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New England's recent economic revitalization is largely attributed to the region's success in technological innovation and adaptation. This capacity to supplant older, maturing technologies with new technologies—a willingness to continually shed the old to make room for the new—has been a characteristic of New England since the early nineteenth century. At that time, as today, the critical factors in the process of technological development were the presence of investment capital, skilled labor, entrepreneurs, and, above all, preeminent colleges and universities that foster unconventional thinking and risk-taking. While the region's economy should continue to benefit from these fundamental factors, it is not without problems, and these merit additional research. The problems specified in this article all relate to maintaining the fundamentals for growth in the face of the adjustments that inevitably occur when a region undergoes periods of structural change. Nonetheless, two centuries of successful technological and manufacturing revitalization confirm the resiliency of New England's economy and underscore its ability to successfully undergo periods of industrial transition and transformation.

One of the great challenges facing industrial economies is the ability to evolve new industries as traditional industries face increased competition from lower-wage countries. History has shown that this process of technological innovation and adaptation is the key to continued economic growth. It is a complex process involving a combination of risk capital, skilled labor, and entrepreneurs.

The New England experience has gained worldwide attention as an example of successful technological adaptation and manufacturing revitalization. This article will focus on that experience and its relevance for regions, or countries, seeking to transform their manufacturing base in the face of increasing international competition. It will also specify a number of critical research priorities.

Throughout much of the 1970s, economic observers, including the Bank of Boston, were openly pessimistic about New England's future, largely because of the region's poor economic performance in the recessions of 1969-70 and especially 1974-75. More recently, however, we have come to fully appreciate the meaning of the maxim "The only thing certain about the future is change." Reflecting on the events of these years from the vantage of 1984, it is clear that the structure of New England's economy has undergone a fundamental change. Relative to the first half of the 1970s, employment

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in manufacturing has swung abruptly from a laggard in overall regional growth (down 5.6 percent) to the second sharpest growth sector (up 4.4 percent), as shown in Table 1. Indeed, approximately one-fourth of the region's employment growth in the second half of the last decade can be explained by the improved performance in manufacturing.

Table 1

Changes in New England Nonagricultural Employment, 1968-1980

	1968-75	1975-80
	%	%
Percent Change in New England Nonagricultural Employment	+5.2	+17.5
Relative Sectoral Contribution		
Construction	−0.5	+0.3
Manufacturing	−5.6	+4.4
Trade	+3.0	+3.7
Services	+5.2	+7.3
Government	+3.1	+1.8

Source: U.S. Dept. of Labor, Bureau of Labor Statistics, selected reports.

That manufacturing activity would demonstrate such economic vitality in the oldest industrialized region of our country is most interesting. It tends to provide clear refutation to those who have argued that older regions must necessarily be condemned to a future of slow economic growth, or even stagnation, as a result of a failing manufacturing base. New England's economic strength—especially as seen in the high-technology industries—demonstrates persuasively that regional growth can be led by manufacturing if industry is technologically innovative and government policy responsive.

The results are impressive. Since 1975 the New England economy has generated more than a quarter of a million new manufacturing jobs. The region's unemployment rate—at roughly 4 percent—remains well below the national average of 7.5 percent, and Massachusetts continues to have the lowest unemployment rate of any industrial state in the nation.[1] Moreover, many older communities in the region have been able to reverse their declining economic fortunes.

New England's resurgence has been noted by *The New York Times, The Wall Street Journal,* and *The Economist.* The analysis in these and other respected publications points clearly to a dramatic "Yankee turnabout" in the New England economy—but few observers have been able to explain clearly why this has occurred.

Why New England? In an attempt to provide answers to this question, this article will address three important issues: (1) the evolution of New England's technology base, (2) the fundamentals of the region's production process, and (3) the perception of the region as a place of opportunity.

The Evolution of New England's Technology Base: Hurrying History Along

Of all the factors affecting this region's economic turnabout, the spectacular growth in high-technology industries clearly stands out.[2] Attempts to trace developments leading to the revitalization of the region generally assume that the technology base of New England emerged somewhere in the post-Sputnik NASA era of the 1960s. There is much

to be said about the technical dynamism of this period and its relationship to the revitalization. To be sure, New England continues to benefit more than other regions from federally sponsored research and Department of Defense contracts: with only 5 percent of the U.S. population, New England receives more than 10 percent of federal research and development funds and 11 percent of federal defense contracts.[3]

Nonetheless, the reality is that New England has always been on the cutting edge of technology. The factors underlying the birth of the American Industrial Revolution in New England in the early nineteenth century are the very ones that account for the success of high technology today:

A supply of investment or, "risk," capital. In years past, this was made available from overseas trade; today much of it comes from the profits of successful technology start-ups.

A relatively large pool of skilled labor. One hundred and fifty years ago, as today, the region could boast of more skilled craftsmen and mechanics in the traditional industries than other parts of the country.

The presence of entrepreneurs who have understood the demands of risky investments and have effectively drawn upon capital and skilled labor in transforming innovations into profitable production.

In the early nineteenth century the commingling of these critical ingredients led to the high concentration of technical development in New England, creating entirely new markets and the need for industries such as machine tools and textiles.

These, in turn, produced many new industrial spin-offs. In fact, a large number of today's leading high-tech firms in the region owe much of their advantage to firms that preceded them. To cite just one example, the robotics industry came out of a long line of New England machine tool developments that can be traced back to the early nineteenth century.[4]

Development planners from other parts of the United States as well as nations overseas have sent representatives to New England to study the "spin-off" process. The lesson they invariably take home is that it takes a variety of resources—specifically skilled workers, capital, and entrepreneurs—to produce technological growth. But the glue that holds the process together is the presence of pre-eminent educational institutions.

In June 1982, a study of high technology carried out by the Joint Economic Committee of the U.S. Congress concluded that "unlike the more traditional manufacturing companies, high technology companies . . . seek out a community noted for the excellence of its academic institutions. . . . Universities provide benefits to high technology companies through their basic research activities and through the intellectual and cultural climate that they provide. More important, . . . universities provide skilled labor in the form of faculty consultants, research assistants, and graduating students."[5] In addition to these benefits, a number of universities are setting up "incubator" facilities that provide low-cost space for start-up companies, technical and management assistance, and laboratory, library, computing, and office service facilities.[6]

New England has powerful advantages with respect to its institutions of higher education. With 260 colleges and universities—65 in the Greater Boston area alone—New England is almost certainly the most knowledge-intensive region of the country. Approximately eight hundred thousand students are enrolled in New England colleges and universities, and many of them stay in the region after graduating—heading out into high-technology and information industries or the professional services market.

Historically, the Massachusetts Institute of Technology has played a critical role in research that furthered the development of industrial products and processes. But MIT is not unique or even alone in this regard. The Worcester Polytechnic Institute, in central Massachusetts, and Brown University, in Rhode Island, have played a role similar to that of MIT in providing engineering input to innovative companies. In reality, it is the total environment of universities and technology-based industries, together making new products and processes in fields of common effort, that has provided the basis for the region's economic turnaround.

Yet no country or region, even New England, can maintain technological excellence without some periods of discontinuity. In New England there have been relatively long periods between the maturing of one technology, with its broad income and employment benefits, and the beginning of the next. In New England's case, the first major growth spurt was the nineteenth-century Industrial Revolution, the second was the technology boom of World War II, and today's is the computer revolution. The movement from one period to the next, however, was most uneven, involving industry dislocation and high structural unemployment.

But however harsh these adjustments have been economically, the educational and technological superiority of New England has greatly facilitated the region's capacity to "hurry history along" in the transition from one period to the next. For other less educationally and technically well-endowed regions of the United States this adjustment process may well be more difficult.

The Fundamentals of the Region's Production Process

Certain fundamental factors have contributed to the recent rebirth in the region's technologically based manufacturing sector; though they have always contributed to the region's adjustment from one technological era to the next, they can be most easily observed in the current period of technological transition.

Factor l: The Role of Aggressive Venture Capital and Commercial Banking in the Region

Throughout U.S. history, New England has provided leadership in developing new ways of providing investment in a dynamic economy. Indeed, taking investment risks has been a habit in New England since the days of the East India trade. As a result, the region has an unusually large number and variety of financial institutions.

Venture capital is a major source of financing for industrial enterprises. For high-tech firms, venture capital, or start-up money, can transform good ideas into salable products. Perhaps not surprisingly, one of the sources of this venture capital is entrepreneurs who have built successful high-tech firms and now choose to channel their own capital resources into new technology starts. For instance, the Boston-based seed capital fund Eastech was created with the financial participation of more than a hundred such individuals.

Geographically, the lion's share of venture capital dollars in the United States has been concentrated in California and Massachusetts. During the 1970s, Massachusetts alone—with only 2.5 percent of the U.S. population—accounted for roughly 25 percent of all the venture capital investments in the nation.[7] Since 1981, two New England states, Connecticut and New Hampshire, have received substantial new venture capital investment.[8]

But venture capital provides only part of the financing for high-tech firms. At the proper stage of development, banks have helped put together the overall financing packages that have allowed "coming" companies to become "going" concerns.

Bank of Boston's commitment to high tech took an interesting form in the late 1960s. At that time, any entrepreneur with a federal contract in hand found it extremely easy to obtain credit at the bank, which is one reason why Route 128—now known as America's high-technology highway—became a reality. This kind of aggressive commercial bank lending to high-tech firms in the region is even more commonplace today.

Factor 2: The Role of State Policies

Before the recession of 1974-75, the region's left-of-center political focus was more on redistributing wealth than on creating it. But the sinking economic conditions of the mid-1970s, coupled with a fast-rising challenge from competitive Sunbelt states, jarred New England out of its "Yankee" reserve.

From Maine to Connecticut the tax-and-spend attitude of state governments in the region that prevailed during the 1960s and early 70s has given way to a recognition that economic health depends on jobs, and that job creation depends on a favorable business and tax climate. Anyone driving through New England can easily see this change in attitude in state advertising posters, bumper stickers, and television commercials—a "good neighbor" policy for business has become a reality.

But the real proof lies beneath the surface—in the changes in state policies that have helped state officials throughout New England put out the welcome mat for business, particularly technology-based firms:

An extensive network of development finance entities has been created to assist business start-ups and expansions with capital and technical assistance. The Massachusetts Technology Development Corporation, for example, is a public agency that provides venture capital to early-stage high-risk technology companies in the state.

States in New England have been among the first in the nation to centralize business-related programs by establishing "one-stop shopping centers" in their governments for businesses seeking information on site location, permit requirements, and state incentive programs.

New England states have launched major new programs for customized job training to ensure that high tech's employee-skill needs are met.

It would be naive to argue that all elected officials in New England have become "born-again capitalists," but there has been a dramatic shift in attitude among elected leaders since 1975—unquestionably contributing to the region's technology-based revitalization.

Factor 3: The Role of Manufacturing Production Costs

The revitalization of New England manufacturing has also come about in part because of the regional equalization of production costs. In a recent milestone study, Dr. Benjamin Stevens demonstrated that the New England economy has become relatively more competitive for manufacturing. Specifically, this analysis shows that during the 1973-80 period there has been a relative production cost improvement in New England vis-à-vis the Old South states that ranges from 30 to 50 percent.[9] The positive adjustment of wages has dominated this change to the point that today New England has the lowest real wages of all regions in the country. The relevant wage data ratios are shown in Table 2.

Table 2

Average Regional Manufacturing Wages as Percent of New England, 1980

	%
New England	100
Great Lakes	114
New South	104
West Coast	136

Source: U.S. Dept. of Labor, Bureau of Labor Statistics, selected reports.

These data confirm that New England enjoys a competitive wage scale, even when judged against our stronger regional rival—the New South. The low wage rates in New England are particularly important to high-tech industries as a whole.[10] The attractiveness of New England's labor force is further enhanced by the virtual absence of unionization within the high-tech industries.

In the final analysis, just as the presence of first-rate educational facilities is critical to technology *start-ups,* so labor availability and wage rates dominate the *expansion* needs of high-tech firms. Here, as with its institutions of higher learning, the region currently stands on firm ground.

However, a cautionary note is in order. Over the long-term, "tight" labor markets are likely to develop as defense contractors and high-tech firms vie for skilled and semi-skilled labor. Looking ahead, the issue of labor availability is likely to become an especially pressing factor in new business growth and a concern for regional policymakers, as labor scarcity pushes wages upward and a new cycle of competition for workers is set into motion.

Perceptions of the Region as a Place of Opportunity

Ralph Waldo Emerson once asked, "Why should not the New Englander try new adventures?" He could have been speaking of the researcher who sees a promising but risky path and pursues it even if it is at odds with conventional thinking, or the entrepreneur who can capitalize on new product ideas in the face of difficulties, or the financier who is willing to back the exciting but uncertain proposal.

Along these lines, Frank Newman, former president of the University of Rhode Island, has remarked that what distinguishes New England from other parts of the country is the presence of an "opportunistic" environment that favors innovation and that, in turn, attracts "risk lovers"—the very kinds of individuals who are most likely to beat the odds, pursue an idea with tenacity and determination, and become successful entrepreneurs. This is also precisely the kind of environment in which the technological breakthroughs occur that generate entirely new products and services.

Although critically important, the concept of entrepreneurship is widely misunderstood. All too often, the terms *entrepreneurship* and *management* are used interchangeably. This is unfortunate, for these two concepts are distinctly different. Management is that organizational function most closely associated with the day-to-day decisions of running a business firm. Entrepreneurship is a much more narrow concept related specifically to the conceptualization of an innovative idea around which a new business firm can be created.

Entrepreneurial energy is vital to the continued strength of the U.S. market economy, as well as to developing an understanding of the industrial revitalization of New England. Indeed, Seymour Martin Lipset, in his essay "Values, Education, and Entrepreneurship," singled out these special individuals as a separate class in society.[11] He argued that it was their tenacious pursuit of change and innovation (and in turn wealth) that sometimes made their behavior "deviant" according to accepted norms.

In the eyes of would-be entrepreneurs, New England *is* a good place to start a business—and it is a particularly good place to start a technology-based business. Start-ups are likely to be more concentrated in existing high-tech centers because they often draw upon the labor and entrepreneurial resources of established firms. As Dr. Lynn E. Browne, vice president of the Boston Federal Reserve Bank, pointed out in a recent article:

"High-tech firm after high-tech firm has been started by individuals previously associated with other high-technological companies. In many cases the new operation is almost next door to the old. The computer industry provides some striking examples. In Massachusetts Data General was founded by a former Digital employee. Apollo Computer was started by a former executive of Prime Computer and, very recently, the former president of Prime announced the formation of Encore Computer Corp. Existing high-tech firms are both training grounds and hotbeds of ideas. They also provide examples of entrepreneurial success which excite the ambitions of their employees."[12]

Watching Massachusetts high-tech entrepreneurs create exciting new businesses provides vivid confirmation of the reality of Lipset's point. Today there are 160 member firms of the Massachusetts High Technology Council. Currently, these firms employ more than 130,000 people in Massachusetts and 240,00 worldwide. Moreover, most of these firms have been in existence for such a short time that they have not yet established their retirement policies.

One may still ask, however, to what extent these factors—that is, the historical importance of labor, capital, and entrepreneurs; the presence of educational institutions in making the region technology-supportive; the roles played by aggressive financiers; changes in state policy; and declining relative wage rates in New England's most recent period of technological vitality—remain important as high-tech firms "grow up."

Robert M. Ady, executive vice president of the Fantus Company, recently provided an answer based on the different growth rates of high-tech companies.[13]

Stage 1. "The entrepreneurs are usually scientists or theoreticians, not necessarily practical business people. . . . They need cross-fertilization of talent and ideas from other high-tech companies in the area. . . .[14] The company may be near a university setting so individuals working on a project can retain close relationships with the university, the professors, colleagues, and facilities. Commercial air service is also important. Entrepreneurs spend a significant amount of time talking with other people working on similar ideas all over the country."

Stage 2. "Locational characteristics are different once the product has viability and is accepted in the marketplace. The availability of skilled labor and vocational/technical schools becomes a critical factor. . . . At this stage the company has a salable product, is still very technical, and needs accessibility to the R&D facility—the theoretical base. A 'magic mileage' formula is usually used here—within 300 to 400 miles of the location of R&D or within two to three hours of travel."

Stage 3. "Price competition enters seriously into the product at this stage. Labor and transportation costs become most important as the new product becomes copied by other firms."

Based on these locational requirements, many New England communities are particularly attractive sites for stages 1 and 2 in the growth of high-tech firms. Moreover, it is during these very stages that high-tech firms have the highest rates of job generation. An unpublished study undertaken by Bank of Boston's Economics Department, based on earlier analyses of the MIT Development Foundation, shows that the employment growth rate is particularly significant in the early growth stages of high-tech firms but diminishes as the companies mature. Tables 3 and 4 clearly tell the story.

Table 3

Mature Companies
Average Annual Growth (Compounded), 1945-1974

	Sales	Jobs
	%	%
Bethlehem Steel	4.9	−1.7
DuPont	8.6	2.6
General Electric	8.4	3.5
General Foods	8.2	4.5
International Paper	9.2	2.8
Procter & Gamble	9.6	3.8
Weighted Average	7.8	1.9

Innovative Companies
Average Annual Growth (Compounded), 1945-1974

	Sales	Jobs
	%	%
Polaroid	14.0	9.0
3M	14.1	9.0
IBM	16.8	10.2
Xerox	24.2	19.4
Texas Instruments (1953-1974)	21.2	17.3
Weighted Average	16.5	10.8

Young High-Technology Companies
Average Annual Growth (Compounded), 1969-1974

Date Incorporated		Sales	Jobs
		%	%
1968	Data General	140.5	82.5
1959	National Semiconductor	54.3	59.4
1960	Compugraphic	50.2	24.0
1957	Digital Equipment	36.8	30.7
1964	Marion Labs	24.5	25.4
	Weighted Average	42.5	40.7

Source: Selected company annual reports.

Table 4

Mature Companies
Average Annual Growth (Compounded), 1975-1980

	Sales	Jobs
	%	%
Bethlehem Steel	6.3	−5.3
DuPont	13.7	0.5
General Electric	12.1	1.4
General Foods	10.7	2.4
International Paper	11.2	−8.0
Procter & Gamble	12.1	2.8
Weighted Average	11.5	0.0

Innovative Companies
Average Annual Growth (Compounded), 1975-1980

	Sales	Jobs
	%	%
Polaroid	12.3	5.5
3M	14.2	0.8
IBM	12.7	3.4
Xerox	15.1	5.2
Texas Instruments (1953-1974)	24.4	9.7
Weighted Average	14.4	4.3

Young High-Technology Companies
Average Annual Growth (Compounded), 1975-1980

Date Incorporated	Sales	Jobs
	%	%
1968 Data General	40.4	34.3
1959 National Semiconductor	31.4	21.4
1960 Compugraphic	30.2	18.1
1957 Digital Equipment	34.7	23.9
Weighted Average	34.6	24.0

Source: Selected company annual reports.

Table 3 shows the job-creation growth rates from 1945 to 1974 for mature companies and innovative companies, and from 1969 to 1974 for young high-tech companies. It is interesting to note that while jobs at mature companies increased at an average annual rate of 1.9 percent, they increased at an average annual rate of 10.8 percent for innovative companies and the remarkable average annual rate of 40.7 percent for young high-tech companies. Admittedly, part of this phenomenon can be explained by "statistical smallness" in the high-tech companies, but the increases are maintained for such a sustained period of time that they cannot be dismissed.

As shown in Table 4, during the 1975-80 period, these job-creation rates slowed for all three categories. However, young high-tech companies were still creating jobs at an average annual rate of 24 percent—a healthy job-growth rate but a 40 percent decline

from the earlier period. The lesson here is that high-tech companies are in a state of dynamic growth and adjustment. Inevitably there will be a slowdown in job creation as a result of maturation in today's high-tech industries, and they will undoubtedly fade as new technologies emerge. *Sustained growth comes only to those regions that encourage a willingness to continually shed the old to make room for the new.*

In west Texas, rattlesnakes shed their skins to give themselves "wiggle room" for new growth. In New England a somewhat similar process is at work: outworn technologies are shed to make room for new ones. Emulating the rattlesnakes can help a region —as it has New England—to "hurry history along" in the transition from one technological era to the next.

Will It Happen Elsewhere?

In the United States today the competition among states for high-tech industries is fierce. State after state is actively engaged in targeting specific high-tech industries and in designing aggressive marketing campaigns to attract them. Indeed, state initiatives to promote technological innovation was a major subject of discussion at the National Governors' Association Conference in Nashville, Tennessee, in 1984.

As stated earlier, the foremost reason why New England generally—and Massachusetts in particular—has done so well in providing a home for high-tech industries is the presence of a substantial number of colleges and universities. The international greatness of a few of these has attracted the best and brightest from all over the world. These individuals—with no stake in Boston's Brahmin society—have consistently provided the state with a ready supply of potential entrepreneurs.

The presence of first-rate higher education institutions is a must for rapid and sustained technological growth. But the New England experience suggests that this kind of educational capacity cannot be created overnight.

Though states cannot build preeminent institutions easily and quickly, there is a resource close at hand to which they can turn: their public land grant colleges and universities. It is no coincidence that Austin, Texas, is becoming an important center for electronic components and small computers in the aftermath of a decision by the University of Texas at Austin to commit over $30 million to microelectronics and computer sciences. North Carolina's Research Triangle Park draws upon the scientific and engineering capabilities of two state universities—North Carolina State University and the University of North Carolina. On a smaller but nonetheless effective scale, R&D centers that encourage applied research and attract industry collaboration are being established in a number of public universities. Ohio State's leadership in welding research is a case in point, as is the University of Rhode Island's in robotics, and the University of Utah's in medical research. Georgia Tech, among others, provides "incubator" space to new technology-oriented businesses.

In short, the revitalization of New England can be traced more than anything else to an educationally fertile environment that fosters entrepreneurship. This means not only a strong college and university system, but one that recognizes that the crucial people in technological development are those who are excited by the prospect of taking a chance in addition to being well educated. In the final analysis, it is the maverick—the nonconformist who persists in spite of the odds—who makes innovation a marketplace reality. Hence the discussion in the concluding section of this article on the set of research priorities that are likely to play a major role in the public policy debates well into the 1990s.

Defining an Appropriate Regional Public Policy Research Agenda

The process of hurrying history along through successive periods of technology development is most complex. Yet because technological renewal is so vitally important in keeping the region competitive in world markets, and because persistent unemployment during periods of industrial discontinuity is so politically unacceptable, it will always be tempting for elected officials advocating new government policies and programs to ameliorate this adjustment process. Indeed, the constant dilemma in developing economic policies is that politicians by the very nature of the electoral process seek short-term solutions to what is a long-term adjustment.

Achieving basic industrial structural change is a painful process for any region. For this reason, it would be worthwhile, as a research project, to address the question of whether a capitalistic, or market-based, region can maintain technological excellence without some periods of industrial discontinuity. The central public policy issue in this research is whether an activist role for state governments in the economy is the most promising approach to maintaining regional technological strength and vitality—and, if so, what the critical aspects of that role should be.

The Process of Industrial Aging

Since 1975, employment growth in high-technology firms in the region has been quite rapid. Indeed, it was pointed out in the foregoing analysis that this employment growth was an important ingredient in the process of industrial renewal. Clearly, it is the initial spurt of job creation that makes the employment impact of labor-intensive, technology-related industries so attractive. Nonetheless, historical experience indicates that this pace of growth cannot be sustained. Inevitably, it seems that job-creation rates will slow, and today's high-technology industries will begin the inexorable process of evolution into tomorrow's mature industries.

The whole process of change is not well understood, prompting the need for further research. Questions such as the following arise: Is industry maturation inevitable? Can the maturation process be delayed or at least slowed through marginal doses of new technology in the existing production process or in related processes? The answers to these questions will ultimately suggest the direction of this region's economic fate and provide valuable lessons for other regions.

Accordingly it would be very worthwhile to attempt to determine whether this slowing down in growth is the result of technological competition or managerial diseconomies. It is generally accepted that larger organizations are less responsive to changes in competitive markets.

The difficulties of organizations in meeting a slowdown in the growth of demand results from their inability to develop domestically and internationally competitive new technologies. However, technological change may also stimulate new types of demand. The most successful companies will be the ones that are the first to identify these demand shifts.

As a result of technological change and the increased intensity of competition, product diversification and variations in organizational structure eventually affect the location of head offices, production units, subsidiaries, contractors, and markets. Organizational structure, in particular, can have a significant influence on a firm's adaptation to change. Smaller organizations, for example, might be more adaptable to change and innovation than larger enterprises in that they are able to make timely decisions without a hierarchically stolid bureaucracy. They are more flexible to changes in opportunity.

An objective of future research should, therefore, be to look at regional high-technology issues from a micro perspective. Such research might, at the very least, show how organizational structure influences, and is influenced by, new technology development under changing economic conditions. The research would also examine how changing corporate strategy might set the issues in a state's economic policy agenda. Such an agenda—if properly drawn and implemented—might help the region delay the industrial maturation that results from changing corporate business strategies as the competition for the region's products intensifies.

Structural Unemployment and Industrial Transition

Throughout the 1950s and 1960s, the troublesome issue of industrial transition and structural unemployment was a matter of considerable and serious research interest.[15] During this period, it was widely accepted that in industrially mature regions such as New England no amount of economic growth would be sufficiently pervasive to pull the structurally unemployed manufacturing worker back into the growing component of the labor market.

This discouraging viewpoint was painted in a most negative way by Barry Bluestone and Bennett Harrison in 1974.[16] Their papers went beyond the traditionally established concerns by demonstrating that most structurally unemployed workers from New England's traditional manufacturing industries not only had severe re-entry problems within this sector but also faced a harsh, limited potential adjustment into other industries within the nonmanufacturing sector.

These studies took as a given that regional growth was not likely to be strong enough to solve these problems. It was also assumed that even if suburban and rural growth were to be significantly accelerated, it would neither spill into the mill towns nor pull out these pockets of structural unemployment.

Based on the vigorous reindustrialization of New England, it would appear that rapid aggregate regional growth has substantially reduced structural unemployment in a number of New England cities. The data in Table 5 vividly illustrate this point.

Table 5

Selected Unemployment Rates*

	1965	1975	1983
	%	%	%
New England	4.5	11.0	6.9
Lowell, Mass.	9.2	13.1	6.2
Haverhill, Mass.	6.9	15.2	7.6
Portland, Me.	3.9	8.7	6.2
Burlington, Vt.	3.9	7.8	4.4
Springfield, Mass.	5.3	12.5	7.6

Source: U.S. Dept. of Labor, Bureau of Labor Statistics, selected reports.
**Data are for June of each year, seasonally adjusted.*

These developments suggest serious new research is needed in at least three areas:

First, to determine the extent to which fast versus moderate growth provides a positive employment impetus for labor markets in these urban areas.

Second, to specify the issue of industry mix and the apparent tenacity with which declining, or industrially mature, industries have "hung on" in some older mill towns and not others. This is a most important line of inquiry because it would help identify those forces that enhance industry transition in some cities and not in others.

Finally, to document the role of capital subsidies in "opening up" the business investment environment in cities and lowering relative unemployment. Specifically, it is interesting to note in referring to Table 5 that the five cities with low unemployment rates have each received an average of 7.2 Urban Development Action Grants, while the four with high unemployment rates have each received an average of 3.5 UDAGs.

Labor Intensity in the High-Technology Firm's Production Function

In the foregoing analysis specific reference was made to the fact that low wage rates in New England have been particularly important to the indigenous development of high-tech industries. And, within this context, it has been demonstrated that the capital to create each job in the high-tech production process amounts to only about 10 percent of that for all U.S. manufacturing industry.

Additional research into the issue of labor intensity in the high-tech production function would be most rewarding. There appear to be two obvious areas that merit such research. The first deals with the definition of the capital base to be appropriately ascribed to the labor variable. We repeatedly speak of the role of R&D expenditures in the development of the region's high-tech industries. Although it would be a most difficult allocation and measurement task, would it not seem appropriate to assign a part of the federal government's long-term investment in MIT's R&D capacity into the capital component of the production functions of high-technology firms? Surely, increments of R&D capital have played a crucial role in the development of these firms, and we know that their production processes are quite different from those of mature industries. Moreover, questions should be asked about the allocation of capital costs between the private and public sectors. A large part of the nation's R&D expenditures comes from the federal government. Does this mean that the lower-than-expected capital quotients in the high-tech firms are the result of a "free externality"?[17]

The second area of research would address the definition of "production worker" in the high-tech industries. We already know that these industries not only conduct research and manufacture products; many of them also sell and service their products. It may well be that the labor component in the production function is more inclusive than in the more traditional industries, but this is merely a working hypothesis.

Regional Underinvesting in Public Capital

At a time when New England has experienced substantial economic growth as a result of its development of high-technology industries, investment in the public infrastructure has declined. The outstanding net direct debt of Massachusetts' cities and towns, for example, declined from more than 5 percent of the gross state product in 1975 to only 2 percent in 1983. Would a decreasing emphasis on public capital spending to maintain and improve the infrastructure cause a bottleneck in the growth of the private sector and/or rising costs of production? Quite obviously, both factors are significant determinants of the region's longer-run competitive position.

The often stated but unproven view that the deterioration of roads, bridges, mass transit, and water and sewer systems will inhibit future growth has at least two critical research dimensions that must be addressed fully before the case is made that this is a

significant economic problem area. The first is the need to document the specific extent of deterioration in public capital, and the second is the linkage between that deterioration and private-sector competitiveness.

With regard to the former, there is still considerable room for rational debate over the extent of deterioration in the region's infrastructure. An unpublished but widely circulated study by Marshall Kaplan for the Joint Economic Committee of the U.S. Congress seems to suggest that the infrastructure needs in New England are not as pressing as elsewhere. Specifically, he concludes that "the highest projected annual average per capita need for infrastructure is forecast for the South Central, followed by the South, the Midwest, and the West, with the lowest projected need being for the Northeast."[18]

But even a relatively slower deterioration in infrastructure in the region is still of concern. Additional analysis in this area has been launched by the Massachusetts Legislature's House Committee on Taxation as a prelude to addressing the Massbank proposal—Governor Michael Dukakis' plan to fund infrastructure repair. This research and the public policy debate on financing infrastructure improvements are certainly worth watching.

Finally, and with regard to the latter, a recent and important study on the current state of the northeastern states' infrastructure concluded the following:

Long-Term Economic Impact. There is a surprisingly strong consensus among researchers that major water resource projects are *not* a critical factor in national economic growth and development. Such projects appear more likely to shift the location of economic growth from one region or location to another than to result in measurable additions to the national economy. Further, there is very little evidence that water resource projects make a critical difference to the industrial growth of a region or local area; other factors such as transportation, work force, and so on, appear to be more important locational criteria.[19]

Infrastructure Rehabilitation. To date, there is virtually no published research on the economic impact of infrastructure investment or rehabilitation. Major studies are under way by HUD, EDA, and the Farmers Home Administration that should provide additional insight on this issue in the next year or two. Preliminary indications suggest that this is likely to prove a matter of considerable importance to the older cities of the nation, many of which are located in the Northeast.[20]

In a sense, this finding is more consistent with one's *a priori* expectations. Otherwise how could New England, especially Massachusetts, successfully have undergone such a fundamental industrial transformation to growth in the face of a badly deteriorated infrastructure? In any case, the linkage between the condition of the infrastructure and business investment is currently an unspecified research issue.

The Changing Demand for Entry-Level Labor

Though not explicitly addressed here, comment should be made about the profound adjustment that is taking place in the region's labor markets. Increasingly it appears that a segmentation or duality in labor occupational demand has developed: that is, the demand for trained labor in New England will more and more fit into two categories. The first consists of a relatively few high-paying jobs in one part of the labor force: sophisticated engineers, scientists, and professional managers with graduate school training. However, the bulk of the jobs will be in the other part of the labor force—entry-level production workers as well as limited-skill white-collar professionals.[21] While this may

well be "good news" for non-college-bound high school students, in terms of job opportunities, it also puts new pressures on the high school to encourage greater academic achievement among its students. Presumably this means better training in the core curriculum skills and, equally important, preparation for adaptability in the work place as the tasks, methods of production, and services provided undergo major change.

Significant new research on high-school curriculum reform is already under way on a number of fronts, but research is also needed in another area: identifying what high schools, vocational schools, and community colleges each can do best in preparing a competent entry-level workforce. This is the long-standing and troublesome real-world issue of program articulation. There is a significant gap in our understanding of the specific details affecting entry-level demand, and of the appropriate roles different institutions should play in meeting this demand in educational training—and thus a pressing need exists for a better definition of goals among the various kinds of institutions.

Finally, inasmuch as this issue touches on so many different and well-established institutional turfs, it is difficult to be certain what constitutes the appropriate research and policy entity to undertake such a project. Nonetheless, if the operational configuration has changed and continues to change for some time, the sooner we begin to make the appropriate educational adjustments, the greater the likelihood of the region's maintaining its relative competitive strength.

Maintaining the Excellence of Institutions of Higher Education

A major theme expressed throughout this article has been the importance of establishing an environment that encourages entrepreneurship. As we have seen, universities and colleges that provide a first-rate education play a vital role in this process.

Nonetheless, there are problems that must be addressed if New England is to maintain its powerful advantage in higher education. Foremost among these is the difficulty in financing the costs of higher education, especially during a period when public resources are increasingly scarce. While there is an overall surplus capacity with respect to physical plant for higher education in the region, a long-overdue upgrading and expansion of research laboratories will require new sources of financing. Moreover, there is a need for financing noncapital costs in some academic fields, such as faculty and curricula development, in response to changing economic needs in the region.

Another potential problem relates to the declining pool of college-age residents and the attendant impact on aggregate educational capacity. The decline in the number of 18-year-olds is a nationwide phenomenon, but in Massachusetts that adjustment is even more severe. From 1979 until 1994, Massachusetts will have a 43 percent reduction in its 18-year-olds.

The dual problems of limited public resources and changing demographics suggest another item on the region's public-policy research agenda: the upward pressures on tuition costs and new sources, techniques, and mechanisms for financing these costs. This requires a continued dialogue, cooperative planning, and new collaborative arrangements among educators, government officials, and business leaders as well as efforts to help stretch our limited educational resources much further. These resources can be used to improve the capacity of colleges and universities to provide technology-oriented skill development.

As emphasized in a recent report by the Commission on Higher Education and the Economy of New England, however, skill development does not imply exclusively vocational skills; it also implies "the capacity to be a well-developed people capable of

having independent thought."[22] This capacity for independent thought lies at the heart of New England's revitalization, for it is the driving force behind the process of technological innovation and adaptation that has been—and remains—the key to the region's economic growth.

Notes

1. Unemployment rates as of July 1984.
2. In the past, there was a tendency to equate the term *high technology* with a very narrow spectrum of enterprises, primarily firms producing computers and semi-conductors. Increasingly, however, high tech has come to be viewed as encompassing a wide array of advanced-technology industries, including health care, communications systems, pharmaceuticals, publishing, and scientific instruments. Even more broadly, high-tech industries can be viewed as knowledge-intensive manufacturing industries actively engaged in developing new products and processes.
3. The principal small-firm beneficiaries of government R&D have been in the electronics industry, where much early military R&D went toward unproven technologies that have since found broad commercial application.
4. This line of reasoning is drawn from J. H. Hekman and J. S. Strong, "The Evolution of New England Industry," *New England Economic Review,* March/April 1981, pp. 35-46.
5. "Location of High-Technology Firms and Regional Economic Development," staff study of the Joint Economic Committee, U.S. Congress (Washington, D.C.: U.S. Government Printing Office, 1982).
6. See "Universities Emerge As an Important Catalyst in the New Business Development Process," *The Venture Capital Journal,* August 1983, pp. 7-12.
7. "Venture Capital Disbursements in 1981: A Statistical Overview," *The Venture Capital Journal,* June 1982, pp. 7-11.
8. "States Venturing into Venture Capital: Opportunity or Problem," *The Venture Capital Journal,* September 1983, p. 10.
9. Benjamin H. Stevens, "Regional Cost Equalization and the Potential for Manufacturing Recovery in the Industrial North." Unpublished paper presented at a conference sponsored by the State University of New York at Albany, April 1982.
10. Empirical analyses undertaken by Bank of Boston's economists have shown that the production processes of high-technology firms are heavily labor intensive. This can be most easily seen when one examines the capital investment (for plant and equipment) required to create each job in overall manufacturing and the comparative capital spending figures for high-technology manufacturing during the critical years of accelerated revitalization in New England.

Capital Investment Per Worker Entering the Labor Force, 1975-1980

	Cost per Job (in thousands)
United States	
All manufacturing	$243.8
New England	
All manufacturing	$ 70.7
High-technology industries ...	$ 33.8

Source: U.S. Department of Commerce, *Survey of Current Business,* selected issues, 1975-81, and unpublished data on capital spending in New England developed by the Economics Department, Bank of Boston.

11. Lipset notes that it is the fabric of social, educational, and cultural factors that produces a steady stream of entrepreneurial behavior. He also reminds us that such factors are not easily replicated. See his "Values, Education, and Entrepreneurship," in Seymour Martin Lipset and Aldo Solari, eds., *Elites in Latin America* (New York: Oxford University Press, 1967).

12. See Lynn E. Browne, "Can High-Tech Save the Great Lakes States?" *New England Economic Review,* November/December 1983, pp. 23-24.

13. Robert M. Ady, "Locational Determinants for High-Tech Firms," address delivered at the University of Rhode Island, May 24, 1983.

14. The process described here is technically known as agglomeration—that is, the clustering of a support network of companies to exploit market opportunities. Agglomeration and spin-offs are mutually reinforcing. The creation of new firms increases further corporate activity, reinforcing the comparative technological advantages of the area.

15. See, for example, C. C. Killingsworth, "Automation, Jobs, and Manpower: The Nation's Manpower Revolution," U.S. Senate, Subcommittee on Employment and Manpower of the Committee on Labor and Public Welfare, Hearings, 88th Congress, 1st session, Washington, D.C., 1963; B. Berman, "Alternative Measures of Structural Unemployment," in A. M. Ross, ed., *Employment Policy and the Labor Market* (University of California); and N. Simler, "Long-Term Unemployment: The Structural Hypothesis and Public Policy," *American Economic Review* 54 (December 1964), pp. 985-1001.

16. Barry Bluestone, "Occupational Transition in Massachusetts Labor Markets," unpublished manuscript, Boston College, 1974; Bennett Harrison, "The Economic Development of Massachusetts," Special Report to the Joint Committee on Commerce and Labor of the Massachusetts General Court, November 1974.

17. Some work has already been undertaken in this field; see especially E. J. Malecki, "Public and Private Sector Interrelationships, Technological Change and Regional Development," in *Papers of the Regional Science Association* 47 (1981), pp. 121-38; P. Horowitz, "Direct Government Funding of Research and Development: Intended and Unintended Effects on Industrial Innovation," in C. T. Hill and J. M. Ulterback, eds., *Technological Innovation for a Dynamic Economy* (New York: Pergamon, 1979), pp. 255-91.

18. Marshall Kaplan et al., *Report on the Nation's Infrastructure Needs,* unpublished paper presented to the Joint Economic Committee, U.S. Congress, 1983. See the chapter entitled "Regional Comparisons."

19. David A. Grossman, *The Economic Impact of Water Projects.* The Northeast Water Resources Project (New York: Nova Institute, September 1979).

20. Ibid.

21. For specific details of this issue see J. M. Howell's remarks published in *The Two-tier Labor Market,* proceedings of a symposium at Rivier College, Nashua, New Hampshire, October 1983. Also see Robert Kuttner, "The Declining Middle," *The Atlantic,* July 1983, pp. 60-72, and Ray Marshall's comments in *The Texas Observer,* April 6, 1984.

22. See *A Threat to Excellence,* Commission on Higher Education and the Economy of New England (Boston: New England Board of Higher Education, March 1982).