The Lowell High-Tech Success Story: What Went Wrong?

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Ten years ago Lowell, Massachusetts was a high-tech success story. After several decades of stagnation, the Lowell area had emerged as a thriving center for high-technology employment. The Lowell story was viewed as a "model for reindustrialization" for older cities throughout the world (*Dun's Review* 1980; Butterfield 1982; Earls 1983).

In recent years Lowell has once again become the focus of international attention, this time as an example of a failed economic development strategy (Ingrassia 1990; *The Economist* 1991; Farley and Yung 1992; Hervieux 1992). Widespread layoffs and plant closings within its computer industry, particularly the collapse of Wang Laboratories, have dealt a crushing blow to the local economy. Lowell's recent economic bust was not an inevitable outcome of its high-tech boom, however. Key signs of the vulnerability of the thriving local economy to production cycles were visible and identified over 10 years ago (Flynn 1984).

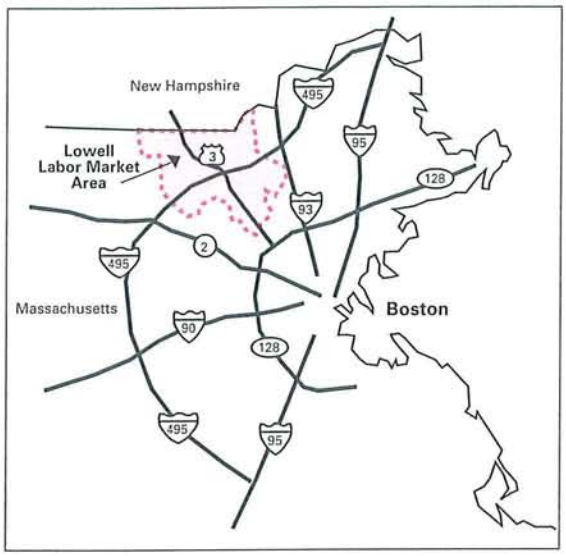
This article analyzes the boom and bust periods the Lowell economy experienced with high-technology employment, identifying what went wrong and what might have been done to mitigate the impacts of economic and industrial change. The first section provides a brief historical overview of the rise and decline of textiles and the more recent cycle (1972–94) of high-technology employment in the Lowell area. The article goes on to address the key factors responsible for the area's high-tech economic revitalization and subsequent decline. The third section considers issues of predictability and control in local economic development and in the future of Lowell. The article concludes with a discussion of the lessons to be learned.

I. Historical Overview

Lowell was the second planned industrial city in the United States, after Paterson, New Jersey.[1] Founded on the vision of Francis Cabot Lowell, its growth and development in the nineteenth century were tied to textile manufacturing.

Map 1

Lowell Labor Market



The Rise and Fall of Textiles

Textile mill owners were attracted to Lowell by its labor force and by the Merrimack River and power canal system, which provided the energy source for power looms. The textile mills incorporated the latest technology and spurred Lowell's transition from an agricultural community to a thriving industrial city. From 1826 to 1850, the population of Lowell expanded from 2,500 to over 33,000; the population more than trebled by 1920 to over 112,000.

This textile-driven employment boom began to subside at the turn of the century, however, as technological change, competitive shifts in the textile industry, and labor unrest prompted many mill owners in Lowell to move their operations to the South, where production costs were significantly lower. Steam power and electricity replaced water as the lowest-cost industrial energy source, reducing the attractiveness of locating in Lowell. In addition, the poor working environment in the mills sparked labor strikes and demands for higher wages and better working conditions.

Lowell entered an extended period of economic decline, and manufacturing employment in the city fell almost 50 percent between 1924 and 1932. This collapse partly reflected the Great Depression, felt nationwide; however, unlike many other industrial areas, the Lowell economy did not revive after the Depression. Instead, the local economy experienced several more decades of stagnation. Employment began to grow in the 1960s, but Lowell's unemployment rate continued to exceed that of the United States.

Although its manufacturing base declined in both absolute and relative terms during the 1960s, Lowell retained a concentration of employment in manufacturing 50 percent above the national average. The manufacturing jobs that remained were primarily in relatively low-wage and declining industries.

The High-Tech Boom

The early 1970s marked a turnaround in Lowell's economic fortunes, and the area prospered until the late 1980s. Total employment in the Lowell labor market area nearly doubled between 1972 and 1989, and impressive job growth occurred in all major industrial categories.

Most significant was the revival and transformation in manufacturing employment, which increased by over 90 percent from 1972 to 1989 (Table 1).[2] The composition of manufacturing employment in the Lowell labor market area shifted dramatically in favor of durable goods, which increased fourfold to over 32,000. Nondurable manufacturing continued to shed jobs, declining nearly 40 percent. Several "high-technology" industries, including industrial machinery (SIC 35), electric and electronic equipment (SIC 36),

[1] Located 25 miles northwest of Boston, the Lowell labor market area (LMA) now includes the towns of Billerica, Chelmsford, Dracut, Dunstable, Groton, Tewksbury, Tyngsborough, and Westford in addition to the city of Lowell (see the map). The geographic definition of the Lowell Labor Market Area (LMA) was changed in 1989, adding the town of Groton. Groton's employment (1,700 total employment and 290 manufacturing employment in 1989) is very small compared to the city of Lowell and other towns in the LMA, and its addition to the LMA does not significantly influence the time series analysis presented here.

[2] All employment data presented in this article, unless indicated otherwise, are for the Lowell LMA and are taken from the U.S. Bureau of Labor Statistics, "Establishment/Payroll Data: Survey 7–90." Detailed data, for example, for 2- and 3-digit SIC industries, obtained from the Massachusetts Department of Employment and Training, could not be presented because of disclosure issues; hence the data included in Table 1 are at a highly aggregated level.

Table 1
Lowell Labor Market Area—Employment Changes from 1972 to 1994
Thousands

				Annualized Growth Rates (Percent)		
	1972	1989	1994	72–89	89–94	72–94
Total Employment	58.9	112.8	103.1	3.9	−1.8	2.6
Manufacturing	20.7	39.6	28.4	3.9	−6.4	1.4
Transportation, Communications, and Utilities	3.0	4.6	5.7	2.5	4.4	3.0
Trade	12.0	23.6	21.6	4.1	−1.8	2.7
Finance, Insurance, and Real Estate	1.6	3.8	3.6	5.2	−1.1	3.8
Services	n.a.	22.4	26.3		3.3	
Government	8.9	13.8	13.4	2.6	−.6	1.9

Note: Services employment not available in 1972.
Source: U.S. Bureau of Labor Statistics.

and instruments (SIC 38), experienced significant growth during this period.[3] Most pronounced was the expansion of the industrial machinery industry.

By 1989, approximately one-third (35 percent) of the local labor market's employment was in manufacturing, with industrial machinery accounting for over one-half of the manufacturing jobs. Industrial machinery had become as important to Lowell manufacturing employment as textiles and apparel were at the turn of the century. Further, over 90 percent of the employment in industrial machinery was in one industry, office and computing equipment (SIC 357), which includes minicomputers. One firm, Wang Labs, accounted for the bulk of the local jobs in that industry.

Gains in average hourly earnings of production workers accompanied this shift in the composition of manufacturing employment in the Lowell economy. Average wages of production workers rose from more than 10 percent below the U.S. average in 1972 to over 5 percent above the national average in 1989.[4] In 1979, Lowell's unemployment rate dropped below the U.S. average for the first time in decades; it reached its lowest point (2.8 percent) in 1988 (Figure 1). This was one year before total employment peaked in the Lowell labor market area at just under 113,000.

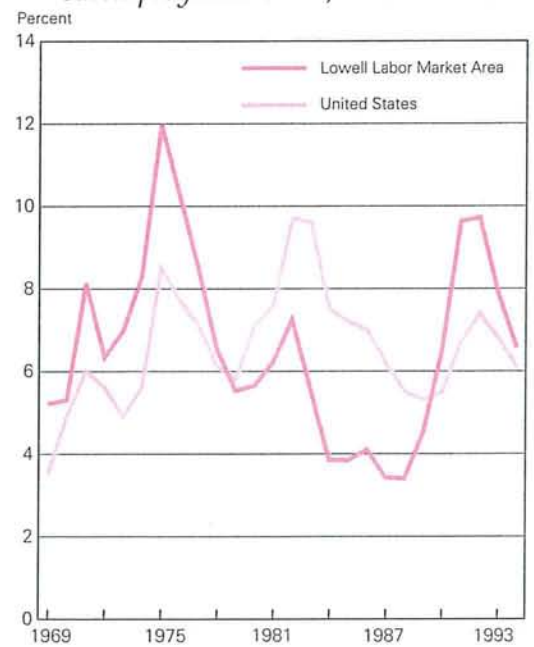
[3] The U.S. Bureau of the Census reclassified some industries in 1989. Of particular importance to the Lowell LMA data, the reclassification moved some 4-digit industrial sectors from SIC 36 to SIC 38. Despite these changes, the Lowell LMA experienced growth in employment in SIC 36 in the period 1972 to 1988.

[4] U.S. Bureau of Labor Statistics, "Employment and Earnings, States and Areas."

The Economic Bust

Economic decline again hit the Lowell economy in the late 1980s. From 1989 to 1994, total employment declined by nearly 9 percent and manufacturing em-

Figure 1
Unemployment Rate, 1969 to 1993



Source: U.S. Bureau of Labor Statistics.

ployment by 28 percent (Table 1); unemployment jumped from its low of 2.8 percent (May 1988) to a peak of 10.7 percent (June 1992).

The loss of jobs in manufacturing precipitated the economic decline in Lowell; manufacturing employment in the Lowell labor market area had peaked in 1984 at just under 40,000 (Figure 2). Initially, job losses were concentrated in the industrial machinery industry. In 1989, for example, this one 2-digit industry was responsible for two-thirds of the drop in employment. The office and computing equipment segment of the industry, and Wang Labs in particular, accounted for the bulk of the decline. The impacts of the income losses of those laid off in the computer industry, combined with reduced spending of other workers fearful of their own job security, then spread throughout the labor market. By the early 1990s, job losses were more broad-based, with employment declines experienced in wholesale and retail trade and in finance, insurance, and real estate (Table 1).

II. Understanding Lowell's High-Tech Boom and Bust

While one industry and one firm played dominant roles in both the boom and the bust in the Lowell economy, a variety of factors, interrelated and mutually reinforcing, were responsible for the area's economic revitalization and subsequent decline.

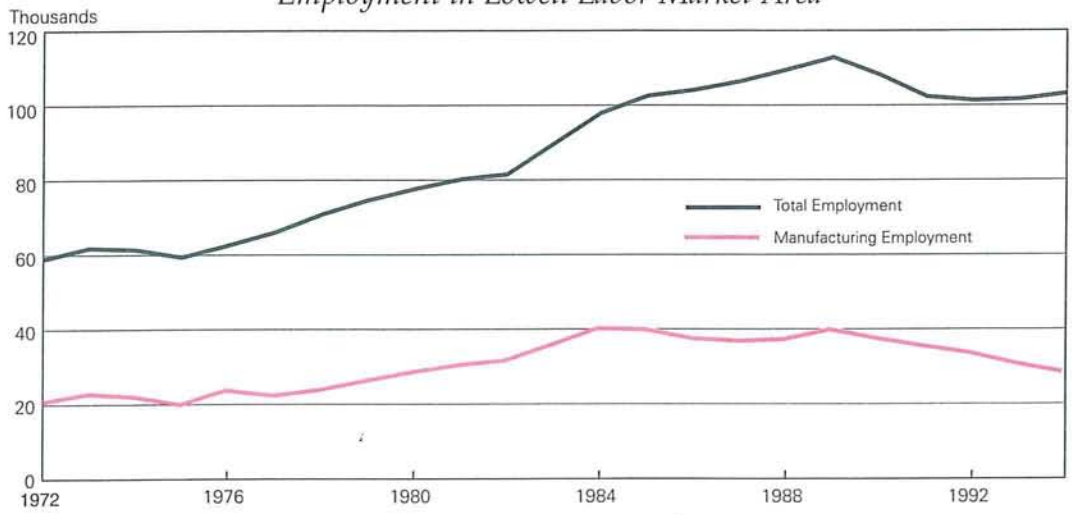
Factors Underlying Lowell's High-Tech Success Story

Several factors were critical to Lowell's reindustrialization into a high-tech success story, in addition to the period of unprecedented prosperity enjoyed throughout Massachusetts in the mid 1980s, often described as "the Massachusetts Miracle." Among these factors were the following: (1) access to an entrepreneurial and highly skilled work force; (2) a pool of relatively low-cost production workers; (3) a local competitive advantage for the newer high-tech industries; (4) an influx of funds from both the private and the public sectors; and (5) effective local leadership.

Access to an entrepreneurial and highly skilled work force. The Lowell area offered ready access to a good supply of highly skilled workers. The Lowell labor market area benefited from its close proximity to Boston and the Massachusetts Institute of Technology as well as many other colleges and universities that generate an ongoing supply of graduates in professional and technical disciplines. These institutions of

Figure 2

Employment in Lowell Labor Market Area



Source: U.S. Bureau of Labor Statistics.

higher education also served as a source of new entrepreneurs (Malecki 1991; Saxenian 1994).

The Lowell area is situated just outside Route 128, which by the early 1970s was densely populated with high-tech firms engaged in R&D and early-stage production activities. This location provided an array of benefits, including access to a wealth of scientific and engineering talent, informal entrepreneurial networks, and business support services that derive from agglomeration economies of an established high-tech employment base (U.S. Congress, Office of Technology Assessment 1984; Malecki 1990). The Lowell economy also benefited from entrepreneurial "spinoffs," as several former employees of established high-tech firms along Route 128 chose to start ventures of their own in the area.

The Lowell economy provided a setting that was highly receptive to the jobs in the newer industries.

Pool of relatively low-cost production workers. In the early 1970s, the Lowell area also provided an abundance of relatively low-cost, low-skilled labor. Relative to the state and the nation, production wages in the Lowell labor market were low. In the late 1970s, production workers in the booming industrial machinery industry and the electrical and electronic equipment industry in the Lowell area were earning less than two-thirds the national average for production workers in these industries. In contrast, local employers in the declining textile and apparel industries had been paying wages above the national average for these more mature industries. In 1982, average hourly wages of manufacturing production workers in the area were still 9 percent below the state average.[5]

Local competitive advantage. The Lowell economy provided a setting that was highly receptive to the jobs in the newer industries. Although the high-tech firms in Lowell were paying less than the state and national averages for production workers in these industries, these wages compared favorably to those paid in the more traditional sectors of the local economy. The newer industries also provided a more highly skilled mix of jobs than had previously been available in the area. The proportion of professional and technical jobs and highly skilled and semi-skilled production jobs was greater in Lowell's high-tech sector than in its more traditional manufacturing industries. A substantially lower percentage of the work force in the newer industries was in low-skilled and unskilled jobs than in the older industries (Flynn 1984).

In addition to relatively high wages and skilled jobs, modern facilities, favorable promotion prospects, and fringe benefit packages (which often included dental insurance, profit sharing, stock options, and pension plans) gave the rapidly growing high-tech firms an edge in the recruitment and retention of workers. The high-tech sector also enjoyed a very positive image, which was aggressively fostered by the local media. Real estate costs, lower than those along Route 128 and in Boston, provided yet another local competitive advantage in attracting firms to the Lowell area.

Influx of funding. While relative factor costs and proximity to an established high-tech employment base set the stage, an influx of private and public funds fueled local redevelopment efforts. In the mid 1970s, for instance, 14 banks in the area supported establishment of the Lowell Development Finance Corporation (LDFC) by committing 0.5 percent of their savings account funds to redevelopment projects in the city. Between 1975 and 1986, the LDFC provided $6 million in 88 loan commitments to the local community. Founded several years later to coordinate local development efforts, the Lowell Plan (which included proposals to renovate the local auditorium, increase local K–12 educational standards, and establish a first-class hotel in the downtown area) raised over $32 million in private funds. These funds were leveraged to secure over $74 million in matching state and federal dollars. In addition, millions of state dollars flowed into the local economy through industrial development bonds, which provided low-interest loans to firms to create or expand employment.

Federal money also flowed into the local economy in the 1970s and 1980s. The first urban park of its kind in the United States was established with $40 million of federal funding for the Lowell Historical Park and the Lowell Historical Preservation District. Federal Urban Development Action Grants (UDAGs) to support firms developing projects in economically depressed areas further bolstered the area's revitaliza-

[5] U.S. Bureau of Labor Statistics (1983).

tion. A UDAG loan for $5 million, for example, was instrumental in the decision of Wang Labs to build its worldwide headquarters in Lowell. Moreover, Lowell greatly extended the use of its UDAG funds by providing firms with low-interest loans rather than outright grants, as was the practice nationwide. As the loans were repaid, the funds were loaned to other firms for industrial expansion.

The city's public and private leaders helped to position Lowell to benefit from the substantial product innovation in the metropolitan region and along Route 128.

Wang Labs served as a magnet to firms in similar and related industries. Computer companies, such as Apollo and Sun, moved to the Lowell area, as did many small electronics firms that did subcontracting work for Wang and other computer firms. Enticed by a $2 million UDAG grant, a major hotel, the Hilton, also located in downtown Lowell under the assumption that the Wang Training Center (used to train Wang customers and employees from around the world), tourism, and the booming high-tech sector would make this a viable site.

Effective local leadership. Strong local leadership contributed to Lowell's transformation. In particular, congressional influence, active participation of business leaders in community affairs, and innovative and aggressive local public officials helped achieve local revitalization.

During the late 1970s, Lowell pursued a development strategy meant to create a "new industrial future" (Gittell 1992b). The city's public and private sector leaders helped to position Lowell to benefit from the substantial product innovation in the metropolitan region and along Route 128 (most notably the increased capabilities of minicomputers). This contrasted strikingly with the experience in the neighboring city of Lawrence, which benefited little from the product innovation in the Route 128 corridor during the late 1970s and early 1980s.

U.S. Senator Paul Tsongas (D-MA), for example, was an extremely effective force behind the local redevelopment drive and in obtaining monies from both the public and the private sectors to support these efforts. Tsongas, a Lowell native, proposed creation of the LDFC and was instrumental in obtaining commitments to participate from each of the city's banks. He also orchestrated through Congress the development and funding of the Lowell National Historical Park. With City Manager Joseph Tully, he formulated the Lowell Plan.

Dr. An Wang, founder and chairman of the board of Wang Laboratories, Inc., was another leader in Lowell's economic turnaround. Dr. Wang's impact on the Lowell area spread far beyond the walls of Wang Labs. The Wang Institute, which awarded master's degrees in computer engineering and software design, was established with over $4 million from Dr. Wang. Operating independently of Wang Labs, this institution provided training for experienced workers from a variety of high-technology companies. Dr. Wang was also a generous philanthropist who contributed frequently to local organizations.

Several other individuals, including ex-city manager William Taupier, credited with the idea of lending rather than granting outright the UDAG monies to firms, and former school superintendent Pat Mogan, who had the vision of creating a national urban park in the city, provided the personal impetus behind the Lowell redevelopment story. Along with the local media, these individuals helped generate widespread support from the "people of Lowell" for the high-tech economic revival (Earls 1985).

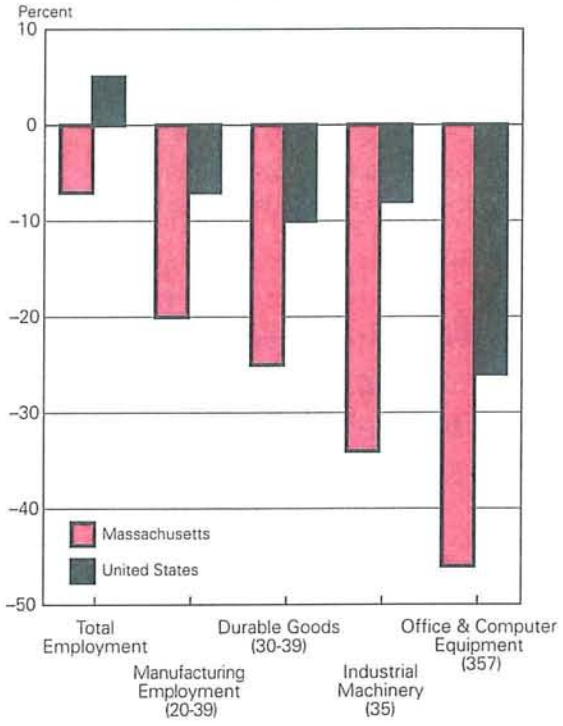
Understanding Lowell's Economic Bust

What went wrong? Analysis of Lowell's economic downturn in the late 1980s highlights the following key factors: (1) economic decline throughout the nation and particularly in the New England region; (2) a regional banking crisis; (3) the effects of development life-cycles; and (4) over-reliance on one industry and one company.

Widespread economic decline: 1989 to 1994. Durable goods manufacturing, and in particular the office computing equipment industry, suffered declines from 1989 to 1994 throughout the country as the economic growth trend of the mid-1980s slowed. While total employment nationwide increased by 5 percent between 1989 and 1994, high interest rates and increased international competition contributed to a 7 percent decline in manufacturing employment, a 10 percent decline in durable goods manufacturing, and a 26 percent drop in the office and computing

Figure 3

Change in Employment, 1989 to 1994
Massachusetts and United States



Note: Numbers in parentheses refer to Standard Industrial Codes.
Source: U.S. Bureau of Labor Statistics.

equipment industry. The nation also experienced a recession (1990–91) during this period, further contributing to manufacturing weakness.

New England was harder hit than the nation overall and, within the region, Massachusetts suffered more from industrial decline than any other state during this period (Figure 3). This outcome was attributable to a combination of factors, including the Department of Defense build-down,[6] the composition of manufacturing in the state (in particular, the concentration of employment in the minicomputer industry), and relatively high factor costs that had moved up noticeably during the boom, especially wages and real estate. The overall pattern of job losses in Massachusetts reflected that of the nation but was more intense: Manufacturing employment in Massachusetts fell 20 percent, durable goods manufacturing fell 25 percent, and jobs in the computer and office equipment industry declined by 46 percent.

These major employment declines were particularly damaging to the Lowell economy, given its disproportionately large share of employment in durable goods manufacturing, and in particular the industrial machinery and office and computing equipment industries. Shift-share analysis, which delineates the change in local employment above or below that expected if each employment sector in an area grew at its state or national rate, demonstrates that the boom (1972 to 1989) and bust (1989 to 1994) employment swings were more pronounced in the Lowell area than in the state, region, or nation. (See the Appendix.) The primary source of the larger fluctuations was the industrial machinery industry.

Banking crisis. As highlighted above, Lowell's banking community contributed significantly to the high-tech boom. As the area prospered, individual banks as well as the LDFC became bullish on the local economy. In fiscal year 1989, the LDFC alone disbursed over $1 million in new loans to 26 local recipients, mostly small and medium-sized businesses. Some of the banks, speculating that the local area's dramatic growth would continue long-term, began funding what hindsight shows were relatively risky development projects. This behavior was encouraged by changes in the federal tax laws and banking regulations that increased the demand for loans (through expanded tax benefits or credits) and increased the effective supply of funds (with the relaxation of restrictions on lending by S&Ls and other financial institutions).

By the late 1980s, the signs of difficulties in the local banking industry were clear. Credit dried up, during a period when many local companies needed funds. Commercial real estate rents dropped more than 50 percent in Lowell from their peak in the mid-1980s (Diesenhouse 1994). By 1994, many banks had failed or merged, and three had been taken over by institutions outside the area; only five relatively small banks remained headquartered in Lowell.

Development cycle effects. The interaction of development cycles (technology, product, process, and factor-price cycles) have strongly influenced Lowell's growth patterns (Gittell 1992a; Flynn 1993). Lowell's

[6] After rapid growth that began in the late 1970s (Defense Department prime contract awards per manufacturing worker doubled between 1980 and 1987), 1987 marked the downturn in prime contract awards in Massachusetts (Department of Defense, *Directorate for Information Operations and Reports.* Prime Contract Awards, 1992).

decline at the turn of the twentieth century can be attributed in large part to a combination of a cyclical rise in factor prices (primarily wages), technological process change (introduction of electricity, which replaced water power as the cheapest industrial energy source), and product maturation (cotton cloth). Cotton cloth production and employment moved from Lowell to southern states where the supply of low-wage workers was abundant and electricity prices were lower.[7]

While Lowell's cyclical position improved during the late 1970s, its status by the late 1980s was again not favorable. Lowell suffered from a concentration of employment in what rapidly had become a mature product industry. In the 1970s, minicomputer firms along Route 128 focused on managing unprecedented growth. Responding to demands buoyed by dropping prices, large volumes of relatively standardized minicomputers were produced. By 1980, the large minicomputer manufacturers along Route 128, including Digital, Prime, Data General, Honeywell, and Wang, controlled more than two-thirds of the minicomputer market (Saxenian 1994).

This rapid growth masked the underlying problems that were emerging, in the guise of personal computers, microcomputers, and open software that would run on equipment from a variety of manufacturers. A recent analysis of the minicomputer industry's cycle summarizes the situation as follows (Saxenian 1994, p. 97):

> Ignoring the lesson of their own origins—that innovation could displace existing technologies and revolutionize product markets—the minicomputer makers organized themselves on the assumption of stable markets and technologies. They adopted autarkic structures that supported their high-volume manufacturing strategies, they sought to stabilize supply by internalizing inputs through vertical integration, they sought to stabilize demand by locking their customers into proprietary technologies, and they built centralized organizations to coordinate the complex process of mass-producing computer systems.

With respect to Wang Labs, Lowell experienced a rapid "ride" on the product life cycle. Wang located in Lowell toward the end of the growth phase in the life cycle of its main product, the minicomputer. The company bet its future on this single product, stayed with proprietary architecture, and operated as if markets and technologies had stabilized (Saxenian 1994; Kenney 1992). The rest is history.

In fact, while the competitive environment in which Wang and other computer manufacturers operated had changed, the "rules of the game" had not. The high-tech companies that located in Lowell during the "boom" period could have learned a lot from the experience of their predecessors, the textile companies: To remain competitive, industries and firms must constantly adapt and innovate to meet changing demands and new challenges in the marketplace.

To remain competitive, industries and firms must constantly adapt and innovate to meet changing demands and new challenges in the marketplace.

Overreliance on one industry and one company. The Lowell economy became overly reliant on the performance of a single industry and one firm, making it extremely vulnerable to the destabilizing effects of development cycles. In several of the boom years, Wang Labs employed over 10,000 workers in the Lowell labor market, accounting for approximately 10 percent of total employment and one-third of manufacturing employment in the local economy (O'Connell 1991a). Jobs in many other local firms (including subcontractors and the Hilton hotel) were dependent on the viability of Wang Labs as well.

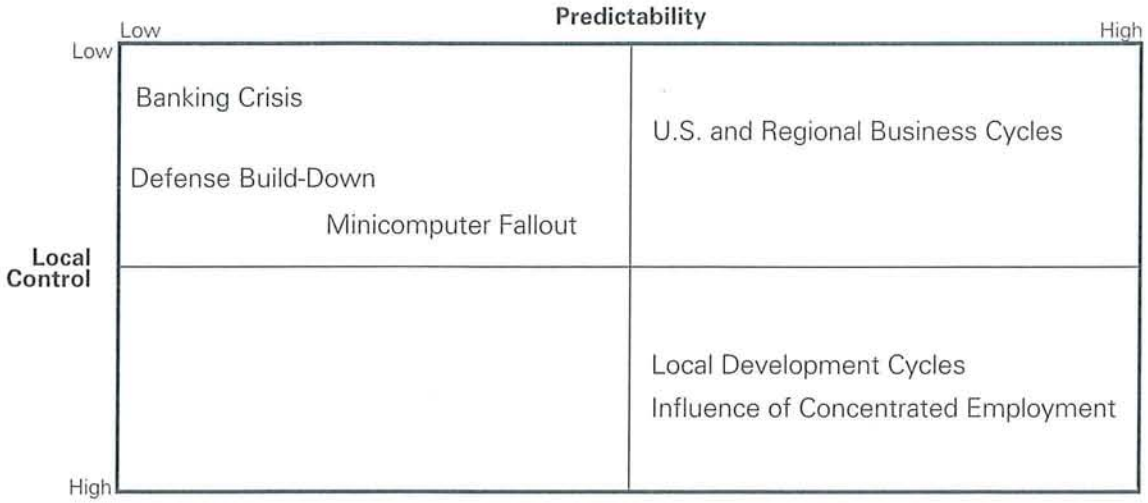
Since 1986, Wang has decreased its worldwide labor force from 31,000 to 6,200 (Zitner 1993b). Approximately 40 percent of Wang's layoffs and work force were in Massachusetts, the majority in the Lowell labor market area (O'Connell 1991b; Adams 1991). After a major round of layoffs from Wang in June 1991, unemployment in Lowell once again hit double digits and economic decline accelerated.

Major restructuring was required at Wang in light of losses of nearly $1 billion in fiscal years 1989 and 1990 and revenue declines approaching 20 percent annually (O'Connell 1991b; Adams 1991). The Wang Training Center was closed. The company entered Chapter 11 in August 1992 and moved away from hardware manufacturing to software development, consulting services ("solutions integration"), and mar-

[7] Finer textile and apparel manufacturing was never concentrated in Lowell; this tended to locate closer to end-use markets (for example, New York City), where products were designed.

Figure 4

Local Development: Predictability and Control Matrix



keting. The "new" Wang, including its downsized Lowell facilities, is designed to operate with significantly fewer workers and a changed skill profile, with a greater concentration of marketing and technical support employees and fewer manufacturing workers (Zitner 1993a, 1993b).

The "Wang era" in Lowell ended in the spring of 1994 when the 15-acre, three-tower, 1.5-million-square-foot Wang office complex built in the 1980s was sold at auction for $525,000, or approximately 1 percent of the $55 million cost to build the facility. Wang, which emerged from bankruptcy in September 1993, sold the headquarters (where it still occupies space) to settle financial claims of the complex's mortgage lender, the Aetna Life and Casualty Company (Diesenhouse 1994; Farley and Yung 1992).

III. Predictability and Control in Local Economic Development

What could Lowell have done to prevent or mitigate the high-tech employment bust? Learning from this experience, what lies ahead for Lowell and other industrial areas seeking to promote economic growth and development?

Figure 4 positions some causal factors of economic decline in a matrix, according to their relative degree of local control and predictability. The factors contributing to economic decline in Lowell that were least likely to be influenced by local actions include national and regional economic decline, the banking crisis, the fallout in the minicomputer industry and the Department of Defense build-down. Factors with the greatest potential to be influenced by local actions include the reliance on single companies and industrial sectors, and positioning relative to local development cycles. In terms of predictability, the factor most difficult to anticipate was arguably the banking crisis. National and regional economic declines can be anticipated over a relatively short time horizon; however, the exact timing and extent of decline are difficult to predict. Other factors contributing to the regional decline, including the reduction of defense contracts and the collapse nationwide of the minicomputer industry, also were difficult to foresee.

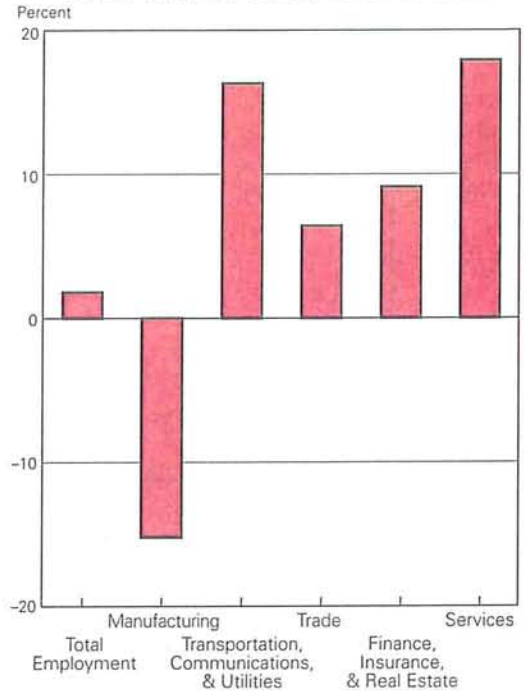
While uncertainty and change cannot be eliminated, areas can reduce their overall risk of wide swings in employment related to such events by diversifying their employment base, thereby avoiding overdependence on recession-prone manufacturing industries, firms reliant on defense contracts, companies at similar stages of technology and product cycles, and so forth. When one industry or firm dominates a

local economy, the future of the area becomes highly linked to that of the major employer(s).

The vulnerability of the Lowell area economy to the destabilizing effects of local development cycles and dependence on one company for employment was foreseeable—particularly given Lowell's history with textiles. In fact, this risk was identified specifically for the Lowell labor market area over 10 years ago (Flynn 1984). The timing and extent of any fallout resulting from a failure to diversify the employment base are hard to anticipate fully, and are to a large extent dependent on the investment and production decisions made within firms. Steps can, however, be taken to mitigate some of the negative consequences of local development cycles (Gittell 1992a, 1992b; Flynn 1994). For example, an understanding of technology and product life cycles would have indicated that sustained growth requires ongoing investment in R&D and innovative activities. It also would have highlighted the need for local economic development efforts to support the continuous change and upgrading of employee, firm, and industry capabilities. In addition, financial incentives such as those used to induce Wang to the area could have been used to support a more diversified portfolio of entrepreneurial efforts, both in emerging industries and in the revitalization of established firms in the area.

Figure 5

Employment Change in Lowell Labor Market Area, 1992 to 1994



Source: U.S. Bureau of Labor Statistics.

Lowell's Future

Even with the bust in the local economy in the late 1980s and early 1990s, Lowell's economy was better off after the high-tech boom and bust than it was beforehand. While employment declined significantly from 1989 to 1994, the employment level in the Lowell labor market in 1994 was still 75 percent above that in 1972 (Figure 2).

Moreover, industrial composition in the local economy over the 1972–94 period had shifted from relatively low-wage and low-value-added production to high-wage and high-value-added industries. The average hourly wage of production workers went from 90 percent of the U.S. average in 1972 to a level slightly above the U.S. average in 1994.

Recently, Lowell's economy has been showing signs of recovery. The unemployment rate dropped from 9.9 to 5.6 percent between November 1992 and November 1994. Between 1992 and 1994 general employment trends in the Lowell area in all sectors except manufacturing suggested that the worst of the bust was over (Figure 5). The area now appears poised for relatively balanced, yet modest growth with no one product, firm, or industry dominating local employment.

Initiatives by local leaders and development organizations during the boom period (for example, the Lowell Plan and the LDFC) appear to have provided an improved base for future growth and a competitive advantage for the labor market over neighboring areas (Gittell 1992b). Some significant foundations were laid in the boom era: improved transportation access to Boston and surrounding cities; restoration of Lowell's downtown area; good relationships of local leadership with the state house and with political officials in Washington, D.C. (as indicated by the recent designation of Lowell as an Enterprise Community);[8] and

[8] The city was designated as a federal Enterprise Community in December 1994, along with 64 other cities and local areas. With the designation, Lowell received a $3 million federal grant. In addition, the city will have priority status when applying for any state or federal money for the next 10 years.

upgrades in higher education locally, including the University of Lowell and Middlesex Community College.

Further, in the Lowell Development Finance Corporation, the city and its financial institutions established a unique multi-sector funding vehicle that had a capital base of nearly $24 million at the end of fiscal year 1993.[9] These LDFC funds are used for a broad range of economic development purposes, including subsidized loans to businesses and community groups.

While the Lowell economy no longer offers a relatively low-cost work force as it did in the 1970s, the area continues to benefit from its excellent location, which provides ready access to well-educated and highly skilled workers. This is consistent with the competitive position of Massachusetts and New England, which historically have drawn strength and economic vitality from a highly educated and skilled work force, as opposed to status as a low-cost producer. The continued attraction of locating a business in Lowell is exemplified by the recent decision of M/A-COM to move its headquarters from Nashua, New Hampshire to Lowell, and NYNEX's decision to locate a regional operations center with 300 to 400 employees in a former Wang Tower.

IV. Beyond Lowell: Lessons for Local Economic Development

Lowell has shown, not once but twice, how boom and bust cycles and the dynamics of industrial change can disrupt a local economy. The lessons from Lowell's experiences extend well beyond Lowell, the minicomputer industry, and Wang Labs.

High-Tech: Part of the Solution, Not the Problem

Lowell's economic decline is attributable in large part to its *failure* to pursue a high-tech strategy. "High tech" is a confusing term. While often used to describe a set of industries or firms, such as computers, biotechnology, and medical instruments, "high tech" is a dynamic concept that describes the early phases of industrial development. Industries, firms, and components thereof pass through high-tech phases, which are characterized by rapid technological change, a relatively high degree of R&D expenditures, and a dependence on relatively highly skilled workers (Browne 1983; Markusen 1985; Malecki 1990). High-tech employment refers to jobs involving R&D, innovation, experimentation, and nonstandardized production activities. Most industries, including those considered mature or declining, such as automobiles, steel, and textiles, have high-tech segments in which R&D and new product and process development take place. A "high-tech" industry and firm were an integral part of the economic boom in Lowell, but they did not remain on the cutting edge of the industry.

The focus of "high tech" in New England (and elsewhere) should be broadened to include the more traditional manufacturing industries in the area, such as chemicals, plastics, and textiles.

At the early stages of development, a competitive edge is gained through innovation, creativity, quality, and uniqueness. In contrast, later phases of production are characterized by relatively mature technologies and products, more standardized processes, and mass production. Competition at these later stages is primarily a function of low costs. Initially, the expansion of output as a product evolves can provide increasing numbers of jobs in an area. Over time, however, layoffs and unemployment can follow as relatively standardized production moves to less costly sites domestically or off-shore.

The New England region has long been characterized by universities, venture capital, a highly skilled work force, R&D, and an established high-tech employment base—key factors for implementing a successful competitive strategy based on high technology and entrepreneurial new firms (Flynn 1994). The focus of "high tech" in New England (and in other areas interested in pursuing a high-tech strategy) should be broadened to include the more traditional manufacturing industries in the area, such as chemicals, plastics, and textiles. For example, New England could be a center of R&D, innovative activities, and corporate headquarters in the textile, plastics, and

[9] The LDFC remains fiscally sound and a valuable resource for development efforts in the labor market. This is the case despite nonpayment on some of the largest loans in its portfolio (including repayment on the Wang/UDAG loan) and the risk taken as a second-mortgage provider.

chemicals industries, as well as in biotechnology, medicine, and the knowledge industries.

The Importance of a Diversified Economic Base

Coupling the broadening of the high-tech base with efforts to revitalize more traditional sectors will foster an economy with a diversified economic base. It could also provide employment opportunities for larger segments of the work force. High technology cannot be expected to generate the bulk of jobs in an area. A high-tech strategy must be part of a larger economic development plan that includes the revitalization of the more traditional industries. New technologies, processes, and products should be integrated into maturing sectors of the economy to add value, productivity, and competitiveness (Browne 1983; OECD 1988). Local employment may contract initially, as technological changes may result in greater output with fewer workers. History demonstrates, however, that the *failure* to adopt new technologies results in greater job loss and economic decline over time than does the integration of new technologies at the workplace (Cyert and Mowery 1987).

Competitiveness, based on value added rather than low cost, can also be enhanced by shifting into market niches and product specialization that require nonstandardized production, flexibility, and relatively skilled workers. A diversified economy provides alternative local employment opportunities to counteract job loss resulting from production shifts in a particular industry to other locations or competition. In contrast, an area whose employment is tied to one or two product lines, or a group of firms with products and technologies at similar stages of development, is at risk of significant declines in economic activity as products and technologies mature.

A single booming, dominant industry can undermine competitive strategies in alternative employment sectors. In the Lowell labor market, for instance, several traditional manufacturers reorganized, moved into market niches, and adopted new technologies to remain competitive. A shoe firm, for example, specialized in women's white, dyeable evening pumps; one textile plant concentrated on tie labels, another on automobile upholstery. Some of the textile firms that remained in the area used highly sophisticated, electronically controlled machinery. In contrast to the stereotypical image of textile mills, these factories were bright, quiet, and spotless, and required more highly skilled workers than in the past. However, even these employers found themselves at a disadvantage in recruiting workers as resources were targeted to the newer industries.

In allocating public resources, the challenge is to balance the needs and benefits of both the new industries and the more traditional sources of employment, which constitute the bulk of the jobs in most communities.

Strategic Management of Local Economic Development

Local economic development is an ongoing process, requiring constant attention and adaptation to changes in the economy and to changing needs of private businesses, financial institutions, and workers. Without effective and timely responses to community concerns and economic opportunities, local development can easily break down (Gittell 1990).

In Lowell, dynamic cycle analysis of industries, firms, products, and technologies during the boom could have highlighted the area's vulnerability and called for action sooner. Beyond industrial employment statistics, local officials should understand and track the mix of products, processes, and technologies in the area (for example, customized, short-run production activities versus standardized mass production); organizational structure and functions (headquarters, R&D, branch plants);[10] and occupational needs and work force skills. Local employment, output, and cost data should be compared with national and regional statistics and productivity and export measures. An assessment should also be made of how "larger" economic and industrial trends may affect local companies, the area's position relative to dynamic cycles, and long-run economic performance.

In many circumstances (such as Lowell in the late 1980s), conditions in the national and regional economy will prevent areas from increasing employment and improving economic conditions, regardless of what actions are taken locally. In these times, such strategic actions as efforts to diversify the economy, bolster emerging industries, and revitalize traditional industries can minimize employment decline and fa-

[10] The ownership arrangement of firms raises the issue of local control, accentuated by recent trends toward greater globalization of industries and the increasing importance of multinational corporations in world trade. Firms producing multiple products in multiple locations are able to shift resources among product lines and plant sites. One can expect that branch plants of established firms whose headquarters are located elsewhere will exercise relatively limited control over employment and training activities in the area.

vorably position an area for future growth when economic conditions improve.

Local control of economic development has real limits. Nevertheless, the Lowell story suggests that local development officials can do many things to position their economies to successfully weather the impacts of events beyond their control, and to effectively guide long-term economic development.

Appendix

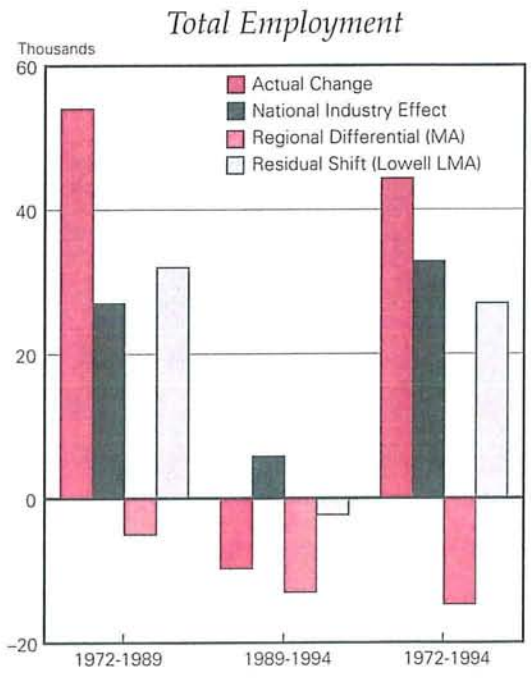
Shift-Share Analysis: Highlighting Pronounced Boom and Bust in Lowell

Undertaking shift-share analysis for the period 1972 to 1994 in Lowell allows identification of changes in employment unexplained by state and national trends, what is commonly referred to as the "residual" or "local effect." Shift-share models provide an accounting framework to identify the effects of national and state industry trends on local employment.

Using shift-share analysis, the period-to-period change in an area's total employment can be broken down into three main components: (1) a *national industry-mix component*, which includes the change expected if the employment sectors in the locality grew at their national rate; (2) a *regional "shift/differential" component*, which reflects the difference in growth rates by industrial sector between the region or state in which the area is located and the nation; and (3) a *residual component*, commonly referred to as the *residual shift*, which is the change in local employment above or below that expected if the area's employment sectors grew at their national rate, with adjustment for differences between state and national growth. A positive (negative) period-to-period residual shift suggests that a sector of the local economy grew at a rate greater (less) than would be expected if it grew at the national rate with adjustment for differential growth between the nation and the state.

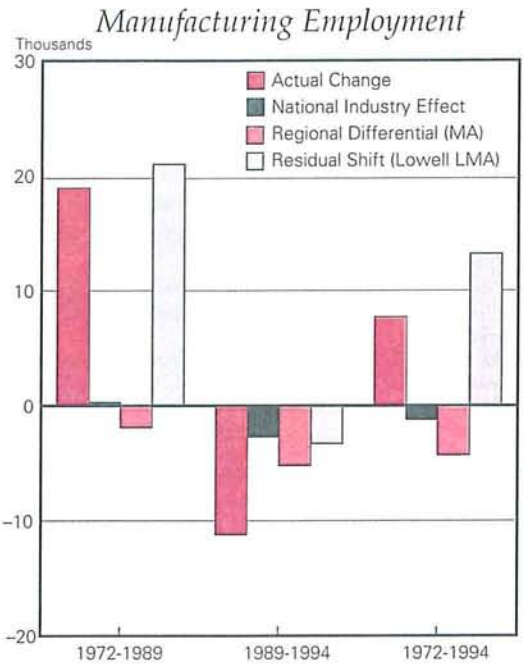
Shift-share analysis was conducted for the Lowell labor market area for two time periods, 1972 to 1989 and 1989 to 1994. During the first period, the Lowell area experienced impressive growth. Shift-share analysis (Figures A1 and A2) highlights that Lowell's main economic strength was in manufacturing, as the labor market area experienced significant and positive residual shifts in this category. In terms of the regional differential, all of the main employment categories in the Lowell area experienced positive shifts from 1972 to 1989, but none as significant as manufacturing. As discussed in the text, industrial machinery employment and more specifically office and computing equipment were the main factors in the growth in manufacturing employment.

Figure A1



Source: Author's shift-share calculations, based on data from U.S. Bureau of Labor Statistics.

Figure A2



Source: Author's shift-share calculations, based on data from U.S. Bureau of Labor Statistics.

After 1989, the Lowell labor market experienced broad-based decline. Just as employment growth in the 1972–89 period exceeded growth in the state and nation, the decline between 1989 and 1994 exceeded the declines at the state and national levels. Again, the most significant residual shift was in manufacturing and more specifically durable goods manufacturing. The shift-share analysis confirms that: (1) the boom and bust cycles were more pronounced in Lowell than in the nation and Massachusetts; and (2) Lowell's boom and bust were led by changes in the manufacturing sector.

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Correction

It has been brought to our attention that minus signs are missing in two of the formulas for computing a reverse mortgage payment that appeared in the article "A New Look at Reverse Mortgages: Potential Market and Institutional Constraints," by Christopher J. Mayer and Katerina V. Simons (*New England Economic Review*, March/April 1994, p. 19). The box in which the formulas appear is reprinted below, with the added minus signs highlighted. Ed.

Computing the Reverse Mortgage Payment

The lump sum reverse mortgage payment (LS) for a single borrower[4] is calculated as a sum, from the borrower's current age (a) to the maximum allowable age in the model (110) of the initial house equity (HEQ) compounded yearly at the house price appreciation rate (RG) discounted by the mortgage rate (RM) and weighted by the probability that the borrower dies in each year (p_t).

$$LS = \sum_{t=a}^{110} \left[(HEQ) * \frac{(1 + RG)^{(t-a)}}{(1 + RM)^{(t-a)}} * p_t \right]$$

If the borrower used the proceeds from the lump sum payment (LS) to purchase an annuity, the annuity payment (PMT) is computed such that the lump sum payment equals the present discounted value of the stream of annuity payments (discounted at the annuity rate, RA) multiplied by the probability that the borrower is still alive.

$$LS = \sum_{t=a}^{110} [(PMT) * (1 + RA)^{-(t-a)} * (1 - p_t)]$$

Solving the above equation for the annual annuity payment (PMT) gives:

$$PMT = \frac{LS}{\sum_{t=a}^{110} [(1 + RA)^{-(t-a)} * (1 - p_t)]}$$

[4] In the case of married couples, the formula is modified to account for the combined probability of survival where the spouse continues to receive the benefit.

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