5
22	Arizona	341,715	1.4	5,579,222	1.9	0.7
23	Indiana	327,720	1.3	6,199,571	2.1	0.6
24	Oregon	317,704	1.3	3,564,330	1.2	1.1
25	Minnesota	297,693	1.2	5,064,172	1.7	0.7
26	Iowa	284,091	1.2	2,941,976	1.0	1.1
27	Utah	264,170	1.1	2,352,119	0.8	1.3
28	South Carolina	226,288	0.9	4,148,744	1.4	0.6
29	Louisiana	224,077	0.9	4,493,665	1.5	0.6
30	Mississippi	207,790	0.8	2,882,594	1.0	0.9
31	New Mexico	199,607	0.8	1,878,562	0.6	1.3
32	Kentucky	172,464	0.7	4,118,189	1.4	0.5
33	New Hampshire	165,497	0.7	1,288,705	0.4	1.5
34	Kansas	155,589	0.6	2,724,786	0.9	0.7
35	Hawaii	148,662	0.6	1,248,755	0.4	1.4
36	Rhode Island	133,560	0.5	1,076,084	0.4	1.5
37	Oklahoma	127,055	0.5	3,506,469	1.2	0.4
38	Nebraska	106,040	0.4	1,737,475	0.6	0.7
39	Nevada	103,532	0.4	2,242,207	0.8	0.5
40	Montana	84,991	0.3	918,157	0.3	1.1
41	Arkansas	82,294	0.3	2,727,774	0.9	0.4
42	Alaska	77,061	0.3	648,280	0.2	1.4
43	West Virginia	73,522	0.3	1,811,440	0.6	0.5
44	Delaware	73,129	0.3	818,166	0.3	1.1
45	Vermont	71,982	0.3	619,343	0.2	1.4
46	North Dakota	66,276	0.3	633,400	0.2	1.2
47	Idaho	55,928	0.2	1,367,034	0.5	0.5
48	Maine	31,293	0.1	1,309,205	0.5	0.3
49	South Dakota	28,195	0.1	764,905	0.3	0.4
50	Wyoming	23,186	0.1	502,111	0.2	0.5

Source: National Science Foundation, Division of Science Resources Statistics, *Academic Research and Development Expenditures: Fiscal Year 2003,* NSF 05-320; U.S. Census Bureau Population Estimates.

At a first level of impact, these federal research grant dollars generate a very large and positive economic effect on a state's economy from the simple fact that they are spent. The spending process itself, through straightforward economic multiplier effects, generates significant secondary economic benefits as buildings are constructed or renovated; equipment bought; scientists, technicians and staff hired; supplies of all types purchased; and so on. Moreover, the higher the quality and depth of the academic and business research environments within a state, the larger the percentage of those federal dollars that will be spent within the state receiving the awards. A sustained federal flow of more than $1 billion per year in technology-oriented research grants over the course of a decade for a state the size of Maryland represents a huge economic impact directly from the business transactions of spending that scale of money annually on the types of sophisticated personnel and materials necessary to conduct the research.

At a second, and more profound, level of impact, these federal grants lead to all the agglomeration benefits of associated private business activities that cluster around large concentrations of science-based research. In addition, such activity enhances the probabilities of successful commercial development of innovations and intellectual property derived from, directly or indirectly, this clustering of science and technology research. The likelihood of commercial success is improved by a readily available, highly skilled workforce trained at the nearby research universities, an extensive and efficient network of suppliers, and the wide range of entrepreneurial services, including sources of venture capital, that also are attracted to the concentration of research activity.

The Jobs Commission Report documents that New Jersey has recently significantly increased its federal research grants. However, both the total dollar amount of the awards and the relative share of federal research dollars awarded to New Jersey can be significantly improved further, especially given the science and technology economic base in the state and New Jersey's legacy in research accomplishments.[29]

[29] As noted previously, New Jersey currently ranks dead last among the fifty states in federal expenditures per federal tax dollar paid. Increasing the amount of federal research grants, particularly those that are competitively awarded, is one highly beneficial way New Jersey can significantly improve on this performance.

To accomplish this, many states have identified strategic research areas to develop and invest in appropriately. The goal is to improve the state's ability to compete for federal research support in these areas and to attract additional private research and economic activity. The additional expectation is that there will be, in time, a significant increase in the commercial development of this research.

The Jobs Commission designated a number of scientific areas in which the state should strive to build centers of excellence.[30] A consolidation of these designated areas and an additional new research opportunity are presented in Table 12. There is considerable existing research strength in these areas in the state although that strength is not evenly developed. Therefore, building further excellence would require varying degrees of investment and attention. A guiding principle for state investment in these areas, given that choices would likely have to be made among them, is to concentrate resources on those where the economic payoff for the additional investment is highest. As noted previously, but worth repeating, the state should not – as it has so often done in parallel situations with respect to other public policy objectives – spread its scarce resources thinly, in this case across all scientific areas, or across all geographic regions of the state. It is also important to note, however, that the scientific areas are not mutually exclusive. Common research themes exist across a number of the designated centers. For example, within nanotechnology, a focus could be developed in biomedical applications. A similar biotechnology focus, e.g., in advanced imaging, can exist in information technology and in aspects of homeland security.

[30] These areas were identified from a large collaborative effort between state government and the state's research universities as part of the work of the Jobs Commission to target scientific areas and associated specific research proposals most appropriate for state investment. The areas listed in Table 12 were chosen on scientific merit, the potential of large amounts of federal research support, and the integration of the research outcomes with the economic development of the state. The Jobs Commission Report designated these as areas to build centers of excellence at the state's research universities.

Table 12
New Jersey's High Potential Research Development Areas

Research Area	Description	Opportunity
Nanotechnology and Advanced Materials	There is significant nanotechnology and advanced materials research capacity at many NJ academic institutions, including NJIT, Rutgers, Princeton, Stevens Institute and UMDNJ. The state's large healthcare and pharmaceutical industries can serve as strong drivers of biomedical nanoscience research, drawing on this strong academic capacity, and homeland security applications also present new opportunities.	The federal government invested over $6 billion in nanotech in 2003. The NSF, DOE, NASA, NIST and EPA are authorized to spend $2.36 billion on nanotech research over the next three years under the National Nanotechnology Research and Development Act of 2003, and the 21st Century Nanotechnology Research and Development Act is expected to provide additional substantial funding for research grants and centers.
Life Sciences	Recent studies have indicated that New Jersey may be losing its edge in the life sciences, as some of its leading pharmaceutical companies have opted to build new research facilities near top-level university research centers in Boston, San Francisco and elsewhere. New Jersey has significant university research capacity in a broad range of cutting-edge life sciences fields, including genetics and genomics, bioinformatics and computational biology, biodefense, and stem cell research. Facilities include the Lewis Sigler Institute for Integrative Genomics at Princeton, Rutgers' Protein Data Bank and Human Genetics Institute, and UMDNJ's Informatics Institute. The state's large-scale pharmaceutical and biotech industries rely on strong research and training in these fields for continued growth.	Funding for the NIH's National Human Genome Research Institute has increased significantly since its establishment in 1989, to $497 million in fiscal 2004. With strong state commitment to stem cell research and a broad array of research efforts in genetics and related fields, New Jersey's universities are well-positioned to capitalize on expected funding increases in these areas from both federal government and industry sources. A life sciences center would provide for sustained interaction between universities and industry.
Tele-communications	Contraction of industry investment in telecommunications research and development is causing some of New Jersey's top researchers in the field to leave for other states. The state needs to maintain its position in this industry to prevent employment declines and further loss of R&D capacity. Homeland security needs are driving demand for new technologies in wired and wireless communications and related fields.	A telecommunications center would bring together academic expertise and industry resources for development of new technologies with high commercial potential and important homeland security applications.
Information Technology	Advancements in the IT sector can act as a key component of R&D in a range of applications, from biology and medicine (advanced imaging technology and bioinformatics) to telecommunications and a wide range of homeland security applications (cryptography, cyber security, disaster and response modeling, etc.). New Jersey has strong research facilities in all these areas of applied IT, including programs and centers at Rutgers, UMDNJ, Montclair, Lucent-Bell Labs, and others, and an NSA Center for Academic Excellence in Information Assurance at NJIT.	A center bringing together state efforts in IT would help to improve institutions' ability to draw large-scale multidisciplinary grants in a wide range of fields. The Department of Homeland Security S&T budget for 2004 was $803 million, and research in the technologies underlying DHS-funded research directions will be supported by additional grants from other agencies.
Alternative Energy	New Jersey currently devotes a percentage of its utility revenues to fund clean energy programs (the Societal Benefits Charge). The state's strong renewable energy portfolio standard requires that 6.5% of electricity sold in the state come from renewable sources by 2008, and the "solar set-aside" portion of the RPS has already begun to spur photovoltaic business activity in the state. Policies such as these will help to expand demand for increasingly efficient alternative energy sources, leading to continuing agglomeration and demand for new technologies.	The DOE has several R&D grant programs, including: $75 million in grants given for hydrogen production and delivery research in 2003-04; $150 million for three federal "centers of excellence" in hydrogen storage research; $102 million and $12 million for SBIR and STTR programs, respectively; and an Inventions and Innovation program offering grants of $50,000-$250,000 for development of new technologies in a broad range of renewable energy fields.

With some irony, it should be noted that the original focus of the New Jersey Commission on Science and Technology was the identification of research areas of significant economic potential, the subsequent construction of capital facilities in these areas, and the recruitment of excellent scientists. This strategy was highly successful and became a model for other states. Unfortunately, other states have embraced and extended this approach, leaving New Jersey behind after its initial leadership position. For example, Texas recently focused on information technology to spur economic growth and recruited 100 new computer science faculty. Kentucky implemented a bluntly named program, "Bucks for Brains," with significant financial support for endowed professorships. New York funded new faculty positions and new centers of excellence in bioinformatics (SUNY Buffalo), photonenics and optoelectronics (University of Rochester), and nanoelectronics (SUNY Albany). The Georgia Research Alliance identified three strategic areas for investment (advanced communications, biotechnology, and environmental technology) and leveraged public resources with private resources to recruit more than 35 new faculty in these areas.[31] New Jersey needs to return to this basic policy of funding centers of excellence in strategic economic areas with appropriate protocols that respect fiscal constraints and the need to leverage state investments with private resources.

Accordingly, a singular priority for New Jersey science and technology policy should be to establish state-of-the-art centers of excellence at the state's research universities, with strong business collaborations, in each of the areas identified in Table 12. There should also be associated resource commitments to attract the very best scientists. The current proposal to build and staff a New Jersey stem cell institute of national excellence is the model to repeat in other areas.[32] The New Jersey Commission on Science and Technology should determine the next scientific area of priority among those listed in Table 12 to establish a center of excellence at one or more of the state's

[31] For more details, see "A Governor's Guide to Building State Science and Technology Capacity," National Governors Association, Washington, D.C., 2002.
[32] The proposed New Jersey stem cell initiative ($380 million investment in capital and research grants) could result in over 20,000 jobs and $1.4 billion of direct economic benefits to New Jersey. See, J.J. Seneca and W. Irving, "The Economic Benefits of the New Jersey Stem Cell Initiative," E. J. Bloustein School of Planning and Public Policy, Rutgers University, June 2005 (www.policy.rutgers.edu/stemcell.pdf).

research universities. The Commission, in collaboration with the state's research universities and with private industry, should provide the comprehensive planning to bring the center to fruition. The Commission should also develop priorities and a timetable to create centers in the remaining areas in Table 12.

The scale and extent of initiatives in other states to create centers of research excellence are impressive. Michigan has created a NextEnergyZone for alternative energy technologies that houses a center, research facilities, and incubator space along with an accompanying comprehensive portfolio of supporting tax-incentive and educational policies. California made a significant commitment to nanotechnology for institutes at UCLA and UC Santa Barbara and has significantly leveraged federal and corporate resources to complement the state's investment. California's recent bold $3 billion plan for stem cell research is an unprecedented level of investment in scientific research for a state. Kansas has supported a number of science centers (e.g., biomedical, advanced materials, and polymers) at its universities. Kentucky is funding research centers at universities in imaging, energy, and agriculture. Thus, extensive and selective investments in research centers to promote economic development are now being made by numerous states.[33] New Jersey needs to return to this proven approach, which it ironically helped to pioneer, in a systematic and aggressive manner.

Not all of the scientific areas identified in Table 12 necessarily require a facility. Research centers could be formed on a distributed basis across institutions where centralization, space, and proximity of the participants are not required. However, all areas require the recruitment and support of the very best scientists and technical staff and access to state-of-the-art scientific equipment.

In summary, building centers of excellence in New Jersey at the research universities in order to support economic growth requires policies that provide:

[33] See "A Governor's Guide to Building Science and Technology Capacity," op.cit.

1. Capital investment in state-of-the-art facilities and equipment in the targeted areas of scientific excellence.

2. Sustained and competitive resource commitments on a scale necessary to attract the best scientists, graduate students, and undergraduates.

Additional policies that are needed to support science and technology based economic growth from research universities include:

1. Grant-matching commitments for strategically selected federal research proposals.[34]

2. Establish a New Jersey Research Alliance. Modeled on the successful Georgia Research Alliance, this would be a partnership of the state's research universities, with state and institutional investments made in joint research facilities and equipment, coordinated hiring of distinguished scientists in order to compete for national centers of excellence in a multidisciplinary and multi-university framework, and collaborative efforts to bring intellectual property to commercial fruition and success.[35]

A necessary and vital component of enhancing the state's economic growth through science and technology is to bring the innovations that emerge in research universities to commercial fruition. Increasing the level of research expenditures by building excellence in faculty, students, and capital facilities will lead to increased research grants from all sources. One goal of the higher level of research expenditures is

[34] Key federal research opportunities can be targeted (i.e., federal programs where no current award exists in NJ and which align with the designated areas of excellence – e.g., an NSF Engineering Research Center in biomedical engineering). Aggressive state matching support for such proposals would be provided.

[35] For a useful description of the Georgia Research Alliance, see www.gra.org. A New Jersey Research Alliance would make necessary adjustments given the structure of our state's research universities and the various comparative strengths across the universities. However, the Georgia Research Alliance is a bold and effective organizational change in the traditional culture of higher education institutions as single, free-standing, independent, competitive entities.

to increase the flow of innovations, disclosures, patents, licenses, and early stage companies generated by the state's universities. This requires a supportive and effective technology transfer environment at the universities and a commitment by the universities to these activities as an important part of their mission. There is mixed evidence concerning the current relationship between research expenditures at the state's research universities and the commercialization indicators noted above.[36] Accordingly, the following recommendations are made to increase the commercialization rate of university research in New Jersey:

1. Increase disclosures of potential intellectual property by faculty.

2. Provide proof-of-concept funding for advancing intellectual property, and establish and expand programs to enhance technology companies' access to university labs and services for proof-of-concept and other research needs.

3. Match private capital for university start-up firms.

4. Raise the capacity and depth of technology transfer offices at public research universities. The NJCST has begun making grants to university tech transfer offices, distributing $1 million in fiscal year 2005, with more planned for fiscal 2006. This program should be should be expanded with support from universities and the state, and supplemented by additional programs, such as support for entrepreneurs in residence to work with university technology transfer offices on identifying and commercializing viable innovations.

[36] Obtaining consistent data for the production of intellectual property across higher education institutions is challenging. Surveys by the Association of University Technology Managers (AUTM) indicate that Rutgers University has higher than national averages in the production of U.S. patent applications and invention disclosures per million dollars of research expenditures, and is at the national average in terms of adjusted gross license income and U.S. patents issued per million dollars of research expenditures. Other data sources, not necessarily measured consistently, indicate that Princeton University also has above average intellectual property output per million dollars of research expenditures, but that other New Jersey research universities trail the national averages. See, *AUTM Licensing Survey, FY 2003 Survey Summary,* editors Ashley J. Stevens and Frances Toneguzzo.

5. Provide state matching support for industry-sponsored research at universities.

6. Provide incentives to jointly develop intellectual property across universities and support collaborative efforts to commercialize this property across technology transfer offices.

7. Expand support on a sustained basis of university incubators for strategic areas of scientific excellence with special emphasis on providing the equipment and technical, financial, and business services needed by start-ups in these areas.

Enhancing the Entrepreneurial Environment

The second policy focus is to ensure that the flow of innovations that exist from entrepreneurs in the state and that also emerge from greater levels of research activity in key science and technology areas moves successfully from the discovery stage to commercialization. The pyramid of innovations that have potential economic viability narrows rapidly to a very much smaller number that ultimately achieves commercial success. There is a high mortality rate of enterprises along the growth path from innovation to becoming a start-up to developing into a growing small business, and ultimately to emerging as a large, established major firm.[37] Accordingly, the issue is how to increase the prevailing low probabilities facing a start-up technology-based business in terms of successfully reaching more mature phases of the business development process.

The Jobs Commission report appropriately focuses on several key policies that can improve the entrepreneurial environment in New Jersey in ways that can lead to increased success for technology businesses. The general approach to an effective policy portfolio is what the Jobs Commission termed *"financial incubation."* This means, for

[37] A ranking of states according to a small business "Survival Index" places New Jersey 44th among the 50 states, indicating that there is room to improve the conditions that lead to successful commercialization. New Jersey has had many successes, however, and a recent example is Vonage Holdings Corporation, a company that provides telephone service over the Internet. This grew from an idea to a small company to a firm with 1,500 employees, with a pending initial public offering. The goal of improving the entrepreneurial environment of the state is to increase the number of such successes.

example, that the state should provide ready access to the financing new business ventures need at every stage of initial development. A repetitive theme of numerous studies, interviews, and surveys across the nation, and in discussions with individuals in New Jersey for the preparation of this report, is that the single largest issue for new firms is obtaining financing and thereby reducing the uncertainties of early-stage business development. Accordingly, an emphasis should be placed on providing effective and flexible access to capital for new and emerging science and technology companies.

A number of state programs provided *capital for new science and technology businesses*, and the Jobs Commission recommended several extensions and improvements. The New Jersey Commission on Science and Technology offers grants to provide working capital to companies that are moving into SBIR Phase II federal funding but are currently between federal grants. The Commission also provides funding for human capital to small tech companies through its Technology Fellowship program. These and similar grant programs represent the initial stage in state financing and should be enhanced.

Recently, the New Jersey Economic Development Authority reorganized its programs in order to provide an accessible and comprehensive continuum of financing and services to early-stage technology companies. This newly reorganized program portfolio– the Techniuum program –makes long-term loans from $100,000 to $1 million on an increasing basis to support companies' development at each phase of growth. Other assistance is also provided in the form of rent subsidies and technical support. An additional forthcoming program will provide insurance guarantees to angel investors in early-stage science and technology companies. The development of a widely marketed, accessible, one-stop, life-cycle support process is highly valuable and needed. The effectiveness of state programs would further benefit from additional elements, such as:

1. Close coordination between the New Jersey Commission on Science and Technology (NJCST) and the New Jersey Economic Development Authority (NJEDA) in identifying companies that would benefit from the funding and

services offered by either or both agencies, and assisting these companies to obtain necessary matching support.

2. An increased supply of venture capital funding drawn from state pension resources and the residuals from the state's Business Employment Incentive Program (BEIP).[38]

3. An examination of the Maryland Technology Development Corporation as a possible model for extending New Jersey's Techniuum program to include state equity investment in early-stage science and technology businesses.[39]

A second important component of the policy portfolio to improve the rate of successful business development of new firms is *technology incubator support and targeted tax, subsidy, and regulatory incentives.* These policies can provide effective assistance at critical points along the path from scientific innovation to commercialization. The following would be specific components of this portfolio.

1. The Commission on Science and Technology should work with the NJEDA on real estate and construction financing for development of additional technology incubators, and should increase support to improve the effectiveness of programs of existing incubators as recently done at the Enterprise Development Center at NJIT and at other incubators. The Commission should designate additional specializations (e.g., for biotech firms) and determine appropriate locations within the state. The choice of location of the additional incubators should promote further clustering of science and technology research and related business activity in conjunction with the development of additional centers of university excellence in science and technology, as previously discussed.

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[38] These "residuals" are the personal income tax revenues remaining with the state after the rebates of such taxes paid to qualifying employers who have created net new jobs.
[39] See, www.marylandtedco.org, and the Maryland Department of Business and Economic Development, www.choosemaryland.org.

2. New Jersey's net operating loss provisions should be expanded so that losses can be used for a longer period of time. The time limitations recently placed for revenue-raising purposes on the net operating loss should expire. The sale of net operating losses – the Technology Tax Certificate Transfer Program – is the largest program the state has to provide capital to early stage companies. The program should be evaluated to ensure it continued effectiveness, and if warranted, the program's resources should be increased.

3. Technology business tax credits for jobs created, investment expenditures, or research and development expenditures should be expanded. New Jersey has a variety of such tax credit programs, and the general approach of providing tax credits for new economic activity in science and technology is common across the states. New Jersey should review its existing programs with the goal of increasing their attractiveness, simplicity, coordination, and degree of applicability (e.g., extend the existing tax incentives in the three New Jersey Innovation Zones to the entire "innovation" state).[40]

4. Another appropriate change in the existing tax incentives of New Jersey is to more aggressively market the Business Employment Incentive Program to *new* science and technology firms.[41] The amount of the award could also be increased for the targeted science and technology business areas.[42]

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[40] Pending legislation would extend the geographic coverage of Innovation Zones; see Assembly No. 3770, State of New Jersey, 211th Legislature, 7 February 2005.

[41] Although new firms are eligible for this tax rebate, nearly all of the awards in this program have been made to firms relocating to New Jersey or to existing firms expanding in New Jersey. The BEIP and its accompanying incentive of Business Retention and Relocation Assistance Grants (BRRAG) have been successful in attracting and retaining exactly the type of high-paying jobs that the state has been losing. In the absence of these programs, the state's high-paying job losses, documented earlier in this report in manufacturing (including pharmaceuticals), finance, and business and professional services, would have been significantly higher.

[42] Existing protocols provide for a 5% bonus if the firm is in the targeted business areas. That amount could be increased significantly to improve the incentive.

5. Tax incentives for firms to transfer patents to other firms that could expand research to improve commercial viability should be provided.

6. Tax credits for rapid-growth science and technology companies should be provided to mitigate the tax impact of a new firm having a very successful year. This recognizes the typical upside volatility of earnings of new companies and is a symmetric incentive to the net operating loss program.[43]

7. Subsidies for rental charges to tenants at state sponsored incubators should be provided.

Specialized Support for Existing Technology Business

There is a large existing core of science- and technology-based companies in New Jersey that warrant support and attention. Beyond ensuring a competitive business climate with respect to taxation and regulation and paying attention, at the highest levels of state government, to the issues and opportunities of these businesses and their associated industries, what specific additional assistance can the state provide?

One potentially useful, but limited, policy is to develop university research institutes that provide applied research services for targeted science and technology industries. These are university-operated institutes that lie outside the traditional academic organization. Their focus is to provide applied research and related technical services for industry. Examples are the Georgia Tech Research Institute, a part of the Georgia Institute of Technology, which works closely with industry and government clients to carry out approximately $100 million of annual research, and SRI International, founded and formerly owned by Stanford University, which carries out a broad range of contract research services ranging from drug development to artificial intelligence.[44]

[43] The fast-growth tax incentive provided by Georgia is a useful policy model. See Jobs Commission Report, Appendix, p. G-39 and www.georgia.org/economic/incentives/10_small_bus.htm, Georgia Department of Economic Development.
[44] For detailed descriptions, see www.gtri.org and www.sri.com, and Appendix I of the Jobs Commission Report.

Such institutes have also been extensively developed in Germany as part of a national economic strategy. Nearly 60 Fraunhofer Institutes provide contract research to industries in targeted science and technology areas. The designated science and technology areas are highly specific, but the institutes also provide collaborative research across common themes through formal alliances among the institutes. Approximately one-third of their collective 1 billion euros research budget is provided by the national government, and two-thirds is contract research support and specific public projects.[45] It is worthwhile to note that Germany, a relatively small country, is the world's largest exporter of goods. The connection between this high level of exports and a national economic strategy based on high technology and science is noteworthy. Recently, the German Fraunhofer model has been extended to the United States, with centers and facilities opened in several states.[46]

A Science and Technology Plan for New Jersey

A summary plan is given below for New Jersey to once again resume leadership in enhancing science- and technology-based economic growth. The state has a long and proud legacy of innovation and discovery that has led to significant improvements in the quality of life of people throughout the world and sustained increases in employment, income, and the standard of living for New Jersey. An ever more competitive global economy, combined with fundamental changes in technology and business cost structures, have placed New Jersey's high-technology and high-paying economic businesses at risk. Recent trends in employment in these sectors have not been encouraging. It is important and timely, therefore, for New Jersey to again emphasize, and provide support for, an effective portfolio of policies that promote economic growth by advancing science and technology businesses. The New Jersey Commission on Science and Technology can be a catalyst and leader in that effort.

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[45] See Fraunhofer-Gesellschaft, www.fraunhofer.de, for a useful description of this integrated science-based national strategy.
[46] See "The Fraunhofer Society: A Unique German Contract Research Organization Comes to America," A. Duff Mitcheff, for U.S. Department of Commerce, Office of Technology Policy (Dr. Phyllis G. Yoshida, Project Director), August 1998.

Four Development Phases for New Jersey Science and Technology Policy

Phase I: **Establish new centers of excellence and facilitate cooperation within the academic research community and among academic research facilities and industry.**	The NJCST has played an important role in launching the Stem Cell Institute of New Jersey, administering stem cell research grants, recruiting scientists, and planning for large-scale financing to develop the center and an ongoing research grant program. The Commission, using peer review protocols and consultation among appropriate groups, should identify the next technology area to develop from among those outlined in Table 12 as the state's next center of excellence. The Commission should determine whether the center would best function as a single physical facility or as a distributed center. The Commission should also provide a priority recommendation for establishing centers in the remaining scientific areas.
	The Commission should actively plan and advocate for this next center, secure financing from state government and industry, and play a leading role with the research universities in the recruitment of top scientists. Numerous other states have enjoyed success through aggressive engagement in all these aspects of development of centers of excellence. New Jersey has had similar successes in the past – e.g., the Center for Advanced Information Processing (Rutgers), Center for Advanced Biotechnology and Medicine (Rutgers/UMDNJ), Center for Photonics and Optoelectronic Materials (now part of the Princeton Institute for the Science and Technology of Materials), and others. The Commission should seek to again establish nationally prominent scientific research facilities.
	The Commission should also determine the priority order for the remaining areas outlined in Table 12 to establish additional centers of excellence or other avenues of development. The Commission should develop appropriate plans for these centers, including funding requirements and implementation schedules.
	The state should establish an Eminent Scholar Endowment program to recruit world-class researchers to New Jersey universities in the strategic priority science and technology areas identified by the NJCST.
	The Commission should increase support of technology transfer activities of the research universities, using leveraging incentives of additional resources for collaboration across universities and for collaborations with private industry.
	The Commission should establish additional programs and expand existing ones in order to enhance technology companies' access to university labs and services for proof-of-concept and other research needs. Programs that help companies to contract with universities on proof-of-concept and prototyping activities will build relationships with university scientists and provide access to technologically trained graduate and undergraduate students for employment.
	The Commission should encourage the development of a network of research facilities akin to Germany's Fraunhofer Institutes and the Georgia Research Alliance (GRA). Entities such as these play a pivotal role in attracting top faculty and federal funding, and present great opportunities for contract research and other forms of collaboration with industry. The Commission should organize site visits to the GRA and the Fraunhofer Institutes for representatives of academia and industry.

Phase II: **Enhance the entrepreneurial environment.**	The NJCST should work to improve the effectiveness of existing technology incubators and to establish new specialized incubators that encourage clustering of research and business activities in conjunction with the development of centers of excellence.
	As a single immediate policy with the most rapid payoff, the state should increase the supply of funding for investments in venture capital funds through the Commission and the NJEDA.
	The NJEDA's Techniuum program, which unites various incentives and opportunities available to technology businesses under a single umbrella, should be strongly promoted and should be closely coordinated with the recommendations and activities of the NJCST. The NJEDA and NJCST should work with the appropriate business associations and governmental, industry, and university entities to increase access to and use of all opportunities for financial support of early-stage science and technology firms. The newly introduced Technology Fellowship program of the NJCST should be expanded.
	The state should review its net operating loss provisions and its research and development and investment tax credits in order to make them simpler and more easily accessible, expand their applicability, and, where appropriate, increase the magnitude of their benefits.
	Support services and information should be centralized and made easily available for entrepreneurs seeking federal research financing, such as SBIR and STTR grants. The newly established NJCST program for SBIR bridge grants should be enhanced.
	The NJCST should coordinate with the state's venture capital associations and other investor groups both within and outside the state to maintain a central database of investment sources and to disseminate information about angel and bridge financing opportunities to technology start-ups. The Commission and other bodies should also examine ways to loosen eligibility requirements and increase the amount of funding available through the state's pension funds.

Phase III: **Improve the state's overall business climate and technology resources.**	Practical science and math curricula should be developed, promoted, and implemented in educational institutions at all levels. In particular, universities should work with representatives of industry to enhance *graduate-level* curricula in order to produce a highly skilled scientific workforce for the state's high-tech industries. In addition, state policy should seek to reduce out-migration of New Jersey's college-aged students.
	A review of the state's overall business climate should once again be undertaken, focusing on alleviating obstacles to growth and developing new incentives and support for technology companies, particularly those with existing large-scale employment. The Commission should lead efforts to formulate improvements to the state's general business climate that promote economic growth as a major goal across state governmental agencies in coordination with, and direct support, from the Office of the Governor.
	The state should examine the alternative corporate business tax and the treatment of capital gains for tax purposes from the sale of science and technology businesses and make changes to provide incentives for the start-up, development and sale of businesses *in* the state.
Phase IV: **Program Evaluation**	NJCST should develop and track measures of the effectiveness of programs implemented from the above recommendations, including indicators of the rate of return on public investment in science and technology.

Interview Themes

The preceding policy recommendations were developed in conjunction with discussions with a cross section of individuals engaged in various aspects of the state's science and technology sector. These individuals, acknowledged at the beginning of the report, are members of the Commission on Science and Technology, business people in the industries involved, heads of business associations, academic leaders, and public officials. They provided highly useful insights, and these are embodied in various specific areas throughout the report. In addition, there were several common themes that emerged from the interviews. A brief summary of those themes is informative.

First, there was the recognition that a number of state agencies have worked extremely hard and well to support economic growth in New Jersey. At the same time, there was a recommendation, repeated across many of the interviews, that the state needs a more systematic organization of its economic growth efforts so as to provide an easily navigable system of support. This reorganized effort should be placed in the Governor's Office to convey the priority the state places on growing its economy.

Second, the state has to take a longer-term view of how policies affect, both positively and negatively, the growth of its economy and make appropriate changes. State investments that result in long-run economic benefits need to be part of an effective growth strategy. That requires the willingness to commit significant resources beyond the immediate political cycle that is the typical focus for fiscal decisions. Symmetrically, obstacles to a competitive business climate need to be eliminated, even if there are short-run revenue costs. Issues such as the negative effects of the alternative corporate business tax, long delays and uncertainties in land use permitting processes, and how the state treats the gains from the sale of businesses (particularly small science and technology businesses) for tax purposes were repeatedly cited in the interviews as examples of obstacles to an attractive business climate.

Third, there was a recurring sense that there was insufficient state investment in higher education, particularly in the areas of higher education that can stimulate and support science- and technology-based economic growth, such as building research capacity, providing state-of-the-art research facilities and equipment, and assisting in the recruitment of excellent science and technology faculty and graduate students. At the same time, there was an expectation that research universities should be generating more intellectual property and commercial activity from their research expenditures.