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The Costs of Defense-Related Layoffs in New England

Yolanda K. Kodrzycki

Since the late 1980s, declines in defense spending have resulted in dramatic employment reductions in defense-related sectors of the economy. Although considerable information exists on the fate of major defense contractors and military bases in New England, little is known about what has happened to laid-off defense workers.

This article starts by estimating the magnitude of defense-related employment reductions in New England since the late 1980s. It then examines the experiences of a sample of approximately 5,000 former defense workers who looked for a new job following their layoffs. The research confirms that the region's work force has suffered considerably as a result of defense cutbacks. The problems are most severe for older workers and those without a college degree, as well as workers located in areas of New England that remain economically disadvantaged despite the employment recovery that began in 1992. 3

The Housing Cycle in Eastern Massachusetts: Variations among Cities and Towns

Karl E. Case and Christopher J. Mayer

Numerous studies over the years have attempted to identify the impact of amenities on housing price levels within specific metropolitan areas. It is well known, for example, that local public goods, tax burdens, school quality, crime rates, and the like are capitalized into land values.

This article divides the Eastern Massachusetts area into small groups of similar towns and examines the pattern of price changes across those groups during the boom, bust, and recovery periods. Since 1982, differences in appreciation rates across cities and towns have been particularly pronounced. The authors find that housing affordability was the most important factor explaining price changes during the boom period, but location, schools, and a town's employment base became relatively more consequential during the bust and the recovery. 24

The Costs of Defense-Related Layoffs in New England

Yolanda K. Kodrzycki

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Since the late 1980s, declines in defense spending have resulted in dramatic employment reductions in defense-related sectors. The costs to New England have been disproportionate, for several reasons. New England industries are relatively more dependent on defense contracts, and contracts to New England businesses have fallen at a greater rate than the national average. Furthermore, a far greater percentage of jobs have been eliminated at New England's military bases than elsewhere in the country. Finally, the downturn in defense coincided with the most severe recession the region has faced since the Great Depression.

Although considerable information exists on the fate of major defense contractors and military bases in New England, little is known about what has happened to laid-off defense workers. On the one hand, if general economic conditions are the most important determinant of job opportunities, then defense workers should have participated in the employment recovery that began in New England in 1992. On the other hand, defense workers may face particular difficulties even as the economy improves if their skills are undervalued in industries that are hiring. Specifically, since New England's recent growth has been concentrated in service-producing industries, the recovery may have left the mostly manufacturing-oriented defense workers behind. As a result, former defense workers may be experiencing disproportionately high rates of unemployment; they may have taken jobs that are significantly less attractive than their previous employment; or they may have decided to leave the New England work force by moving away or retiring.

This article starts by estimating the magnitude of defense-related employment reductions in New England since the late 1980s. It then examines the experiences of a sample of approximately 5,000 former defense workers who looked for a new job following their layoffs. The research confirms that the region's work force has suffered considerably as a result of defense cutbacks. Even though greater job opportunities exist now than at the depths of the regional recession, changes in the

region's mix of jobs and the associated skill requirements mean that former defense workers continue to have difficulties finding work and in recouping their former income even when they do find a job. Moreover, a comparison with national surveys of displaced workers in the 1980s suggests considerably greater difficulties for New England workers laid off in 1991 and 1992. The problems are most severe for older workers and those without a college degree, as well as workers located in areas that remain economically disadvantaged.

I. Defense-Related Cutbacks in Employment

Defense-related jobs are inherently difficult to count, because they form a subset of employment in a broad array of economic sectors, and because distinguishing workers dependent on defense projects from those who are not can be a challenge.[1] By all accounts, however, reductions in defense spending deepened the recession job losses that started in New England in the late 1980s, and they have slowed down the pace of job gains in the subsequent economic recovery. According to the estimates presented in this section, defense cutbacks appear to account directly for a 1.7 percent drop in total New England employment since 1989. This equals almost one-third of the total net drop in New England jobs during that period.

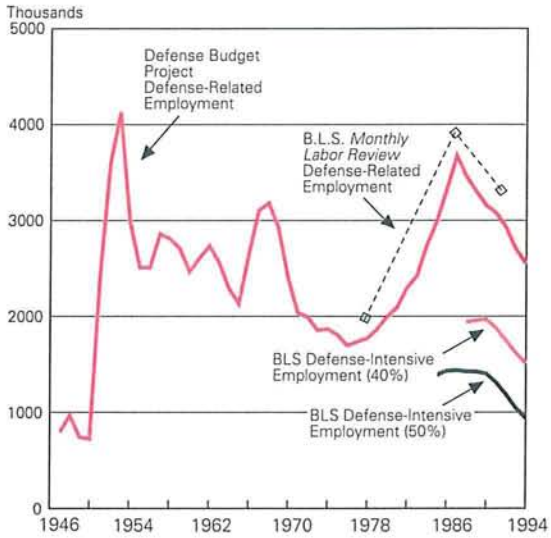
Defense-Related Private Sector Employment

The Defense Budget Project, a private research organization, has prepared national estimates of defense-related employment in private industry (Figure 1). These figures include jobs that depend directly on Pentagon contracts, as well as jobs at subcontractors or suppliers of goods and services to support Pentagon contracts. At its 1987 peak, national defense-related employment in private industry stood at 3.665 million (3.5 percent of total private nonfarm employment). By 1992, 742,000 defense-related jobs had been eliminated, and 363,000 more positions were cut or predicted to be cut in 1993 and 1994—for a total reduction from peak of 30 percent.

For comparison, Figure 1 also displays estimates produced at the U.S. Bureau of Labor Statistics and published in the *Monthly Labor Review*. These figures show somewhat higher 1987 defense-related private sector employment, 3.939 million (3.9 percent of total private nonfarm employment), but a similar number of jobs lost through 1992.

Figure 1

Defense-Related Employment in U.S. Private Industry



Note: Defense Budget Project data are for fiscal years; FY94 is estimated.

Source: National Defense Budget Estimates for FY 1995, March 1994, U.S. Bureau of Labor Statistics, *Monthly Labor Review*, April 1993.

An alternative measure of defense jobs—total employment in industries that depend heavily on defense business—is less comprehensive but easier to track over time and for subnational areas such as states. Table 1 lists the industries that, nationally, are at least 40 percent defense-dependent, as determined by the U.S. Bureau of Labor Statistics. This measure is less comprehensive than defense-related employment because it omits defense workers in industries that are not defense-intensive (Figure 1; national employment using 40-percent and 50-percent dependency is shown).[2] For example, the Massachusetts Institute of

[1] This issue as well as other measures of New England's defense intensity and the costs of defense cutbacks are discussed in Henderson (1990).

[2] Conceptually, employment in defense-intensive industries could be more comprehensive than defense-related employment to the extent it includes all workers at a defense contractor, not only those involved in defense work. For example, defense-intensive industry employment includes employees at Connecticut defense contractor Pratt & Whitney who work on commercial aircraft projects.

Table 1

Defense-Intensive Industries: 40 Percent or Greater Dependency

SIC 2892:	Explosives
SIC 348:	Ordnance and accessories[a]
SIC 3663:	Radio and TV communications equipment
SIC 3669:	Communications equipment, not elsewhere classified
SIC 372:	Aircraft and parts[a]
SIC 3731:	Shipbuilding and repairing[a]
SIC 376:	Guided missiles and space vehicles[a]
SIC 3795:	Tanks and tank components[a]
SIC 381:	Search and navigation equipment[a]
SIC 8731:	Commercial physical research
SIC 8732:	Commercial nonphysical research
SIC 8734:	Testing laboratories

[a]50 percent or greater dependency.

Source: U.S. Bureau of Labor Statistics, Division of Monthly Industry Employment Statistics.

Technology is a major recipient of Defense Department funding, even though the education industry (and even MIT) would not count defense as a major source of its overall revenues.[3]

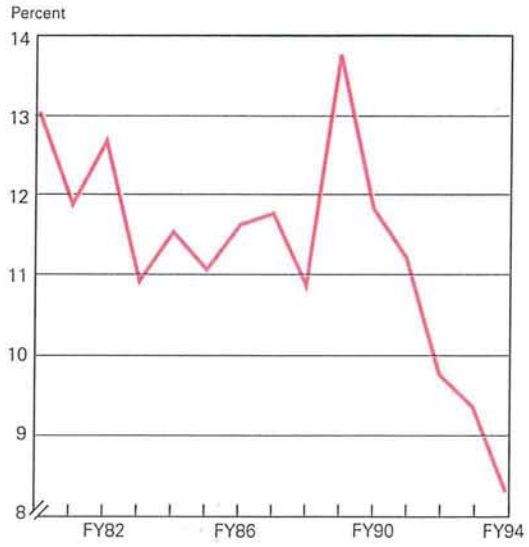
For New England, estimates of defense-related jobs are available from the Defense Budget Project only for 1992 (Kosiak and Bitzinger 1993), but defense-intensive industry employment is available from state statistical agencies each quarter. The 1992 data indicate that the region was unusually dependent on private-sector defense jobs. While defense contracts to private industry accounted for 2.5 percent of national employment, they accounted for 4.3 percent of New England employment. Connecticut and Massachusetts ranked number one and two, respectively, among all states in terms of private-industry dependence on defense, and all the New England states except Vermont were among the top half.

These data suggest that even if New England receives its "fair share" of cutbacks in Pentagon contracts, the proportional impact on the region's labor markets would be above-average (especially in Connecticut and Massachusetts) because of the above-average regional significance of defense-related jobs. In fact, however, even though New England was relatively late in experiencing reductions in contracts, the region has suffered more than its "fair share" of the cutbacks to date (Table 2 and Figure 2). New England's share of national defense contracts has fallen from a range of 11 to 13 percent in the 1980s to 8.5 percent more recently. The percentage decline from peak has been substantially larger in Connecticut than in Massachusetts.

To construct a New England estimate of the number of private-sector jobs lost as a direct result of defense cutbacks, this study relies on the 1992 employment levels as measured by the Defense Budget Project combined with the trend in total employment in industries that depend heavily on defense business. Although the two measures differ in the ways discussed above, the similarity in recent national trends for defense-related private sector employment and employment in defense-intensive industries suggests some value in splicing together these two sources of

Figure 2

New England Share of Defense Prime Contract Awards



Source: U.S. Department of Defense, *Prime Contract Awards by State.*

[3] Another example would be major computer companies that are defense prime contractors, but for which defense is a relatively small component of total business. Among the New England states, Massachusetts appears to have a particularly large share of defense-related employment outside defense-intensive sectors.

Table 2
Total Prime Contract Awards, FY 1980 to FY 1994
Millions of Dollars

	United States	New England	Connecticut[a]	Maine	Massachusetts	New Hampshire	Rhode Island[b]	Vermont
FY 1980	68,070	8,775	3,879	459	3,743	306	262	125
FY 1981	87,761	10,372	4,494	476	4,605	393	236	168
FY 1982	103,858	13,037	5,905	788	5,317	539	285	202
FY 1983	118,744	12,967	5,132	405	6,328	541	381	180
FY 1984	123,995	14,249	5,459	532	7,029	663	396	170
FY 1985	140,096	15,487	5,543	957	7,714	678	431	163
FY 1986	136,026	15,748	5,441	584	8,735	471	394	124
FY 1987	133,262	15,606	5,031	830	8,685	469	478	113
FY 1988	125,767	13,673	4,911	518	7,212	481	429	122
FY 1989	119,917	16,268	6,082	370	8,757	478	417	163
FY 1990	121,254	14,271	4,241	843	8,166	391	555	75
FY 1991	124,119	13,889	4,979	1,065	6,933	427	413	71
FY 1992	112,285	11,033	3,099	1,305	5,686	424	455	63
FY 1993	114,145	10,788	2,895	1,110	5,936	396	390	63
FY 1994	110,316	9,329	2,450	925	5,106	369	422	57
Percent Change, Peak to FY94	−21.3	−42.7	−59.7	−29.1	−41.7	−45.6	−24.0	−71.8
Year of Peak	1985	1989	1989	1992	1989	1985	1990	1982

[a]Including Electric Boat site in Rhode Island.
[b]Excluding Electric Boat.
Source: U.S. Department of Defense, *Prime Contract Awards by Region and State*, selected years.

information for constructing estimates for the New England states.[4]

Between the 1989 peak and 1994, it is estimated that private industry defense-related employment fell from 362,500 to 269,200 (25.7 percent) in New England (Table 3). Over this five-year period, the Massachusetts figure fell from 168,900 to 127,800 (a decrease of 24.3 percent), and the Connecticut figure from 114,800 to 79,800 (30.5 percent).[5]

To date, the percentage reduction in defense-related employment appears to have been smaller in the region than the nation. This is probably because defense contracts to New England companies held up fairly well in the late 1980s, after the national decline had started.[6] Given the sharp reductions in prime contracts to New England in the early 1990s, however, regional defense-related industry employment appears likely to fall by a greater percentage than the national average in the near future.

Employment at Military Bases

As a result of reductions in its budget, the U.S. Defense Department also has cut back its own employment. Total military and civilian employment reached its recent peak at 3.292 million in 1987, but stood at only 2.555 million in 1994 (Figure 3; line labeled "total"). For analyzing regions, it is more relevant to include only those employees stationed at domestic military bases. This employment was 2.357 million in 1987, but has since dropped by 416,000 (17.6 percent) to 1.941 million in 1994.[7]

[4] At the national level, estimated defense-intensive industry employment and defense-related private employment both fell by about 23 percent from 1989 to 1994.

[5] State figures for employment in defense-intensive industries are shown in Appendix Table 1. Because of disclosure restrictions, Vermont data are entirely lacking and Maine data for the shipbuilding and repair industry are not available prior to 1990. This is the largest defense industry in Maine, with most of the employment at Bath Iron Works. The adjustments to correct for these omissions are described in the Appendix. For Rhode Island, the estimates incorporate results from a state survey that tracks defense-related jobs in private industry.

[6] Trends in employment often lag trends in contracts, as a contract awarded in a given year can result in work spanning several years.

[7] The Atlas/Data Abstract numbers exclude Defense Department personnel in transit or otherwise considered in a transient status (which typically number in the hundreds of thousands), as well as personnel stationed abroad or at sea. Employee counts from different sources also differ in their treatment of indirect hires. Neither data series in Chart 3 includes reservists.

Table 3
Defense-Related Employment in the New England States
Thousands

Year	New England Total	Connecticut	Maine	Massachusetts	New Hampshire	Rhode Island	Vermont
Private Industry							
1988	362.2	116.0	23.1	162.9	21.4	30.6	8.2
1989	362.5	114.8	25.2	168.9	20.8	24.6	8.2
1990	355.6	110.7	31.4	163.6	18.6	23.8	7.3
1991	333.0	105.9	28.8	152.5	16.9	22.1	6.8
1992	308.7	96.7	26.6	143.4	16.2	19.4	6.4
1993	290.1	86.4	24.1	138.9	15.6	19.0	6.1
1994	269.2	79.8	24.2	127.8	14.9	16.5	6.0
Military Bases							
1988	63.3	12.5	16.2	20.5	5.5	8.0	.7
1989	64.5	11.7	16.3	21.8	5.5	8.6	.7
1990	61.5	12.2	15.7	20.7	3.8	8.3	.8
1991	57.3	12.0	14.7	20.2	1.7	7.9	.8
1992	53.1	11.3	13.0	18.2	1.8	8.0	.8
1993	49.9	10.0	12.2	17.4	1.7	7.8	.8
1994	44.1	9.8	8.1	16.0	1.7	7.7	.8
Total							
1988	425.6	128.5	39.3	183.4	26.9	38.6	8.9
1989	427.1	126.5	41.6	190.7	26.3	33.2	8.8
1990	417.1	122.9	47.1	184.3	22.4	32.1	8.1
1991	390.3	118.0	43.5	172.7	18.6	30.0	7.6
1992	361.8	108.0	39.6	161.6	18.0	27.4	7.2
1993	340.0	96.4	36.3	156.3	17.3	26.8	6.9
1994	313.3	89.6	32.4	143.9	16.6	24.2	6.8

Source: Connecticut Department of Labor, Maine Division of Economic Analysis and Research, Massachusetts Department of Employment and Training, New Hampshire Labor Market Information Center, Rhode Island Department of Economic Development, New England Economic Project October 1994 Vermont Forecast, U.S. Department of Defense *Atlas/Data Abstract for United States and Selected Areas*, and author's calculations. 1994 Private Industry Employment data are for the first three quarters of 1994.

Although the New England states apart from Maine traditionally have been less dependent on Department of Defense jobs than the national average, downsizings and closures of military bases have had a disproportionate effect on the region. New England employment at military bases has fallen by about 20,000 (31.6 percent) since the 1980s peak, with the reductions concentrated in Maine, Massachusetts, and New Hampshire (Table 3).

Summary of Defense Downsizings

In summary, counting reductions in the private and public sectors, New England defense-related employment fell by about 113,700 (26.6 percent) between 1989 and 1994. This decline amounts to 1.7 percent of total nonagricultural payroll employment in 1989. By comparison, at the national level, defense directly accounted for only a 1.1 percent drop in total employment.

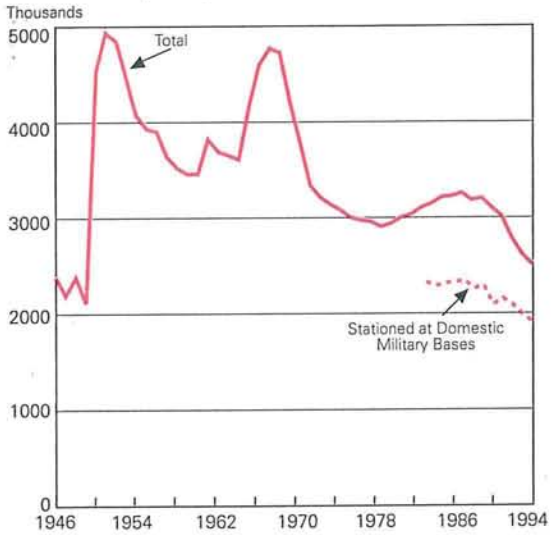
In New England, defense cutbacks were a significant contributor to the severity of the regional recession that started in 1989 and have been a factor slowing down the recovery in jobs since 1992. In 1994, total nonagricultural payroll employment in the region was 371,000 below its 1989 average. The 113,700 decline in defense-related jobs accounts for 30.6 percent of the net reduction in total employment.

II. Experiences of Displaced Defense Workers

With so many workers losing their jobs during New England's severe recession, policymakers have been concerned about their reemployment prospects.

Figure 3

Total U.S. Military and Civilian Employment of Department of Defense



Note: 1994 Defense Budget Project data are estimates.

Source: Domestic from Dept. of Defense Atlas/Data Abstract for the United States and Selected Areas. Total from Defense Budget Project National Defense Budget Estimates for FY 1995.

States have set up centers providing job search assistance, retraining, and other forms of support to laid-off workers.[8] This section describes the defense workers served by assistance centers and examines their experiences in seeking reemployment. Dislocated defense workers generally have had difficulty locating new jobs, with many experiencing long unemployment spells or terminating their use of center services without finding employment. Even when they have been successful, the new jobs typically have paid substantially less than their defense jobs.

The Dislocated Worker Sample

The information on dislocated defense workers is both anecdotal and statistical. In the first stage of the research, on-site interviews were conducted with officials from nine worker assistance centers and summary information was obtained from two additional centers. These eleven locations encompass defense contractors and military facilities in each of the six New England states.[9] In the second stage, statistical information on individual displaced workers served by assistance centers was requested from each of the New England states; Maine, Massachusetts, and Vermont were able to comply.[10] The resulting sample consists of about 5,000 workers laid off from military facilities and private defense contractors. The Defense Department employees are all civilian workers, as separate relocation assistance is available for military personnel. (For further information on the sample, see the Appendix.)

The combined data base provides considerable information on demographic and job characteristics of former defense workers in New England. For those workers who found new employment through a center, information is available on the duration of unemployment and the characteristics of the new job. Thus, the statistical data can be used to measure the economic costs of job loss and the influences of factors such as the worker's age, occupation, pay and length of experience at the defense employer, and geographic location, as well as the general condition of the local

[8] These programs were established under Title III of the federal Job Training Partnership Act (JTPA), as amended by the Economic Dislocation and Worker Assistance Act (EDWAA) of 1988. More recently, funding for some centers has come from federal monies specifically dedicated to defense conversion. States apply for worker assistance grants under the auspices of these federal programs and design services within the guidelines set by the federal government. Displaced workers' former employers also may play a role in developing services provided by assistance centers.

[9] State officials were instrumental in arranging visits to worker assistance centers. The following locations were visited: Bath, ME (serving employees of Bath Iron Works); Bridgeport, CT (Textron Lycoming); Hartford, CT (the Pratt & Whitney and Hamilton Standard divisions of United Technologies); Kittery, ME (Portsmouth, NH Naval Shipyard); Loring Air Force Base, ME; New London, CT (Electric Boat); Pittsfield, MA (Martin Marietta; formerly General Electric Company); Quonset Point, RI (Electric Boat); Wilmington, MA (Martin Marietta; formerly General Electric Company). Additional information was obtained concerning former employees of General Electric facilities in Lynn, MA and Burlington, VT. In the case of Lynn, the information came in the form of unpublished statistical data and an interview with a labor leader familiar with the plant; for Burlington, the source is Kessel and Maher (1991).

[10] Statistical information was requested from individual states rather than the federal government, for two reasons. First, states have been required to share standardized records on assisted displaced workers with the federal government only since the year that began July 1993, and data processing problems in some states reportedly caused delays in meeting the first of these deadlines (in the summer of 1994). Thus, at best only one year of information would have been available from the federal government. Second, information from the federal government would not have permitted the identification of defense-related layoffs. The data include a broad array of displaced workers served by JTPA programs, and states are not required to report the industry of the former employer.

economy at the time. Officials at worker assistance centers were able to provide additional information not encompassed in the statistical data bases. These interviews also served as an indication of experiences in states for which statistical data were not available.

The information has several notable limitations, however. The statistics cover only what is included in states' data bases. In general, data on layoffs in more recent years are more complete than for earlier layoffs, in part because of the introduction of federal reporting requirements since 1993. The more recent the layoff, however, the less is likely to be known about the eventual duration of unemployment or the characteristics of any new job. Second, this study's sample is limited to individuals who were working at recognized defense facilities and does not include individuals laid off from jobs at vendors or suppliers with less obvious ties to defense.[11]

Dislocated defense workers generally have had difficulty locating new jobs, with many experiencing long unemployment spells.

A final limitation is that the information pertains only to dislocated workers who chose to seek government assistance in finding a new job. Because of a lack of advance notice concerning layoffs and/or funding delays, some worker assistance centers opened after layoffs had already occurred; center officials noted that a smaller fraction of eligible workers tended to register when services were delayed. In other cases, workers' decisions not to seek help were more idiosyncratic. For example, some officials noted that blue-collar workers have become accustomed to "self-help" in the aftermath of previous layoffs, in contrast with white-collar workers, who were more likely to be losing a job for the first time. In other cases, individuals may have had other resources on which to draw, such as a company severance package or income from a working spouse; this might have caused them to drop out of the work force without registering at an assistance center. Furthermore, even among those who did seek help at a worker assistance center, a sizable fraction eventually stopped using services without locating a job; comparatively little is known about their eventual labor market experiences.

These various limitations mean that the sample cannot be used to form a precise "statistical profile" of all dislocated defense workers in New England (or even in the three states that provided detailed data). Also, because some workers have not been tracked "long enough" after being laid off (because either the sample period or use of center services ended), questions about their subsequent successes and failures cannot be fully resolved with these data. Nevertheless, the sample does provide considerable information about a large group of dislocated defense workers in New England who were motivated to seek new employment and who took advantage of government support programs. In this respect, it far surpasses other potential sources of information.[12]

Characteristics of Displaced Defense Workers in New England

Table 4 provides basic summary information about sampled defense workers at the time they lost their job. As a benchmark for comparison, the last column indicates national statistics on all civilian workers.

Dislocated defense workers were concentrated in prime working ages and had considerable experience in their last job. Close to 60 percent were in the 35- to 54-year-old age group, compared to about 45 percent in this age range among all workers. Eighty percent of the defense workers had been with their previous employer for at least five years, and 45 percent for at least ten years. Almost three out of four dislocated defense workers had finished high school but did not

[11] It also excludes some displaced defense workers who found temporary employment outside of defense. A study in Rhode Island found that some defense workers were able to obtain nondefense jobs for a short time before being laid off for a second time. Specifically, 15.6 percent of Rhode Islanders who filed for unemployment benefits in 1991 had been laid off from a defense-dependent job. The fraction increased to 21.8 percent if all jobs during the previous year were counted. The author is grateful to Diane Disney, formerly of the University of Rhode Island and now with the Department of Defense, for sharing these unpublished findings.

[12] A number of other studies of labor markets have used the biennial national survey of dislocated workers (see, for example, U.S. Congressional Budget Office 1993). The advantage of these surveys is that they are based on a representative sample of households across the nation. The disadvantage is that recent samples average about 3,800 workers a year. This is too small to permit analysis of specific categories of workers in selected regions of the country.

Table 4
Characteristics of Displaced Defense Worker Sample for New England
Percent

	N.E. Defense Worker Sample	Memo: All U.S. Civilian Workers[a]
Age		
Less than 35 Years	29	43
35 to 44 Years	33	27
45 to 54 Years	25	18
55 Years and Over	12	12
Job Tenure[b]		
Less than 5 Years	20	50
5 to 9 Years	35	19
10 to 19 Years	27	} 30
20 Years or More	18	
Education		
Less than High School	6	13
High School	46	33
Some College	26	29
College Degree	19	17
More than College	4	8
Gender		
Male	66	54
Female	34	46
Race		
White	92	86
Nonwhite	8	14
Occupation[c]		
Professional, Technical, and Managerial Occupations	41	30
Architecture, Engineering, and Surveying	18	n.a.
Computer-Related	3	n.a.
Admin. Specializations, Managers and Officials Not Elsewhere Classified, and All Other	15	n.a.
Clerical and Sales	14	28
Service	3	14
Production[d]	41	29
Hourly Wage		
Below $10.00	14	n.a.
$10.00 to 11.99	14	n.a.
$12.00 to 14.99	34	n.a.
$15.00 to 17.99	15	n.a.
$18.00 and above	23	n.a.
Industry		
Durables Manufacturing	75	9
Other Private Industry	4	73
Government	21	17[e]

n.a. = not available. [a]National data circa 1992. [b]Job tenure not available for defense workers from Maine and approximately one-third of defense workers from Vermont. [c]Occupation not available for defense workers from Maine and Vermont. [d]Includes operators, fabricators, laborers, precision production, craft, repair, farming, forestry and fishing occupations. [e]Includes military employment.

Source: Author's calculations using sample of 5,001 defense workers (see Appendix). Data for defense worker sample refer to worker and job characteristics at the time of layoff. National statistics on job tenure from U.S. Congressional Budget Office (1993). National statistics on age, gender, race, occupation, and industry from *Employment and Earnings* (1993). National statistics on education from U.S. Bureau of Labor Statistics calculations using *Current Population Survey* (1994).

have a college degree. Twenty-three percent had graduated from college, including 4 percent with post-college coursework. In the population as a whole, relatively more workers lack a high school diploma. Laid-off defense workers were disproportionately male; 92 percent were white.

Three-quarters of the defense workers had been employed in durables manufacturing industries—far above the 9 percent overall share of national employment for this industry. The remainder mostly had been employed at military bases. Occupational data, available only for the Massachusetts sample, indicate that 40 percent had been in professional, technical, and managerial jobs; close to half of these were in engineering and related fields. Only small numbers held clerical and sales positions or service jobs. The remaining 41 percent were production workers. Representative production worker occupations included machinist, mechanic, materials handler, welder, pipefitter, electrician, assembler, and inspector, according to interviews at worker assistance sites.

The median dislocated defense worker in the sample earned $13.77 per hour at the time of layoff. The top quartile earned $17.46 or more. In Massachusetts, the average wage among displaced defense workers not classified as professional, technical, or managerial was $13.90—more than 30 percent above national average hourly earnings and 15 percent above the Massachusetts average for manufacturing production workers—and professional salaries averaged close to $20 an hour.[13]

Laid-off workers across the New England states were similar in many respects, but a relatively greater fraction of Massachusetts workers had been highly paid. Close to half the Massachusetts sample had been earning $15 or more per hour, compared to only 11 and 17 percent, respectively, in Maine and Vermont. Conversely, 37 percent of the Maine workers and 21 percent of the Vermont workers had earned less than $10 per hour; in Massachusetts, only 8 percent of the sample had such low wages.[14] Another difference was

[13] National hourly earnings averaged $10.58 in the 1991–93 period. This figure relates to production workers in mining and manufacturing; construction workers in construction; and nonsupervisory workers in transportation and public utilities; wholesale and retail trade; finance, insurance, and real estate; and services. Average hourly earnings for Massachusetts production workers were $12.11; state data for broader categories of workers are not available. See U.S. Bureau of Labor Statistics, January and May 1994.

[14] In Maine, the lower wages can be explained partly by the relatively large share of young workers who were laid off (37 percent were under age 35), as well as the relative paucity of college degree recipients (only 14 percent). In Vermont, over 70 percent of

in industry composition. While manufacturing layoffs accounted for most of the displaced workers, three-quarters of the Maine sample were former employees of Loring Air Force Base.

Overview of Worker Experiences after Layoff

The post-layoff experiences of former defense workers varied considerably. While virtually all who registered at a worker assistance center experienced some unemployment while they searched for new jobs, the duration of unemployment ranged widely among individuals. Furthermore, some enrolled in job training or more general education classes in the course of seeking a new job. While a sizable fraction eventually found another job, some stopped searching and left the local labor force, either retiring, giving up, or migrating elsewhere; others were still looking when the data were collected. Among those who did find jobs, some were quite successful in recapturing their previous occupation or pay level, but most experienced a drop in pay. The sampled defense workers thus faced a series of adjustment costs after losing their defense-related jobs, and the difficulty of adjustment can be assessed in several ways: how long they were unemployed, what fraction eventually found another job, how their new job differed from their old job, and how much lower their earnings were in the new job.

Table 5 reports employment status 12, 18, 24, and 30 months after the date of layoff. Results are shown for workers laid off in three time periods, in part because more recent cohorts are not observed as long as those laid off in earlier years, but also to highlight possible influences of changing economic conditions. In general, the results indicate that defense workers have had considerable difficulty finding new employment.

For defense workers who lost their job in 1991 or earlier, only 22 percent were known to be reemployed 12 months later, while 70 percent were still looking for a job or preparing for a new job through enrollment in vocational or general education classes.[15] After 12 months, 8 percent had stopped using the services of the center. Although a few of these workers dropped out of the labor force for a specified reason (such as to retire or care for a sick family member), nothing is known about the subsequent employment histories for most of the dropouts. Some of them may have found a job on their own after terminating their search through the assistance center, while others were unemployed or no longer actively looking. After 24 months, the percentage known to be reemployed had increased to 48 percent, and the percentage that had stopped using worker assistance services had increased to 28 percent. Twenty-five percent remained unemployed or in training.[16]

Table 5
Employment Status of Displaced Defense Workers after 12, 18, 24, and 30 Months, by Year of Layoff
Percent

Subgroup and Number of Months	Reemployed	No Longer Enrolled	Unemployed or In Training	Memo: Sample Size
Laid Off in 1991 or Earlier				1,018
12	22	8	70	
18	36	16	48	
24	48	28	25	
30	51	37	11	
Laid Off in 1992				1,098
12	43	14	44	
18	59	24	17	
24	63	28	10	
Laid Off in 1993				2,071
12	35	13	52	

Note: An additional 814 workers in the sample were laid off in 1994.
Source: Author's calculations based on sample of displaced defense workers from Maine, Massachusetts, and Vermont.

the displaced workers had no formal education beyond high school, and only 10 percent had a college degree. Interviews in Connecticut indicate that defense workers there were, on average, relatively highly educated and highly paid. For example, 23 percent of the displaced workers from Pratt & Whitney and Hamilton Standard had a college degree, according to data provided by the Career Transition Center in East Hartford. Both that center and the one serving Textron Lycoming workers in Bridgeport cited relatively high average hourly pay among those who had been laid off.

[15] The reemployment rate for this cohort is probably understated because of selection bias (and the subsequently discussed increase in the speed of reemployment for the 1992 cohort is correspondingly overstated). The Maine data base includes enrollees starting in July 1991 and ending in September 1994. The Massachusetts data base counts those receiving services as of July 1992. As a result, the sample underrepresents laid-off defense workers from these states who lost their job prior to the starting date for the statistical data but who found a job or stopped attending the worker assistance center after a relatively short period of time.

[16] The reemployment rates cited in this article are computed as the number reemployed as a percent of the total number of workers who were laid off and used the services of an assistance center. By contrast, placement rates as computed for JTPA purposes are based on the number reemployed as a percent of the total number of workers who terminate their enrollment at an assistance center. That is, they do not take into account workers still registered who are actively seeking a job or preparing to seek a job. For the example

Total New England employment began to rise gradually in 1992, following three years of decline. Thus, to the extent that defense workers' fortunes depend on the general economic climate, those who lost their job during the recovery should have fared better than those who lost their job in the recession. Table 5 confirms this hypothesis. Workers laid off in 1992 had a reemployment rate of 43 percent after 12 months (compared to only 22 percent for the 1991 and earlier cohort) and 63 percent after 24 months (compared to 48 percent), and the fraction known to lack a job at any given interval is substantially lower. Nevertheless, even these improved results for the 1992 cohort suggest that displaced defense workers face significant barriers in finding reemployment.

Although some workers undoubtedly found better jobs by searching or training longer, this was found not to be the general case.

The final portion of the table raises some doubt about whether defense workers' job prospects have shown additional improvement as the New England economy continues to recover. Twelve months following the date of displacement, the reemployment rate for those laid off in 1993 was not higher than that of the 1992 group.[17] One reason may be the changing characteristics of the unemployed. Several worker assistance officials indicated that, even though economic opportunities were better in 1994 than a year or two earlier, defense-related layoffs increasingly are affecting older and more specialized workers. This is particularly the case for blue-collar jobs, where layoffs frequently are determined by seniority.[18]

A question arises as to how to interpret the column headed "unemployed or in training." The percentages shown in this category are far higher than the prevailing jobless rates for the New England region (which averaged 8.0 percent in 1991 and 1992, and 6.2 percent in 1993). On the other hand, some displaced workers were availing themselves of educational opportunities and other resources in order to find a better job. In this sense, high fractions in this category may not be a totally bad sign. This issue is addressed below, in the section on earnings gains and losses. Although some workers undoubtedly found better jobs by searching or training longer, this was found not to be the general case. Therefore, the fraction without a job is a legitimate indicator of the difficulty of making the transition from defense to nondefense work.

Table 6 examines employment status for different types of workers at 18 months (for all displaced defense workers observed for at least 18 months, regardless of the year of layoff). In total, 49 percent found reemployment through the worker assistance centers within 18 months of losing their job. The most striking result is that reemployment rates decline with age (confirming the interview reports). Over half of all workers under age 45 were reemployed after 18 months, but less than one-third of those 55 years and older had found a job. The oldest group was also much more likely to stop using the services of an assistance center, which suggests some discouragement about the likelihood of finding a job. Those who had been with their defense-sector employer for 20 years or more were also relatively unlikely to find work. Long-term employees may have handicaps such as overly specialized skills or a lack of ability to adjust to changing circumstances; many also were older.

The table indicates that former manufacturing workers had somewhat better success than nonmanufacturing workers in finding new work. This is surprising, given declining employment opportunities in New England manufacturing during this period. The explanation probably is found in the identity of the nonmanufacturing workers. Many had been employed at Loring Air Force Base, which is located in a remote northern section of Maine that has had unem-

just cited in the text, the JTPA-computed placement rate would be 63 percent (48 as a percent of 48 plus 28). The 25 percent noted as "unemployed or in training" are not taken into account. If, however, all of these workers found jobs through the center, the ultimate JTPA-computed placement rate for those laid off in 1991 would be 73 percent (48 plus 25 as a percent of 100). Another difference is that the reemployment rates in this article include workers recalled by their former employer, while statistics for JTPA purposes omit recalls from both the numerator and the denominator. The numerical significance of this definitional difference is small, however.

[17] The reemployment share for 1993 is probably biased downward a little, as data for workers laid off after September were available for less than 12 months.

[18] In the sample, the median age at time of layoff increased from 39 years in 1992 to 41 in 1993.

Table 6

Employment Status and Unemployment Spells for Displaced Defense Workers, by Worker and Job Characteristics

Subgroup	Employment Status after 18 Months (Percentages)			Median Unemployment Spell for Reemployed Workers (Months)
	Reemployed	No Longer Enrolled	Unemployed or In Training	
All Workers	49	21	30	11
Age				
Less than 35 Years	56	16	28	11
35 to 44 Years	52	20	29	11
45 to 54 Years	48	19	32	12
55 Years and Over	31	35	34	13
Job Tenure				
Less than 5 Years	51	18	31	11
5 to 9 Years	54	18	28	11
10 to 19 Years	52	18	29	11
20 Years or More	37	35	28	12
Education				
Less than High School	43	24	33	12
High School	52	22	26	11
Some College	48	19	33	12.5
College Degree	44	19	38	13
More than College	56	17	28	10
Gender				
Male	50	21	29	11
Female	46	21	32	13
Race				
White	49	21	30	11
Nonwhite	45	22	33	13
Industry				
Manufacturing	50	21	29	11
Nonmanufacturing	44	19	36	12
Occupation				
Professional, Technical, and Managerial	46	17	37	13
Clerical and Sales	42	28	31	14
Service	52	19	29	11
Production	48	22	30	11

Note: Employment status for 2,444 workers laid off at least 18 months prior to September 1994. Unemployment spells for 1,258 workers laid off prior to 1993 and subsequently reemployed.

Source: Author's calculations based on sample of displaced defense workers from Maine, Massachusetts, and Vermont.

ployment rates in the vicinity of 9 to 11 percent in recent years.[19]

Additional differences show up between men and women, and between whites and nonwhites. Differences by education and occupation show mixed patterns.

Unemployment and Training

The foregoing data on employment status after various amounts of time have elapsed following a defense layoff suggest that one indicator of adjustment difficulty might be the duration of unemployment. For those workers who eventually found a job, and who were observed for 18 months or more, the median spell of unemployment was 11 months (Table 6).[20] One-fourth of reemployed workers took at least 17 months to find a job, while another one-fourth took 7 months or less.

Jobs increasingly emphasize services skills and, in many cases, use of modern information technologies. Accordingly, most training courses for former defense workers reflected these new workplace demands. White-collar workers often were enrolled in computer classes, especially data base management, spreadsheet software, and networks. In addition, some former blue-collar workers were trained in computer repair. Other popular training courses have prepared displaced defense workers for jobs in accounting, health care (including jobs as medical technicians or nurses), law (as paralegals), heating and air

[19] Another explanation is that the average length of job search is overstated for some former employees of Fort Devens Army Base. Many Fort Devens employees registered for assistance services before they actually lost their job. In those cases where the date of layoff was not recorded, this study uses the date of registration to calculate the length of unemployment. A similar issue arises with respect to some additional workers, not from Fort Devens. These cases tend to be scattered across a variety of work sites, and therefore they do not result in any obvious bias in comparing different groups of workers.

[20] Limiting the subsample to displaced workers who were observed for a longer period of time would lengthen the estimated typical spell of unemployment, as more long-term unemployed would be included. Conversely, shortening the time frame would make the typical unemployment spell appear to be shorter.

conditioning maintenance, truckdriving, automotive repair, and culinary arts.

Although some centers offered classes in entrepreneurship, relatively few laid-off defense workers have ended up starting their own business. In some cases, however, professionals have started consulting practices, usually to tide themselves through until they found full-time employment or qualified for full retirement benefits. For engineers and software specialists, contract work has been quite common—either through an agency or, in some cases, with their former employer. In addition, some former blue-collar employees have become independent contractors, particularly for general maintenance work (such as snow removal or lawn care).

Most centers indicated that local community colleges, specialized training schools, and universities offered an ample selection of courses of study for displaced defense workers. The exception was the center in Pittsfield, Massachusetts, which reportedly had a relatively small selection of classes in the immediate area.

Nevertheless, several serious barriers to effective retraining were said to exist. First, limited or uncertain budgets constrained what could be offered to any individual worker. Officials noted the frequently large differences in the skill set required for the "new good jobs" as compared to defense work. As a result, retraining for positions that would allow defense workers to recoup their former pay would require considerably greater per-worker funding than has been available. Second, officials asked the question "retraining for what?" Given projections of a slow rate of growth in New England employment, with no obvious sizable high-growth segments and expected declines in manufacturing, heavy investments in retraining were risky. Some interviewees noted that even what seemed to be attractive service sectors in the recent past, such as health care and the law, might not be significant generators of jobs in the future because of market changes. Finally, some former defense workers have been reluctant to invest in retraining or otherwise to adapt to changing circumstances. Craft workers have been bitter and frustrated over the lack of jobs in their area of specialization. Engineers have felt that they would waste their talents by moving into more commercially oriented work with less exact standards.

While statistics to measure the extent of migration are lacking, assistance center officials indicated that laid-off defense workers with whom they have had contact have tended to limit their job search to the local area—even though attractive opportunities existed elsewhere (and were publicized at the center) and relocation assistance was available. The reluctance to migrate has been greatest for those with strong ties to a community, either through a long family tradition of living in the same area, having children in local schools, or homeownership (especially for those threatened with capital losses upon sale of their home). Indeed, the only location where strong outmigration was cited is Loring Air Force Base, where many ex-civilian employees were married to military personnel who were being transferred to other installations. Officials estimated that about one-fifth of laid-off workers had moved out of Aroostook County. In Pittsfield, Massachusetts, mention was made of professionals moving away, as very few opportunities remained locally following their layoff from General Electric (later Martin Marietta).

Probability of Reemployment

To explore further the factors that make reemployment more difficult, regressions were run to explain the likelihood of finding work. These regressions take into account information on employment outcomes at all intervals, instead of looking at progress after an arbitrary number of months, as did Tables 5 and 6. They simultaneously examine hypotheses about economic conditions, characteristics of workers and their jobs, and selected additional determinants not mentioned above. The Cox proportional hazards model was used to estimate the coefficients in Table 7, which represent the relative likelihood of finding employment in any given time period, for a unit increase in the value of the explanatory variable (Cox and Oakes 1992).[21]

[21] For each individual in the sample, define $h(t)$ as (the probability of becoming reemployed between times t and Δt)/[(Δt) × (the probability of becoming reemployed after time t)]. In the Cox model, $h(t) = h_0(t)e^{b_1x_1+\ldots+b_nx_n}$, where $x_1 \ldots x_n$ are the explanatory variables and $h_0(t)$ is the so-called baseline hazard function—that is, the value of $h(t)$ if all the explanatory variables equal zero. The parameters $b_1 \ldots b_n$ are estimated using maximum likelihood. Note that the change in the relative likelihood of becoming reemployed if the value of variable x_k changes by one unit equals $(e^{b_1x_1+\ldots+b_k(x_k+1)+\ldots+b_nx_n})/(e^{b_1x_1+\ldots+b_kx_k+\ldots+b_nx_n}) = e^{b_k}$. These are the values reported in Table 7 under the heading "Hazard Ratio."

The model takes into account time censoring—that is, some workers sever their relationship with the assistance center prior to finding a job, while in other cases, the sample period ends before an employment outcome can be observed. The Cox technique is efficient, in that the lack of employment for such workers during the time period in which they were observed is taken into account in estimating parameters. The term "hazard" indicates that the Cox technique was used originally to analyze the probability of failure;

Table 7
Reemployment Probabilities—Estimates Using Cox Proportional Hazards Model

Independent Variable	Hazard Ratio	Standard Error
Age[a]		
Less than 25 Years	1.00	.13
25 to 34 Years	1.02	.06
45 to 54 Years	.88*	.05
55 Years and Over	.61**	.05
Education[a]		
Less than High School	1.29*	.13
High School	1.05	.06
College	1.06	.07
More than College	1.17	.15
Male	1.15**	.06
White	1.11	.09
Number of Dependents	1.09**	.02
Recalled	3.75**	.33
Dummy for Proxied Layoff Date	.52**	.05
County Unemployment Rate at Time of Layoff		
Level	.80**	.02
12-Month Change	.79**	.03
Difference between State and County Unemployment Rates at Time of Layoff		
Level	.73**	.03
12-Month Change	.79**	.03
Loring Dummy	.38**	.05
Year of Layoff[a]		
1992	1.79**	.13
1993	1.69**	.14
1994	2.00**	.25
Pseudo R^2 = .02		
Number of Observations = 4,743		

*Significantly different from one at 5 percent level.
**Significantly different from one at 1 percent level.
[a]The omitted categories are as follows: age, 35 to 44 years; education, some college; year of layoff, 1991 and earlier.
Source: Author's calculations based on sample of displaced defense workers from Maine, Massachusetts, and Vermont.

As a group, the oldest workers had great difficulty in finding a new job, regardless of their qualifications or when they lost their defense-related job. All else equal, a person 55 years of age and older was only about 60 percent as likely to be reemployed after any given time interval as someone under age 45. It appears that workers begin to experience difficulties starting in their mid-forties.[22]

Workers with less than a high school diploma were more likely to be hired than those who had completed more years of schooling.[23] (But, as will be shown below, they suffered relatively greater income losses upon reemployment.) Men had a greater chance of finding work than similarly qualified women.

Greater family responsibilities increased the probability of reemployment, which suggests that worker motivations play some role even when economic conditions and other worker qualifications are considered. Each added dependent raised the likelihood of employment by about 9 percent.

Those who were offered and accepted reemployment with their previous employer found work much more quickly than those who searched elsewhere. This finding is evidenced by the high and statistically significant coefficient for the recall dummy.[24]

Economic conditions are very important in determining reemployment for all workers. Defense workers laid off when the prevailing unemployment rate in their county was, say, 8 percent were only 80 percent as likely to find a job as those laid off when the unemployment rate was 7 percent. (For an unemployment rate of 9 percent, the relative likelihood drops to 64 percent.)[25] For each percentage point by which the state unemployment rate at the time of layoff exceeded the county unemployment rate, the likelihood of reemployment was only 73 percent as great as if the two were identical. Increases in either the county or state unemployment rate in the 12-month period following layoff also reduced the chances of finding work. A

however, the technique is equally applicable to analyzing the probability of success. Standard errors may be used to determine whether the hazard ratio is significantly different from one.

[22] Job tenure was always insignificant when age was included. This variable is not available for the Maine sample and about one-third of the Vermont sample; hence its inclusion required using a smaller number of observations.

[23] Those who had gone beyond college also had higher than average reemployment probabilities, but the deviation was not statistically significant. Previous occupation was not significant in the presence of the other variables.

[24] A total of 158 workers were recalled. An additional variable, the "dummy for proxied layoff date," equals one if the registration date was used in place of the layoff date (because the layoff date was unknown). This was the case for some workers who registered for services before they were laid off. Because the length of unemployment was overstated for these workers, the hazard ratio is below one. Finally, an additional specification included previous industry as an explanatory variable; this coefficient was not significantly different from one.

[25] The estimate of 64 percent comes from squaring the hazard ratio reported in the table—to obtain the effect of a two-unit change in the value of the explanatory variable.

1-point increase lowered the likelihood of reemployment to about 79 percent of what it would have been had the unemployment rate remained constant. Because Aroostook County had by far the worst unemployment rates and the most remote location of all the areas studied, the regression includes a separate dummy variable for former Loring workers; as expected, their reemployment chances were far below those of other workers.

The year of layoff remained highly significant, with workers losing their job after 1991 almost twice as likely to find new employment as those losing their job in 1991 or earlier. The year dummies pick up other aspects of the local economy (such as the rate of employment growth) that are not captured in the unemployment rate, as well as economic conditions outside the state that may affect reemployment.[26]

Table 9
Percentage Distribution of Previous and New Occupations for Reemployed Defense Workers from Massachusetts

	Previous	New
Professional, Technical, and Managerial	37.4	36.5
Clerical and Sales	12.4	16.9
Services	2.2	4.0
Production	48.0	42.5
Total	100.0	100.0

Note: Based on 1,237 observations for which previous and new occupations were available. Previous occupation was not available for Maine or Vermont. Numbers may not add to totals because of rounding.
Source: Author's calculations based on sample of displaced defense workers from Massachusetts.

New Jobs

New jobs entailed considerable changes. Fewer than half the workers remained in manufacturing and government (Table 8). Sectors such as services and trade, which are important in the economy at large, became major sources of jobs for former defense workers. According to the data for Massachusetts, the percentage working in professional, technical, and managerial jobs remained almost the same, but a net shift occurred out of production jobs and into services and clerical and sales positions, which are much more prevalent outside of defense sectors (Table 9). Most defense workers who became reemployed earned less in their new job.[27] New jobs paid a median hourly wage of $10.90, and half of all new positions paid in the range of $8.00 to $14.87. The median earnings replacement rate was 82 percent. Twenty percent of the sample had hourly earnings that were roughly the same as at their defense employer (that is, between 95 and 104 percent of their former wage), and only 16 percent earned more (Table 10, first column). The remaining 64 percent had noticeably lower hourly earnings. Indeed, for over one in five workers who found a new job, the new wage rate represented a pay cut of 40 percent or more.[28]

Table 8
Percentage Distribution of Previous and New Industries for Reemployed Defense Workers from Massachusetts and Vermont

	Previous	New
Construction	.2	1.7
Manufacturing	92.9	41.0
Transportation	.2	2.3
Trade	.6	7.0
Finance, Insurance, and Real Estate	.1	1.8
Services	1.6	19.8
Government	4.0	2.3
Other and Unknown	.4	24.1
Total	100.0	100.0

Note: Based on 1,877 observations for which previous industry was known. New industry was not available for Maine. Other includes agriculture, mining, and nonclassified industries.
Source: Author's calculations based on sample of displaced defense workers from Massachusetts and Vermont.

[26] Interviewees in Connecticut, in particular, indicated that the low state unemployment rate (measured at around 5 percent in 1994) gave much too positive an impression of labor market conditions. Declining unemployment in other areas also has reflected reductions in the size of the labor force as some workers choose not to look for a job and others move away, in addition to added employment. According to the National Bureau of Economic Research, the national recession ended in March 1991. However, employment remained quite sluggish for another year or so. This may help to account for more positive placement outcomes starting in 1992. A final explanation for the significance of the year dummies is that they reflect selection bias, as discussed in footnote 15.

[27] The data include only the wage at placement, thereby ignoring any subsequent increases that might have occurred following a probationary period at the new job. This fact may cause an overstatement of earnings losses. On the other hand, Jacobson, LaLonde, and Sullivan (1993) show that the pay of displaced workers begins to fall behind the pay of other workers prior to the time of layoff. By ignoring pre-layoff trends, this study may be understating earnings losses.

[28] Information from Connecticut is consistent with these estimates. One center there cited a 72 percent replacement rate for hourly workers and an 80 percent replacement rate for salaried

Table 10
Current Earnings as a Percent of Previous Earnings for Reemployed Defense Workers
Percent

Replacement Rate	All Workers, Hourly Earnings	Former Full-Time Workers: Hourly Earnings	Former Full-Time Workers: Weekly Earnings
Under 60 Percent	23	18	21
60 to 79 Percent	25	26	26
80 to 94 Percent	16	17	17
95 to 104 Percent	20	23	22
105 to 120 Percent	9	9	8
Over 120 Percent	7	6	6
Memo: Number of Observations	1,850	1,492	1,442

Source: Author's calculations based on sample of displaced defense workers from Maine, Massachusetts, and Vermont.

Given inflation, which averaged about 3 percent a year in New England during the early 1990s, real purchasing power dropped more than wages. Other ways in which workers can be made worse off include involuntary cuts in hours worked and cuts in employment-related benefits. It does not appear that many former defense workers shifted from full-time to part-time work. The distribution of weekly earnings for those who formerly worked full-time look very similar to the distribution of their hourly pay (last two columns of Table 10). As for benefits, the picture is less clear. Three-quarters of the new jobs for defense workers did come with some form of employer-sponsored health and/or pension benefit. However, worker assistance officials noted that in many cases, contributions on the part of the new employer were not as generous as those of the defense employer. They also indicated that contract work typically did not pay benefits.

Determinants of Earnings Losses

Earnings losses varied with characteristics of workers and jobs (Table 11). Although the median hourly earnings replacement rate was 82 percent, reemployed workers 55 years of age and older replaced only 69 percent of their former wage, while those under age 35 replaced 89 percent. More highly educated workers generally suffered lower wage losses. For those with college degrees, the median replacement rate was 90 percent or more, compared with less than 80 percent for those who never attended college. Although former manufacturing workers typically had wage losses of 20 percent, the median nonmanufacturing worker who found a new job had no loss in earnings. The nature of the new job also mattered, with those finding work in manufacturing replacing more of their previous wage than those who did not. Also, there were relatively small earnings losses for those who found work in a professional, technical, or managerial position, and relatively large earnings losses for those who went into clerical, sales, or service jobs.[29]

Regressions were used to measure the effects of individual factors on earnings replacement rates, and to test some additional hypotheses. In contrast to the information in Table 11, the regressions identify the independent effect of each variable, holding all other variables constant. The results are shown in Table 12. The columns labeled "Without New Industry" show the most comprehensive set of results.

All else equal, the older the worker, the greater the earnings loss upon reemployment. Compared to the typical worker aged 35 to 44, 45- to 54-year-olds suffered a wage loss that was 3 percentage points greater, and those 55 years and older suffered a 5 point greater loss.

More highly educated workers fared much better than less educated workers. Compared to a reference group who had attended college but did not graduate, the

workers. Officials at a second center indicated that a 50 percent replacement rate was typical for hourly workers, but that salaried workers did better on average than hourly workers. At the third Connecticut center, it was estimated that the replacement rate was 87.5 percent (for all workers combined).

[29] Professionals who remained in professional jobs upon reemployment had average hourly earnings equal to 96 percent of what they had earned at their defense job, and 78 percent of the professional jobs were filled by former professionals. The typical person who had held a service job at the defense employer earned about the same amount at his or her new job; earnings losses in service jobs therefore were concentrated among those who switched into service work from a more highly compensated occupation. For example, professionals and production workers who found a service job on average replaced only 62 percent of their former wage. A similar trend, though not as pronounced, occurred for clerical and sales jobs.

Table 11

Hourly Earnings Replacement Rates for Reemployed Defense Workers, by Worker and Job Characteristic

Percent

Subgroup	Median Replacement Rate
All Workers	82
Age	
Less than 35 Years	89
35 to 44 Years	83
45 to 54 Years	75
55 Years and Over	69
Job Tenure	
Less than 5 Years	86
5 to 9 Years	77
10 to 19 Years	79
20 Years or More	86
Education	
Less than High School	73
High School	77
Some College	82
College Degree	93
More than College	90
Gender	
Male	85
Female	78
Race	
White	82
Nonwhite	82
Previous Industry	
Manufacturing	80
Nonmanufacturing	100
New Industry	
Manufacturing	89
Nonmanufacturing	72
Previous Occupation	
Professional, Technical, and Managerial	90
Clerical and Sales	79
Service	100
Production	82
New Occupation	
Professional, Technical, and Managerial	91
Clerical and Sales	71
Service	62
Production	82
Memo: Number of Observations = 1,850	

Source: Author's calculations based on sample of displaced defense workers from Maine, Massachusetts, and Vermont.

wage replacement rate was about 7 percentage points lower for high school dropouts, 4 points lower for those with only a high school education, and 11 points higher for those with a degree from a four-year college or a postgraduate education. The sharp earnings losses for high school dropouts, combined with the earlier results indicating they were faster in finding a new job, suggest that they could not afford to search as long to find a comparable job as more highly educated workers. Given a worker's age and education, other characteristics of his or her previous job (except the wage level, discussed below) generally were insignificant in explaining earnings losses. The only exception was that former professional, technical, and managerial workers tended to do better than production workers.[30]

New employers tended to discount the skills and experience of former defense workers. Those who were recalled to their former job had a wage replacement rate about 21 percentage points higher than those who accepted a job with a new employer. Also, defense-related layoffs have apparently resulted in some leveling of wages for workers with similar backgrounds. Consider, for example, a defense worker who had been earning $12 an hour, and who earned $9.60 an hour upon reemployment (for a replacement rate of 80 percent). According to the regression, a "similar" person (on the basis of age, education, race, and gender) who had been earning $13 an hour would be expected to earn a new wage just under $10.[31] In other words, the marketplace is willing to pay only 40 cents of this worker's previous dollar wage premium. The remaining 60 cents could have been due to a variety of factors. The more highly paid worker might be capable of performing a specialized task (such as a particular kind of welding or pipefitting work) that was not applicable in the new job. Or the worker might have benefited from higher wages resulting from unionization, seniority, or an exceptionally generous employer. Although this particular numerical example is illustrative only of how much a new employer might discount the skills and experience of a former defense worker, the negative coefficient on the previous wage (combined with the very low positive coefficient on

[30] Results are not shown in the table; regressions using data on the previous occupation were possible only for the Massachusetts sample. Additional alternative regressions examined the effects of the worker's job tenure. These specifications require dropping observations for Maine and about one-third of the Vermont sample. Job tenure had a statistically insignificant effect on wage replacement rates.

[31] Using the reported coefficients for the previous wage and the square of the previous wage, and the assumption of an 80 percent replacement rate for the less highly paid worker, the more highly paid worker's replacement rate is calculated at 76.7 percent, for an hourly earnings rate of $9.96.

Table 12
Hourly Wage Replacement Rates: Regression Results
Dependent Variable = New Wage as Percent of Previous Wage

	Without New Industry		With New Industry	
Independent Variable	Coefficient	Standard Error	Coefficient	Standard Error
Age[a]				
Less than 25 Years	3.31	3.22	−.82	4.51
25 to 34 Years	1.21	1.45	.04	1.56
45 to 54 Years	−3.36*	1.51	−1.42	1.63
55 Years and Over	−5.02*	2.23	−4.47	2.31
Education[a]				
Less than High School	−6.80*	2.78	−5.75	3.02
High School	−4.46**	1.43	−5.57**	1.61
College Degree	10.83**	1.99	10.59**	2.24
More than College	10.94**	3.45	7.36*	3.66
Male	1.72	1.33	1.97	1.46
White	−1.65	2.28	−1.61	2.25
Recalled	21.38**	2.23	17.04**	2.57
Previous Wage	−6.10**	.45	−4.50**	.50
Previous Wage Squared	.11**	.01	.08**	.01
New Occupation[a]				
Professional, Technical, and Managerial	14.33**	1.57	15.62**	1.84
Clerical	−8.03**	1.71	−2.15	1.94
Service	−13.43**	2.51	−9.85**	3.00
New Industry = Manufacturing			7.71**	1.38
Duration of Unemployment	−.29**	.06	−.50**	.08
Constant	146.98**	5.09	127.27**	5.70
Adjusted R^2	.24		.24	
Number of Observations	1,823		1,310	

Note: Observations with replacement rates over 200 percent were omitted.
*Significantly different from zero at 5 percent level.
**Significantly different from zero at 1 percent level.
[a]The omitted categories are as follows: age, 35 to 44 years; education, some college; new occupation, production.
Source: Author's calculations based on sample of displaced defense workers from Maine, Massachusetts, and Vermont.

the previous wage squared) indicates that a convergence in wages has been a general consequence of defense-related layoffs.

Those who managed to find professional or technical work, or a job in manufacturing, fared better than others. All else equal, the wage replacement rate for white-collar jobs was about 14 points higher than for those whose new occupation was production work. Workers finding service jobs had replacement rates about 13 points lower than production workers, and workers finding sales and clerical jobs about 8 points lower. Information on the industry of the new employer was not available for defense workers from Maine (nor for some workers from Massachusetts and Vermont). For the subset of reemployed workers for which industry data were available, a manufacturing job raised the wage replacement rate by almost 8 percentage points, holding other factors constant (see columns labeled "With New Industry").[32]

The longer they searched for a job, the more likely unemployed defense workers were to accept pay cuts. The coefficient on the duration of unemployment indicates that, for each additional year of looking for a job, the replacement rate falls by 3.5 points.

[32] Given the included explanatory variables, previous industry was not significant in explaining wage replacement rates.

Comparisons with Other Displaced Workers

The research reported here indicates that defense workers in New England have suffered large costs upon displacement; have they experienced more serious losses than other types of workers who were laid off? Some partial conclusions emerge from comparing the current findings with those from national studies of displaced workers (U.S. Congressional Budget Office 1993).[33]

Comparisons with national studies suggest that laid-off New England defense workers experienced greater difficulty in finding employment.

Defense workers were definitely at a disadvantage in terms of replacing their former earnings. In the national surveys, 45 percent of displaced workers recovered less than 95 percent of their former hourly pay upon finding a new job; for 32 percent the replacement rate was less than 80 percent. In the New England defense worker sample, 64 percent replaced less than 95 percent of their former hourly pay and 48 percent replaced less than 80 percent.

With respect to the likelihood of finding employment, the comparisons suggest some greater difficulty for defense workers in the recent New England experience. In the national surveys of workers displaced during the 1980s, 27 percent were not employed one to three years after losing their job. By comparison, between 25 and 54 percent of sampled defense workers laid off in 1991 or earlier, and between 10 and 38 percent of those laid off in 1992, were not employed after two years. The lower bound in these statistics represents only those unemployed or in training, while the upper bound also includes those no longer using worker assistance services. However, it is likely that the New England figures generally underestimate the fraction who were not working, as the sample excludes those who decided not to seek reemployment assistance. Presumably, many of these workers dropped out of the labor force. As for those who searched on their own, it is hard to make a convincing argument that they would have done better than the sampled workers, who had access to organized career counseling and job retraining.[34]

III. Summary and Conclusions

Defense cutbacks appear to have resulted directly in the loss of almost 114,000 jobs in New England between 1989 and 1994. This article has examined the implications of these layoffs for a sample of about 5,000 former defense workers who tried to find a new job.

Improving regional economic conditions over the past couple of years have helped to speed up job searches for laid-off defense workers. Nevertheless, their employment rates remain disappointing. Among the sampled workers who lost their job in 1992, 63 percent had found reemployment through a worker assistance center two years later, and 10 percent were still enrolled in training or were looking for a job through a center. The remaining 28 percent had stopped attending an assistance center, presumably having decided either to drop out of the labor force or to look for work on their own.

In some parts of New England, economic recovery has remained slow or nonexistent, further limiting defense workers' prospects. In Aroostook County, Maine, where Loring Air Force Base recently closed, the unemployment rate exceeds 11 percent. Employment has been recovering slowly in Connecticut and Rhode Island, and some areas in southeastern Massachusetts continue to have unemployment rates that are substantially above the statewide average.

The transition to a less defense-dependent economy has entailed substantial losses of income. Among all sampled defense workers who found a job, the median loss in hourly earnings was 18 percent. Twenty-three percent faced declines of 40 percent or more. Clearly, defense workers had amassed specific experience at their old jobs that was not fully valued at their new jobs. On average, retraining programs did not provide enough new skills to offset the obsolescence of old skills.

Income losses were severe for older workers in the sample. Their probability of finding a job was below average, and for those 55 years of age and older who did, the median hourly earnings decline was 31 percent. For displaced defense workers aged 45 to 54

[33] In subsequent research, the author plans to study the experiences of different types of displaced workers in New England.

[34] Somewhat surprisingly, the median duration of unemployment among those who found a job is 18 months in the national displaced worker surveys, but only 11 months in the New England defense sample. This disparity may be due to the fact that the national survey polls workers one to three years following their layoff, and therefore is likely to include more completed long-term unemployment spells.

years, the median wage drop upon reemployment was 25 percent. Income losses also varied inversely with education: median hourly wages declined 23 percent for high school graduates but only 7 percent for college graduates. Given decreasing opportunities in manufacturing, many former defense workers took jobs in other sectors or other occupations that resulted in large reductions in pay.

This study did not specifically analyze the efficacy of general support services and training programs for laid-off defense workers. The findings suggest, however, that achieving better reemployment and income results would require significantly higher investments on the part of both government and workers, as the experiences of displaced defense workers reflect broad structural changes occurring in U.S. labor markets.[35] Manufacturing traditionally has provided high-wage opportunities for workers with a variety of educational backgrounds, but has been shrinking. Meanwhile, highly paid services sector jobs require new skills that many former manufacturing workers lack. These structural issues continue to confront displaced defense workers, even as the overall economic environment improves and even if they are served by well-run assistance centers.

[35] For further discussion of general trends, see, for example, Freeman and Katz (1994), Levy and Murnane (1992), and U.S. Congressional Budget Office (1993, 1994).

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Appendix by Karen A. Therien

Measuring Defense Employment

The extent of defense downsizing in New England since 1988 is indicated in Appendix Table 1. Employment in Connecticut, Maine, Massachusetts, and New Hampshire is estimated using ES-202 data for the following defense-dependent SIC codes: 2892, 348, 3663, 3669, 372, 3731, 376, 3795, 381, 8731, 8732, and 8734. These industries, described in Table 1, were used to calculate defense-intensive employment because at least 40 percent of the industry's national product is for defense purposes. Disclosure restrictions prevented the state of Maine from releasing employment estimates for the shipbuilding and repair industry (SIC 3731) prior to 1990.

Estimates for Vermont and Rhode Island use different industry definitions. Vermont employment in its two large defense-intensive industries (SIC 348 and 372) is not disclosed. Instead, total defense-related employment in Vermont in Table 3 was constructed using New England Economic Project data for the 2-digit SIC codes 34 and 37

Appendix Table 1
New England Employment in Defense-Intensive Industries
Thousands

Year	Connecticut	Maine	Massachusetts	New Hampshire	Rhode Island[a]
1988	96.2	n.a.[b]	67.7	13.0	17.4
1989	95.2	n.a.[b]	70.2	12.6	14.0
1990	91.8	13.6	68.0	11.3	13.5
1991	87.8	12.4	63.4	10.2	12.5
1992	80.2	11.5	59.6	9.8	11.0
1993	71.6	10.4	57.7	9.5	10.8
1994[c]	66.2	10.5	53.1	9.0	9.4

[a]Defense-related employment in all industries, as described in the Appendix text.
[b]Prior to 1990, employment in the shipbuilding and repair industry was not disclosed.
[c]1994 data are an average of the first three quarters.
Source: Estimates based on unpublished data supplied by the Connecticut Department of Labor; the Maine Department of Labor, Division of Economic Analysis and Research; the Massachusetts Department of Employment and Training; the New Hampshire Department of Employment Security; and the Rhode Island Department of Employment Security.

(along with Defense Budget Project fiscal year 1992 estimates of defense-related employment).

The Rhode Island Department of Economic Development uses a company survey to estimate defense-related employment in all industries for firms reporting 10 percent or more defense sales. The figures in Appendix Table 1 equal total employment at these Rhode Island establishments times the fraction of sales reportedly related to defense. Conceptually, these employment numbers are comparable to the Defense Budget Project estimates, but a substantial difference exists in practice. For example, the Rhode Island Department of Economic Development survey estimates defense employment of 10,995 in 1992, while the Defense Budget Project estimates that Rhode Island's defense-related employment was 19,400 in fiscal year 1992. The estimates in Table 3 use the trends from the Rhode Island survey, benchmarked to the employment level estimated by the Defense Budget Project.

Displaced Defense Worker Sample

Appendix Table 2 lists the former employers of the 5,001 individuals in the dislocated defense worker sample. The Massachusetts Industrial Services Program provided a data base of approximately 21,000 displaced workers. Individuals who were formerly employed by a defense prime contractor or who were civilian employees at a military facility in Massachusetts were included in the displaced defense worker sample. In addition, the Massachusetts sample includes individuals who were formerly employed at the Connecticut facilities of Pratt & Whitney and Hamilton Standard, but who resided in Massachusetts, for a total of 3,619 observations. The Bureau of Employment and Training Programs in Maine provided data for 878 individuals formerly employed at Loring Air Force Base and Bath Iron Works. Until its closure, Loring was the largest military facility in Maine. Bath Iron Works is the largest private employer in the state and accounts for most of the defense prime contracts awarded. The Vermont Department of Employment and Training furnished data for 504 individuals formerly employed by General Electric and Simmonds Precision, the predominant defense prime contractors in that state.

Appendix Table 3 provides statistics for the displaced defense worker sample. The job tenure variable, measuring the years of employment at the former defense employer, is the length of time between the start date and the end date at the former employer. The hourly replacement wage was constructed as a ratio of the hourly wage on the new job to the hourly wage on the former job. The weekly replacement wage is the ratio of the weekly wage on the new job to the weekly wage on the old job. Weekly wages were determined by multiplying the hourly wage and the hours worked per week. The observed length of unemployment was calculated as the number of months between the date of layoff and the date of termination from the center. The date of layoff was taken as the ending date of work at the former employer. The date of application at the worker assistance center was used as the layoff date if the end date was unknown. In cases where the date of termination was not available because the sample period ended, the observed unemployment spell was calculated as the number of months between the layoff and the end of the sample (September 1994 for Maine and Massachusetts and October 1994 for Vermont).

County unemployment rates were assigned based on the location of the former employer. If the former employer had locations in more than one county (such as General Electric), and the particular location was unknown, the county unemployment rates for all of the possible locations in that state were averaged. Observations that do not have county unemployment data represent individuals formerly employed at a military facility with an unknown location or individuals displaced before 1988.

Adjustment of State Data

Vermont. The first day of the month was filled in as the day of birth because the date of birth contained only the year and month. The number of dependents was not included in the Vermont data base, but was constructed using family size. An SIC code was assigned according to the primary

Appendix Table 2
Corporations and Military Facilities Represented in the Sample

Name	Number of Employees
Maine	
Loring Air Force Base	586
Bath Iron Works	292
	878
Massachusetts	
General Electric[a]	980
Raytheon Company	959
Fort Devens	431
Martin Marietta	252
Textron	151
Hamilton Standard	132
Northrop	100
GTE	89
Kollmorgen	59
Craig Systems	58
Varian	58
MA/Com	54
U.S. Armed Forces	45
Computervision	42
Loral	39
Nuclear Metals	31
Chamberlain Manufacturing	30
All Other	109
	3,619
Vermont	
General Electric Company	474
Simmonds Precision	30
	504
Total	5,001

[a]Includes facilities purchased by Ametek from General Electric.
Source: See Appendix text.

Appendix Table 3
Displaced Defense Worker Sample Variables

Variable	Mean	Standard Deviation	Number of Observations
Worker			
Age (years)	41.3	10.3	5,001
Education (years)	13.3	2.1	4,967
Number of Dependents	.9	1.2	4,765
Former Job			
Hourly Wage (dollars)	15.1	5.7	4,891
Hours per Week	40.1	5.5	4,093
Job Tenure (years)	11.7	8.4	3,350
New Job			
Hourly Wage (dollars)	12.3	6.1	1,966
Hours per Week	38.7	5.2	1,837
Comparison between Old and New Job			
Hourly Replacement Wage (percent)	83.6	31.7	1,850
Weekly Replacement Wage (percent)	82.8	30.6	1,450
Unemployment			
Observed Length of Unemployment (months)[a]	11.7	18.6	4,924
County Unemployment Rate at Time of Displacement (percent)	7.3	2.3	4,979
12-month Change in County Unemployment Rate (percentage points)	−.7	1.1	4,979
Difference between State and County Unemployment Rates at Time of Displacement (percentage points)	.0	1.8	4,979
Difference between 12-month Change in State and County Unemployment Rates (percentage points)	.1	.9	4,979

[a]See description in the Appendix text.
Source: See Appendix text.

industry of the defense employer. Comparing the new weekly wage to the former weekly wage was not possible, because the number of hours worked per week at the former employer was not available.

Maine. The number of hours worked per week at the former employer was not provided, but was assumed to be 40 if the individual's working status had been full-time. Because of this, the former weekly wage could be calculated only for those individuals who had been displaced from full-time jobs. The start date at the former job was not provided, making it impossible to calculate tenure at the former job. Appropriate SIC codes were assigned for the two Maine employers. Dates containing 00 or 32 for the day of the month were changed to 01 and 31, respectively.

Massachusetts. Unlike the data for Maine and Vermont, SIC codes for the former employers were included in the state's data base, but they were in the form of 2-digit, 3-digit, and 4-digit codes. 2- and 3-digit SIC codes were changed into 4-digit codes by adding zeros. Observations that did not have an SIC code for the former employer were supplied with one if it could be determined from the name of the employer. SIC codes for the new employer in the form of 2-digit and 3-digit codes were also changed into 4-digit codes by adding zeros.

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The Housing Cycle in Eastern Massachusetts: Variations among Cities and Towns

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Numerous studies over the years have attempted to identify the impact of amenities on housing price levels within specific metropolitan areas. It is well known, for example, that local public goods, tax burdens, school quality, crime rates, and the like are capitalized into land values.[1] While reasonably good cross-sectional data bases on house prices have been available for some time, data limitations have prevented researchers from looking at *changes* in home prices over time at any meaningful level of geographic disaggregation. Newly available data show that appreciation and depreciation rates over the cycle have varied widely within metropolitan areas, particularly in those parts of the country that have experienced large swings in home prices.

In Eastern Massachusetts since 1982, differences in appreciation rates across cities and towns have been pronounced. During the boom, houses in various towns appreciated in value on average from 141 to 250 percent. These variations were far from random: Houses located in towns close to Boston and towns with lower initial price levels appreciated at above-average rates. Subsequent price declines also varied significantly, between 9 and 25 percent, and the largest losses were concentrated in towns located farthest from Boston.

Case and Mayer (1995) explore the cross-sectional pattern of house price appreciation in the Eastern Massachusetts area during the 1980s boom and bust. Their study finds that affordability, proximity to downtown Boston, the shift from manufacturing to services-based jobs, the aging of the baby boom, and new construction all had significant effects on which towns' house prices rose fastest. In addition, the authors show that the premium associated with higher-quality schools actually fell during the 1980s, when Massachusetts public school enrollments declined dramatically.

This article expands upon the results in Case and Mayer (1995) by dividing the Eastern Massachusetts area into small groups of similar towns and updating the analysis, using recently acquired data from the

1991–94 period. The first part of the article discusses the previous literature. Next, similar towns in Eastern Massachusetts are grouped and the pattern of price appreciation across those groups during the boom, bust, and recovery periods is examined. This examination reveals that housing affordability was the most important factor explaining price changes during the boom period, but location, schools, and a town's employment base became relatively more consequential during the bust and the recovery.

I. Previous Results

Since Tiebout (1956) and Muth (1969), most research in urban economics has used variations in the level of public services and taxes and distance from the city center to explain differences in price levels among individual cities and towns within a metropolitan area. Although not explicitly addressed, the implication of these early articles was that changes in the relative prices between different towns are caused by unexpected development (causing a shift in the rent gradient) or changes in the level of town services or the taxes that finance them. In the Tiebout tradition, however, towns are assumed to constantly adjust their public services and zoning requirements in order to maximize the price of housing within the town. Thus, observed changes in a town's public services might be related to shifts in the cost of providing those services.

The rate of house price appreciation within a metropolitan area can vary significantly for properties in different price ranges.

Several articles have shown that the rate of house price appreciation within a metropolitan area can vary significantly for properties in different price ranges. Smith and Tesarek (1991) develop a methodology to estimate a price index for different quality levels. Using data from Houston over several years between 1970 and 1989, they find that high-quality properties appreciated faster than average during the boom of the 1970s, but that they fell faster during the oil bust of the 1980s. Case and Shiller (1994) show that house price appreciation by price tier differed between Boston and Los Angeles over the boom/bust cycle.[2]

Although these papers provide little hard evidence on the reasons for the patterns observed, several recent studies have attempted to provide explanations for differential movements in house prices that are unrelated to differences in the cost of providing public services or shifts in the rent gradient. Poterba (1991) suggests that high marginal tax rates and expectations of rising inflation led high-priced properties to appreciate faster than low-priced properties in the late 1970s. Mayer (1993) shows that even after accounting for taxes, population shifts, and changes in the income distribution, higher-priced homes exhibit more price volatility than lower-priced homes. He argues that this volatility is consistent with a Stein (1993)-type liquidity model, in which the wealth of existing home owners is affected more by shocks to the housing market than is the wealth of first-time buyers.

Previous empirical articles on cross-sectional price changes have tended to focus on movements in price tiers rather than on town-by-town deviations in house price appreciation, because of data limitations. In a statistical study of determinants of house price appreciation, Case and Mayer (1995) combine town-level house price indexes for the Boston metropolitan area with detailed data about town residents' employment and demographic characteristics, town amenities, and location. The authors regress the change in house prices by town on town characteristics and find that these characteristics can explain a significant portion of observed changes in single-family house prices in towns from trough to trough.

Their results validate some of the predictions of the standard urban models discussed earlier. For example, house prices over the cycle increased faster in towns located closer to Boston, resulting in a steeper rent gradient as the local economy expanded. In addition, marketwide shifts in the employment base and in demographics also had significant housing market implications. House prices in towns with a large share of residents working in the manufactur-

[1] See Oates (1969), Brueckner (1982), Roback (1982), Yinger et al. (1988), and a host of other tests of tax capitalization and the Tiebout (1956) hypothesis.

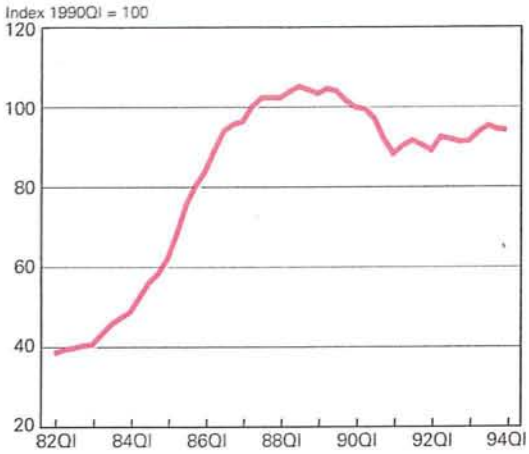
[2] Case and Shiller (1994) present three reasons for the observed differences in price behavior by tier in the two cities: (1) Boston had a higher rate of first-time buyers entering the market; (2) Boston had a greater increase in the supply of homes at the bottom than at the top, and poorer areas were hit hardest by the 1990–91 recession; (3) low-tier prices in California have been supported by immigration and pent-up demand for ownership.

ing sector in 1980 grew less quickly in the ensuing years, when aggregate manufacturing employment fell. Houses appreciated faster in towns with a larger initial percentage of middle-aged residents, as baby boomers moved into middle age.[3] Housing values rose more slowly in towns that allowed additional construction. Finally, the price premium associated with housing in towns with good schools appeared to fall as demographic shifts resulted in fewer families with children attending public schools in Massachusetts.

While the statistical analysis in Case and Mayer (1995) is suggestive and helps explain patterns of home price movement across towns, it is by nature an aggregate analysis. The research presented here is an attempt to better understand the causes of the observed aggregate patterns by looking in more detail at specific submarket areas, defined geographically.

Figure 1

House Price Changes in the Boston Metropolitan Area



Source: Case Shiller Weiss Inc.

II. Data Summary and Town Groupings

The indexes presented in this article were estimated using a variation on the weighted repeat sales methodology first presented in Case and Shiller (1987). The method uses the arithmetic weighting proposed by Shiller (1991) and is based on recorded transactions for all properties that sold more than once between 1982 and 1994. The price indexes were produced using an iterative process, in which an aggregate index was calculated based on all recorded sale pairs for each broad market area and then separate town indexes were calculated for 168 individual towns in Eastern Massachusetts.[4] Figure 1 presents the movement of the aggregate price index for the Boston metropolitan area.

Table 1 summarizes the data for the 168 cities and towns used in this paper. Apart from the price indexes, most information about them comes from the 1980 and 1990 Censuses; exceptions are noted below. The advantage of using Census data is that they are available in detail at the individual city and town level. The limitation of Census data, however, is that they are available only for the decennial Census years of 1980 and 1990. Clearly, data for the key years 1982 (trough), 1988 (peak), and 1992 (trough) would have better captured changes in the towns over the real estate cycle, but they were not available.

School and crime data come from various Massachusetts state government departments and are available for selected years after 1980. Except for crime statistics, all the data used in the analysis are available for all 168 towns in eastern Massachusetts. The crime data are reported only for larger towns, which generally have higher crime rates. Crime rates for certain small towns are not reported.[5]

A comparison of the 1980 and 1990 Census data shows considerable economic change over the 10-year period. Most obviously, real median household income rose by over one-third, a rate much higher than the national increase in real household income. Over the same period, employment in the manufacturing sector fell substantially; the percentage of workers employed in the manufacturing sector declined from 32 to 23 percent. The percentage of the population in

[3] The empirical estimates in Case and Mayer (1995) suggest only modest differences in appreciation rates as a result of these aggregate changes in employment or demographics, however. For example, with an average total appreciation of 132 percent over the cycle, house prices appreciated by a total of 6 percentage points less in a town with a 1980 share of manufacturing workers that is one standard deviation above the mean. The impact of a change in demographics on cross-sectional appreciation rates was even smaller.

[4] Case Shiller Weiss Inc. supplied all of the house price indexes used in this article.

[5] Even for larger towns, reported crime rates are still a rough proxy for the actual number of crimes committed because of differences in reporting rates across cities and towns.

Table 1
Summary of Data for 168 Cities and Towns in Eastern Massachusetts

	Mean	Standard Deviation	Minimum	Maximum
Housing Price Data (percent, except as noted)				
Price Change: 1982-Peak[a]	175	19	141	249
Price Change: Peak-Trough[a]	−16	3	−25	−9
Price Change: Trough-1994[a]	6	3	0	13
Price Change: 1982–1994[a]	145	16	110	187
Miles from Boston	31.5	16.1	0	118
1980 Data for Town Residents (Census data, except as noted)				
Percent of Residents Working in Manufacturing	32	10	11	56
Percent of Residents Working in Services	34	8	20	62
Percent of Residents 35 to 60 Years Old	28	4	20	40
School Spending per Weighted Pupil[b]	$ 1,837	$ 332	$ 1,049	$ 3,255
Median Single-Family House Value	$ 56,000	$19,000	$33,000	$144,000
Median Household Income	$ 21,700	$ 5,800	$11,500	$ 47,600
Crimes per 1,000 Residents[c]	42	19	10	135
1990–1992 Data for Town Residents (Census data, except as noted)				
Percent of Residents Working in Manufacturing	23	7	9	42
Percent of Residents Working in Services	40	7	28	68
Percent of Population 35 to 60 Years Old	32	4	23	47
1992 School Spending per Weighted Pupil (1980 Dollars)[b]	$ 2,465	$ 581	$ 1,209	$ 4,496
Median Single-Family House Value (1980 Dollars)	$116,700	$38,500	$70,600	$314,000
Median Household Income (1980 Dollars)	$ 29,300	$ 8,300	$14,000	$ 60,000
Crimes per 1,000 Residents (1992)[c]	31	21	3	109
1988 Assessment Test Scores[b]	2,673	164	2,190	3,090

[a]Source: Case Shiller Weiss Inc.
[b]Source: Massachusetts Department of Education.
[c]Source: Massachusetts Department of State Police.
Source of remaining data, U.S. Bureau of the Census.

the middle-age years (age 35 to 60) also increased during the decade, as the first 10 years of the baby boom generation passed the 35-year-old threshold.

The town data also show that, contrary to public perception, reported crime rates fell and real school spending per weighted pupil increased substantially.[6] While the mean amount of school spending increased, so did the differences across towns. One measure of dispersion, the ratio of the standard deviation to the mean, increased from 0.18 in 1980 to 0.24 in 1992.

To make the subsequent analysis more tractable, the 168 cities and towns in the sample were divided into 27 separate submarket groups. The groupings were subjective and based on the authors' knowledge of the metropolitan area housing market, data on income levels, and geography, and are intended to reflect groups of towns that buyers would find close substitutes for one another.

Table 2 presents the submarket groups, ranked by nominal price appreciation between the beginning of the period (1982) and the market peak in each town. Peaks occurred between late 1987 and mid-1989. The table also shows changes from the town-specific peak to the cyclical trough, which occurred for some towns as early as mid-1991 and for others as late as 1994. The third column shows the extent of price recovery for each of the submarket groups by mid-1994. The price change for each group is the population-weighted average of each town's individual price change. The rest of the article analyzes these price changes. Appendix Table 1 presents population-weighted means for selected data series for each of the 27 groupings.

[6] The weighted pupil count is reported by the Massachusetts Department of Education and reflects estimates of the additional cost of educating students who have special needs, or whose families are below the poverty line or do not speak English as a first language. Dividing school spending by weighted pupils yields a per-pupil spending estimate that is adjusted for such costs.

Table 2
Changes in Nominal House Prices, for Submarket Groups of Cities and Towns

Submarket Group	Percent Change in House Prices 1982 to Peak	Percent Change in House Prices Peak to Trough	Percent Change in House Prices Trough to Mid-1994	Percent Change in House Prices 1982 to Mid-1994
1) Fall River, New Bedford	235	−19	2	177
2) City of Boston	228	−22	1	159
3) Acushnet, Fairhaven, Mattapoisett, Marion, Westport, Wareham	220	−18	2	167
4) Attleboro, Taunton, Rehoboth, Somerset, Seekonk, Swansea	211	−19	6	168
5) Brockton, Bridgewater, East Bridgewater, West Bridgewater	204	−21	1	142
6) Raynham, Norton, Middleborough	201	−19	5	158
7) Everett, Saugus, Malden, Medford	200	−14	3	165
8) Braintree, Quincy, Randolph, Rockland, Abington, Whitman, Stoughton, Holbrook	193	−14	3	160
9) Lawrence, Lowell, Methuen, Haverhill	186	−21	4	134
10) Cambridge, Waltham, Arlington, Watertown	185	−12	6	167
11) Salem, Peabody, Danvers, Beverly, Marblehead, Lynn, Swampscott	179	−14	1	143
12) Dedham, Norwood, Canton, Milton	176	−13	5	154
13) Woburn, Burlington, Reading, Wakefield, Melrose, Stoneham, Lynnfield, Billerica, Bedford	176	−16	7	160
14) Fitchburg, Leominster, Lunenburg, Westminster, Gardner, Ashburnham, Shirley, Princeton, Groton, Pepperell, Townsend, Tyngsborough, Templeton	175	−21	2	122
15) Uxbridge, Blackstone, Hopedale, Upton, Southbridge, Webster, Douglas, Mendon	175	−19	5	134
16) Hingham, Cohasset, Norwell, Marshfield, Hull, Duxbury	173	−11	6	159
17) Worcester	172	−19	1	123
18) Belmont, Winchester, Newton, Lexington	171	−11	9	164
19) Gloucester, Topsfield, Ipswich, Rowley, Middleton, Rockport, Manchester, Amesbury, Merrimac, Boxford	171	−15	4	139
20) Franklin, Wrentham, Bellingham, Foxborough, Sharon, Walpole, Norfolk, North Attleborough	168	−15	8	145
21) Plymouth, Halifax, Carver, Pembroke, Hanson, Hanover	164	−17	7	135
22) Concord, Wellesley, Weston, Carlisle, Acton, Wayland, Sudbury, Dover, Sherborn, Westwood	164	−14	11	153
23) Auburn, Millbury, Grafton, Oxford, Spencer, Leicester, Shrewsbury, Holden, West Boylston, North Brookfield, Rutland	162	−19	4	119
24) Andover, North Reading, Tewksbury, North Andover, Dracut, Chelmsford	160	−13	7	142
25) Westford, Ayer, Littleton, Harvard, Maynard, Hudson, Clinton, Marlborough, Northborough, Southborough, Westborough, Stow, Lancaster, Sterling	157	−17	9	132
26) Medfield, Medway, Millis, Holliston, Hopkinton, Milford, Ashland	153	−16	10	134
27) Framingham, Natick	152	−14	11	140

Note: Peak and trough values are calculated based on price indexes for individual towns. Average price changes for each group are weighted based upon each town's 1980 population.
Source: Case Shiller Weiss Inc.

Table 3
Boom Period Appreciation, by City/Town Groupings and City/Town Characteristics

	Percent Change in Nominal House Prices 1982 to Peak	Percent of Residents Working in Manufacturing 1980	Median Household Income 1980	Median Single-Family House Value 1980	Assessment Test Scores 1988	School Spending Per Weighted Pupil 1980	Crimes Per 1,000 Residents 1980	Distance to Boston[a]	Percent Decrease in Public School Enrollment 1980 to 1988
Highest Quartile	214	31	$15,700	$40,300	2,490	$1,773	66	31	−15.6
Second Quartile	181	30	$19,100	$52,100	2,565	$1,900	49	21	−27.4
Third Quartile	171	29	$20,300	$54,500	2,640	$1,841	36	36	−20.5
Bottom Quartile	158	33	$24,300	$64,200	2,751	$1,962	30	30	−28.5
Mean	175	32	$21,700	$56,000	2,673	$1,837	42	32	−22.8

[a]Distance to Boston is in miles from the center of the grouping.
Source: See Table 1.

III. The Boom Period

The great boom in housing prices began in late 1984, and peaked between the end of 1987 and mid-1989, depending on the town. Single-family home prices in the average town increased 175 percent; that is, a house worth $100,000 at the beginning of the period was worth $275,000 less than seven years later. At their height, appreciation rates were nearly 40 percent per year, and the average appreciation rate was over 18 percent per year. The boom was also very broad-based, with all towns experiencing a dramatic rise in house prices. In the top seven groups of Table 2 (the top quartile), house values at least tripled. Even in the bottom two groups, average house prices appreciated at least 150 percent. A $50,000 home in the Framingham/Natick and Medfield/Medway, etc. groups in 1982 was worth about $125,000 at the market peak; that home in Fall River or New Bedford was worth about $168,000 at peak.[7]

Table 3 shows city/town characteristics for group quartiles (shown in Table 2) based on the appreciation rate from 1982 to peak. The results clearly indicate that the groups that appreciated the most had the *lowest* initial values, the *lowest* incomes, the *worst* schools, and the *highest* crime rates. These high-appreciation-rate groups saw house prices rise 214 percent and had an average median household income of $15,700 and an average median home value of $40,300 in 1980. The groups with the least appreciation saw prices rise "only" 158 percent and had an average median household income of $24,300 and an average median home value of $64,200.

The Fall River/New Bedford and Boston groups provide the most dramatic examples, with house prices rising 228 to 235 percent during the boom. Fall River/New Bedford had the *lowest* median household income among the 27 groups, at $11,600 in 1980. The City of Boston (itself a group), with appreciation second only to Fall River/New Bedford, had the second lowest median household income in 1980 at $12,500. The lower-income towns of Brockton, Bridgewater, Everett, Malden, and Taunton were also in the highest quartile of appreciation during the boom. The geographic pattern of price changes can be seen in Appendix Figure A1.

At the other end of the spectrum, the highest income grouping among the 27 in 1980 included such west suburban towns as Concord, Dover, Wellesley, and Weston, with an average median household income in 1980 of $34,100. This group was in the *lowest* quartile of towns by appreciation during the boom. The average house price increase there was just 164 percent. Also in the quartile with the least appreciation were such high-income towns as Andover and the more distant southwestern suburban group that includes Medfield, Medway, and Hopkinton.

The groups with the lowest 1980 median house values and income levels had the highest crime rates and the worst schools, as measured by test scores and

[7] In the regression analysis in Case and Mayer (1995), the most important coefficient is the one on the constant term. The constant term ranges from 1.72 to 2.08 in the boom equations with t-statistics no lower than 8.2.

Table 4
Housing Affordability,[a] 1980 and 1990: Selected Massachusetts Towns

	Median Value 1980	Median Value 1990	Income Needed to Purchase, 1980: Amount	Income Needed to Purchase, 1980: Percent of Mass. Households with Income >	Income Needed to Purchase, 1990: Amount	Income Needed to Purchase, 1990: Percent of Mass. Households with Income >
Wellesley	$99,400	$349,500	$39,760	15.3	$139,800	1.9
Belmont	$87,000	$307,800	$34,800	20.2	$123,120	3.2
New Bedford	$32,600	$115,900	$13,040	66.7	$ 46,360	34.1
Fall River	$34,100	$127,800	$13,640	66.4	$ 51,120	30.2
Brockton	$38,200	$131,700	$15,280	60.1	$ 52,680	29.8

[a]Affordability assumes that a household can afford to spend 30 percent of after-tax income on monthly payments on a 30-year fixed-rate mortgage at 8.5 percent. Ratio of affordable home to pre-tax income: 2.5.
Source: U.S. Bureau of the Census, 1980 and 1990 User Tapes.

expenditures per weighted pupil. The Fall River/New Bedford pair had the lowest average test scores, the lowest cost-adjusted per-pupil expenditures, and the third highest crime rates among the 27 groups. In contrast, four of the top six groups ranked by school test scores were in the lowest appreciation quartile, while the other two (the Belmont/Winchester and Hingham/Cohasset groups) were in the third quartile. Table 3 shows that the average crime rate among the cities and towns in the highest appreciation quartile (66 per 1,000) was twice that of the two lowest appreciation quartiles (36 and 30 per 1,000).

What explains the somewhat counterintuitive result that house values in towns with high crime rates and poor schools increased at above-average rates? Housing affordability is one likely explanation. During the boom, as house prices grew much more rapidly than incomes, the pool of potential buyers shrank faster for the more expensive towns relative to the cheaper towns, despite the fact that housing prices increased more rapidly at the bottom. For the entire Commonwealth of Massachusetts between 1980 and 1990, nominal median income increased from $19,666 to $41,678, an increase of 112 percent. During the same period, the statewide median price of owner-occupied housing rose from $51,047 to $167,450, an increase of 228 percent.[8] The ratio of median house price to median income rose from 2.6 to 4.0. The distribution of income is such that an increase in the median home price relative to income disproportionately reduces potential demand for the most expensive houses.

This point is illustrated in Table 4, which presents affordability calculations for the median-priced single-family home in three low-priced towns and two high-priced towns in 1980 and 1990. The third column shows the income needed to buy the median-priced home in each town in 1980. This calculation assumes that 30 percent of after-tax income is spent on principal and interest with a 30-year fixed-rate mortgage at 8.5 percent, which translates into a house price/income ratio of 2.5. The fourth column shows the percentage of Massachusetts households in 1980 that could afford the median-priced home in each town. For example, 15.3 percent of Massachusetts households could afford the median-priced home in Wellesley in 1980, while about two-thirds of the Massachusetts population could afford the median-priced home in New Bedford.

Columns 5 and 6 show how much more expensive housing became in the subsequent 10 years. By 1990, only 1.9 percent of households in the Commonwealth could afford the median-priced home in Wellesley, an 88 percent reduction in the pool of potential buyers, while slightly over one-third of households could afford the median-priced New Bedford home, a decrease of 51 percent. Put simply, as the distribution of home prices rose, potential buyers were priced out of the high-priced towns, disproportionately increasing demand for houses in low-priced towns. Case and Shiller (1994) show that the homeownership rate among middle-income households in-

[8] In fact, the median house price increased faster than average house prices over the same time period, in part because of changes in the mix of sold properties and new construction of above-average-price houses.

creased significantly during the boom in Massachusetts. This rush to home ownership clearly was concentrated in the low-priced towns, which were the only towns with houses that middle-income households could afford to buy.

Also apparent from the data shown in Table 3 is the relatively large increase in house prices in towns with poorer-quality schools, at least as measured by assessment test scores.[9] Because homes in good school districts command a premium over homes in lesser districts, other things equal, this result suggests that those premiums declined between 1982 and 1988.[10]

The boom in housing prices was very broad-based, with all cities and towns experiencing a dramatic rise in house prices, but the groups that appreciated the most had the lowest initial values, the lowest incomes, the worst schools, and the highest crime rates.

While slower price appreciation for homes in towns with good schools may seem counterintuitive at a time when incomes were rising, a powerful explanation can be found in school enrollment figures. Enrollment in public elementary and secondary schools (K–12) in Massachusetts dropped 13 percent between 1982 and 1988, while enrollments nationwide dropped 2 percent. The drop in overall enrollments was the largest among the 50 states.[11] Since enrollment rates in Massachusetts actually increased during the period, the phenomenon seems to be almost entirely demographic. That is, fewer children of school age lived in Massachusetts in 1988 than in 1982. The public school enrollment decline was made worse by a relative increase in enrollments in private elementary and secondary schools.

In addition, the pattern of enrollment declines is consistent with the view that affordability problems led households with children to disproportionately locate in towns with lower house prices, even if those towns had worse-than-average schools. The right-hand column of Table 3 shows the enrollment declines (per capita) by grouping quartile. Between 1980 and 1988, per capita enrollments dropped 15.6 percent in the highest-appreciation quartile, while they dropped more than 28 percent in the lowest-appreciation quartile.

Whether because of demographics or an increase in the popularity of private schools, fewer home buyers were concerned with the quality of public schools in 1990 than in 1980, and thus the premium associated with good schools fell.

IV. The Bust Period

Beginning in 1989, housing prices began to fall. An excess supply of properties on the market, a national recession, and an even more severe regional recession all began to take their toll. After some initial resistance,[12] nominal prices fell. The mean nominal decline from peak to trough across the 168 towns was 15.8 percent. The biggest drop was in Boston (22 percent) followed closely by the Lawrence/Lowell, Brockton/Bridgewater, and Fitchburg/Leominster groups (21 percent each). The smallest declines were along the South Shore in the Hingham/Cohasset group (11 percent), and in the Belmont/Winchester group (11 percent). The geographic pattern of price declines is shown in Appendix Figure A2.

Table 5 shows bust-period depreciation for city/town groups ranked by the quartile of the price change from peak to trough. In towns in the quartile with the greatest declines, prices overall fell by more than 20 percent, while prices in the quartile with the smallest declines fell by just over 12 percent.

Consistent with the findings in Case and Mayer (1995), house price declines were the steepest in the cities and towns with a large percentage of manufacturing workers. The quartile with the sharpest drops in value had 38 percent of residents employed in the

[9] In fact, Case and Mayer (1995) found that school test scores were significant and had a negative effect on appreciation rates during the boom, even controlling for initial median house value and other town characteristics. Unfortunately, assessment tests were only given beginning in 1988 and are not available for the start of the sample period.

[10] See Yinger et al. (1988) for a survey of the literature on school quality and home prices.

[11] The enrollment data come from the U.S. Bureau of the Census, *Statistical Abstract of the United States*, 1994, Table 242, from the U.S. Department of Education, *Digest of Educational Statistics*, 1988 and 1993, and the Massachusetts Department of Education.

[12] See Case (1991 and 1994) for a discussion of price dynamics during the period, and Case and Shiller (1994) for a discussion of behavior by price tier.

Table 5
Bust Period Depreciation, by City/Town Groupings and City/Town Characteristics

	Percent Change in Nominal House Prices Peak to Trough	Percent of Residents Working in Manufacturing 1980	Median Household Income 1980	Median Single-Family House Value 1980	Assessment Test Scores 1988	School Spending Per Weighted Pupil 1988	Crimes Per 1,000 Residents 1988	Distance to Boston[a]
Highest Quartile	−20.3	38	$15,500	$39,800	2,502	$2,751	63	40
Second Quartile	−17.9	32	$18,600	$45,800	2,568	$3,025	36	39
Third Quartile	−14.6	28	$22,000	$59,600	2,659	$3,732	29	19
Bottom Quartile	−12.3	23	$23,200	$66,000	2,712	$3,935	32	16
Mean	−15.8	32	$21,700	$56,000	2,673	$3,505	29	32

[a]Distance to Boston is in miles from the center of the grouping.
Source: See Table 1.

manufacturing sector in 1980, while in the quartile with the smallest drops only 23 percent were manufacturing workers.

Manufacturing employment is particularly significant, since Massachusetts lost nearly 120,000 manufacturing jobs between 1988 and 1992 while gaining almost 17,000 services jobs.[13] For this analysis, information on the location of lost manufacturing jobs would have been preferable, but it is not available from the decennial Census data. Instead, the Census provides data on the industry of employment for each town's residents. With the relative decline in manufacturing jobs, towns containing larger concentrations of manufacturing workers ultimately experienced the biggest home price declines during the bust. The analysis in Case and Mayer (1995) finds that the 1980 percentage of manufacturing workers is correlated with larger price declines, even after controlling for changes in income between 1980 and 1990. That analysis suggests that the percentage of manufacturing workers who live in a town is proxying for the proximity of that town to manufacturing jobs, presumably because workers choose to live close to where they work.

In particular, the four largest concentrations of manufacturing workers in 1980 were in the Fall River/New Bedford (50 percent), Lawrence/Lowell (46 percent), Uxbridge/Blackstone (46 percent), and Fitchburg/Leominster (44 percent) groups, which also had some of the largest percentage declines in house values. Boston itself is an outlier in this analysis. Only 16 percent of its residents were employed as manufacturing workers in 1980, but Boston suffered the largest percentage drop in home value (−22 percent).

Table 5 also shows that the communities where house prices fell further had the lowest incomes and the highest crime rates. In other words, many of the towns that experienced the biggest price run-ups during the boom, fell the furthest during the bust. The 1980 median household income for the town groups in the quartile with the greatest losses was $15,500, much lower than the median income of the other three groups.

Similarly, the cities and towns with the greatest declines in house prices had poorer schools, as measured by average test scores and spending per weighted pupil, than those with smaller losses in house values. The three groups with the lowest test scores, Lawrence/Lowell, Fall River/New Bedford, and Boston, were in the quartile with the greatest price declines, while the highest test scores were in the west suburban group of Concord/Wellesley, a group in the quartile experiencing the smallest losses.

With the obvious exception of Boston itself, distance from Boston also was strongly associated with price changes during the bust. The final column of Table 5 clearly shows that the price declines were more prevalent in towns that were located farther out from Boston.[14] The increased importance of proximity to Boston may be related to the increased importance of service sector in the economy. Many service sector jobs are located in downtown Boston's 50 million square feet of office space. In fact, Boston is the fifth largest office market in the United States.[15]

[13] Data from the *New England Economic Indicators* data base.
[14] The distance calculation excludes Boston proper.
[15] *CB Commercial*/Torto-Wheaton, quarterly.

Table 6
Recovery Period Appreciation, by City/Town Groupings and City/Town Characteristics

	Percent Change in Nominal House Prices Trough to Mid-1994	Percent of Residents Working in Manufacturing 1990	Median Household Income 1990	Median Single-Family House Value 1990	Asessment Test Scores 1992	School Spending Per Weighted Pupil 1992	Crimes Per 1,000 Residents 1992	Distance to Boston[a]
Highest Quartile	9.3	21	$57,100	$213,400	2,843	$4,913	15	26
Second Quartile	6.0	22	$43,600	$178,600	2,696	$4,039	29	32
Third Quartile	3.6	23	$38,900	$163,100	2,643	$3,708	27	28
Bottom Quartile	1.3	22	$31,000	$143,800	2,497	$3,250	50	33
Mean	5.7	23	$46,500	$185,500	2,750	$4,200	31	32

[a]Distance to Boston is in miles from the center of the grouping.
Source: See Table 1.

V. The Recovery Period

For some cities and towns, the period since 1991 has seen substantial recovery in home prices; for others, prices continue to fall. In fact, the pattern of relative price changes observed during the bust period has continued into the recovery. The town groups that experienced the biggest declines during the bust seem to have recovered the least between their trough values and 1994, while the towns that suffered the smallest declines during the bust seem to have recovered the most. That is, house prices in towns with the highest incomes, the lowest crime rates, the best schools, and smallest distance to Boston have risen at above average rates.

Table 6 presents the city/town groups ranked by the percentage increase in prices between the date of the town-specific trough and the middle of 1994. The highest quartile experienced house price appreciation of 9.3 percent while the lowest quartile saw nominal house prices increase only 1.3 percent. The geographic pattern of price changes during the recovery is shown in Appendix Figure A3.

Although the town characteristics associated with price changes in the bust and the recovery are similar, manufacturing employment provides one exception. Column 2 of Table 6 shows that the four quartiles have virtually identical 1990 concentrations of manufacturing workers. As is clear from Column 3, however, household income appears to play an even greater role during the recovery than it did in earlier periods. Median 1990 household income in the towns in the quartile with the largest percentage house price increases in the recovery averaged $57,100, which was 84 percent higher than the $31,000 median income in the towns in the bottom quartile. Specifically, groups such as Concord/Wellesley ($75,000) and Plymouth/Halifax ($41,960) were in the top quartile, while the lowest quartile includes the Fall River/New Bedford ($22,500), Worcester ($28,960), and Boston ($29,180) groups.

Average appreciation rates for house prices were also higher for towns with higher 1992 school assessment test scores. Test scores in the highest quartile averaged 2,843 during the recovery, 14 percent higher than the average score in the lowest quartile. In addition, spending per weighted pupil in the highest quartile averaged about 50 percent more than expenditures in the lowest quartile.

Massachusetts school enrollments, which had fallen so sharply prior to 1988, reversed sharply after that time and provide one reason for the greater turnaround in house prices in towns with good schools. Indeed, demographic projections for the 1995–2000 decade suggest an increase in public primary and secondary school enrollments (K–12) in Massachusetts of 50,000 or 5.5 percent, and an increase in high school (9–12) enrollments of 12 percent.[16]

Another reason for the faster recovery of house prices in high-income, high-priced towns was the reversal of the affordability problems that many of these towns faced in the mid-1980s. The decline in housing prices beginning in 1989 and 1990 and the drop in mortgage interest rates between 1990 and 1993

[16] See U.S. Department of Education, National Center for Educational Statistics, *Projections of Education Statistics to 2005*, January 1995.

reduced the monthly payments for new home owners. Interest rates for conventional 30-year fixed-rate mortgages fell from over 10 percent in 1990 to under 7 percent by 1993.[17]

In addition, trade-up buyers who owned a home during the boom period found themselves with a large amount of equity, which did not disappear during the bust. Recall that house prices in the average town grew 175 percent in the boom, but fell only 16 percent during the bust, for a total nominal increase of 131 percent. Finally, many members of the baby boom generation had moved into their prime earning years by 1990.

Thus, while median household incomes in Massachusetts did not grow during the early 1990s,[18] households in the upper-middle income brackets saw their incomes rise.[19] While precise calculations are difficult in non-Census years, the pool of potential buyers for houses in the more expensive city/town groups expanded relatively more during the 1990s than did the pool of potential home buyers for properties in the less expensive city/town groups.

VI. Conclusions

The dramatic housing cycle that swept the Eastern Massachusetts housing market between 1982 and 1994 had very disparate impacts on different cities and towns. Between 1982 and the end of the boom, housing prices grew more rapidly in lower-income towns with lower initial home prices and less rapidly in towns with higher incomes and higher initial home values. Several explanations are apparent. First, as housing prices increased more rapidly than incomes, higher-priced towns became unaffordable to all but a very small percentage of Massachusetts households. Thus, the number of potential buyers shrank more at the high end of the market than it did at the low end. In addition, declining school enrollments in the 1980s reduced the relative importance of good schools to potential home owners, resulting in a relatively slower increase in home prices in cities and towns with high-quality schools.

During the bust and the subsequent recovery periods, however, higher-income cities and towns did much better relative to lower-income areas. That is, the cities and towns in which house prices fell more during the bust period and showed little sign of recovery by the middle of 1994 had lower median incomes, lower-quality schools, and higher crime rates, and they were farther from Boston. Areas with smaller price declines in the bust and more recovery since were those with higher incomes, better schools, and less crime, and areas with better access to Boston. In fact, house prices in many affluent cities and towns in Eastern Massachusetts have exceeded their previous peak.

Housing affordability was the most important factor explaining price changes during the boom period, but location, schools, and a town's employment base became relatively more consequential during the bust and the recovery.

Several factors seem to explain the pattern since the peak of the market. The decline of manufacturing in the Commonwealth has hurt towns with higher concentrations of manufacturing workers, which are mostly located around the periphery of the Boston metropolitan area, and has benefited towns with better access to the service sector jobs located in and around the City of Boston. The actual and projected increases in public school enrollments during the 1990s have helped towns with high-quality schools. Finally, changes in interest rates and demographics, the drop in home values, and the build-up of housing equity accumulated during the boom have combined to make higher-priced towns accessible to more potential buyers. The increase in the number of potential buyers in high-priced towns was significantly greater during the early 1990s than was the case for lower-priced towns. In a sense, with increased affordability, a shift to quality occurred, along with an increase in demand for cities and towns with strong fundamentals.

The pattern of price changes over the whole cycle presents an interesting picture. During the boom, the towns with initially lower prices gained the most, compressing the distribution of home values. That is,

[17] *Economic Report of the President*, 1995.

[18] *Statistical Abstract of the United States*, 1994, Table 713.

[19] U.S. Bureau of the Census, household income statistics from the 1993 Current Population Survey, press release received by fax February 1995.

the price differential between the more expensive towns and the less expensive towns shrank during the boom as demand shifted toward more affordable sub-markets. During the subsequent bust and recovery periods, the distribution of home values widened again. Through mid-1994, however, the gap remains smaller than it was in 1982. The right-hand column of Table 2 shows that the overall change in home values over the entire cycle has been the largest in the lower-priced groupings.

If the trend of 1991–94 continues, however, it will not be long before the distribution of home prices across towns looks much as it did in 1982. This trend has at least two possible interpretations. One might argue that the equilibrium prices prior to the boom were consistent with the distribution of town characteristics, and that the boom period created a temporary distortion. Thus, the current trend could be interpreted as a simple restoration of the "correct" equilibrium price structure.

Alternatively, it could be argued that amenities changed over the period, initially to favor towns at the lower end of the price range and subsequently to favor towns at the higher end. Certainly the pattern of school enrollments and sectoral changes in employment provides support for this second hypothesis. Nonetheless, because the evidence in Eastern Massachusetts is consistent with both scenarios, additional evidence will be needed to determine the extent to which fundamental factors explain short-run variations in house prices across cities and towns within a metropolitan area.

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Appendix Table 1

Submarket Groups of Cities and Towns: Population-Weighted Means of Data

Submarket Group	Median Household Income 1980 $	Median Household Income 1990 $	Median Single-Family House Value 1980 $
1) Fall River, New Bedford	11,570	22,550	33,330
2) City of Boston	12,530	29,180	36,000
3) Acushnet, Fairhaven, Mattapoisett, Marion, Westport, Wareham	16,170	33,940	40,190
4) Attleboro, Taunton, Rehoboth, Somerset, Seekonk, Swansea	18,100	36,640	41,740
5) Brockton, Bridgewater, East Bridgewater, West Bridgewater	16,390	34,360	39,970
6) Raynham, Norton, Middleborough	17,680	39,750	40,680
7) Everett, Saugus, Malden, Medford	17,410	36,170	50,000
8) Braintree, Qunicy, Randolph, Rockland, Abington, Whitman, Stoughton, Holbrook	18,610	37,380	44,960
9) Lawrence, Lowell, Methuen, Haverhill	14,480	28,590	43,120
10) Cambridge, Waltham, Arlington, Watertown	17,320	38,050	61,720
11) Salem, Peabody, Danvers, Beverly, Marblehead, Lynn, Swampscott	18,220	37,280	52,670
12) Dedham, Norwood, Canton, Milton	24,110	50,510	60,790
13) Woburn, Burlington, Reading, Wakefield, Melrose, Stoneham, Lynnfield, Billerica, Bedford	23,450	48,490	60,200
14) Fitchburg, Leominster, Lunenburg, Westminster, Gardner, Ashburnham, Shirley, Princeton, Groton, Pepperell, Townsend, Tyngsborough, Templeton	17,240	36,170	41,280
15) Uxbridge, Blackstone, Hopedale, Upton, Southbridge, Webster, Douglas, Mendon	15,600	34,860	41,770
16) Hingham, Cohasset, Norwell, Marshfield, Hull, Duxbury	24,110	53,820	61,370
17) Worcester	14,120	28,960	35,500
18) Belmont, Winchester, Newton, Lexington	27,310	60,930	83,360
19) Gloucester, Topsfield, Ipswich, Rowley, Middleton, Rockport, Manchester, Amesbury, Merrimac, Boxford	19,700	42,610	59,330
20) Franklin, Wrentham, Bellingham, Foxborough, Sharon, Walpole, Norfolk, North Attleborough	22,530	49,600	53,790
21) Plymouth, Halifax, Carver, Pembroke, Hanson, Hanover	18,640	41,960	46,130
22) Concord, Wellesley, Weston, Carlisle, Acton, Wayland, Sudbury, Dover, Sherborn, Westwood	34,100	75,020	96,430
23) Auburn, Millbury, Grafton, Oxford, Spencer, Leicester, Shrewsbury, Holden, West Boylston, North Brookfield, Rutland	20,340	40,870	43,380
24) Andover, North Reading, Tewksbury, North Andover, Dracut, Chelmsford	24,520	53,420	65,360
25) Westford, Ayer, Littleton, Harvard, Maynard, Hudson, Clinton, Marlborough, Northborough, Southborough, Westborough, Stow, Lancaster, Sterling	21,720	46,650	56,640
26) Medfield, Medway, Millis, Holliston, Hopkinton, Milford, Ashland	23,550	50,930	59,730
27) Framingham, Natick	21,630	44,900	63,390

Source: U.S. Bureau of the Census; Massachusetts Department of Education; Massachusetts Department of State Police.

(continued)

Appendix Table 1 continued

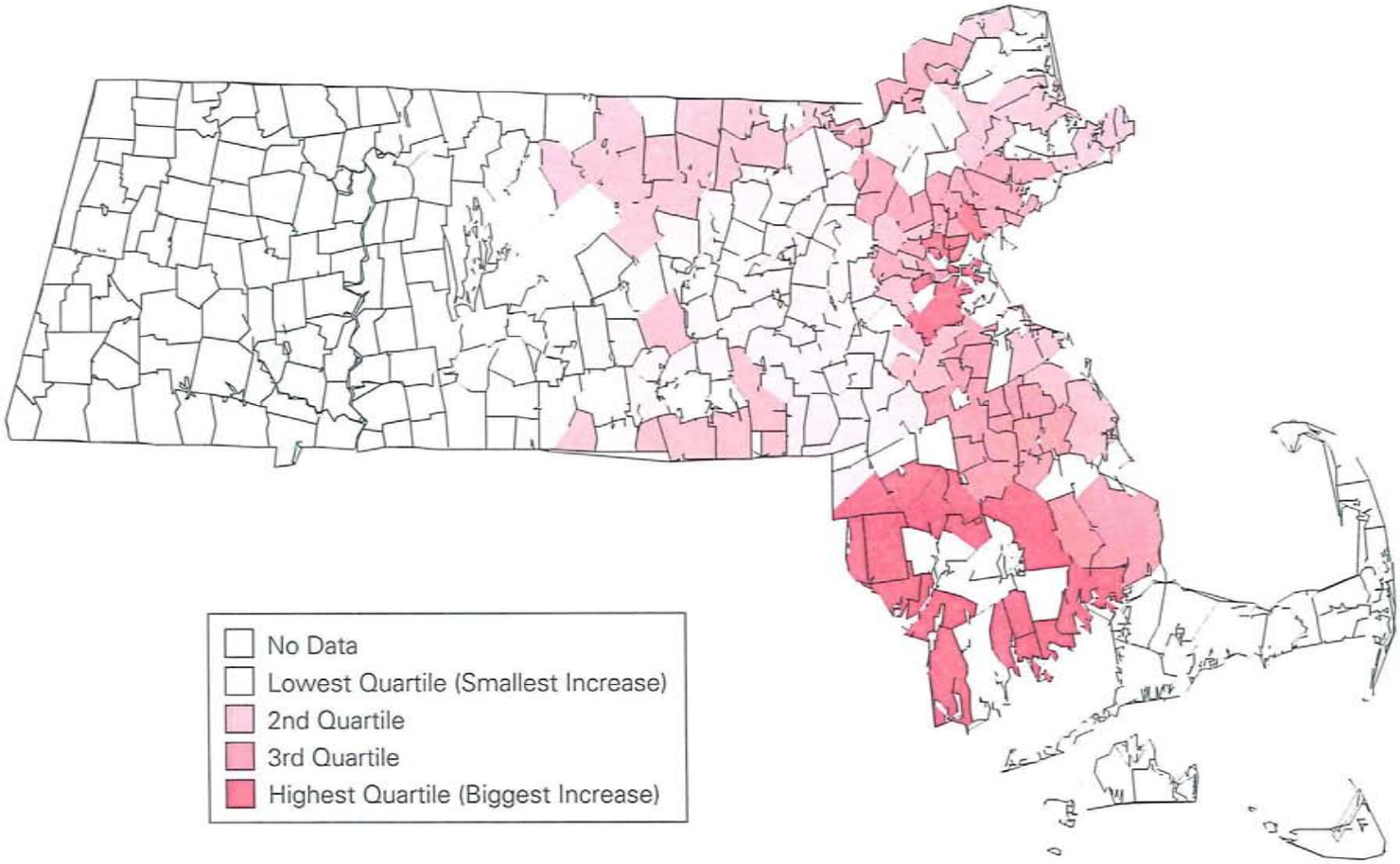
Submarket Groups of Cities and Towns: Population-Weighted Means of Data

Assessment Test Scores 1988	School Spending Per Weighted Pupil 1980 $	Crime Per 1,000 Residents 1980	Percent of Residents Working in Manufacturing		Miles to Boston	Percent Decrease in School Enrollment 1980 to 1988
			1980	1990		
2,326	1,465	7	50	34	54	−.2
2,390	2,403	13	16	12	0	−18.7
2,542	1,811	5	28	21	57	−4.6
2,522	1,627	5	38	26	40	−18.9
2,551	1,643	8	28	20	25	−17.4
2,595	1,548	4	31	22	37	−16.1
2,502	1,911	4	23	17	8	−33.1
2,614	2,016	5	22	15	12	−49.0
2,367	1,503	6	46	34	32	−5.4
2,584	2,377	6	20	16	6	−25.7
2,518	1,838	6	30	22	18	−23.6
2,589	1,984	4	18	14	13	−31.9
2,653	1,855	3	29	20	14	−30.8
2,628	1,726	4	44	33	51	−25.5
2,564	1,578	3	46	33	72	−8.6
2,765	1,898	5	19	13	25	−27.2
2,400	1,866	1	30	21	42	−8.9
2,903	2,447	4	17	14	12	−28.0
2,665	1,766	4	32	24	34	−24.1
2,710	1,680	3	36	24	29	−27.0
2,474	1,653	5	23	15	38	−19.5
2,948	2,588	3	23	19	19	−26.1
2,685	1,679	3	34	24	45	−35.6
2,750	1,826	3	36	27	30	−28.6
2,717	1,695	3	44	33	31	−23.3
2,723	1,847	2	33	25	31	−28.0
2,681	2,135	4	27	19	23	−29.2

Figure A1

Changes in House Prices by Quartile, 1982 to Peak

Town Groups

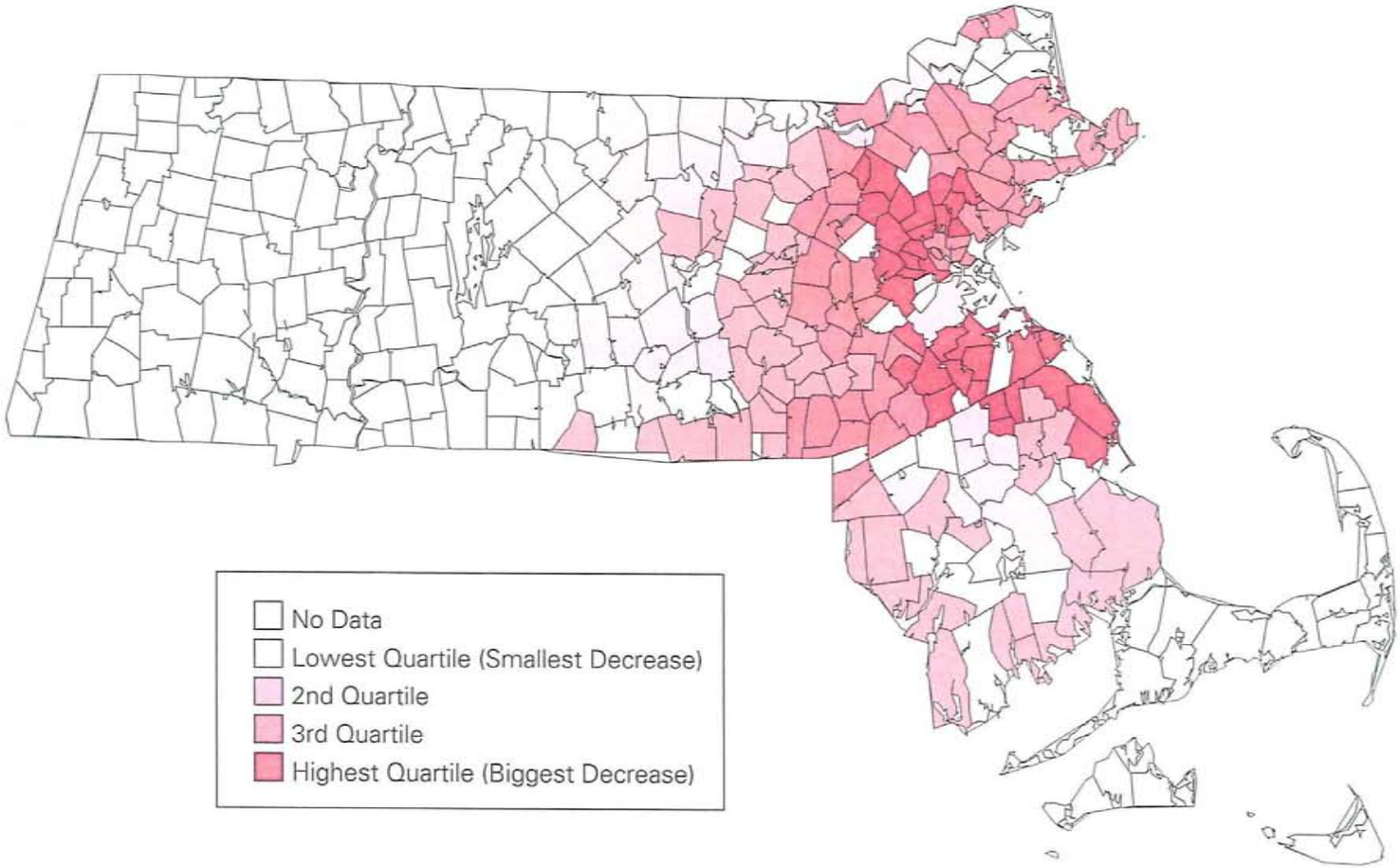


Source: Case Shiller Weiss Inc.

Figure A2

Changes in House Prices by Quartile, Peak to Trough

Town Groups

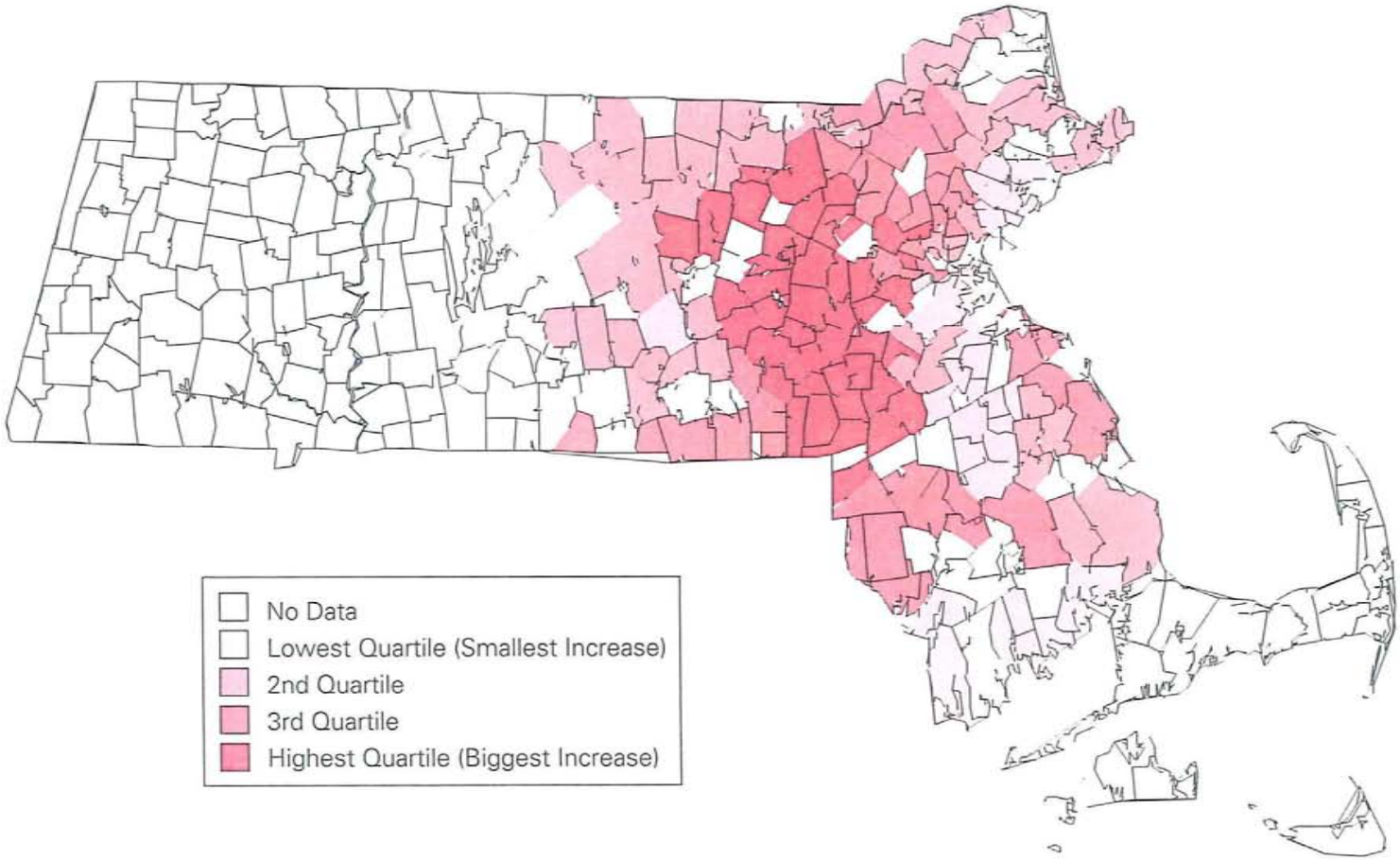


Source: Case Shiller Weiss Inc.

Figure A3

Changes in House Prices by Quartile, Trough to 1994

Town Groups



Source: Case Shiller Weiss Inc.

The Phillips Curve Is Alive and Well

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The Federal Reserve Bank of Boston's 1978 economic conference was entitled "After the Phillips Curve." Many of the papers in the conference volume sounded the death knell of the Phillips curve, citing its dismal performance in the face of oil shocks in the 1970s, and its inappropriateness as a policy guide because of its presumed sensitivity to shifts in the underlying macroeconomic structure.

Seventeen years after the publication of the conference volume, rumors of the death of the Phillips curve appear to have been greatly exaggerated. In fact, the Phillips curve is alive and well, and living in a good number of (although certainly not all) widely used macroeconometric models. This paper takes the view that the primary reason for its longevity is that, in contrast to the common perception at the time of the 1978 conference, the Phillips curve has been an extremely robust empirical relationship, showing little or no sign of instability over the past 35 years. To outward appearances, at least, the Phillips curve is as structural a relationship as macroeconomists have ever had at their disposal.

The major criticism levied against the Phillips curve and many macroeconometric models of the 1960s and 1970s was that they were not truly structural. That is, they captured empirical regularities between aggregate variables like the unemployment rate and the rate of inflation, but they did not take account of all the interactions in the underlying or structural behavior of consumers and firms in the economy. The risk to this approach, as articulated by Lucas and Sargent (1978), was that even if the underlying structural behavior of economic agents remained stable, the measured relationships among aggregate variables could easily shift as conditions changed in the linkages not incorporated into the aggregate relationships. A fuller description of this criticism (the "Lucas critique") and a simple example are described in Section III below.[1]

Ultimately, however, as Lucas and Sargent (1978) emphasized, "the question of whether a particular model is structural is an empirical, not a theoretical, one." Thus, while the theoretical force of Lucas and Sargent's

arguments still holds—macroeconomic models not based on underlying structure are subject to shifts—it is the empirical force of their point that is of interest for macroeconomists and policymakers. This paper examines an array of empirical evidence bearing on the stability of the Phillips curve, and calls into question the empirical force of the Lucas critique as it applies to the Phillips curve.

I. A Brief History of the Phillips Curve

The essence of the modern Phillips curve is that the rate of change of nominal wages depends upon the expected rate of change of the overall price level—workers want their wages to keep pace with inflation, all else equal—and on the level of the unemployment rate relative to its natural rate. The dependence of wage inflation on expected inflation (as well as unemployment) is the difference between the "expectations-augmented" Phillips curve, first implemented empirically in the 1960s, and the original Phillips curve.[2] The natural rate of unemployment, or NAIRU (non-accelerating-inflation rate of unemployment), is defined by the behavior of inflation: It is the rate of unemployment that exerts neither downward nor upward pressure on wage inflation, given expectations of price inflation.[3]

The Phillips curve is alive and well, and living in a good number of widely used macroeconometric models.

Many current versions of the Phillips curve cast it as the link between the rate of inflation in overall prices and the level of unemployment. In fact, this portrayal is a simplification of an underlying relationship between the rate of change of wages and unemployment, and among the levels of wages, prices, and productivity. The first link in this chain is the original Phillips curve; the second link relates prices to unit labor costs, defined as the difference between wages and productivity.[4]

The strong empirical bond between the rate of change of wages and the level of unemployment was first documented in Phillips (1958) for United Kingdom data from 1861 to 1957.[5] Although subsequent authors (notably Robert J. Gordon) built upon the work of Phillips, many of their significant alterations to the original Phillips curve were anticipated by Phillips.

For example, Phillips postulated that the rate of change in wages could depend on the (expected) rate of change of retail prices, "operating through cost of living adjustments" (p. 283). This notion is the grandfather of the "expectations-augmented" Phillips curves of today, as outlined above. In addition, Phillips argued that the rate of change of unemployment, as well as its level, could be an important determinant of wages. These "speed limit" effects are motivated by the possibility that inflation responds more when unemployment is changing rapidly than when it changes gradually, holding constant the level effect. Phillips also recognized the importance of the effect of prices of imported goods on the overall determination of wages (p. 284). Finally, the original Phillips curve recognized the possibility of requiring larger and larger increments of unemployment to reduce inflation as inflation approached zero.[6] Thus, while his statistical work, undertaken before the advent of modern computing technology, focused solely on the correlation between wage inflation and unemployment,

[1] The essence of Lucas's critique was articulated earlier by Haavelmo (1944), in the context of interpreting multi-equation econometric models, and Duesenberry (1948), in the discussion of his consumption model. Lucas (1976) is the first development of his version of the critique.

[2] Perry (1966) includes lags of the consumer price index as adjustments for the cost of living in his wage-price Phillips curve. In his view, wages adjust to *past* changes in the cost of living. Gordon (1970) explicitly includes expected changes in the overall price level as a determinant of wage changes. He uses a distributed lag of past price changes as a proxy for expected price changes.

[3] Equivalently, the NAIRU is the rate of unemployment at which the rate of change of nominal wages equals the expected change in the overall price level. For more detail on specification and interpretation of the Phillips curve and the NAIRU, see Tootell (1994).

[4] If the unemployment rate proxies well for the tightness in markets for all factors of production, then the Phillips correlation may reflect the underlying correlation between general price pressures and inflation.

[5] Klein and Goldberger's model (1955) includes an equation that makes the change in wages a function of the unemployment rate and the lagged change in the price level. However, they are not commonly cited as the discoverers of the inflation/unemployment relationship.

[6] Phillips' original curve is estimated as $\log(a + \Delta w_t) = \log(b) + c \log(U_t) + \epsilon_t$, where the constant a is included in order to ensure non-negativity of the left-hand side of the equation. This form implies that as wage inflation falls below some level (typically as it approaches zero), the proportionate effect of unemployment decreases.

his theoretical work suggested many of the improvements made to the empirical Phillips curves in the last 40 years.

II. Strengths and Weaknesses of the Phillips Curve

The great strength of the Phillips curve is that it captures an economically important and statistically reliable empirical relationship between inflation and unemployment. Figure 1 portrays the essence of this relationship. The figure plots the change in the inflation rate (three standard measures are displayed in the solid lines) against the difference between the civilian unemployment rate and an assumed NAIRU of 6 percent. When unemployment falls below about 6 percent, inflation in wages and prices tends to rise; when unemployment rises above 6 percent, inflation tends to fall. After publication of Phillips's seminal paper, the presence of this correlation was documented by many researchers for many countries.

Perhaps the greatest weakness of the Phillips curve is its lack of theoretical underpinnings: No one has derived a Phillips curve from first principles, beginning with the fundamental concerns and constraints of consumers and firms.

The figure focuses on the post-1979 period for two reasons. First, adjusting for the effects of oil price shocks that mask the underlying correlation is not as important in this period as in the 1970s.[7] Second, the academic literature of the 1970s proclaimed the death of the Phillips curve; finding that the underlying correlation appears robust from that time to today sheds some light on the empirical relevance of the theoretical objections to the Phillips curve. Section IV examines in more detail the stability of the Phillips curve.

Perhaps the greatest weakness of the Phillips curve is its lack of theoretical underpinnings: No one has derived a Phillips curve from first principles, beginning with the fundamental concerns and constraints of consumers and firms. Few models that articulate the supply of and demand for labor imply a simple aggregate relationship that looks at all like a Phillips curve. This is not to say that the empirical relationship makes no sense. Labor costs account for about two-thirds of the total cost of producing output, so that pressures in the labor markets should strongly influence changes in wages and prices. Still, some feel that this lack of rigorous theoretical foundations is a fatal flaw; many find this deficiency less life-threatening. The next section discusses a specific implication of this asserted deficiency of structure, widely referred to now as "the Lucas Critique."

III. The Lucas Critique

Robert E. Lucas, Jr. (1976) criticized the use of econometric models, such as the Phillips curves that were estimated at that time, for policy evaluation. In principle his critique applies to the Phillips curves presented in this paper. The best way to understand his critique is through an example, and for our purposes, the best example is the Phillips curve.

Recall that the Phillips curve assumes that workers set wage changes so as not to lose ground relative to expected changes in the cost of living. Most econometric models during the late 1970s modeled expected changes in the cost of living, π^e, as a distributed lag of past changes in the cost of living, or

$$\pi_t^e = \sum_{i=1}^{k} \alpha_i \pi_{t-i}. \qquad (1)$$

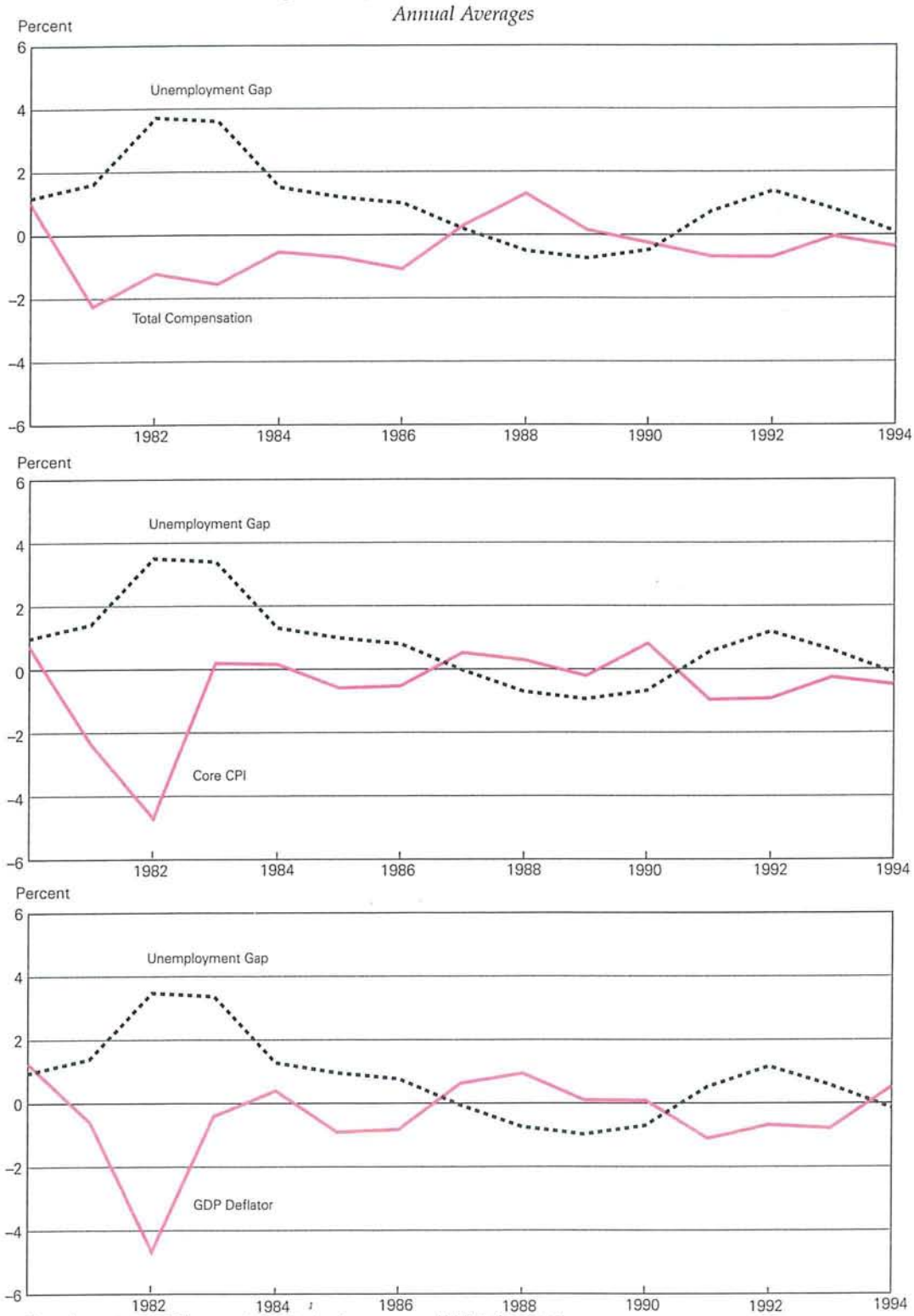
This characterization of expected inflation is implemented empirically by estimating the coefficients α_i on lagged inflation from historical data.[8] Such a simple

[7] The significant drop in oil prices in the mid-1980s appears to be of relatively small importance for overall inflation. However, during the two major oil price shocks of the 1970s, inflation increased at the same time that unemployment increased. This does not negate the underlying Phillips curve, it simply makes clear that changes in important relative prices can adversely affect *both* inflation and unemployment. Thus, a careful empirical implementation of the Phillips curve must at the very least control for the effects of rapid oil price increases. The regressions presented in section IV capture the underlying inflation-unemployment correlation, controlling for changes in oil prices.

[8] The sum of the coefficients on lagged inflation is normally constrained to one, so that in the long run, inflation equals expected inflation.

Figure 1

Phillips Curve Correlation in the 1980s
Change in Inflation vs. Unemployment Gap
Annual Averages



Unemployment gap is civilian unemployment rate minus an assumed NAIRU of 6 percent.
The three measures of inflation are shown as the change in the annual average of the four-quarter rate of change.

Sources: Civilian unemployment rate: U.S. Bureau of Labor Statistics.
Total compensation: U.S. Bureau of Labor Statistics.
Before 1982: Nonfarm business sector, compensation per hour.
1982-present: Employment cost index, compensation, civilian workers.
Core CPI: consumer price index, all items excluding food and energy: U.S. Bureau Labor Statistics.
Gross domestic product deflator: U.S. Bureau of Economic Analysis.

description of inflation expectations is assumed to provide a reasonable forecast of inflation in the short run, particularly if monetary policy and other important influences on inflation have remained relatively stable.

There are two theoretical objections to using this description of expectations formation for policy questions. First, equation (1) incorporates no knowledge of the effect of unemployment on the rate of inflation, even though the premise of the Phillips curve is that unemployment is critical in determining the direction of the inflation rate. Second, the estimated equation implies a particular path for inflation, depending on where it has been in the past, that does not depend on how vigorously or sluggishly monetary policy is pursuing its inflation target (if any).

Lucas argues that these omissions in modeling inflation expectations make econometric equations, such as the Phillips curve, not useful for evaluating alternative policies. The reasoning is essentially as follows: Suppose that in period I monetary policy has an inflation target of 5 percent, and that it moves only very gradually to achieve that target (perhaps because policymakers do not wish to bear the cost of high unemployment entailed in a more rapid move toward the inflation target). A distributed lag model of inflation estimated on period I data will build in the slow return of inflation to its target, reflected in the pattern of the coefficients on lagged inflation.[9]

Now consider period II, in which monetary policy has the same inflation target, but in which it moves quickly and vigorously to achieve the target. A distributed lag model of inflation will build in the vigor of (presumably effective) monetary policy, shortening the lag responses to reflect the quicker return of inflation to its target. Thus, the appropriate lag pattern in forming expected inflation will differ for different monetary policy regimes.[10]

Suppose that monetary policymakers who live in period I entertain changing monetary policy to the more vigorous policy of (as yet unexperienced) period II. The policymakers want to know how inflation will respond under the new regime, so they pull out the Phillips curve (estimated under period I data), alter the forecast of the unemployment rate based on the more vigorous policy assumption, and produce a forecast of inflation.

Will the inflation prediction so obtained be useful for policymakers? This is the crux of the Lucas critique. If wage and price setters know about the new monetary policy behavior and understand its implications for expected cost-of-living changes (and its implications for the unemployment rate), then presumably their expectations of cost-of-living changes will change under the new regime, and the old Phillips curve model will not be a good predictor of inflation. Lucas's insight in the context of the Phillips curve is that *price setters' expectations of future events may depend upon the behavior of other agents in the economy, particularly upon those who set monetary policy.* Thus, as monetary policymakers consider changing policy, they need to use econometric models that take into account the possible change in expectations that this will induce in other actors in the economy, in this case wage and price setters.

This insight certainly holds water theoretically, as long as the assumptions hold about how expectations are formed, but it need not hold water empirically. We cannot know *a priori* how agents form their expectations. In particular, we do not know whether they adjust their expectations to changes in monetary policy behavior, as Lucas's theoretical objection suggests they might. Even if agents' expectations react to changes in monetary policy, we cannot know *a priori* whether the historical changes in monetary policy have been large enough to cause empirically significant shifts in expectations in the Phillips curve. Evidence bearing on these empirical issues is presented in the following sections.

IV. An Empirical Assessment of the Lucas Critique for the Phillips Curve

Lucas's critique suggests that the Phillips curve will not be stable over long periods of time, particularly as the behavior of the monetary authority changes. This hypothesis is testable, and this section provides some straightforward tests for instability in the Phillips curve, with concern for both the statistical and the economic significance of any changes in the relationship over time. We begin with the simplest and least stringent, and progress to somewhat more complex and stringent tests.

The first test is to see whether a Phillips curve estimated on data over the last 30 years shows signs of going off track. This is an important first step in looking for signs of instability, but it is the least

[9] The expectations component of an estimated Phillips curve is examined in more detail in section IV.

[10] A fully internally consistent model of expectations would adjust the lag coefficients on past inflation *and* build in the expected effect of swings in the unemployment rate, as suggested by the Phillips curve.

stringent test because it uses the information that was used to estimate the equation to gauge its success within the estimation sample. More stringent tests that gauge the performance of the equation outside its estimation sample are presented below.

The basic specification used here is a "price-price" Phillips curve that subsumes the "wage-price" Phillips curve and the unit labor cost equations into one. Current inflation in the core CPI—the CPI excluding its food and energy components—Δp_t, depends on lagged inflation (with coefficients α_i constrained to sum to 1), two lags of the unemployment rate, U_t, and the rate of change of oil prices, Δpo_t:[11]

$$\Delta p_t = \sum_{i=1}^{12} \alpha_i \Delta p_{t-i} + \sum_{j=1}^{2} \beta_j U_{t-j} + \gamma \Delta po_t + \epsilon_t. \qquad (2)$$

While results are reported for the "price-price" version of the Phillips curve using the core CPI, parallel results have been computed for the "wage-price" version of the Phillips curve, and for "price-price" versions using the overall CPI, and for the GDP deflator.[12] All of these versions give qualitatively similar results (see Tables 1–1c for the estimated equations). The results for the core CPI are presented because it is perhaps the most widely monitored measure of the "core" or "trend" rate of inflation. Important quantitative differences for different price measures will be noted throughout.

We expect the sum of the coefficients on unemployment to be negative and the coefficient on the change in oil prices to be positive.[13] The estimated equation is presented in Table 1. The estimated overall response to the unemployment rate, at −0.28, is quite similar to those estimated in similar studies, for example Gordon (1994). The estimated NAIRU, at 6.1 percent, is completely in line with conventional wisdom, and the uncertainty surrounding the estimate (its standard error) easily admits NAIRUs of 5.5 to 6.5 percent.[14]

Note that the coefficients on the two lags of the unemployment rate may be interpreted as a "level of unemployment" effect and a "change in unemployment" or "speed limit" effect.[15] If the unemployment contribution to the Phillips curve is written as $aU_{t-1} + bU_{t-2}$, it is straightforward to show that this is equivalent to a level and a change effect, $(a + b)U_{t-1} - b\Delta U_{t-1}$. Thus, the significance of the second lag coefficient determines the significance of the "speed limit" effect. In the estimates presented in Table 1, the level effect is displayed as the sum of the unemployment rate coefficients. The implied change effect is −1.8. For a given level of unemployment, the speed limit coefficient says that every one-tenth percentage point increase in the unemployment rate drops the inflation rate by almost two-tenths percentage point. Note that, as shown in Table 1c, the compensation Phillips curve exhibits no rate-of-change effect; the estimated coefficient on a second lag of unemployment is small and not significantly different from zero, and is therefore omitted from the specification.

[11] An exchange rate term, meant to reflect the influence of the exchange rate on imported goods prices on the overall domestic price level, did not enter significantly. Separate terms that measure the effect of changes in the trade-weighted average of foreign CPIs or in the real exchange rate, which combines the ratio of domestic to foreign CPIs with the nominal exchange rate, were also insignificant. Similarly, terms that might measure the effect of productivity growth through the unit labor cost relationship were found to be insignificant.

[12] The wage measure used in these unreported regressions splices total compensation for nonfarm business with the employment compensation index (ECI) measure of compensation beginning in 1982.

[13] Including the contemporaneous unemployment rate with the two lagged rates yields an estimate of the contemporaneous coefficient that is insignificantly different from zero. The possibility of simultaneity bias for the contemporaneous coefficient suggests that the coefficient should be instrumented. However, likely candidates for instruments would include lags of unemployment and inflation that are already in the regression model. An instrumental variables estimate that uses lags of unemployment, inflation, the federal funds rate, and federal government expenditures, yields an estimate of the contemporaneous coefficient that is insignificantly different from zero (standard errors are corrected for heteroskedasticity and serial correlation). For the purpose of this paper, the exclusion of the instrumented value of contemporaneous unemployment is unlikely to change the fit or behavior of the estimated equation.

[14] The NAIRU standard error is the standard error of a function of several estimated parameters: the negative of the constant (not reported) divided by the sum of the coefficients on lagged unemployment. Its standard error is computed using an asymptotic approximation:

$$SE(NAIRU) = \sqrt{\frac{\partial f(\beta)}{\partial \beta} \Omega \frac{\partial f(\beta)'}{\partial \beta}}$$

where $f(\beta)$ is the function that translates the underlying estimated parameters (constant and unemployment rate coefficients) into the NAIRU, and Ω is the estimated variance covariance matrix of those parameters. The NAIRU for the wage-price Phillips curve is not reported, as it varies over time, depending on the average level of productivity growth in the current and preceding seven quarters.

[15] The speed limit effect gets its name from the suggestion that more rapid changes in the unemployment rate may cause larger changes in the inflation rate for a given level of the unemployment rate. The intuition is most clear for rapid decreases in the unemployment rate, when it is argued that rapidly growing demand for labor might put greater pressure on wages (due to bottlenecks, for example) than a gradual increase in labor demand and decline in the unemployment rate.

Table 1
Phillips Curve Estimates: Quarterly Inflation Rate, CPI excl. Food and Energy
Seasonally Adjusted (SA)

Variable	Estimated Coefficient	Standard Error	T-Statistic
Δp_{t-1}	.31	.090	3.4
Δp_{t-2}	.27	.095	2.9
Δp_{t-3}	.34	.097	3.5
Δp_{t-4}	−.05	.096	−.5
Δp_{t-5}	.03	.095	.3
Δp_{t-6}	.14	.095	1.5
Δp_{t-7}	−.01	.095	−.1
Δp_{t-8}	−.17	.095	−1.8
Δp_{t-9}	.12	.095	1.3
Δp_{t-10}	.04	.094	.4
Δp_{t-11}	.04	.092	.4
Δp_{t-12}	−.07	.084	−.8
U_{t-1}	−2.08	.499	−4.2
U_{t-2}	1.81	.518	3.5
Sum of U Coefficients	−.28	.121	−2.3
Δpo_t	.01	.006	1.9
NAIRU	6.09	.557	10.9

Standard Error of Regression: 1.762
Estimation Range: 1960:II to 1993:IV

Table 1a
Phillips Curve Estimates: Quarterly Inflation Rate, CPI All Items (SA)

Variable	Estimated Coefficient	Standard Error	T-Statistic
Δp_{t-1}	.17	.088	2.0
Δp_{t-2}	.16	.083	1.9
Δp_{t-3}	.39	.080	4.9
Δp_{t-4}	.02	.086	.2
Δp_{t-5}	.24	.086	2.8
Δp_{t-6}	.03	.083	.4
Δp_{t-7}	−.03	.081	−.3
Δp_{t-8}	−.19	.079	−2.4
Δp_{t-9}	.07	.079	.9
Δp_{t-10}	−.04	.076	−.5
Δp_{t-11}	.12	.074	1.6
Δp_{t-12}	.06	.070	.8
U_{t-1}	−3.93	.533	−7.4
U_{t-2}	5.91	1.056	5.6
U_{t-3}	−3.63	1.135	−3.2
U_{t-4}	1.30	.608	2.1
Sum of U Coefficients	−.34	.119	−2.9
Δpo_t	−.02	.011	−2.3
Δe_{t-1}	.03	.006	5.7
NAIRU	5.81	.418	13.9

Standard Error of Regression: 1.56
Estimation Range: 1960:II to 1993:IV

Table 1b
Phillips Curve Estimates: Quarterly Inflation Rate, GDP Deflator (SA)

Variable	Estimated Coefficient	Standard Error	T-Statistic
Δp_{t-1}	.30	.091	3.3
Δp_{t-2}	.26	.093	2.7
Δp_{t-3}	.19	.095	2.0
Δp_{t-4}	.16	.097	1.7
Δp_{t-5}	−.09	.097	−1.0
Δp_{t-6}	−.12	.097	−1.2
Δp_{t-7}	.08	.097	.8
Δp_{t-8}	−.02	.096	−.2
Δp_{t-9}	.03	.095	.4
Δp_{t-10}	.16	.093	1.7
Δp_{t-11}	.09	.088	1.0
Δp_{t-12}	−.03	.083	−.3
U_{t-1}	−.38	.102	−3.7
NAIRU	6.12	.329	18.6

Standard Error of Regression: 1.44
Estimation Range: 1960:II to 1993:IV

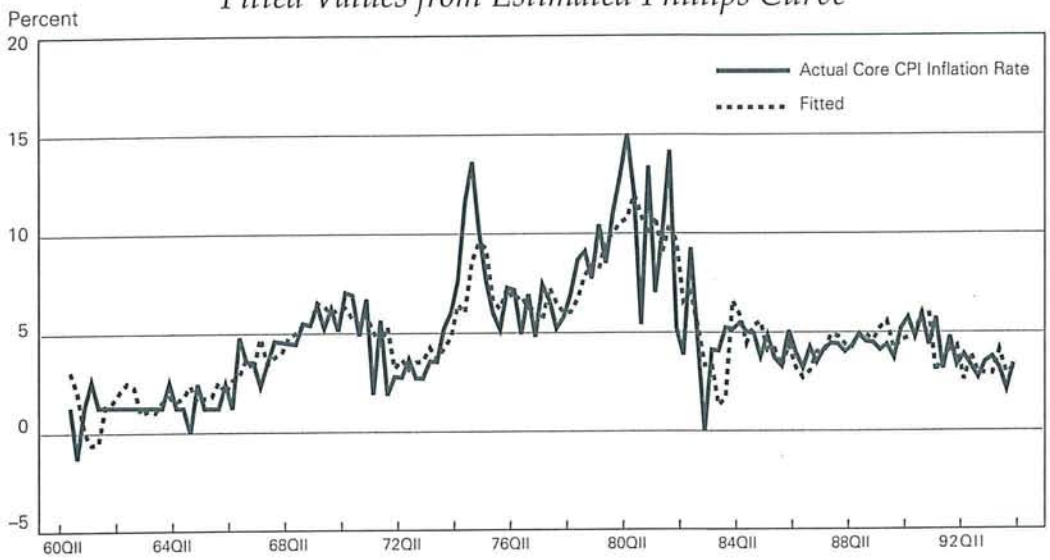
Table 1c
Wage-Price Phillips Curve Estimates

Variable	Estimated Coefficient	Standard Error	T-Statistic
Wage Inflation Equation			
Dependent variable: Quarterly Inflation Rate, ECI (SA)			
Δp_{t-1}	.17	.077	2.3
Δp_{t-2}	.17	.082	2.1
Δp_{t-3}	.09	.083	1.1
Δp_{t-4}	.15	.087	1.8
Δp_{t-5}	−.09	.084	−1.1
Δp_{t-6}	.12	.083	1.5
Δp_{t-7}	−.08	.083	−.9
Δp_{t-8}	.06	.083	.8
Δp_{t-9}	.07	.084	.9
Δp_{t-10}	.08	.079	1.0
Δp_{t-11}	.12	.078	1.6
Δp_{t-12}	.12	.071	1.7
U_{t-1}	−.86	.116	−7.3
Nixon/off	−5.05	1.422	−3.6
Constant	6.47	.736	8.8
Unit Labor Cost Equation			
Dependent variable: Quarterly Inflation Rate, Total CPI			
Δw_t	.46	.131	3.5
Δw_{t-1}	.40	.133	3.0
Δw_{t-2}	.14	.138	1.0
Δw_{t-3}	.11	.138	.8
Δw_{t-4}	.03	.137	.3
Δw_{t-5}	.00	.137	.0
Δw_{t-6}	−.05	.131	−.4
Δw_{t-7}	−.11	.129	−.8
ΔProductivity	−1.00	.000	.0
Constant	.34	.200	1.7

Standard Error of Wage Inflation Equation: 1.60
Standard Error of Unit Labor Cost Regression: 2.23
Estimation Range: 1963:I to 1993:IV

Figure 2

Actual Core CPI Inflation Rate vs. Fitted Values from Estimated Phillips Curve



Source: Consumer price index, all items excluding food and energy, seasonally adjusted, U.S. Bureau of Labor Statistics. Fitted values are author's calculations.

Figure 2 displays the actual data for the core CPI inflation rate and the fitted values from the estimated regression equation. As the figure indicates, there is no sign within the estimation sample that the Phillips curve has run amok. In fact, its within-sample prediction errors have decreased in the last ten years.

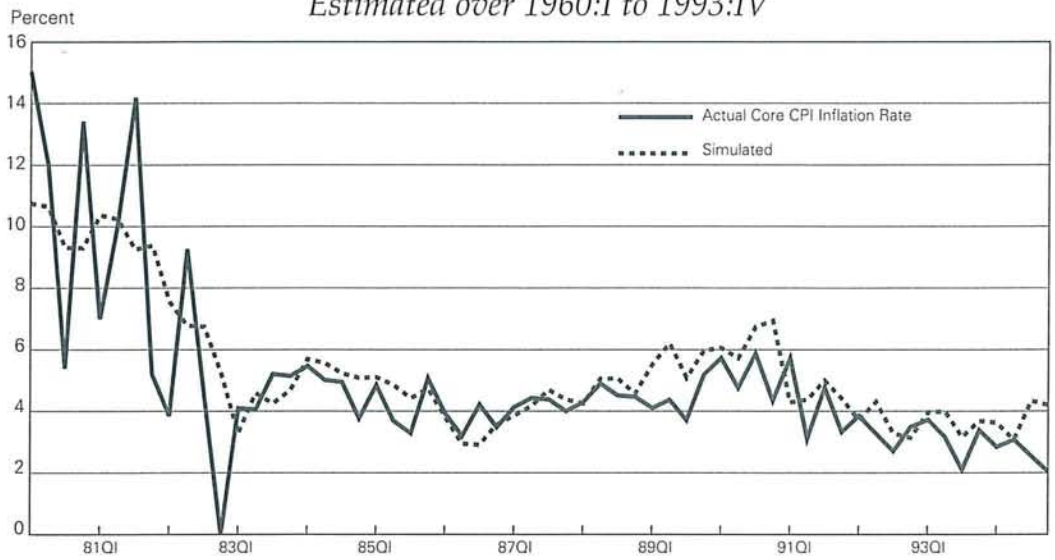
Another test of the specification involves simulating the Phillips curve over a fairly long period, feeding in the simulated values for the current period as lagged values in subsequent periods. This "dynamic" simulation is designed to reveal the multi-period forecast performance of the equation. The in-sample fit test is a one-period-ahead forecast test, and as such it allows the equation to "get back on track" by feeding in actual lagged observations for inflation that the equation did not predict. The dynamic simulation does not give the equation this information, so that one large error in predicting inflation can feed into all subsequent predictions, and the equation will wander significantly off track if it is not well specified.

Figure 3 shows the results of the dynamic simulation described above. Using the coefficients estimated over the 1960:I to 1993:IV sample, the simulation begins with actual lagged values for all variables in 1980:I, and then proceeds for the next 15 years. As the figure indicates, the Phillips curve does not wander off even without referring to an actual inflation rate for 15 years, in large part because it relies on the robust correlation between inflation and unemployment.

Two considerably more stringent tests involve out-of-sample (outside the estimation sample) simulations. In the first, the Phillips curve is estimated from 1960:II to 1979:IV. The estimates are not presented here, but the differences between this estimation and the results shown in Table 1 are few: The estimated NAIRU is 5.3 (not statistically significantly different from the estimate in Table 1). The estimated sum of the unemployment coefficients is still −0.28. These results in themselves indicate that the Phillips curve is quite stable across fairly long stretches of time. However, because the estimated NAIRU is different (likely due to changes in demographics) and the lag patterns in the expected inflation component of the curve differ

Figure 3

Dynamic Simulation of Core CPI Phillips Curve Estimated over 1960:I to 1993:IV



Source: Consumer price index, all items excluding food and energy, seasonally adjusted, U.S. Bureau of Labor Statistics. Fitted values are author's calculations.

somewhat between the two estimates, it is interesting to see if the 1960s and '70s Phillips curve can accurately predict the 1980s and '90s inflation outcomes.

Figure 4 shows the "fitted values"—the one-quarter-ahead forecasts of inflation, feeding actual lagged inflation into the equation—for 1980 to the present, using the coefficients from the Phillips curve estimated up through 1979. As the figure indicates, the inflation forecasts made using coefficients estimated from the earlier period are quite accurate, and show no significant sign of consistent under- or overprediction.

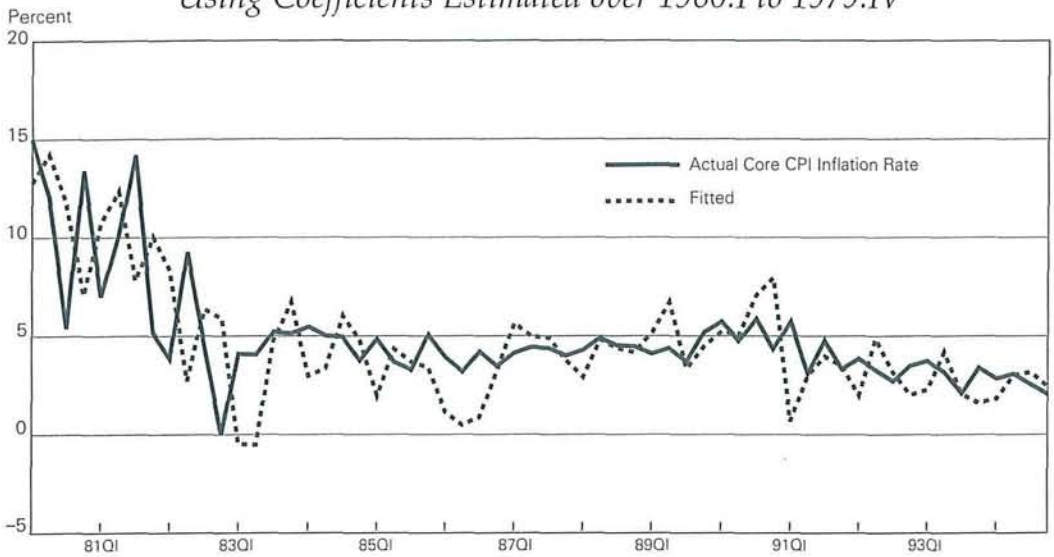
Figure 5 shows the results of a dynamic simulation of the same estimated Phillips curve outside its sample. Using coefficients estimated before 1980, and giving the equation no information about actual inflation during the period, the Phillips curve tracks the 1980s disinflation extremely well. In a sense, the simulated values from the Phillips curve reveal the underlying trend in inflation better than the measured inflation rate. The out-of-sample tests of Figures 4 and 5 would be difficult for any macroeconomic relationship to pass, and overall, the Phillips curve does quite well.

A final out-of-sample simulation test pits the Phillips curve estimated from 1960:I to 1987:IV against the data in a dynamic simulation from 1988 to 1994. Again, the estimates for equation (2) themselves convey an overall impression of stability of the Phillips curve. The estimated sum of unemployment rate coefficients is −0.28, and the estimated NAIRU is 5.9. Both are insignificantly different from the estimates displayed in Table 1. Figure 6 displays the dynamically simulated values of inflation versus the actuals. The equation does a very good job of capturing the general contours of inflation over this period. It overpredicts a bit in periods in which oil prices swung wildly, but this does not put the predictions permanently off track, and the equation completely regains its composure after 1990.

Overall, then, conventional tests of the stability of the Phillips curve indicate remarkable stability. There may be no other macroeconomic relationship that could perform as well by these criteria.

Figure 4

Actual Core CPI Inflation Rate vs. Fitted Values Using Coefficients Estimated over 1960:I to 1979:IV



Source: Consumer price index, all items excluding food and energy, seasonally adjusted, U.S. Bureau of Labor Statistics. Fitted values are author's calculations.

A More Direct Test of the Lucas Critique

The stability of the expectations component of the Phillips curve can also be tested directly. This, after all, was the main point of contention of the Lucas critique. To do so, a variety of statistical and graphical tests are performed to see if economically or statistically significant shifts have occurred in the expectations component of the Phillips curve. To be specific, we test whether there have been important changes in the coefficients on the lagged inflation terms in equation (2).

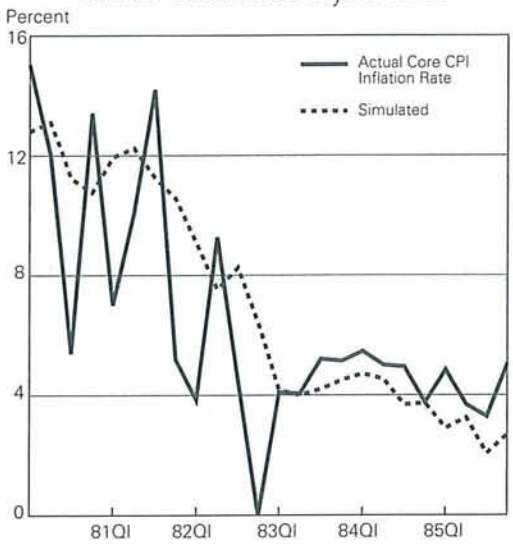
Choosing a breakpoint at which the coefficients may have shifted is difficult. Here, we focus on October 1979, when the Fed changed its operating procedures and, according to many accounts, began in earnest its disinflation program. Formally, we test to see if we can reject the hypothesis that the estimated coefficients on lagged inflation—the α_is—are the same before a breakpoint as they are after a breakpoint.[16]

Table 2 displays the results of several tests of coefficient stability for a variety of breakpoints centered around 1980. The table presents results both for the core CPI inflation equation and for the total compensation equation, which more closely mirrors the spirit of the original Phillips curve. The values in the table (column pairs 1, 2, and 3) represent the probability that the estimated shift coefficients for inflation, unemployment, or both differ from zero due to chance. A low value in these columns indicates that we can be fairly sure that a shift occurred at the indicated breakpoint. A high value indicates that the estimated shift coefficients may differ from zero only

[16] We accomplish this test by estimating equation (2), adding an interactive term that multiplies a dummy, which takes the value one after the breakpoint and zero before, with the inflation rate. The sum of the coefficients on the lagged interactive terms must be constrained to zero, in order to preserve the overall constraint that the sum of the lagged inflation terms equals 1. Note that the breakpoint is chosen in reference to a monetary policy breakpoint. It can be argued that important changes were made in fiscal policy as well during the 1980s, although those breakpoints would not necessarily correspond to the monetary policy breakpoints. As the results presented below show, however, there is little evidence to indicate a breakdown of the Phillips curve at *any* point in the sample.

Figure 5

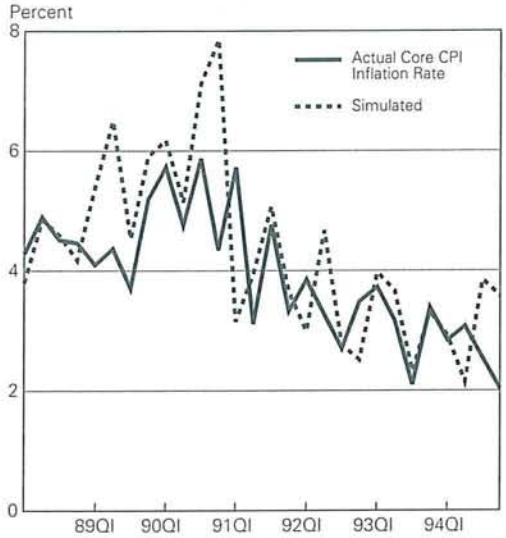
Dynamic Simulation of Core CPI Phillips Curve Estimated before 1980



Source: Consumer price index, all items excluding food and energy, seasonally adjusted, U.S. Bureau of Labor Statistics.
Fitted values are author's calculations.

Figure 6

Dynamic Simulation of Core CPI Phillips Curve Estimated over 1960:I to 1987:IV



Source: Consumer price index, all items excluding food and energy, seasonally adjusted, U.S. Bureau of Labor Statistics.
Fitted values are author's calculations.

due to chance. Thus, the values of 0.68 to 0.99 in the right-hand column under (1) show that we find no evidence of a shift in the expected inflation coefficients for the total compensation Phillips curve. The values of 0.01 and 0.03 in the left-hand column under (1) strongly suggest a shift in the expected inflation coefficients for the core CPI at those dates.[17]

As indicated in the pair of columns labeled (1) in the table, for most breakpoints around the 1980 shift in monetary policy, no compelling evidence (probabilities well below 0.1) can be found to indicate a shift in the lagged inflation (or expected cost of living increase) component of the Phillips curve. The exception arises for the core CPI when the breakpoint is chosen between 1980 and 1982. The pattern of test values suggests that if a shift occurred, it was isolated to a short period beginning around 1980 and probably ended by 1983. The final two rows of columns (1) present results of a test of the "transience" of the shift in lag coefficients. The test regression allows the first four lagged inflation coefficients to shift in 1980:I, and for all the lagged coefficients to shift again in 1983:I. As the second-to-last row of columns (1) indicates, allowing the lags to shift in the 1980–82 period and thereafter strengthens the certainty with which we could accept the hypothesis of a shift in the lag coefficients for the core CPI. The final row in columns (1) tests for the equality of the lagged inflation coefficients in the pre-1980 and the post-1982 periods. We cannot reject the hypothesis that they were equal for either variable, strengthening the suspicion that if any shifting occurred, it was isolated to the 1980–82 period. Was the shift detected for the core CPI evidence of a three-year temporary change in expectations due to a temporary policy change, or is it simply evidence of overfitting a particular pattern of inflation outcomes?[18]

[17] The values reported in the table are the fraction of the area to the right of the test statistic for the distribution constructed under the null hypothesis that the coefficients are equal before and after the breakpoint.

[18] The results for the total CPI and for the GDP deflator provide, overall, much weaker evidence of shifts. For the total CPI, the obvious breakpoint for the lagged inflation coefficients also occurs in 1980:I, but it is not nearly as significant statistically as for the core CPI. The GDP deflator never develops a probability below 0.4 for the same test. Estimates of the baseline Phillips curves for the total CPI and the GDP deflator, as well as an estimated wage-price Phillips curve with a unit labor cost equation, are presented in Tables 1a–c.

Table 2
Tests for Shifts in Estimated Coefficients

	Probability that estimated shift coefficients differ from zero due to chance							
	Joint test of all coefficients on:							
	(1) Lagged inflation		(2) Lagged unemployment		(3) Both		(4) Shift in sum of unemployment coefficients	
Breakpoint(s)	Core CPI	Total Comp.	Core CPI	Total Comp.	Core CPI	Total Comp	Core CPI	Total Comp
1978:I	.08	.94	.64	.69	.15	.96	.04	−.01
1979:I	.09	.68	.68	.74	.17	.78	.02	−.02
1980:I	.00	.95	.93	.28	.00	.97	−.02	−.04
1981:I	.01	.99	.69	.49	.02	.99	.02	−.05
1982:I	.03	.99	.11	.77	.02	.99	.03	−.02
1983:I	.69	.98	.04	.90	.47	.99	.02	−.01
1984:I	.99	.95	.85	.78	.98	.94	−.02	−.02
1980:I, 1983:I	.00	.94						
Pre-1980 = Post-1982	.88	.79						

The dependent variable is the log change in the CPI excluding food and energy or the log change in total compensation, as defined in the text. The baseline equations are the estimated equations from Tables 1 and 1c, respectively.

To answer this question we examine the expected inflation components of the estimated Phillips curves during the potential shift periods. Figure 7 presents the Phillips curve's estimates of expected inflation, allowing for a possible shift in 1980 (the solid red line) and holding the coefficients constant for the entire sample (the dashed red line), for the core CPI and for total compensation. This figure shows graphically what the test results in Table 2 suggest. Core inflation from 1980 to 1982 gyrated wildly between 0 and 15 percent. Allowing the coefficients on lagged inflation to shift in 1980 allows the equation to better mimic this unusual pattern in inflation, and thus improves the in-sample fit of the Phillips curve. In addition, using this lag pattern does not worsen inflation predictions after 1982, when inflation moved more smoothly. Many would be reluctant to call this a true shift in the expectations component of the Phillips curve, especially when there is no evidence of any such shift in the compensation Phillips curve. Instead, the estimated shifts in the lagged inflation coefficients amount to an over-fitting of an unlikely-to-be-repeated pattern of inflation in the three-year span from 1980 to 1982.

The bottom panel of the figure shows the estimated change in the expectations component for the total compensation Phillips curve. Consistent with the results in Table 2, there is essentially no evidence of any shift in the expectations behavior at any year around the proposed shift time of 1980. Because the underlying motivation of the Phillips curve makes most sense when applied to compensation data, this panel seems the most damning for the empirical significance of the Lucas critique for the Phillips curve.

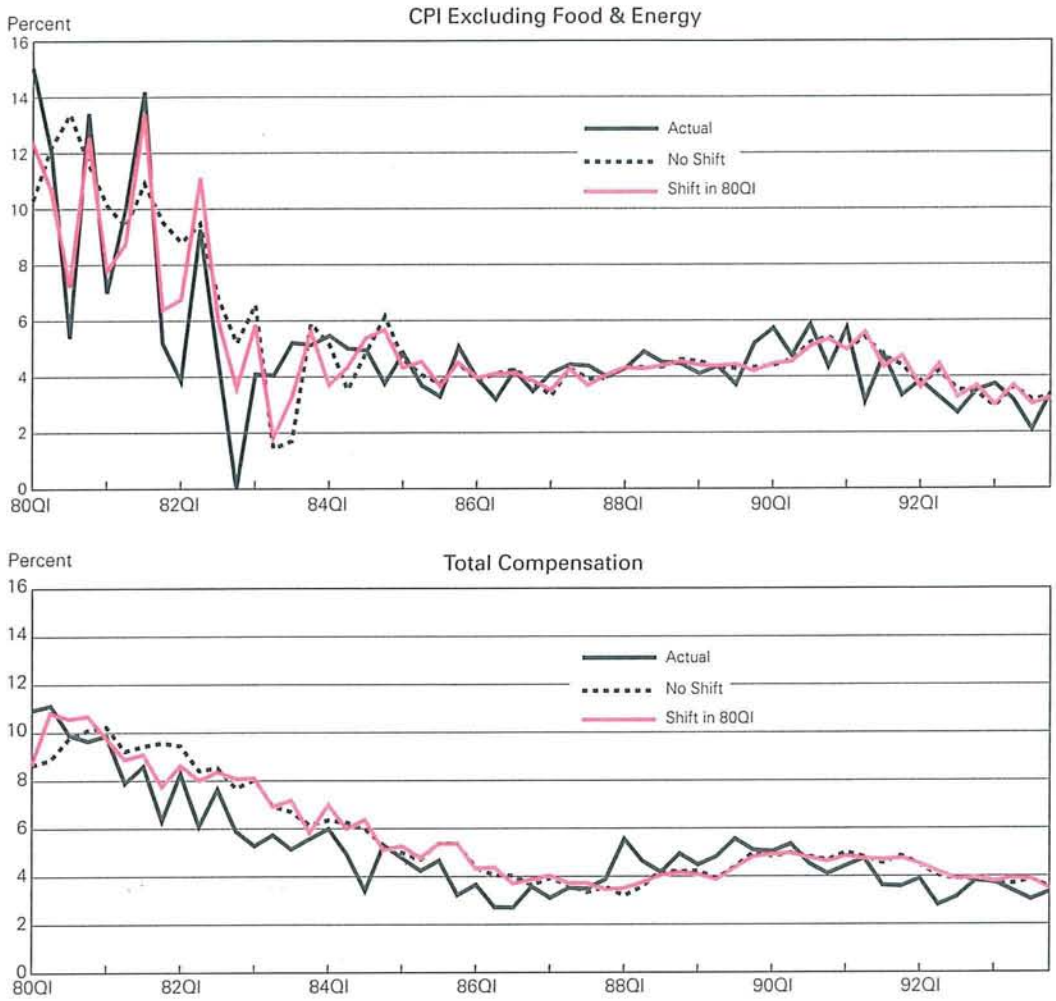
Shifts in the Unemployment Coefficients

What about the other coefficients in the Phillips curve? Were they stable as well? Tootell's article in the September/October 1994 issue of this *Review* addresses the stability of the NAIRU, finding no evidence for a shift in the NAIRU, and this research endorses that conclusion. But the NAIRU could remain stable even if the unemployment coefficients shift, as long as the sum of the unemployment coefficients remains the same or the constant in equation (2) shifts in the same direction as the sum to maintain the ratio that determines the NAIRU. Thus, it is of interest to see whether the unemployment effect in the Phillips curve has shifted over time.

In general, the possibility of a shift in unemployment coefficients can be viewed as another implication of the Lucas critique. Suppose the "underlying structure" behind the Phillips curve includes a monetary policy response that raises interest rates when inflation is currently higher than desired and raises the unemployment rate. Then part of the contemporane-

Figure 7

Expected Inflation Component of Phillips Curve



Source: Consumer price index, all items excluding food and energy, seasonally adjusted, U.S. Bureau of Labor Statistics
Total compensation, seasonally adjusted, U.S. Bureau of Labor Statistics.
Before 1982 - Nonfarm business sector, compensation per hour.
1982 to present - Employment cost index, compensation, civilian workers.
Author's calculations.

ous inflation-unemployment correlation captured by the Phillips curve could include an imbedded monetary policy response to inflation. When the policy response changes, that part of the inflation-unemployment correlation will also change, and the Phillips curve will not be stable for that reason. This potential source of instability is less important when the Phillips curve is specified with a lagged unemployment rate, as it is in Tables 1 to 1c.

Columns (2) of Table 2 present tests of the significance of shifts in the lagged unemployment coefficients. For most of the breakpoints tested, no evidence is found of a shift in these coefficients. In 1983, however, there appears to be some benefit to the core CPI equation fit from allowing the unemployment coefficients to shift. Note, however, that while the coefficients may have shifted, the overall effect of unemployment on inflation (the sum of the coefficients) appears not to have shifted significantly. Columns (4) display the estimated shift in the sum of the

lagged unemployment coefficients. All of the shifts are 0.04 or less, not significantly different from the sum reported in Table 1. Thus, these results suggest that overall, the unemployment effect in the Phillips curve has also been quite stable. A slight shift in the lag pattern may have occurred around 1983, but it did not persist after 1983, and so it is as likely that this statistical result simply reflects overfitting of a few observations as was the case with the expected inflation component, discussed above. Once again, coefficients in the compensation Phillips curve show no sign of instability.[19]

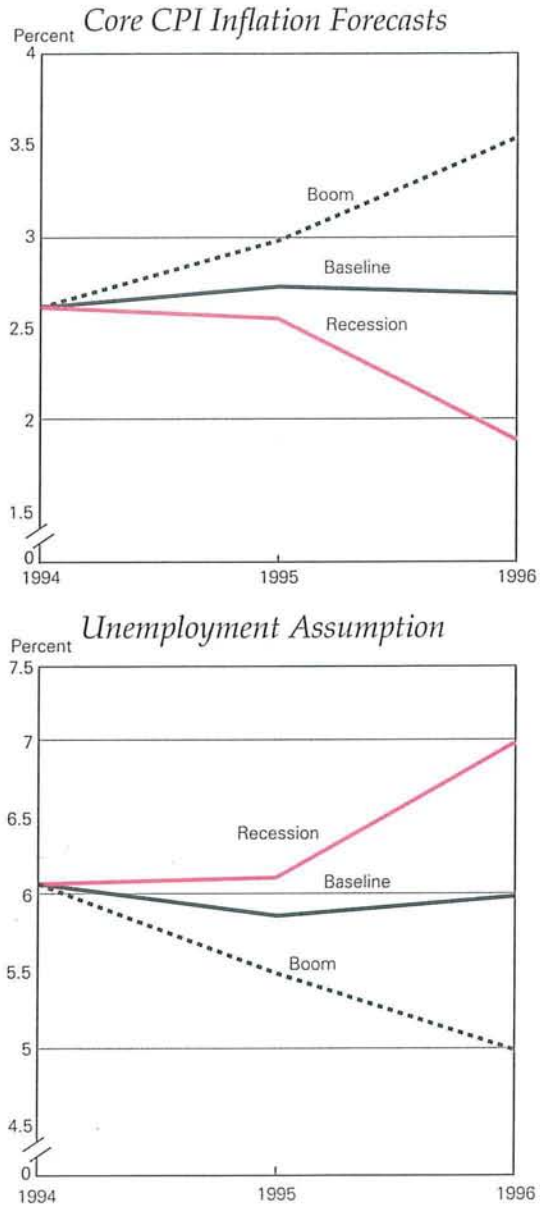
The Empirical Force of the Lucas Critique

Lucas and Sargent (1978) argued that "there is no reason, in our opinion, to believe that these models have isolated structures which will remain invariant across the class of interventions that figure in contemporary discussion of economic policy." Taking the results of Figures 2 to 7 and Tables 1 and 2 together, it would be difficult to argue that the Phillips curve is unstable across the observed changes in policy regimes. Whether using in-sample fit, out-of-sample simulation, coefficient stability tests, or a direct examination of the expected inflation component of the curve, the same conclusion emerges. The Phillips curve has exhibited remarkable stability over the past 35 years, even across data for what must be the most dramatic shift in monetary policy regime in the United States since World War II. As an empirical matter, the Lucas critique does not apply to the Phillips curve.

V. Phillips Curve Predictions

What does the estimated core CPI, price-price Phillips curve of Table 1 predict for inflation over the next two years? The answer depends, of course, on the assumed path of the unemployment rate.[20] Figure 8 depicts the annual average inflation rates predicted by the Phillips curve for three different unemployment scenarios. In the baseline case (the solid black line), the unemployment rate rises back to the estimated NAIRU in 1995, remaining there through 1996. In the "recession" case (the red line), the unemployment rate rises to 1 percentage point above the NAIRU in 1996. In the "boom" case (the dashed black line), the unemployment rate falls to 1 percentage point below the NAIRU by 1996.

Figure 8



Source: Author's calculations.

[19] The results for total CPI are no more distinct than those for the core CPI. For total CPI, only in 1982 and 1983 does the probability dip below 0.05, and it then quickly reverts to 0.63 in 1984. The GDP deflator results are still weaker, as the probability gets only as low as 0.07 in 1981, and never dips below 0.30 for any other breakpoint date.

[20] A fully articulated model would include an equation that describes the behavior of the unemployment rate, as well as the price of oil. With such a model, we could jointly forecast the behavior of unemployment and inflation. Such an effort lies outside the scope of this paper.

In all cases, the changes in inflation predicted by the Phillips curve are modest. As a result of the inertia imparted by the expectations component of the estimated equation, inflation adjusts very gradually to the unemployment gaps. Within the first year of the forecast, a difference of about 0.5 percentage point either way in the unemployment rate alters the inflation forecast by no more than 0.3 percentage point. As the unemployment gaps widen to plus or minus 1 percentage point in the second year of the forecast, the differences in inflation forecasts become more noticeable, yielding changes in inflation of about 0.6 percentage points relative to the 1994 average rate.

Of course the strong persistence of inflation implies that a rising inflation rate at the end of 1996 will not immediately reverse its course in 1997. Thus, the inflation outlook beyond 1996 is also of interest. However, it would be unwise to use the Phillips curve in isolation for longer forecast horizons. The projected outcomes for inflation and unemployment shown in Figure 8 would likely elicit a significant monetary policy response that would alter the outcomes for inflation and unemployment. A model that incorporates the dynamic interactions among inflation, interest rates, and unemployment is required for such an exercise. Still, the basic structure of the Phillips curves explored in this paper suggests that unemployment outcomes like those displayed in Figure 8 should result in only modest changes in the core inflation rate in the short run.

VI. Conclusions

Do these empirical results suggest that the Phillips curve can and should be used for policy exercises, counter to the expectations of Lucas and Sargent at the 1978 Boston Fed conference? It would appear so, although some caveats are in order.

As Lucas and Sargent suggested, the ultimate test of whether equations are structural or not lies in their empirical performance. Taking the empirical results in section IV literally, there is no sign that the Phillips curve is not structural. The double negative in the preceding sentence, however, indicates the certainty with which we can hold the conclusions of the empirical results. We cannot prove that the equation is structural; we simply cannot find evidence that it is not.

This last objection is not simply semantic. The economic content to the caveat is that we may not have observed the shifts in policy behavior that are important enough to derail the empirical performance of the Phillips curve. While the disinflation from the late 1970s levels of inflation to the present was dramatic, it was still relatively gradual (as compared to the ends of some hyperinflations, for example), and thus could be captured by a model that allows for a gradual influence of the unemployment rate on the rate of inflation. Perhaps more dramatic departures from historical monetary policy might not be captured as well by the Phillips curve.[21]

One such qualitatively different policy would be an effort by the Federal Reserve to target the level of prices, rather than its rate of change. Hall (1984, pp. 137–38) provides an entertaining narrative that highlights the difference between this strategy and the inflation-targeting strategy pursued over the past 30 years. Would the Phillips curve retain its remarkable stability across such a change in monetary policy? The experiment has not been attempted yet, and so we cannot know.[22]

[21] Thomas Sargent (1981) finds evidence in favor of the Lucas critique in economies that recover from hyperinflation. The causes of inflation rates that are measured in the 100s or 1000s are considerably different from the causes of more common single- and double-digit inflation rates (hyperinflations are most often due to extreme lack of fiscal restraint). Thus, policies that stop hyperinflation have fundamentally altered the process generating inflation, and expectations about inflation's behavior after the hyperinflation are much more likely to differ from expectations during the hyperinflation.

[22] While Phillips' sample (1861–1957) included periods during which the inflation rate was approximately zero and the price level was fairly flat, the periods do not parallel the exercise contemplated in the text. First, monetary policy in the United Kingdom was not charged with actively leaning against the wind as it is currently in the United States, and in any event was almost certainly not directly targeting the price level. Second, Phillips' original curve did not include the expected inflation component at issue here, so we do not know from his evidence that an expectations-augmented Phillips curve would have performed well in zero-inflation or stable price-level environments.

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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).

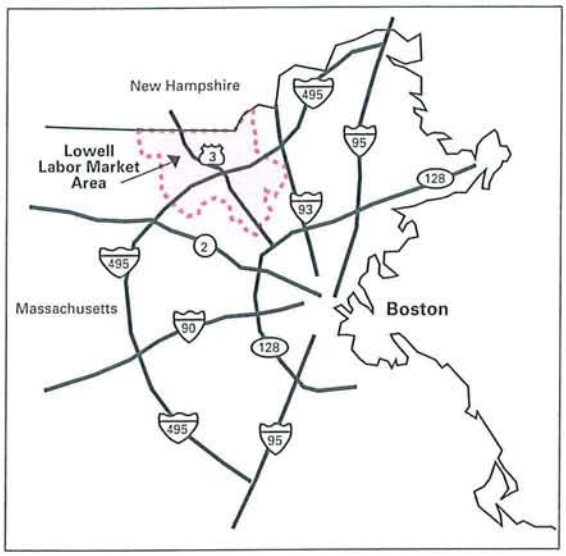
This article analyzes the boom and bust periods the Lowell economy experienced with high-technology employment, identifying what went wrong and what might have been done to mitigate the impacts of economic and industrial change. The first section provides a brief historical overview of the rise and decline 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

	1972	1989	1994	Annualized Growth Rates (Percent) 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.

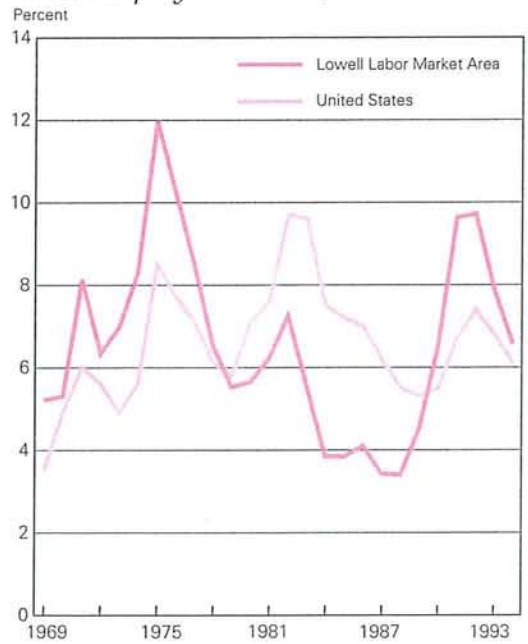
[4] U.S. Bureau of Labor Statistics, "Employment and Earnings, States and Areas."

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.

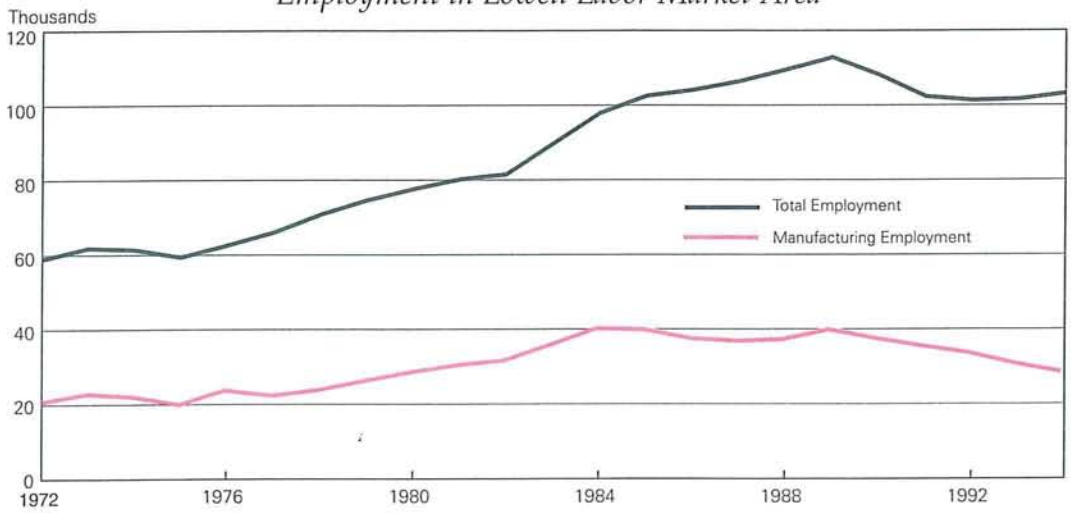
Factors Underlying Lowell's High-Tech Success Story

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).

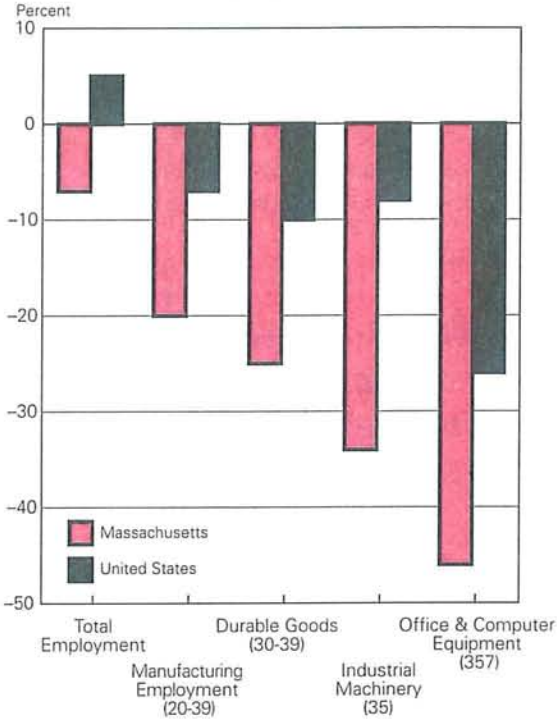
Understanding Lowell's Economic Bust

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.

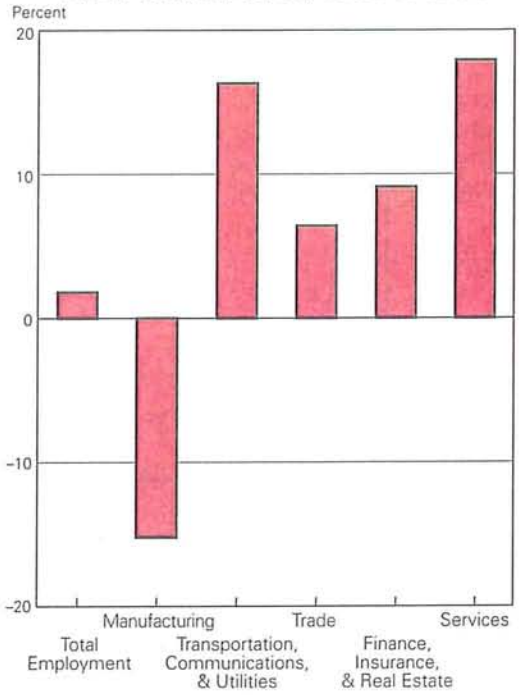
While uncertainty and change cannot be eliminated, areas can reduce their overall risk of wide swings in employment related to such events by diversifying their employment base, thereby avoiding overdependence on recession-prone manufacturing industries, firms reliant on defense contracts, companies 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

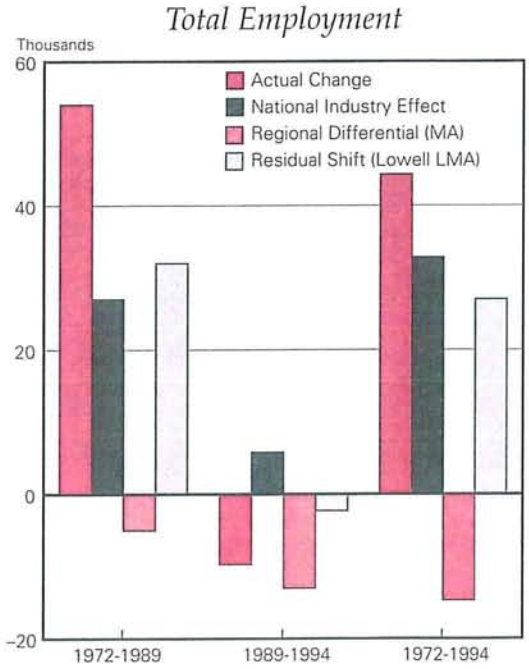
Shift-Share Analysis: Highlighting Pronounced Boom and Bust in Lowell

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.

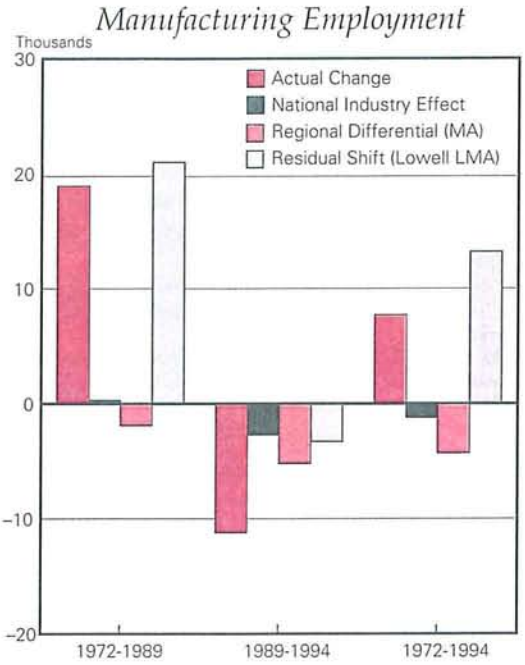
Shift-share analysis was conducted for the Lowell labor market area for two time periods, 1972 to 1989 and 1989 to 1994. During the first period, the Lowell area experienced impressive growth. Shift-share analysis (Figures A1 and A2) highlights that Lowell's main economic strength was in manufacturing, 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.

Contents

The Phillips Curve Is Alive and Well

Jeffrey C. Fuhrer

Rumors of the death of the Phillips curve appear to have been greatly exaggerated. In fact, the Phillips curve is alive and well, and living in a good number of (although certainly not all) widely used macroeconometric models. The author takes the view that the primary reason for its longevity is that the Phillips curve has been an extremely robust empirical relationship, showing little or no sign of instability over the past 35 years.

He examines an array of empirical evidence and finds that the Phillips curve has exhibited remarkable stability, even across data for what must be the most dramatic shift in monetary policy regime since World War II. To outward appearances, at least, the Phillips curve is as structural a relationship as macroeconomists have ever had at their disposal. 41

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

Ross J. Gittell and Patricia M. Flynn

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.

In recent years Lowell has once again become the focus of international attention, this time as an example of a failed economic development strategy. Widespread layoffs and plant closings within its computer industry, particularly the collapse of Wang Laboratories, have dealt a crushing blow to the local economy. 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. 57

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