Maine's Science and Technology Environment

Prepared for:

Maine Science and Technology Foundation

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Presentation to

Maine Science and Technology Foundation

Nexus Associates, Inc.
September 16, 1997

The report is intended to provide a foundation for the implementation of the Maine science and technology plan.

- It profiles the structure and comparative performance of technology-intensive industries in Maine.
- It analyzes important trends in R&D, patenting and venture capital activity.
- It provides a framework for thinking about the relationships among technology, industrial performance and economic growth.

Technology-intensive industries are increasingly important to economic prosperity.

- Technology-intensive industries tend to grow faster and pay higher wages than other sectors.
- Technology-intensive industries share a number of outstanding characteristics primarily with respect to their propensity to invest in intellectual property as well as human and physical capital. Specifically, they invest disproportionately in some combination of R&D, skilled workers and capital equipment.
- Technology-intensive industries are not limited to the manufacturing sector.

Technology-intensive industries were identified using a rigorous screening process.

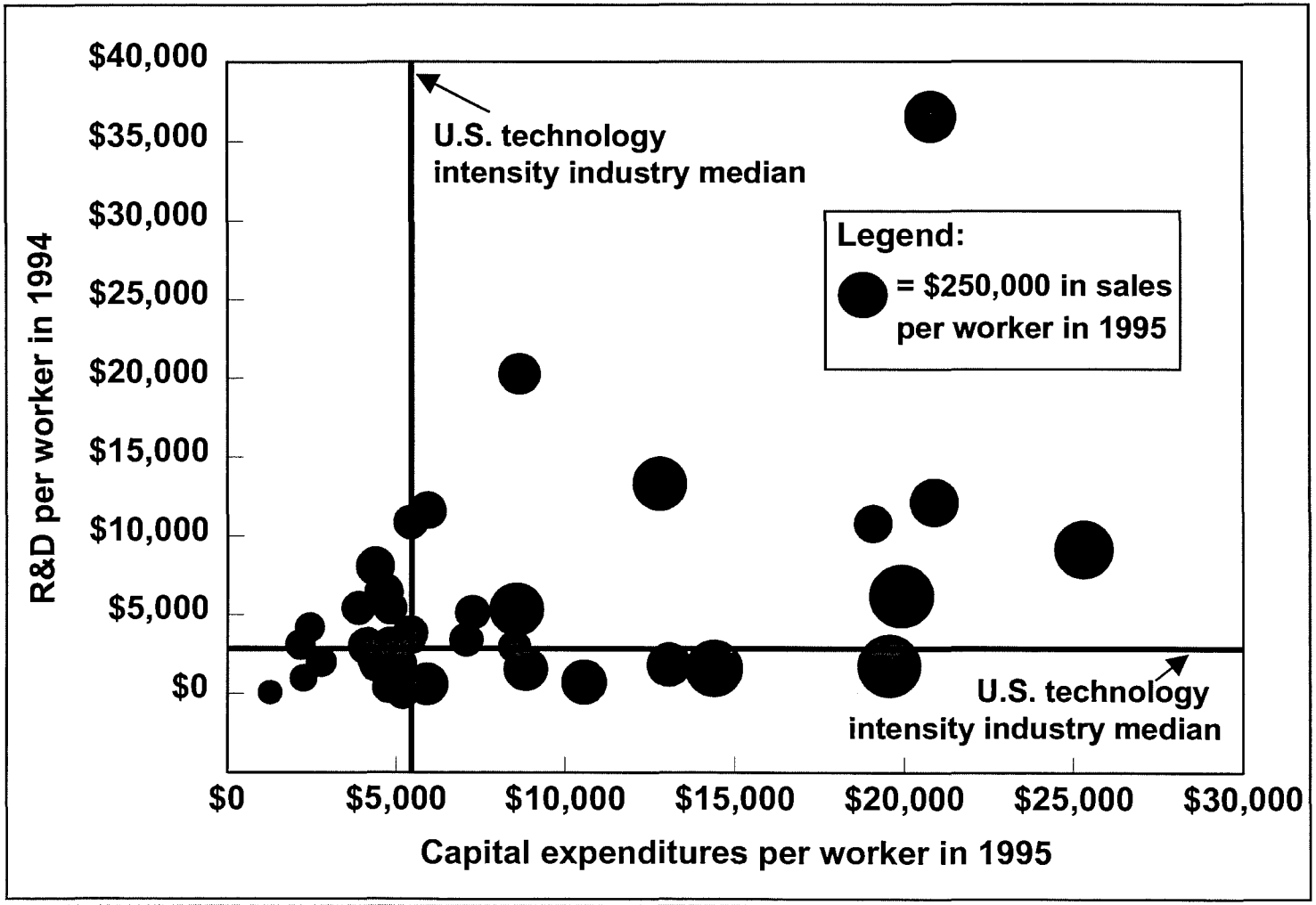
- Technology-intensive industries are defined as those industries that are in the top 25% in two of the following three categories:
  - R&D expenditures per worker;
  - Capital investment per worker; and
  - Scientists and engineers as a % of total workforce.
- National-level data were used in the screening process, using 3-digit SIC codes.
- Additional industries of importance to the Maine economy were added to the initial list; a few were dropped because of data disclosure problems.

The list of technology-intensive industries includes both manufacturers and service sector industries.

Industry	SIC code	Industry	SIC code
Animal aquaculture*	273	All other machinery	other 35
Commercial fishing*	910	Electric distribution equipment	3610
Fish hatcheries*	920	Household audio & video equip	3650
Heavy construction*	1600	Communications equip	3660
Grain mill products	2040	Electronic components	3670
Sugar & confect prods	2060	Misc. electrical equipment	3690
Beverages	2080	All other electrical equip	other 36
All other food products	other 20	Motor vehicles & equip	3710
Textile mill products*	2200	Ship & boat building*	3730
Apparel products*	2300	All other transportation	other 37
Sawmills & planing mills*	2420	Measure & control devices	3820
Paper & allied products	2600	Medical instruments	3840
Indust inorganic chemicals	2810	Other instruments	other 38
Drugs	2830	Telephone communications	4810
Soaps, cleaners, etc.	2840	Electric services	4910
Agricultural chemicals	2870	All other utility services	other 49
All other chemicals	other 28	Security & commodity services	6280
Petroleum & coal prods	2900	Life insurance	6310
Ordnance, etc. n.e.c.	3480	Medical & health insurance	6320
Farm & garden machinery	3520	Fire, marine insurance	6330
Construction machinery	3530	Investment & holding offices	6700
Metalworking machinery	3540	Computer & data process	7370
Special indust machinery	3550	Engineering & archetectural	8710
General indust machinery	3560	Research & testing labs	8730
Refrigeration machinery	3580	Management & public relation	8740

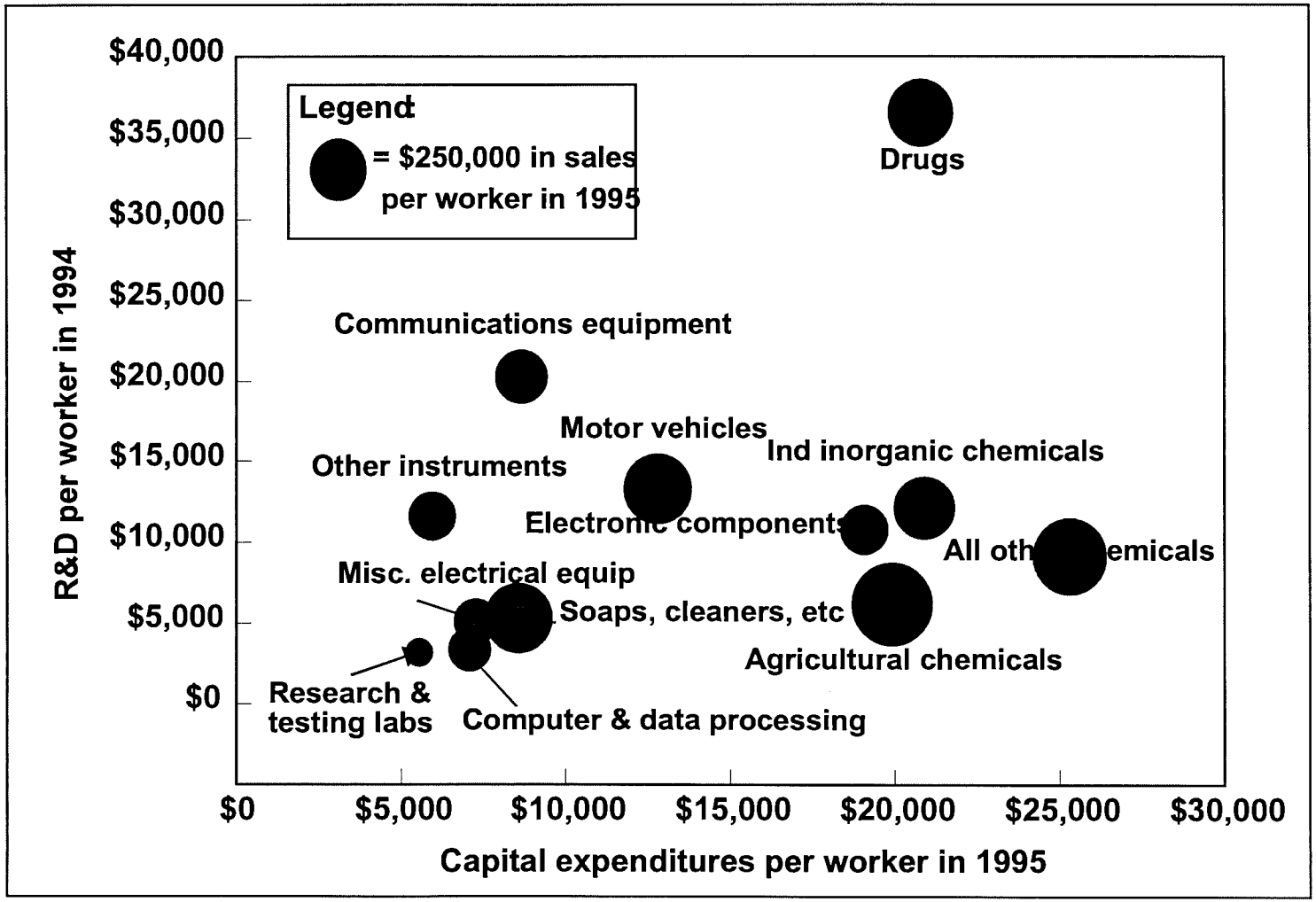
* Added after initial screen

At the national level, there is a positive correlation between R&D activity, capital spending, and productivity...



Source: Nexus Associates, Inc. based on National Science Foundation and U.S. Bureau Of Census data

… with the chemical, electronics, motor vehicle and computer programming industries making above-average investments in both R&D and capital equipment.



Source: Nexus Associates, Inc. based on National Science Foundation and U.S. Bureau Of Census data

Roughly 80,000 workers in Maine are employed in technology-intensive industries...

Industry	SIC code	Employment in 1996	% of total private	Location quotient
Paper & allied products	2600	14,721	3.31%	4.81
Ship & boat building	3730	9,282	2.09%	13.20
All other food products	other 20	5,879	1.32%	1.02
Textile mill products	2200	4,712	1.06%	1.68
Electronic components	3670	4,365	0.98%	1.59
Heavy construction	1600	4,015	0.90%	1.16
Electric services	4910	3,408	0.77%	1.96
Engineering & architectural	8710	3,056	0.69%	0.81
Sawmills & planing mills	2420	2,696	0.61%	3.30
Mangement & public relations	8740	2,665	0.60%	0.68
Telephone communications	4810	2,644	0.59%	0.66
All other machinery	other 35	2,502	0.56%	0.70
Apparel	2300	2,112	0.47%	0.54
Research & testing labs	8730	2,108	0.47%	0.83
Fire, marine insurance	6330	1,742	0.39%	0.73
Medical & health insurance	6320	1,711	0.38%	1.18
All other transportation	other 37	1,662	0.37%	0.56
Computer & data processing	7370	1,613	0.36%	0.30
All other electrical equip	other 36	1,150	0.26%	0.56
Drugs	2830	1,064	0.24%	0.92

Continued...

… accounting for approximately 18% of all private sector employment ...

Industry	SIC	Employment in 1996	% of total private	Location quotient
Communications equipment	3660	906	0.20%	0.75
Metalworking machinery	3540	784	0.18%	0.51
Misc. electrical equipment	3690	739	0.17%	1.08
Measuring & controlling devices	3820	537	0.12%	0.40
All other utility services	other 49	530	0.12%	0.24
Ordnance, n.e.c.	3480	516	0.12%	2.42
Medical instruments & supplies	3840	453	0.10%	0.38
Construction machinery	3530	390	0.09%	0.37
Motor vehicles & equipment	3710	356	0.08%	0.08
Petroleum & coal products	2900	327	0.07%	0.51
Beverages	2080	324	0.07%	0.40
Life insurance	6310	318	0.07%	0.14
Special industry machinery	3550	312	0.07%	0.39
Electric distribution equipment	3610	278	0.06%	0.76
Grain mill products	2040	245	0.05%	0.43
Investment & holding offices	6700	207	0.05%	0.22
Soaps, cleaners, & toilet goods	2840	190	0.04%	0.27
Household audio & video equipm	3650	178	0.04%	0.48

Continued...

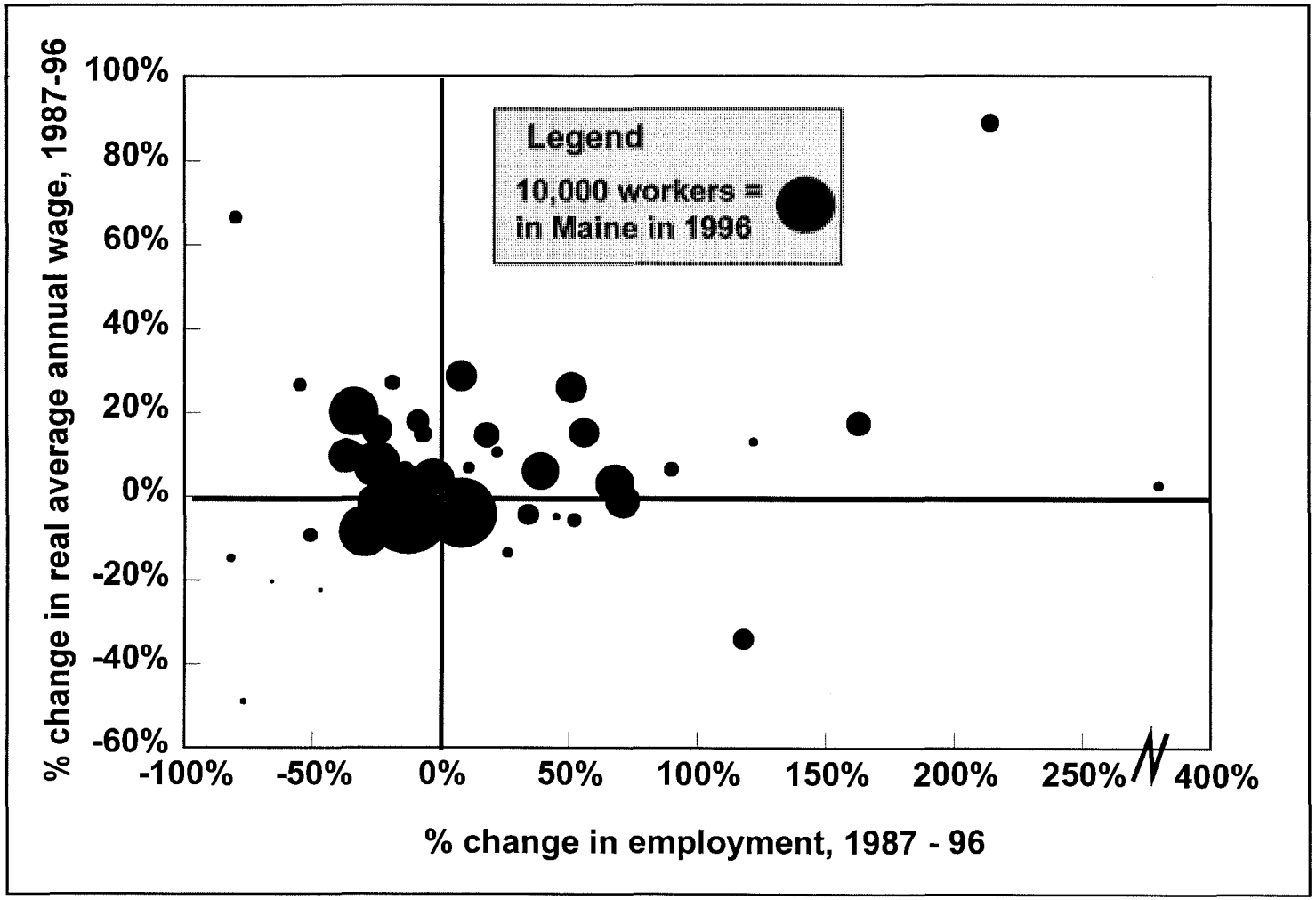
… or slightly less than the national average.

Industry	SIC	Employment in 1996	% of total private	Location quotient
Industrial inorganic chemicals	2810	177	0.04%	0.33
All other chemicals	other 28	168	0.04%	0.08
Refrigeration machinery	3580	163	0.04%	0.18
Fish hatcheries	920	150	0.03%	23.39
Animal aquaculture	273	137	0.03%	7.17
Security & commodity serices	6280	121	0.03%	0.25
Commercial fishing	910	111	0.02%	2.46
General industrial machinery	3560	105	0.02%	0.09
Agricultural chemicals	2870	73	0.02%	0.31
Other instruments	other 38	47	0.01%	0.04
Sugar & confectionery products	2060	24	0.01%	0.05
Farm & garden machinery	3520	12	0.00%	0.03
Total technology-intensive		81,976	18.4%	0.94
Total other		362,724	81.6%	1.01
Total private		444,699	100%	1.00

Note: U.S.. = 1.00 for all industry location quotients

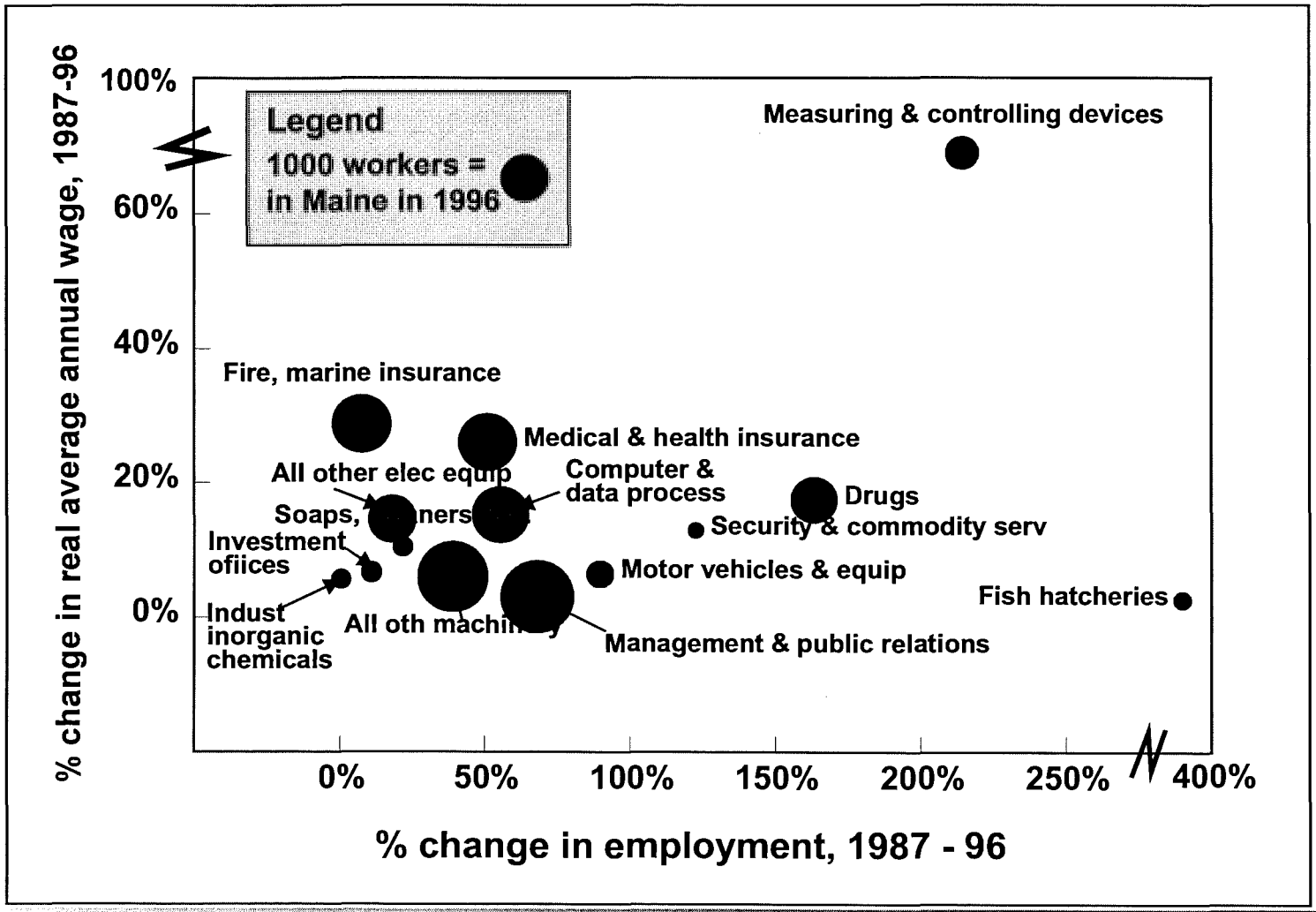
Source: Nexus Associates, Inc. based on Maine Department of Labor data

Many of Maine's larger technology-intensive industries have experienced declines in employment and/or wages.



Source: Nexus Associates, Inc. based on Maine Department of Labor data

However, several industries have been able to add workers and raise average real wages.



Source: Nexus Associates, Inc. based on Maine Department of Labor data

One way to judge the competitive performance of Maine's technology-intensive industries is by using a technique known as shift share-analysis.

- Shift-share is frequently used in regional economic analysis to evaluate how well individual industries in a particular state are performing compared to other states.
- Specifically, shift-share analysis indicates which portion of the change in employment in Maine is due to changes in the national economy, the mix of industries in the state, and state-specific competitiveness factors.
- The following tables show the total net change in employment between 1987 and 1996 in Maine and the number of jobs gained or lost due to changes in Maine's competitive position. A positive "competitiveness" value indicates that the industry has outperformed the national average; a negative value indicates that it has underperformed.

Many of Maine's technology-intensive industries have increased employment as a result of greater competitiveness.

Industry	SIC	Total job change 1987-96	Job change if industry grew at national rate	"Competitive" job change 1987-96
Ship & boat building & repairing	3730	727	-1,402	2,129
All other machinery	other 35	702	-129	831
Research & testing labs	8730	878	190	688
Drugs	2830	660	82	578
Misc. electrical equipment	3690	400	-34	435
Electric services	4910	-95	-486	391
Measuring & controlling devices	3820	366	-14	381
All other electrical equip	other 36	175	-118	293
All other transportation	other 37	-555	-712	157
Motor vehicles & equipment	3710	168	21	147
Ordnance, n.e.c.	3480	-86	-228	142
Petroleum & coal products	2900	111	-29	141
Metalworking machinery	3540	198	65	133
Fire, marine insurance	6330	122	17	105
Fish hatcheries	921	119	16	103

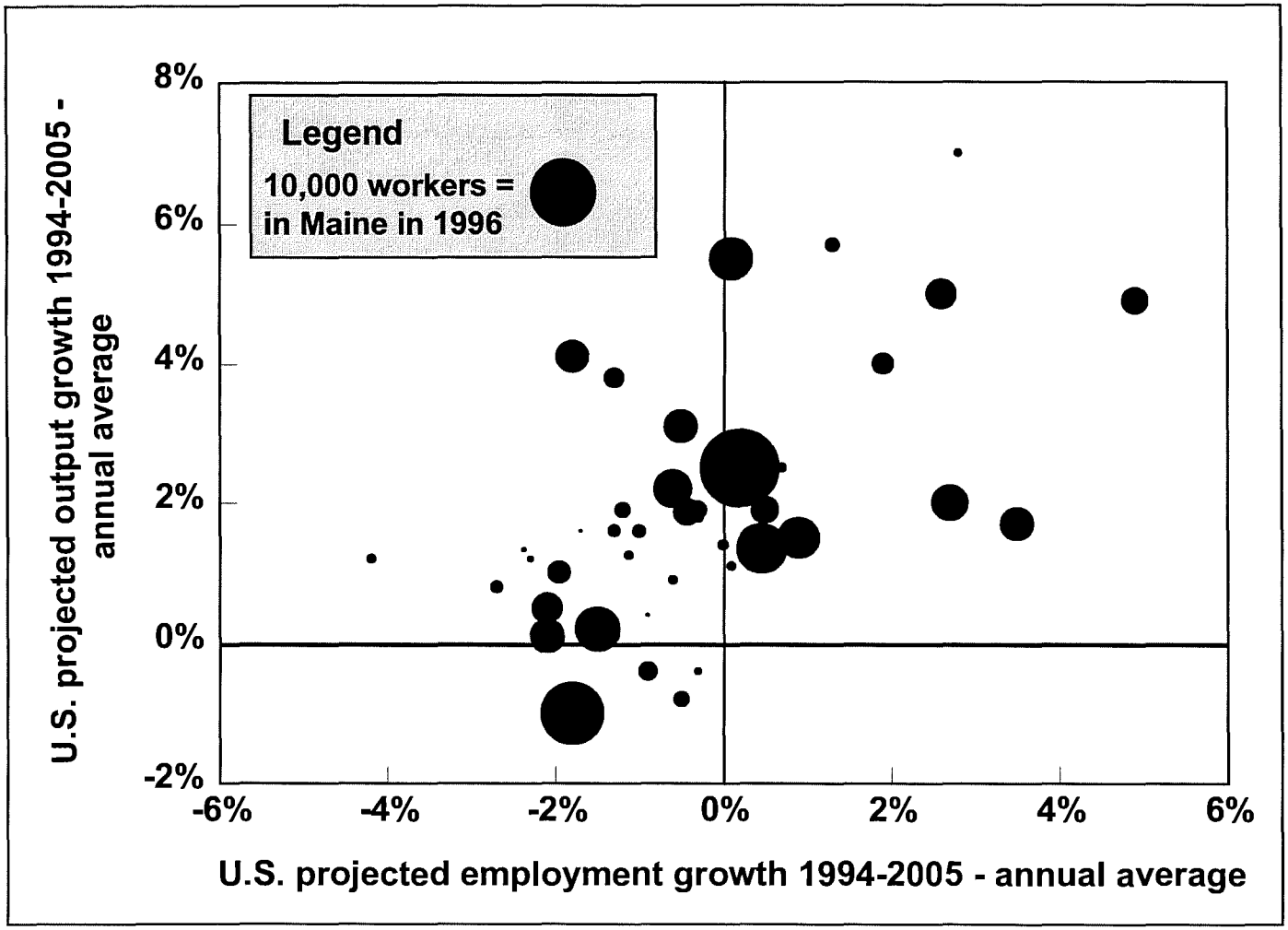
However, Maine has seen its competitive position erode in several leading industries and the technology-intensive sector as a whole.

Industry	SIC	Total job change 1987-96	Job change if industry grew at national rate	"Competitive" job change 1987-96
Paper & allied products	2600	-2,201	176	-2,376
Electronic components	3670	-2,200	84	-2,284
All other food products	other 20	-1,164	567	-1,731
Heavy construction	1600	-1,331	224	-1,554
Textile mill products	2200	-1,984	-934	-1,050
Engineering & architectural servs	8710	-270	629	-899
Electric distribution equipment	3610	-1,138	-282	-856
Sawmills & planing mills	2420	-897	-341	-556
General industrial machinery	3560	-470	77	-547
Apparel & other textile products	2300	-1,226	-709	-517
Special industry machinery	3550	-376	119	-495
Computer & data processing	7370	576	955	-379
Telephone communications	4810	-381	-14	-367
Life insurance	6310	-338	-64	-274
Medical instruments & supplies	3840	-76	84	-160
All technology-intensive industries		**-8,296**	**2,516**	**-10,812**

Except for ship building, Maine's largest technology-intensive industries have shed workers.

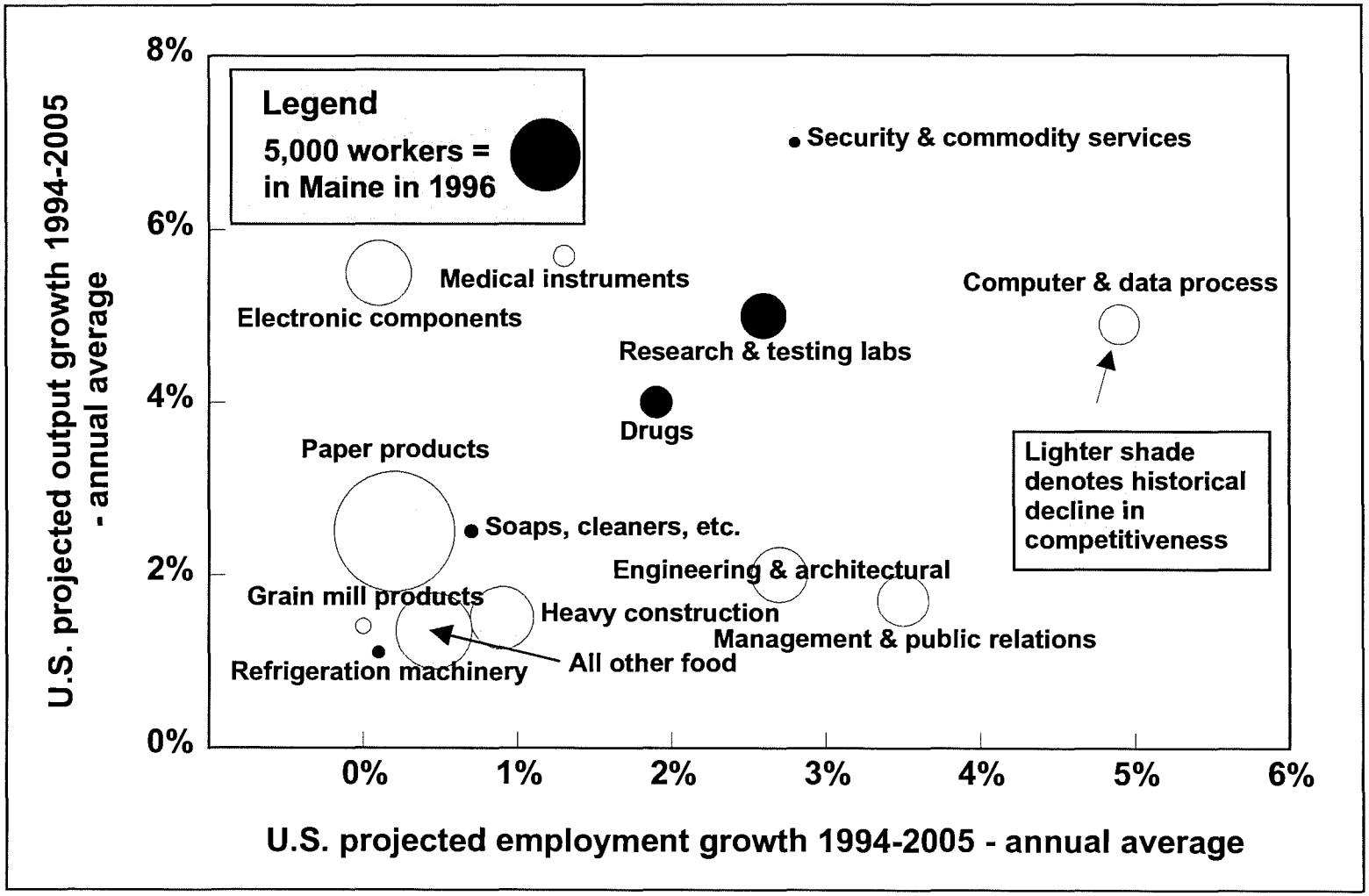
- Maine lost nearly 8,300 jobs in technology-intensive industries between 1987 and 1996.
- Over 10,800 jobs were lost due to local factors indicating that if the state's technology-intensive industries had grown at the national rate, over 2,500 jobs would have been added during the period.
- The paper, electronics, food processing, construction, textiles and apparel industries have experienced significant job losses due to local factors.
- Ship building, other machinery, drugs and research labs showed large gains in employment due to factors specific to the state.

While output is projected to increase for most technology-intensive industries, employment is expected to rise in only a handful.



Source: Nexus Associates, Inc. based on U.S. Bureau of Labor Statistics projections and Maine Dept of Labor data

Maine has become less competitive in many of the industries expected to grow both in terms of output and employment.

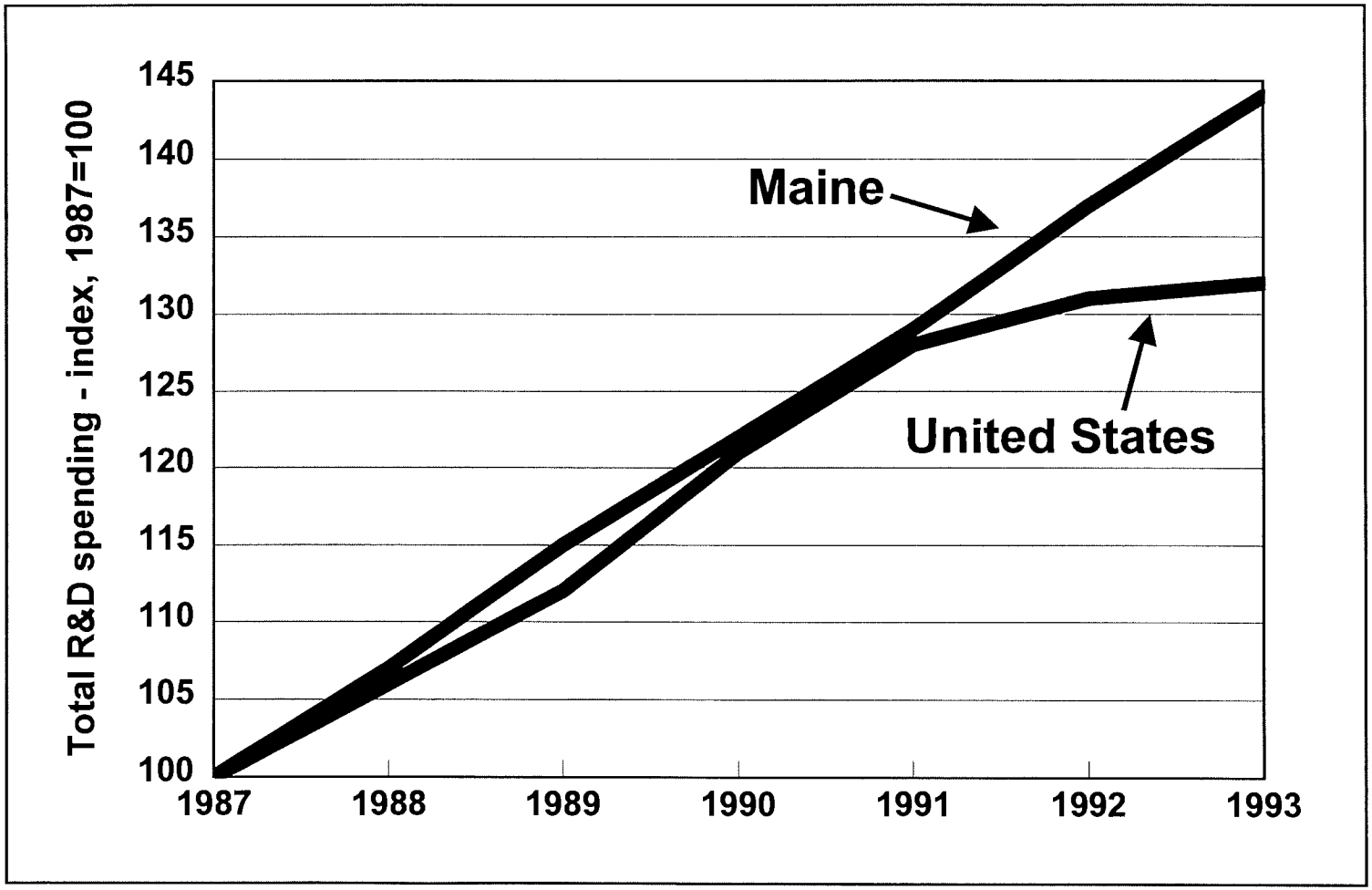


Source: Nexus Associates, Inc. based on U.S. Bureau of Labor Statistics projections and Maine Dept of Labor data

R&D is critical to the performance of technology-intensive industries and long-term economic growth.

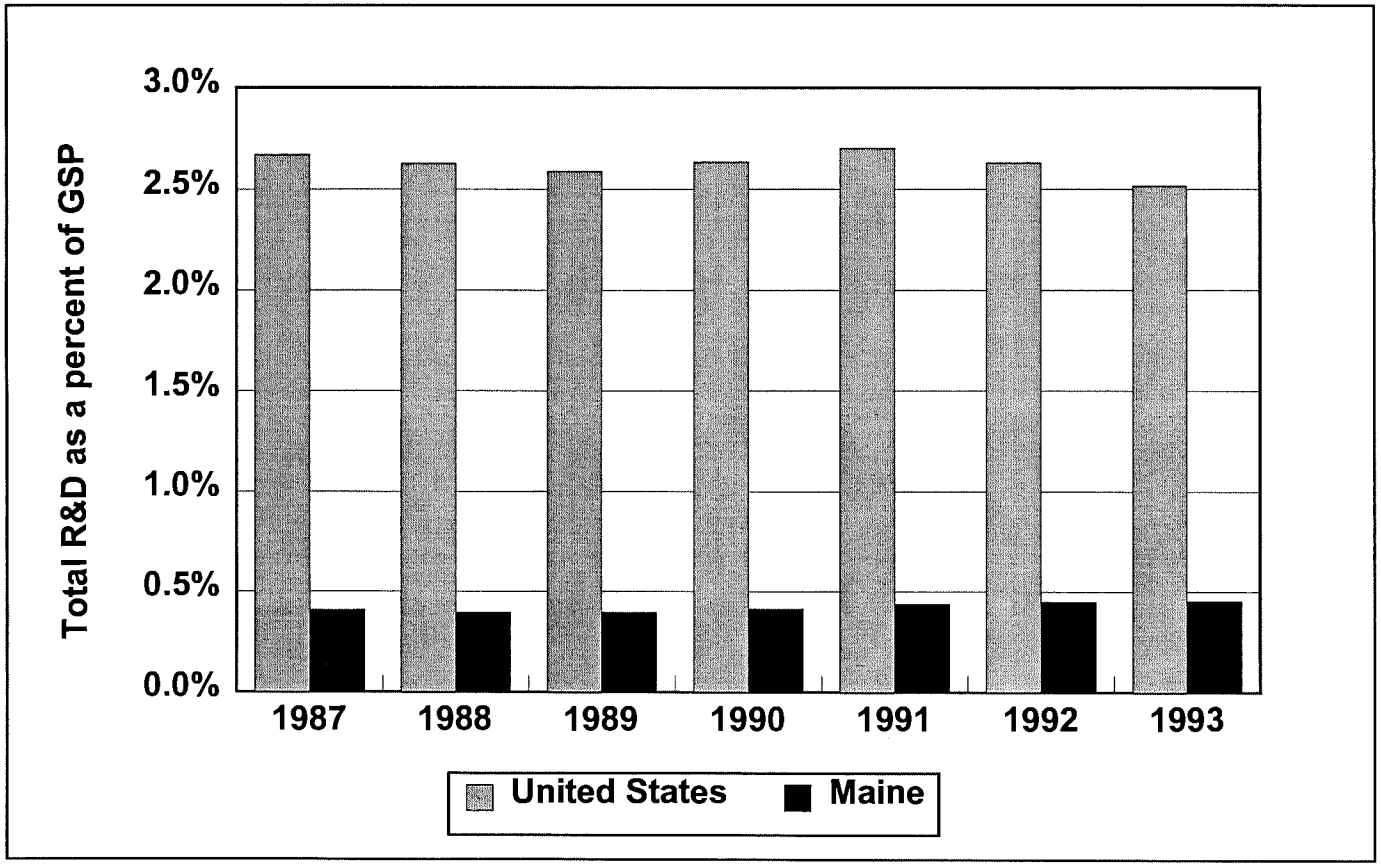
- Companies in technology-intensive industries rely on a continuous stream of new products and process improvements to strengthen their position in increasingly competitive markets.
- R&D provides the foundation for new commercial products and improved processes.
- Investments in R&D are estimated to account for half or more of the increase in productivity in the United States.

R&D spending has recently been growing faster in Maine than in the United States...



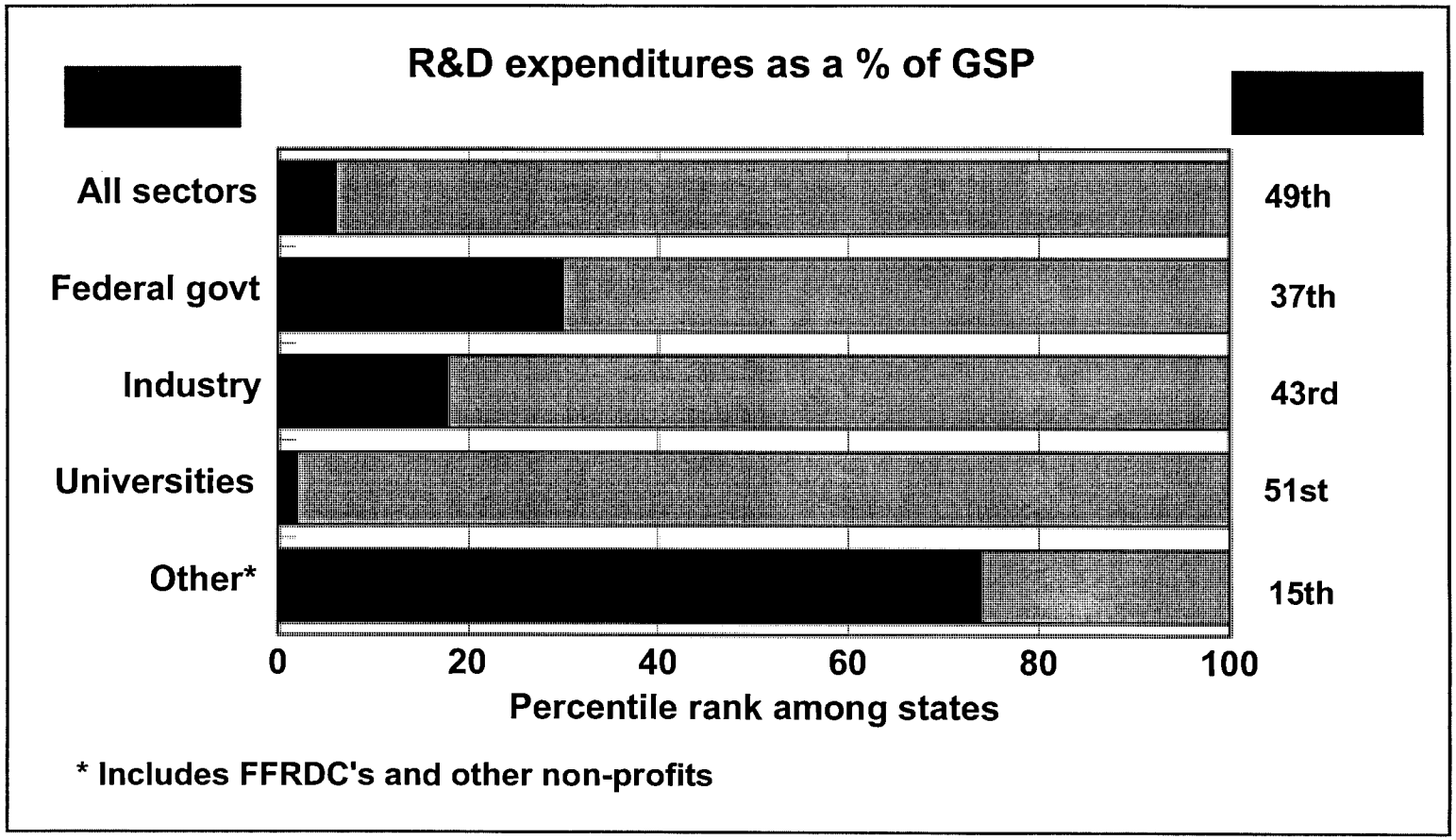
Source: Nexus Associates, Inc. based on National Science Foundation data

… however, the relative level of expenditure is still considerably lower than the national average.



Source: Nexus Associates, Inc. based on National Science Foundation data

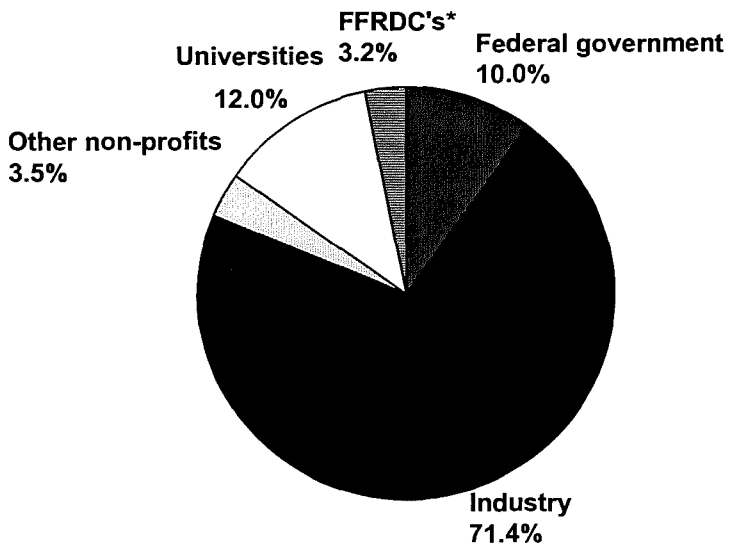
Compared to other states, most sectors in Maine rank low with respect to R&D expenditures as a % of GSP.



Source: Nexus Associates, Inc. based on National Science Foundation and U.S. Bureau of Economic Analysis data

Maine relies more on its university system for R&D than the nation as a whole...

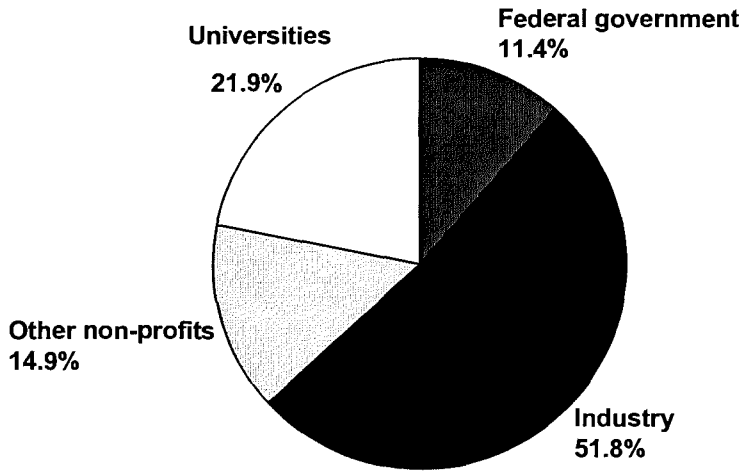
Distribution of R&D performance in the United States (1993)



Total = $165.8 billion
R&D/Gross National Product = 2.53%

*Federally funded research and development centers

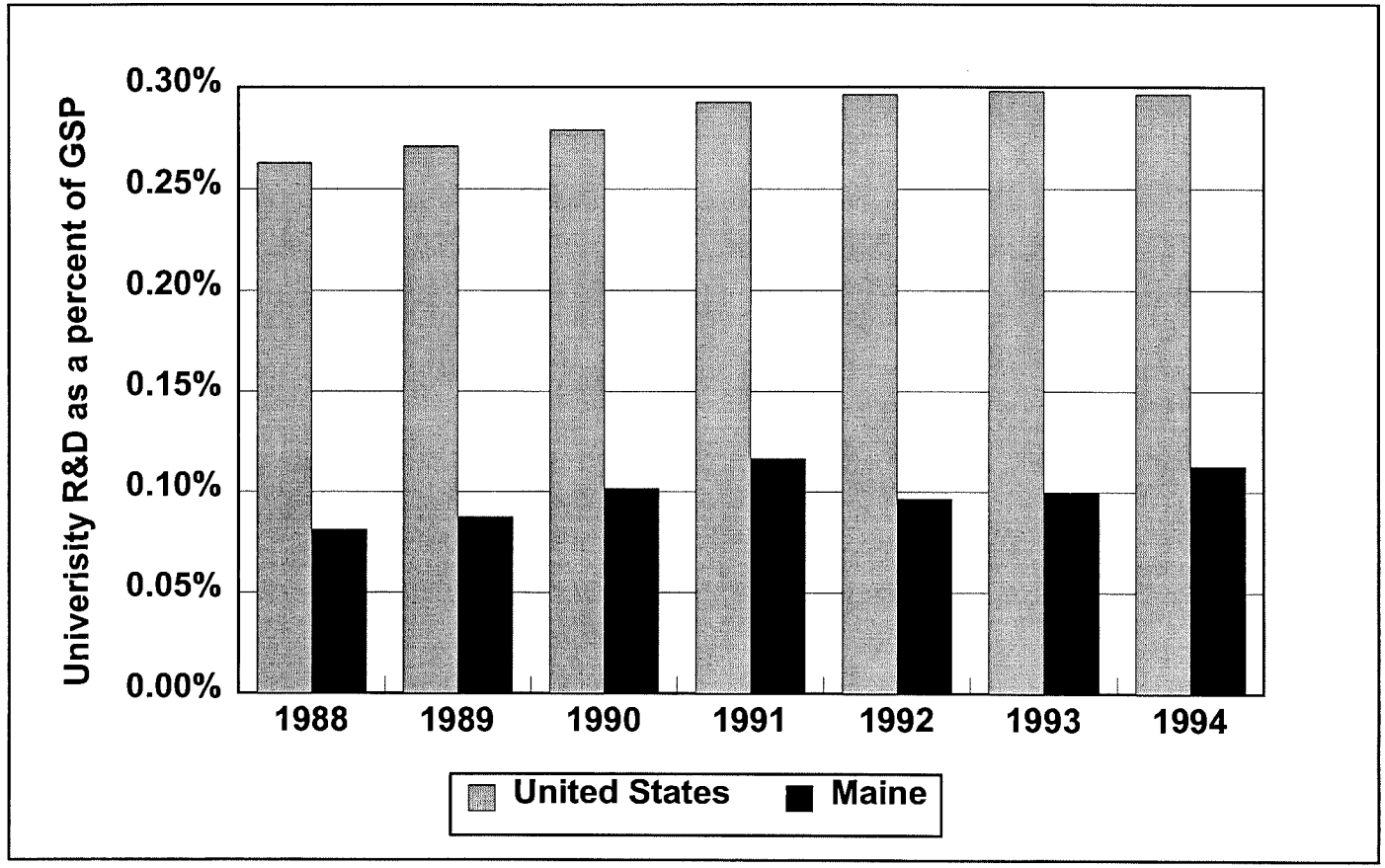
Distribution of R&D performance in Maine (1993)



Total = $114 million
R&D/Gross State Product = 0.46% (State rank = 49th)

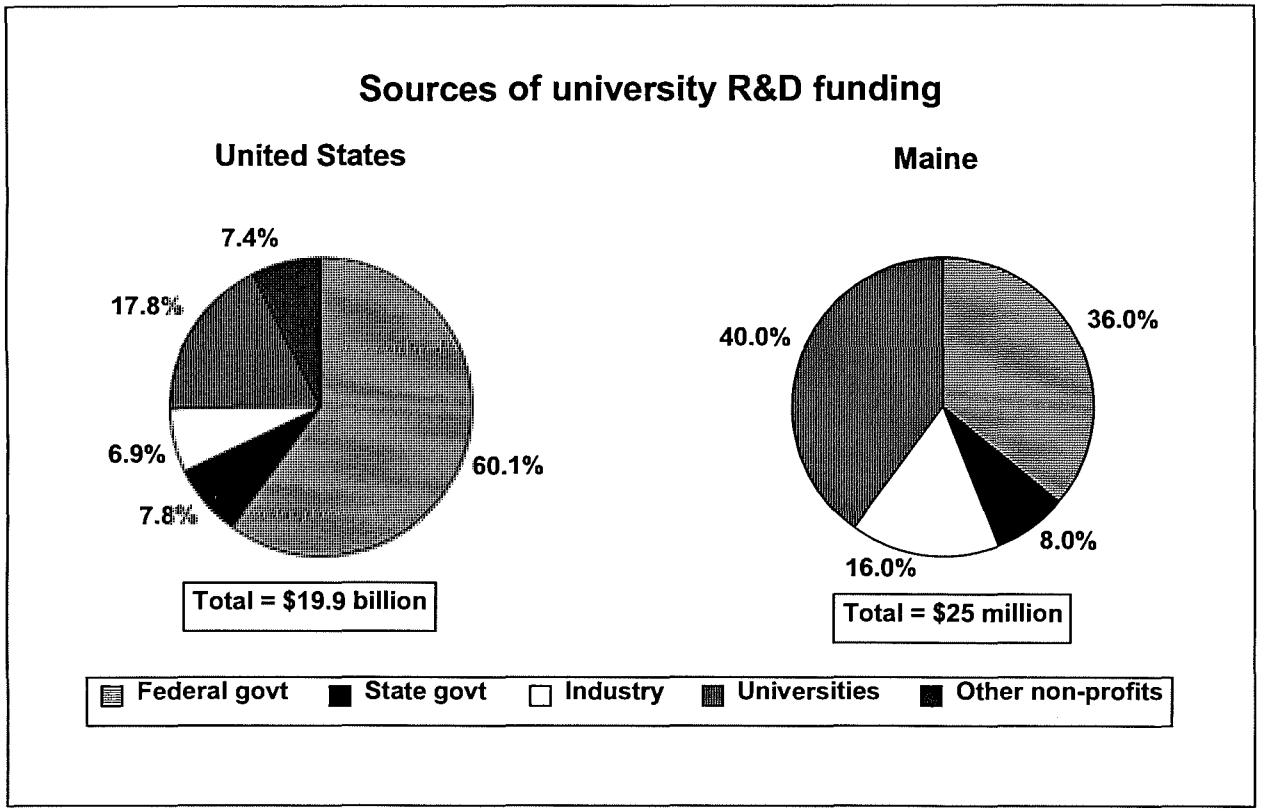
Source: Nexus Associates, Inc. based on National Science Foundation and U.S. Bureau of Economic Analysis data

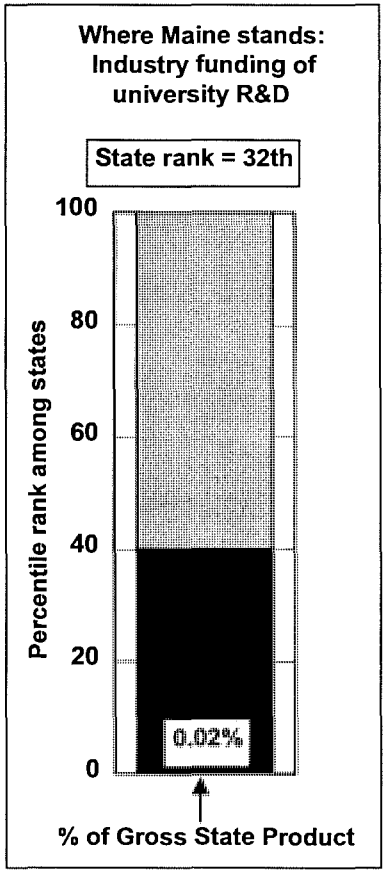
… but the University of Maine spends considerably less on R&D as a % of GSP than universities in other states.



Source: Nexus Associates, Inc. based on National Science Foundation data

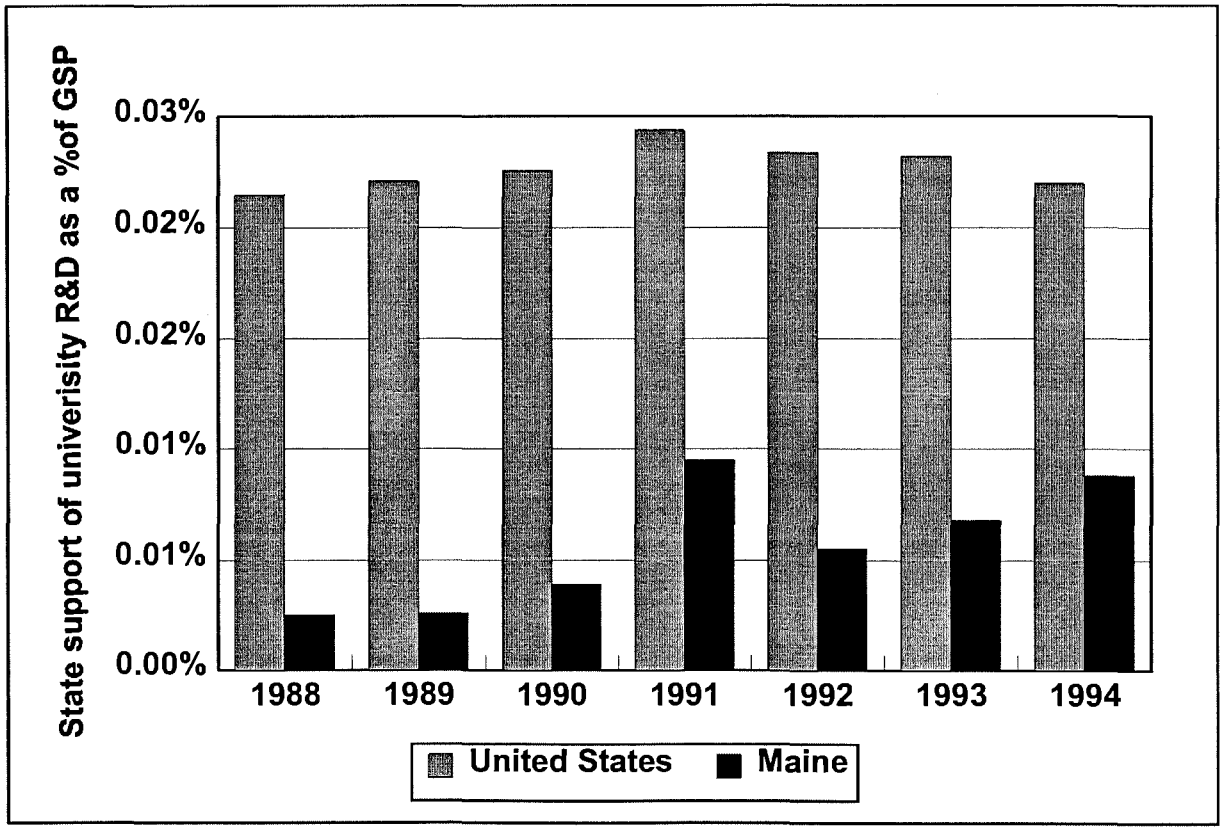
Universities in Maine rely more on industry than those in other states; however, the level of support is still low.

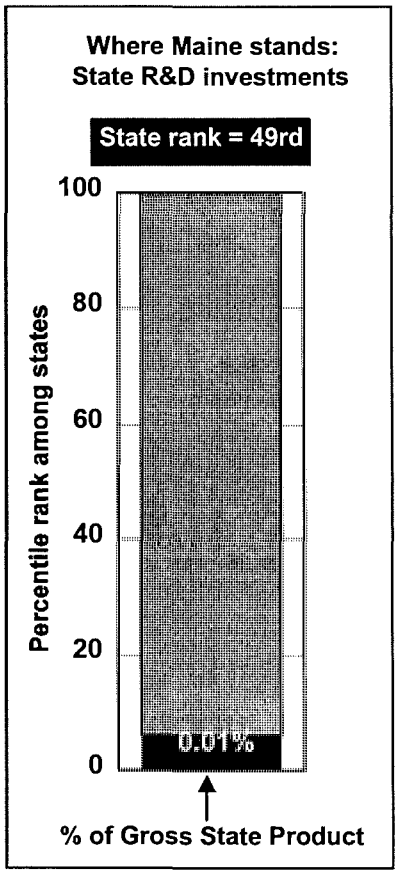




Source: Nexus Associates, Inc. based on National Science Foundation and U.S. Bureau of Economic Analysis data

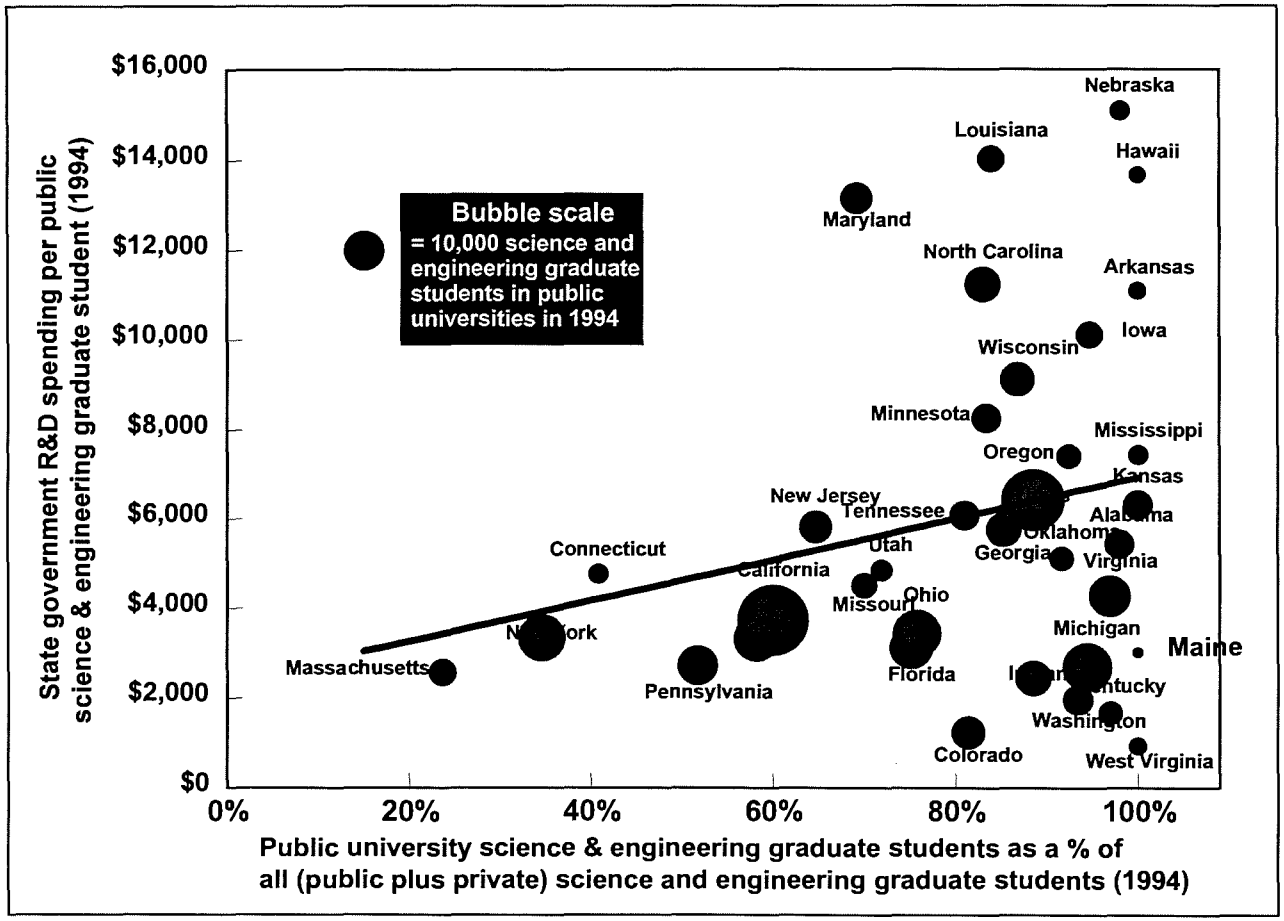
While the state government has increased its support for university R&D, it still spends relatively little compared to other states...





Source: Nexus Associates, Inc. based on National Science Foundation data

… even after controlling for the number of graduate students in public universities.

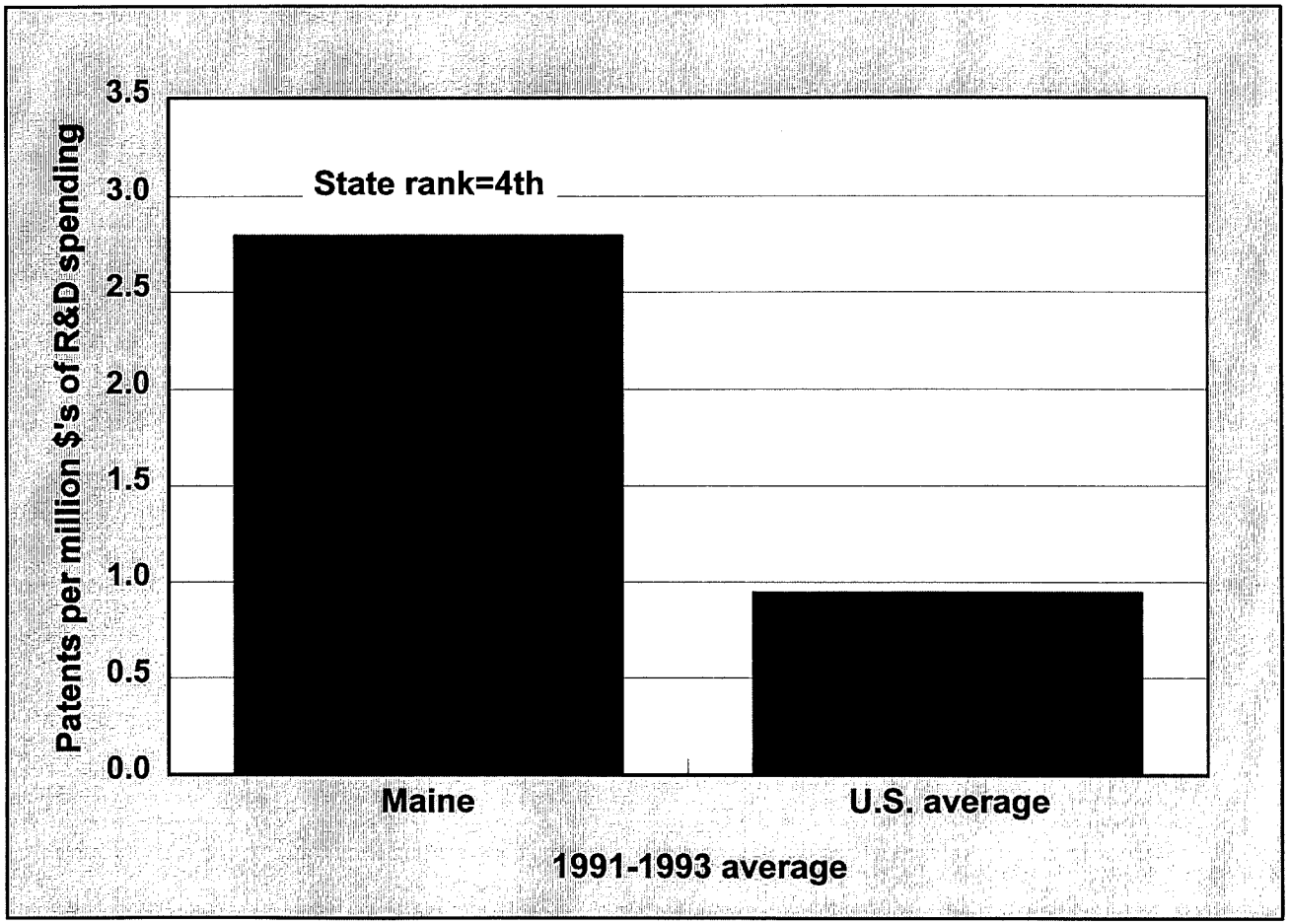


Source: Nexus Associates, Inc. based on National Science Foundation data

Universities provide a vital foundation for ongoing technological innovation in the state.

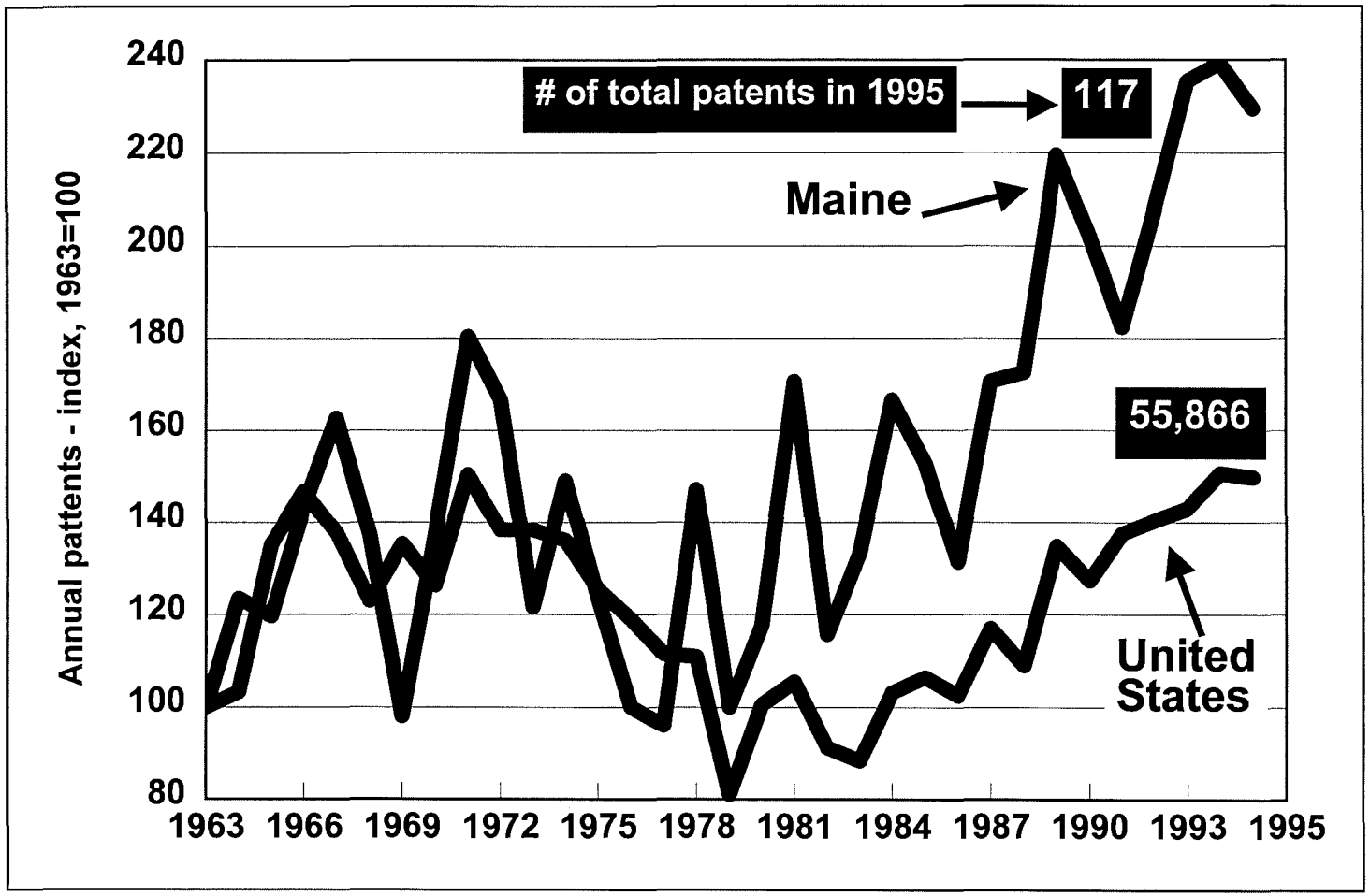
- Universities contribute to the knowledge underlying technological advances in the commercial marketplace.
- Universities are taking steps to foster greater collaboration with industry and are becoming more aggressive in licensing intellectual property.
- One recent study of U.S. manufacturing firms suggested that 11 percent of their new products and 9 percent of their new processes were developed as a direct result of research done at universities within the past 15 years. The same study estimated that the public rate of return, i.e., the payoffs to society as a whole, to university research is 28 percent.

Maine has been successful in converting R&D expenditures into technological innovations.



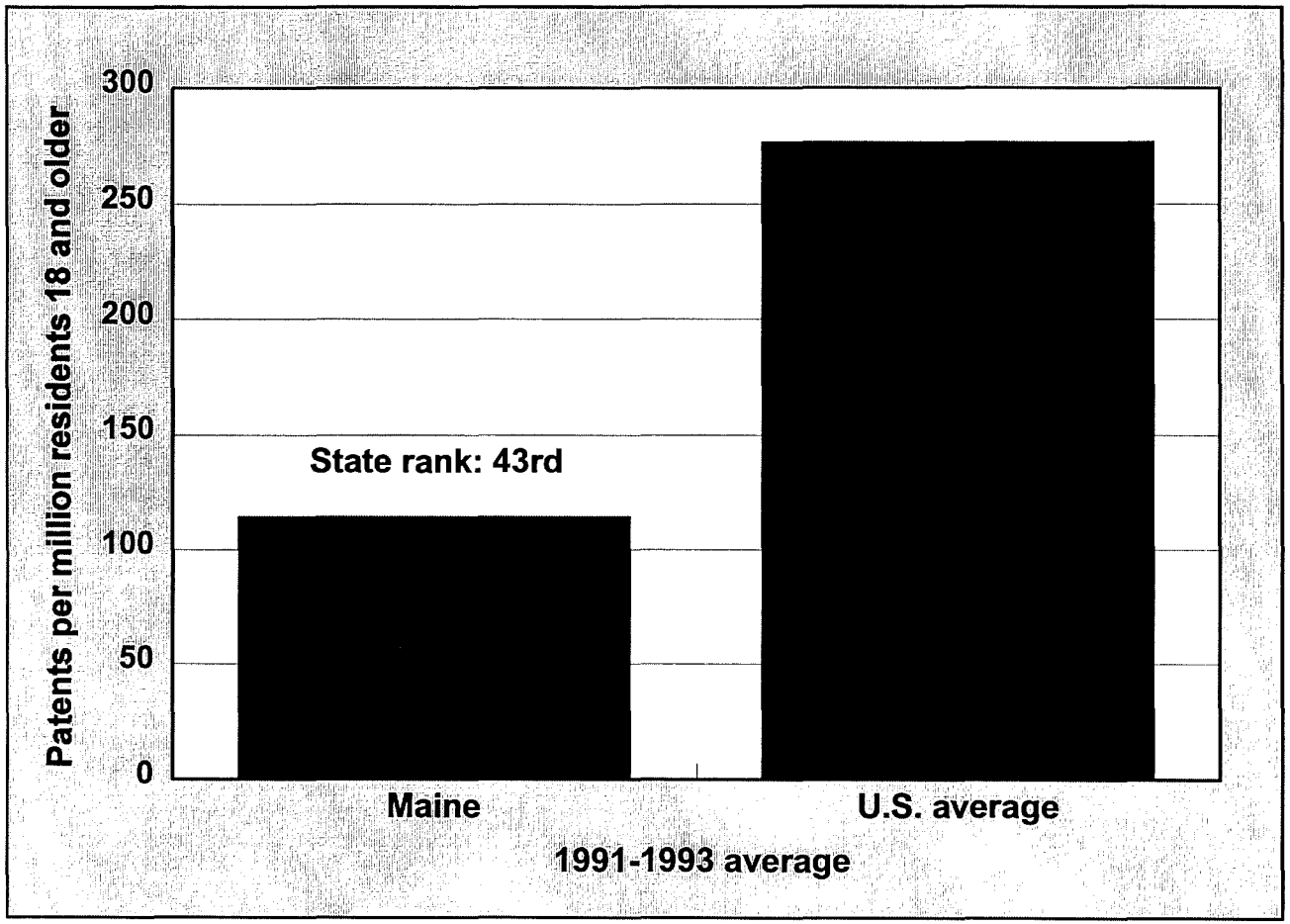
Source: Nexus Associates, Inc. based on National Science Foundation and U.S. Patent and Trade Office data

Patenting activity in Maine has been growing more rapidly than in the rest of the United States.



Source: Nexus Associates, Inc. based on U.S. Patent and Trade Office data

Given the size of the population, patenting activity in Maine is lower than in most other states.



Source: Nexus Associates, Inc. based on U.S. Patent and Trade Office and Bureau of the Census data

Patenting activity in Maine is heavily concentrated in electronics, communications and instruments.

SIC code	Industry	5 year total	% of Maine total	% of U.S. industry total	Patent location quotient
SIC 366-367	Electronic components & comm equip	99	17.7%	0.3%	1.33
All other SIC's	All other SIC's	95	17.0%	0.4%	1.70
SIC 38 (EX 3825)	Instruments	68	12.2%	0.2%	0.86
SIC 34 (EX 3462,3463,348)	Fabricated metals	46	8.2%	0.2%	1.11
SIC 355	Special industrial machinery	27	4.8%	0.3%	1.48
SIC 30	Rubber and plastic products	26	4.7%	0.2%	1.12
SIC 356	General industrial machinery	21	3.8%	0.2%	0.93
SIC 361, 3825	Electrical trans & distribution equip	17	3.0%	0.3%	1.34
SIC 354	Metalworking equipment	14	2.5%	0.3%	1.39
SIC 357	Computers & office equipment	12	2.2%	0.1%	0.42
SIC 283	Drugs	11	2.0%	0.1%	0.68
SIC 358	Refrigeration machinery	10	1.8%	0.2%	1.12
SIC 348, 3795	Ordnance except missiles	9	1.6%	0.6%	2.99
SIC 365	Radio & television equipment	9	1.6%	0.4%	1.89
SIC 353	Construction machinery	9	1.6%	0.2%	0.74

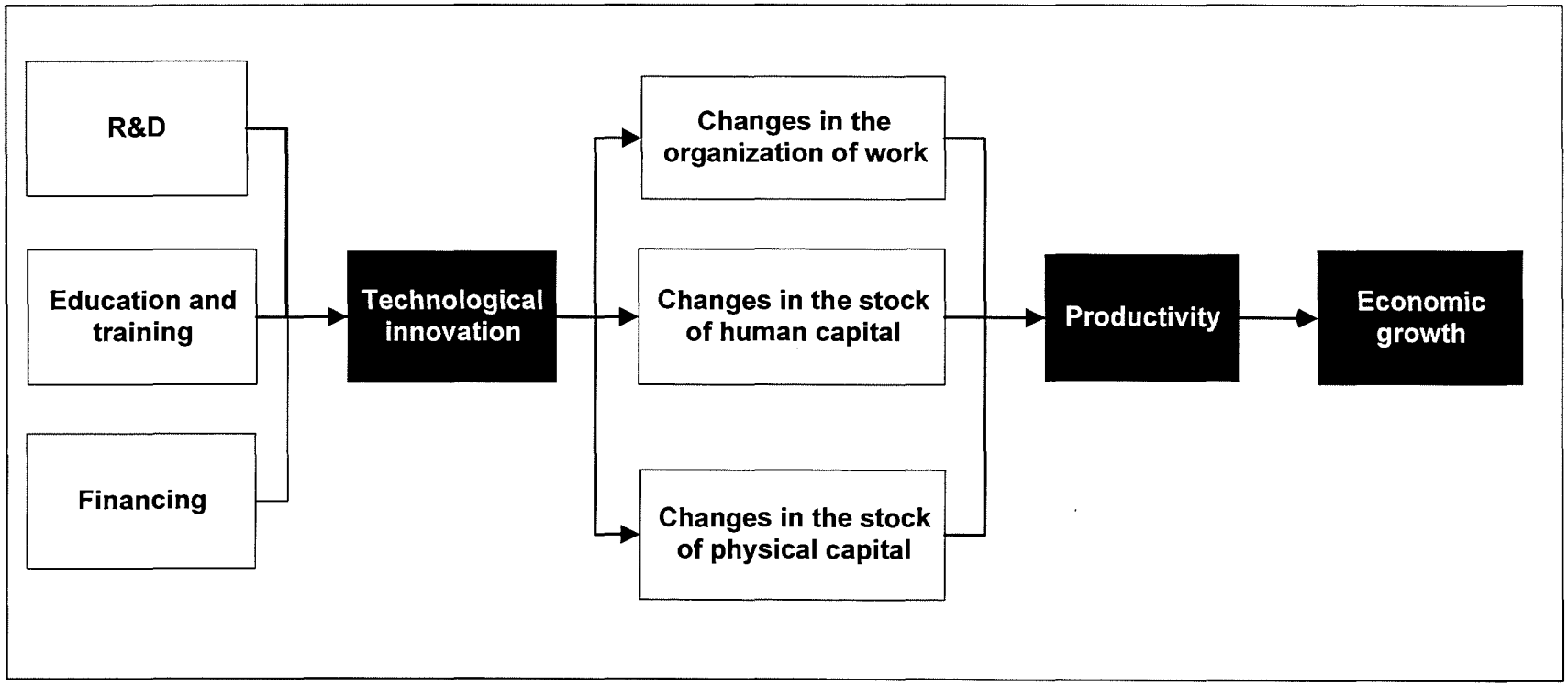
Source: Nexus Associates, Inc. based on U.S Patent and Trade Office data

Technological innovation depends on a steady flow of financing.

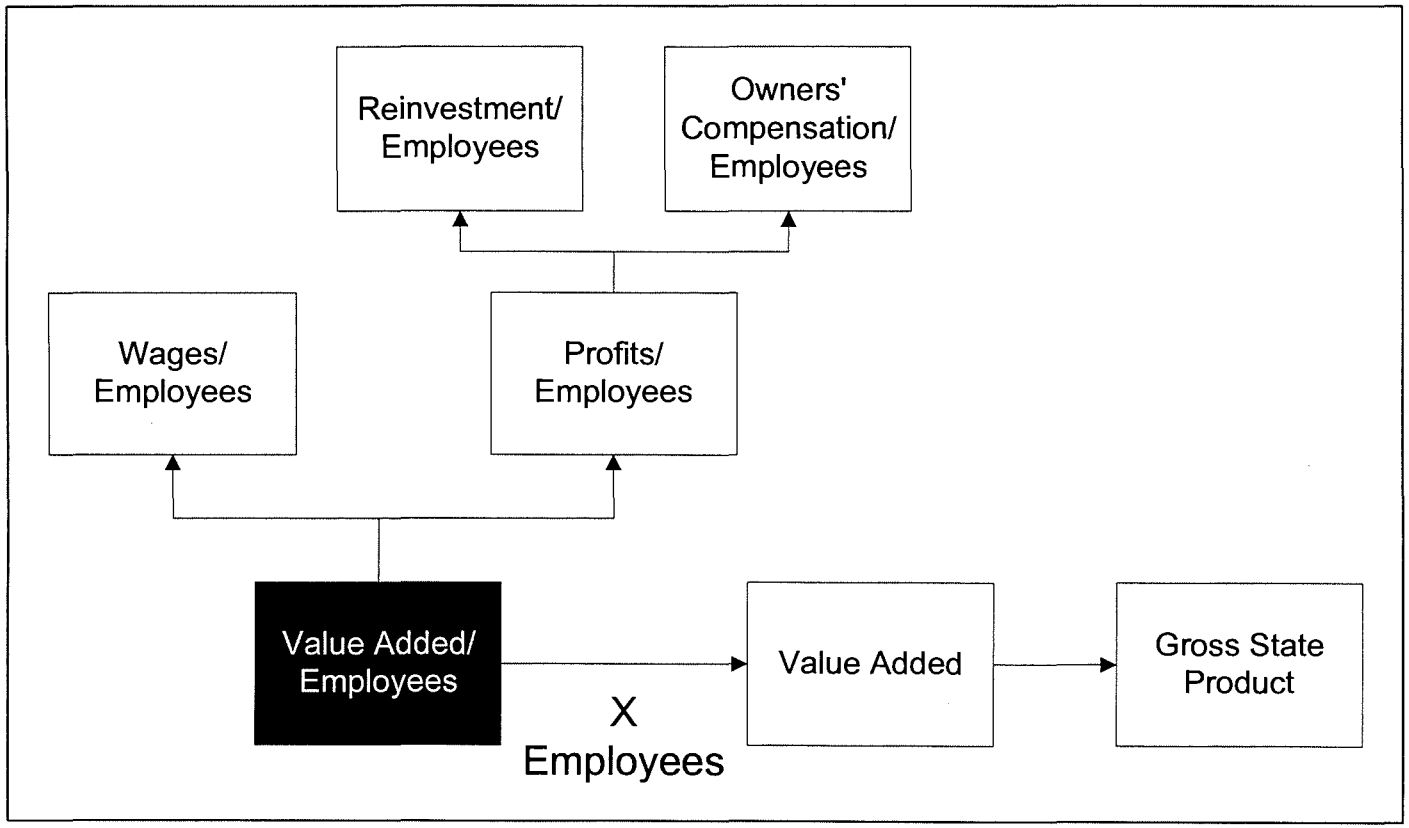
Venture capital summary: 1995 -1997:Q2 totals		
Industry	Number of deals	Value of investments
Consumer	2	$900,000
Distribution/retailing	2	$14,000,000
Industrial	2	$3,500,000
Software & information	1	$200,000
Business services	1	$2,000,000
Computers & peripherals	1	$13,500,000
Healthcare	1	$1,200,000
Communications	1	$3,660,000
Total	**11**	**$38,960,000**
Maine venture capital investments as a % of U.S. total		0.17%
Venture capital investments as a % of personal income:		
-- Maine		0.06%
-- United States		0.14%

Source: Price Waterhouse LLP

Technological innovations are critical to advances in productivity and long-term economic growth.



Productivity gains lead to higher wages, owners' compensation, and reinvestment.



Recommendations

- The state should devote greater resources to R&D and technological innovation by:
  - Increasing investment in university R&D;
  - Providing incentives for industrial R&D; and
  - Encouraging investment in technologies that are critical to target industries, focusing on technologies with broad applications.
- The state should also encourage greater collaboration among researchers in the university system, industry, and non-profits.
- The state should target high productivity, high wage industries with significant growth potential.
- It should adopt a portfolio approach to its investments, noting the potential for "disruptive technologies."