How Diversified Is New England?

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Despite steady growth in the United States economy over the past eight years, several regions of the country have suffered severe economic slumps. Oil-producing and agricultural states in particular have experienced economic conditions that usually occur only during national recessions. Lack of diversity in the economies of these regions contributed to their economic problems.

While these regions were experiencing difficulties in the 1980s, the New England economy grew rapidly, spurred by growth in industries such as computers, financial services and defense. From 1984 to 1988 the unemployment rate in New England averaged only 3.9 percent, while the national average was 6.7 percent. Along with New England's growth in employment and personal income, the value of its real estate rose sharply, with the median house price doubling over the five-year period.

Recently, it has been New England's turn; its economic performance has deteriorated significantly. Employment growth has slowed, real estate values have dropped, and loan losses of banks and thrifts have risen. Whether these problems are an indication of more severe difficulties to come depends in part on the diversity of New England's economy.

Even a highly diversified economy will experience economic slowdowns during nationwide recessions. But regions that have highly specialized resources may face downturns for other reasons as well, such as a decline in demand for the products of industries concentrated there. If the shift in demand is long-lasting, a region may experience economic difficulties far longer than with a nationwide recession.

Analysis of a region's economic diversity requires more than a tallying of industrial concentration. Only 5 percent of Texas employment was directly involved in oil production, yet its importance to the Texas economy was far greater because other industries depended on the oil industry. Measures of diversification must capture not only

industrial fluctuations, but also whether these fluctuations are synchronized across industries. If they are, then a fall in employment in a major industry may depress the entire region. Conversely, if industrial declines are not correlated, a drop in employment in one industry may have relatively little effect on the region as a whole.

This article examines the diversity of the New England economy. The first section relates diversification to industrial composition and highlights those industries more concentrated in New England than in the nation. The second section examines the correlations of employment in New England industries with each other and with the same industries nationwide. The third section examines the industries responsible for most of the recent variations in New England employment. The article concludes that New England has a diverse industrial base, and that this should, in the absence of a major national downturn, help prevent a recession of the magnitude experienced earlier in farming and oil-producing states.

I. Measures of Regional Diversification and Industrial Mix

Definitions of regional diversification vary. Some measures assume that a diversified regional economy should have similar concentrations of employment in all industries. However, such a definition has several problems. First, it ignores the diversity within industry classifications. For example, "Industrial Machinery and Computer Equipment" includes such varied activities as manufacturing machine tools, computers, and farm machinery. Sales of these products depend on very different factors. Second, it ignores the interaction among industries. If service and retail industries depend on the health of local farming or mining, falling agricultural or mineral prices will reduce employment in these other sectors. However, if the products of the region's service industries are used nationwide, those industries will be less affected by slower employment growth in the regional economy.

This article uses a definition of diversification consistent with finance theory. In finance theory, a diversified portfolio of stocks has returns highly correlated with those on all existing assets. Ideally, to determine the degree of diversification provided by a portfolio of stocks, one would compare the movements in the return on the portfolio of stocks and the return on all assets. In practice, the return on all assets is difficult to measure, so the return on the portfolio would normally be compared to the return on a broad index of stocks.

Applying this definition of diversification to regional employment requires comparing the movements of employment in the region with those of the nation.[1] A diversified region is one that is unlikely to experience major or prolonged deviations in employment growth from that of the nation. However, the most diversified region may not be the region with the lowest employment variance. If the national economy is very volatile, an undiversified region may have lower employment variance if its employment is concentrated in industries that do well despite declines in the nation's employment.

Employment Composition of New England

The degree of diversification will be affected by a region's industrial mix. Industrial concentration does provide some indication of which industries may be responsible for major deviations in employment from that of the nation. A region with a mix of industry employment identical to that of the nation is not likely to experience major variations from national employment patterns. However, industrial concentration alone is not a good measure of diversification because it ignores co-movements in employment between industries in the region and between the region and the nation.

Industrial concentrations tend to vary across regions and states as each uses its comparative advantage. For example, a state such as Oklahoma, with only a few universities but with substantial oil reserves, does not have significant employment in high technology but has a large concentration of workers in the oil industry, while Massachusetts, with no oil but several major research universities, has the opposite employment composition.

Table 1 shows the twenty industries where New England's employment shares most diverge from the national average. The employment shares were calculated for sixty-seven industries, using the U.S. Bureau of Economic Analysis industrial classification,[2] with each industry ranked according to the absolute difference in employment share between New England and the United States for 1988. New England employment is underrepresented relative to the United States in natural resource industries and government and overrepresented in services and high technology.

Table 1
New England and United States Employment Shares
Percent

2-Digit Industry[a]	1975 NE Share	1975 US Share	1975 NE − US	1982 NE Share	1982 US Share	1982 NE − US	1988 NE Share	1988 US Share	1988 NE − US
Farming	1.02	4.06	−3.04	.86	3.22	−2.35	.64	2.47	−1.83
State and Local Government	11.80	12.59	−.79	10.05	11.56	−1.51	9.38	10.88	−1.50
Educational Services	2.86	1.37	1.48	2.87	1.38	1.49	2.88	1.43	1.46
Health Services	6.50	4.75	1.75	7.41	5.75	1.66	7.23	6.12	1.10
Electric and Electronic Equipment	2.84	1.76	1.08	3.23	1.81	1.42	2.61	1.58	1.03
Insurance Carriers	1.96	1.13	.83	2.04	1.14	.90	1.94	1.12	.82
Industrial Machinery and Computer Equipment	2.89	2.16	.73	3.07	2.03	1.04	2.42	1.60	.81
Military	2.11	2.73	−.62	1.51	2.32	−.82	1.32	2.09	−.77
Transportation Equipment except Motor Vehicles	1.90	.95	.95	1.96	.92	1.03	1.66	.91	.75
Federal Civilian Government	2.09	3.00	−.91	1.78	2.61	−.83	1.65	2.39	−.74
Instruments and Related Products	1.34	.56	.78	1.56	.64	.92	1.19	.56	.64
Mining	.08	.86	−.78	.11	1.20	−1.10	.10	.73	−.64
Food and Kindred Products	1.07	1.73	−.66	.86	1.47	−.62	.62	1.24	−.62
Motor Vehicles and Equipment	.13	.81	−.68	.12	.63	−.51	.09	.64	−.55
Miscellaneous Manufacturing Industries	1.32	.48	.84	1.12	.41	.71	.85	.35	.50
Trucking and Warehousing	1.10	1.45	−.34	.99	1.39	−.40	1.08	1.52	−.45
General Building Contractors	1.11	1.28	−.16	1.09	1.17	−.08	1.79	1.37	.42
Business Services	2.87	2.78	.09	4.63	4.20	.44	6.33	5.92	.41
Special Trade Contractors	2.62	2.68	−.05	2.65	2.77	−.12	3.72	3.33	.39
Social Services	.94	.79	.15	1.26	.99	.27	1.59	1.22	.37

[a]The industries where New England's shares diverge most from the national average

The five industries where New England is most underrepresented in employment shares relative to the United States are farming, state and local government, military, federal civilian government, and mining. The low employment shares in farming and mining are not unexpected, since New England has few mineral resources and its land is less suitable for agriculture than other parts of the country. More surprising is that New England has smaller shares of government workers, state, federal, and military, than the rest of the country.[3]

The five industries where New England has the largest shares of workers relative to the nation are educational services, health services, electrical and electronic equipment, insurance carriers, and industrial machinery and computer equipment. While New England is known for high-technology manufacturing, the most overrepresented industries are service industries. Health, education, and insurance comprise 12.1 percent of employment in New England, but only 8.7 percent in the United States.[4]

New England has always had a greater share of its employment in manufacturing than the country as a whole, 24 percent in 1975 compared to 19 percent nationwide. While United States employment in manufacturing declined to 15 percent by 1988, the relative decline was even greater in New England, where manufacturing dropped to 17 percent of total employment. This decline in the region's manufacturing employment has been widespread, affecting high-technology categories such as electric and electronic equipment, industrial machinery and computer equipment, and instruments and related products.

Eight of the ten industries where New England employment shares diverged the most from the United States in 1988 were also on the list in 1975. The industries themselves have changed, however. For

example, New England has maintained a much larger share of employment in industrial machinery and computers, but computers composed a much larger share of this category in 1988 than they did in 1975.

Business cycles also alter employment shares. Industries that are relatively insensitive to business cycles, such as educational and health services, have larger shares of employment during recessions; industries that are very cyclical, such as durable goods manufacturing, have smaller shares. Therefore during recessions such as the one occurring in 1982, noncyclical industries (cyclical industries) have larger (smaller) shares of employment than during periods of expansion.

Changes in Employment Concentration

Several recent studies have attempted to measure regional industrial concentration. While these measures of concentration are often interpreted as measures of diversification, they differ from the definition used in this paper because they measure similarities in concentration but do not capture the co-movement of employment in the region with that of the nation. Therefore, they should be referred to as measures of dissimilarity rather than measures of diversification. Perhaps the most common measure of dissimilarity is the "goodness-of-fit" index used by Conroy (1975) and Sherwood-Call (1988), which compares a region's distribution of employment to that of the United States.[5] A region whose employment share more closely resembles that of the United States over time is becoming less dissimilar, while a region whose employment share becomes less like that of the United States would be considered more dissimilar.

$$(1) \qquad GF = \sum_{i=1}^{67} \frac{(E_{NE_{it}} - E_{US_{it}})^2}{E_{US_{it}}}$$

where: $E_{NE_{it}}$ = employment share in New England for industry i in year t.

$E_{US_{it}}$ = employment share in the United States for industry i in year t.

In equation 1, if New England's employment shares are identical to the nation's employment shares, the numerator for each industry will be 0. If New England's employment shares differ from those of the United States, the difference is squared (which eliminates negative signs and weighs more heavily large differences in employment shares); each squared difference in employment share is then weighted by the nation's employment share for that industry.[6]

A second measure of regional dissimilarity is "employment entropy" originated by Theil (1972), a variant of which is used by Fomby and Hirschberg (1989) and Brewer (1985). The difference in entropy between the nation and a region is summarized in equation 2 and described in more detail in Appendix 1.

$$(2) \qquad ENT = \sum_{i=1}^{67} E_{NE_{it}} \ln\left(\frac{E_{NE_{it}}}{E_{US_{it}}}\right)$$

In equation 2, if New England's employment shares are identical to the nation's employment shares, the ratio for each industry is 1, the natural log of which equals 0. The log of the ratio is then multiplied by the employment share of the region. The greater the difference in employment shares, the larger the ratio, and the greater the value in ENT.

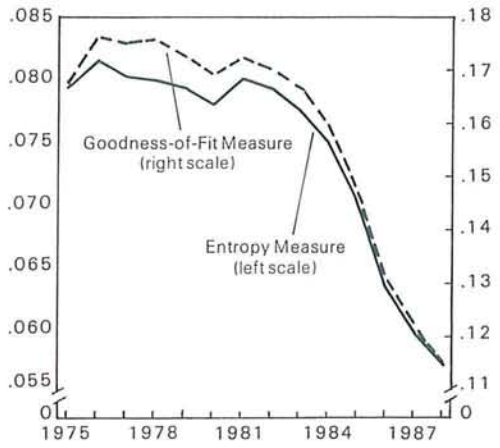
If the regional employment shares are identical to those nationwide, both GF and ENT equal 0. The more dissimilar the shares, the larger the values of GF and ENT. One would expect most regions of the country to diverge from national averages, since the composition of human and material endowments differs across regions.[7]

Figure 1 shows the two measures of dissimilarity for New England for the period 1975 to 1988. Both GF and ENT indicate that New England's industrial structure is becoming more like that of the nation. Both measures remained relatively stable between 1975 and 1982 and then dropped rapidly in the remainder of the 1980s. This convergence reflects the recent decline in New England's employment in manufacturing, particularly in high technology industries. The major industries of high technology manufacturing, industrial machinery and computer equipment, electrical and electronic equipment, and instruments, grew rapidly between 1975 and 1981, but have since shrunk. As a result, New England's share of employment in manufacturing is not as large relative to the nation's as it was in the beginning of the 1980s.

Several changes in the United States economy have also contributed to the convergence in employment shares. Industries with few employees in New England, such as farming and mining, now account for a much smaller proportion of employees nationwide than they did in 1982.

Figure 1

Employment Dissimilarity Index for New England 1975-88



The only New England industries whose employment shares became less like those of the United States in the 1980s were general building contractors and special trade contractors. While employment in these industries grew nationwide through 1988, it grew even faster in New England because of the real estate boom. The increased fraction of employment in construction made New England more vulnerable to the recent softening in the real estate market.

The individual New England states all follow a pattern similar to that of the region as a whole, with their industrial composition of employment converging toward the national averages. Every New England state is overrepresented in manufacturing and since 1982 has experienced sharper declines in manufacturing than the nation as a whole.

The severity of the difficulties created by recent employment declines in some high technology and other manufacturing industries as well as in construction depends at least in part on how other industries in the region fare. If employment in most industries depends on employment growth of the nation, and if national growth remains steady, the diversity of the region should prevent a sharp overall decline in employment. The next section considers which New England industries are most dependent on nationwide employment growth.

II. National Influences on Employment in New England

The previous section has shown that service industries such as insurance, health, and education and high-technology industries such as industrial machinery and computer equipment and electrical and electronic equipment are overrepresented in New England relative to employment patterns in the nation. This section will analyze how employment in each New England industry corresponds to that of the nation. Equation 3 was estimated for each of the sixty-seven New England industries:

$$(3) \qquad EM_{it} = c_0 + c_1 EM_{US_t} + u_{it}$$

where: EM_{it} = percentage change in employment in New England industry i for time t.

EM_{USt} = percentage change in total employment for the United States for time t.

u_{it} = error in fitting the data.

The coefficient, c_1, measures the changes in industry i's employment relative to changes in total national employment. It does not measure the proportion of the variation in employment growth in an industry that is "explained" by the variation in employment growth in the same industry in the nation. In other words, c_1 does not describe how well the line fits the data. A measure of how well equation 3 "explains" employment growth in each industry is provided by R^2. R^2 is bounded by 0 and 1, with 1 indicating a perfect fit of the data and 0 indicating no fit of the data.

It is possible for an industry to have both a large coefficient c_1 and a small R^2.[8] For example, an industry may be sensitive to the national business cycle but competitors in a region may be highly sensitive to innovations by competitors in other regions of the country. If most of the variation in employment for a New England industry is due to shifts of business to competitors, an industry that is sensitive to the business cycle and thus has a large c_1 may nonetheless have a low R^2.

Table 2 lists the 67 industries by ascending order of c_1, showing the R^2 for each industry as well. Educational services, health services, and insurance carriers, three of the most overrepresented industries in New England, are among the industries whose employment growth corresponds least to that of national employment in the industry, as represented by a low R^2. In addition, the coefficient c_1 for those

Table 2
The National Economy's Effects on New England Industries

2-Digit Industry	c_1	R^2	2-Digit Industry	c_1	R^2
Forestry	−5.51	.41	Amusement and Recreation Services	1.00	.33
Heavy Construction Contractors	−2.16	.30	Paper and Allied Products	1.00	.37
Security and Commodity Brokers and Services	−1.10	.09	Auto Repair, Services, and Garages	1.06	.31
Motion Pictures	−.45	.01	Eating and Drinking Places	1.11	.47
Communications	−.28	.02	Automobile Dealers and Service Stations	1.11	.22
Mining	−.18	.00	Wholesale Trade	1.12	.59
Legal Services	−.08	.01	Rubber and Misc. Plastics Products	1.18	.20
Electric, Gas, and Sanitary Services	−.05	.00	Apparel and Accessory Stores	1.21	.47
Insurance Carriers	−.04	.00	Furniture and Home Furnishing Stores	1.23	.21
Educational Services	.03	.00	Other Transport[a]	1.32	.44
Health Services	.09	.02	Miscellaneous Repair Services	1.34	.26
Military	.11	.00	Special Trade Contractors	1.39	.18
Fisheries	.13	.00	Real Estate	1.40	.24
Banking and Credit Agencies	.16	.02	Building Materials and Garden Equip.	1.41	.34
Farming	.17	.00	Local and Interurban Passenger Transportation	1.41	.48
Food Stores	.19	.05	Museums, Botanical, Zoological Gardens	1.42	.50
Member Organizations	.22	.04	Fabricated Metal Products	1.60	.37
Private Households	.24	.01	Miscellaneous Services	1.65	.42
Chemicals and Allied Products	.26	.04	Instruments and Related Products	1.70	.27
Leather and Leather Products	.30	.00	Social Services	1.75	.29
Federal Civilian Government	.38	.11	Electric and Electronic Equipment	1.86	.22
Insurance Agents, Brokers, and Services	.48	.08	Textile Mill Products	1.89	.30
Food and Kindred Products	.49	.11	Trucking and Warehousing	1.96	.71
Printing and Publishing	.50	.39	Holding and Other Investment Cos.	2.12	.07
Business Services	.51	.11	Other Nondurable Goods[b]	2.18	.21
Personal Services	.54	.04	Misc. Manufacturing Industries	2.28	.63
Apparel and Other Textile Products	.56	.03	Industrial Machinery and Computer Equipment	2.71	.45
Miscellaneous Retail Stores	.64	.20	Transportation by Air	2.79	.55
Agricultural Services	.71	.12	Stone, Clay, and Glass Products	2.88	.74
Hotels and Other Lodging Places	.72	.20	Lumber and Wood Products	2.91	.65
Transportation Equipment except Motor Vehicles	.80	.17	Primary Metal Industries	2.94	.59
Combined Real Estate, Insurance, etc.	.85	.04	General Building Contractors	3.15	.34
State and Local Government	.88	.41	Other Durable Goods[c]	3.42	.60
General Merchandise Stores	.93	.24			

Note: c_1 is the coefficient measuring the change in the New England industry's employment relative to the change in total national employment. R^2 is a measure of how well a variation in employment growth in New England is "explained" by the national variation in the same industry.
[a] Includes Railroad Transportation, Water Transportation, Pipelines, and Transportation Services.
[b] Petroleum & Coal Products and Tobacco Manufacturing.
[c] Furniture & Fixtures and Motor Vehicles & Equipment.

industries is low, indicating that the growth of employment in those industries is not closely correlated to that of total employment in the nation.

The high technology industries have large values of c_1 but do not have particularly large values for R^2. Of all sixty-seven industries, the R^2 for industrial machinery and computer equipment is thirteenth largest (0.45), instruments is twenty-eighth largest (0.27), and electronic and electrical equipment is thirty-third largest (0.22). Changes in the growth rates in those industries do not correspond closely to national rates. These industries are nonetheless highly sensitive to changes in the nation's total employment. The coefficient c_1 is high for all three industries: 2.71 for industrial machinery and computers (seventh largest); 1.86 for electronic and electrical equipment (thirteenth largest); and 1.70 for instruments (fifteenth largest).

Correlation between Industries

While the service industries in New England are not highly correlated with employment in the nation, they may be sensitive to the local economy. Will these services maintain their employment growth, with several of our high technology industries experiencing falling employment? If many of the region's service industries market their products nationwide, the effect of falling employment in the high technology industries here is likely to be relatively modest. If, however, New England's service industries depend on local industries, employment in those industries would likely move together.

A statistical measure of the co-movement of two variables is provided by the correlation coefficient. The correlation coefficient is bounded between 1 and −1, with 1 showing a perfect positive linear relationship, −1 showing a perfect negative linear relationship, and 0 representing no linear relationship between the two variables.[9] If decreases in employment in one industry correspond to increases in employment in the other, the correlation coefficient is negative. If changes in employment tend to move together, the correlation coefficient is positive. Table 3 details the correlations between the service industries and the high technology industries in which New England has large employment shares relative to the United States. The most overrepresented service industries, education and health, have very low correlations with many of the manufacturing industries. For example, health services is negatively correlated with electrical and electronic equipment, general building contractors, and transportation equipment. The low and frequently negative correlations indicate that our most overrepresented service industries have relatively modest correlations with many of our high technology industries. If decreases in employment in high technology industries have little relationship to changes in employment in service industries, then their effect on overall New England employment is moderated.

How Diversified Is the Regional Economy?

Individual industry movements cannot measure a region's diversification, because increases in employment in one industry may be offset by decreases in other industries. To measure a region's diversification, it is necessary to compare the correlation between employment growth in New England and that of the nation. To measure the diversification of each of the nine census regions (here, New England) required estimating equation 4.

$$(4) \qquad EM_{NE_t} = a_0 + a_1 EM_{US_t} + u_{NE_t}$$

where: EM_{NE_t} = growth in employment for New England during time t.
EM_{US_t} = growth in employment for the United States during time t.
u_{NE_t} = error in fitting the data.

The coefficient a_1 measures the correlation of the region's growth rate to that of the nation and is the slope of the line fit by equation 2. A coefficient of less than 1 would indicate that a fluctuation in the growth of national employment would correspond to fluctuations of a smaller magnitude in the region. A coefficient greater than 1 would indicate that national fluctuations would correspond to regional fluctuations of greater magnitude. R^2 measures how well changes in the growth rate of national employment correspond to changes in the growth rate of employment in a particular region.

A region with an economy identical to that of the

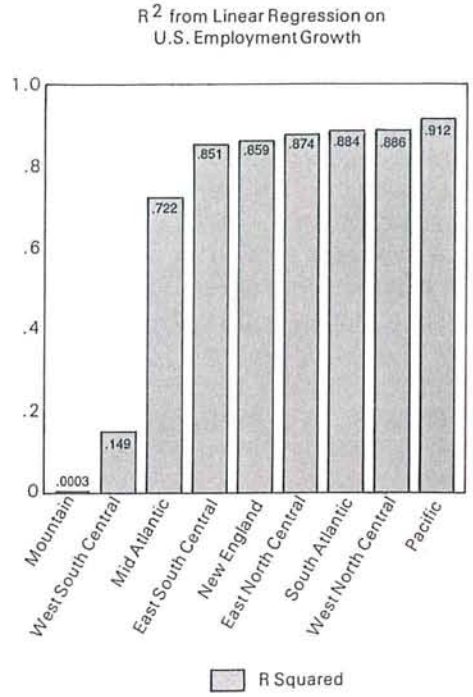
Table 3
Correlations between Industries Overrepresented in New England

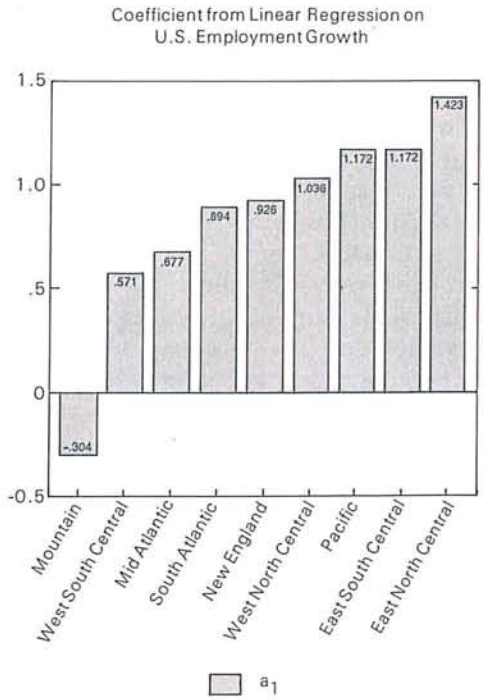
2-Digit Industry	Health Services	Educational Services	Business Services	Insurance Carriers
Electric and Electronic Equipment	−.59	.75	.81	−.39
Industrial Machinery and Computer Equipment	.34	.29	−.11	−.39
Transportation Equipment except Motor Vehicles	−.17	.01	.23	.62
Instruments and Related Products	.63	−.32	−.28	.14
General Building Contractors	−.46	.18	.58	.29
Miscellaneous Manufacturing Industries	.03	.54	.05	−.03

Figure 2

Figure 3

Comparison of Regional and National Growth Rates in Employment, 1976-88





nation would have an a_1 equal to 1 and a R^2 equal to 1. Otherwise, the region is likely to have a lower R^2, since changes in the growth of employment in the region would not correspond entirely to those in the nation.

Figure 2 shows the value of R^2 for each of the nine census regions.[10] Over 80 percent of the fluctuations of the rate of growth in New England correspond to fluctuations in the nation. New England has the median R^2. Only the growth rates of employment in the Mountain and West South Central regions do not correspond reasonably well to that in the nation.

Figure 3 shows a_1 estimated from equation 4 for each of the regions. A value of 1 would indicate that fluctuations in the growth rate of employment in a region correspond to similar fluctuations in the nation. New England again has the median value. The East North Central region, which has an R^2 similar to that of New England, is much more responsive to national trends, with a coefficient close to 1.5. The Mountain and West South Central regions again show little correlation with the nation.

The estimates of equation 4 for New England indicate that changes in the growth rate of employment in New England are positively correlated with those of the nation and that the relative magnitudes of these changes are similar. In contrast, the growth rates of employment in the Mountain and West South Central regions are not correlated closely with the growth rate of employment in the nation. It appears that New England is not likely to experience declines in employment growth of the magnitude experienced in the Southwest unless the nation experiences substantial declines in employment growth.

III. Analysis of Employment Variance in New England

The previous section established that New England employment moves closely with that of the nation, despite major differences across industries. This section shows how the industries fit together by calculating each industry's contribution to the vari-

ance of employment in New England. The interactions among a region's industries may be described in a manner analogous to the descriptions of interactions among a portfolio of stocks. Portfolio variance of employment is a statistical measure of the influence of industrial mix on the total variance of employment in a region. The formula for portfolio variance (PV) is summarized in equation 5.

$$(5) \quad PV = \sum_{j=1}^{67} w_j^2 VAR_j + \sum_{i=1}^{67} \sum_{\substack{j=1 \\ j \neq i}}^{67} w_i w_j COV_{ij}$$

where: VAR_j = variance in industry j,
COV_{ij} = covariance between industry i and industry j, and
w_i = the proportion of total employment in industry i.

The double sum includes all possible permutations of two industries except where i = j.

The portfolio variance of employment is the sum of all the variances of employment for each of the industries plus the sum of the covariances of employment between each of the industries, with both terms weighted by each industry's share of total employment. Each industry's variance measures the fluctuation in employment in that industry. The greater the fluctuation in employment, the greater the variance of the industry and the greater the portfolio variance, holding all other things constant.

Industry covariances are an important component of portfolio variance, measuring the fluctuation of employment in one industry relative to another. If decreases in employment in one industry usually correspond with increases in employment in another industry, the covariance between those industries is negative, and this tends to reduce the portfolio variance below the sum of the individual industry variances.

The variances and covariances are weighted by each industry's contribution to overall employment. Following the work of Conroy (1975), Brewer (1985), Sherwood-Call (1990) and Gruben and Phillips (1989), the weights are calculated on a "long-run" basis. The calculation of variances, covariances, and weights is described in more detail in Appendix 2. Summing the 67×67 matrix of weighted variances and covariances of employment by industry equals the variance of total employment in New England.

The main advantage of examining the portfolio variance is that each industry's contribution to overall variance can be calculated. Table 4 lists each industry's contribution to the portfolio variance (beta) and each industry's weight (percent of total employment) in the portfolio. Beta is similar to the beta used in finance studies and its calculation is also described in more detail in Appendix 2. Beta for industry i is the weighted sum of the variance of employment in industry i and the sum of the covariances between industry i and the other sixty-six industries in the portfolio. If beta is greater than 1, the industry increases portfolio variance; if beta is less than 1, it decreases portfolio variance.

Table 4 lists each New England industry sorted by beta in ascending order, and gives the weight of each industry in the New England "portfolio." An industry's contribution to portfolio variance will depend both on the size of its beta and the size of the industry as measured by its weight. Health services, the second largest industry in the region, has a negative beta. The other two service industries among the ten largest industries are business services, with a beta of 0.47, and education, with a beta of −0.25. Insurance carriers, the thirteenth largest industry, has a beta of 0.17. The three service industries most overrepresented in New England employment share relative to the United States—health, education, and insurance carriers—all have large weights and low betas.

The industries with both large betas and large weights tend to be manufacturing or those related to real estate. Industrial machinery and computer equipment, real estate, and special trade contractors all have employment shares of over 2 percent and betas substantially greater than 1. As shown in the previous section, these industries are all quite sensitive to the business cycle.

Among the dozen other largest industries in New England, state and local government and wholesale trade both have betas greater than one, while miscellaneous retail stores and electric and electronic equipment have betas of less than one. While these industries are important because of their employment size, their betas are not in the largest or smallest 25 percent of the sample.

Table 5 lists the ten New England industries whose employment shares grew the most between 1975 and 1988, along with their betas. These industries split evenly between those with betas greater than one and those with betas less than one. The fastest-growing industry, business services, includes such firms as management consulting and computer services. Business services has a beta of 0.47, indicat-

Table 4
Contributions of New England Industries to Portfolio Variance

2-Digit Industry	Beta	Weight (%)	2-Digit Industry	Beta	Weight (%)
Forestry	−6.98	.03	Personal Services	.99	1.64
Heavy Construction Contractors	−2.71	.48	Rubber and Misc. Plastic Products	1.06	.95
Communications	−.61	1.07	Agricultural Services	1.17	.54
Security and Commodity Brokers and Services	−.30	.29	Auto Repair, Services, and Garages	1.22	.80
Chemicals and Allied Products	−.26	.65	Wholesale Trade	1.30	4.77
Educational Services	−.25	2.82	State and Local Government	1.35	10.26
Leather and Leather Products	−.14	.73	Apparel and Accessory Stores	1.35	1.06
Apparel and Other Textile Products	−.10	.88	Amusement and Recreation Services	1.37	.99
Health Services	−.07	7.00	Museums, Botanical, Zoological Gardens	1.41	.07
Motion Pictures	−.05	.16	Fabricated Metal Products	1.41	1.92
Mining	.02	.09	Other Nondurable Goods[b]	1.47	.04
Food Stores	.14	2.79	Miscellaneous Repair Services	1.59	.44
Electric, Gas, and Sanitary Services	.15	.69	Local and Interurban Passenger Transportation	1.65	.48
Military	.17	1.57	Miscellaneous Services	1.65	1.81
Insurance Carriers	.17	1.96	Combined Real Estate, Insurance, etc.	1.66	.05
Legal Services	.18	.84	Automobile Dealers and Service Stations	1.67	1.71
Private Households	.34	1.06	Farming	1.68	.87
Member Organizations	.36	1.32	Real Estate	1.72	2.05
Business Services	.47	4.65	Furniture and Home Furnishing Stores	1.95	.65
Banking and Credit Agencies	.56	1.89	Special Trade Contractors	2.01	2.89
Printing and Publishing	.57	1.45	Trucking and Warehousing	2.06	1.05
Miscellaneous Retail Stores	.58	2.92	Textile Mill Products	2.10	.81
Electric and Electronic Equipment	.67	3.11	Building Materials and Garden Equip.	2.13	.61
Fisheries	.67	.24	Social Services	2.20	1.30
Federal Civilian Government	.75	1.79	Industrial Machinery and Computer Equipment	2.36	2.89
Hotels and Other Lodging Places	.76	1.00	Misc. Manufacturing Industries	2.58	1.14
Insurance Agents, Brokers, and Services	.80	.63	Primary Metal Industries	2.88	.65
Transportation Equipment except Motor Vehicles	.80	1.88	Stone, Clay, and Glass Products	3.10	.46
Other Transportation[a]	.81	.50	Lumber and Wood Products	3.15	.59
Paper and Allied Products	.84	.97	Holding and other Investment Cos.	3.18	.26
Food and Kindred Products	.88	.84	Transportation by Air	3.27	.21
General Merchandise Stores	.88	1.92	Other Durable Goods[c]	3.36	.42
Instruments and Related Products	.88	1.41	General Building Contractors	3.84	1.32
Eating and Drinking Places	.94	4.66			

Note: Beta measures the contribution to portfolio variance and is described in appendix 2. Weight represents the percent of total New England employment.

[a] Includes Railroad Transportation, Water Transportation, Pipelines, and Transportation Services.

[b] Petroleum & Coal Products and Tobacco Manufacturing.

[c] Furniture & Fixtures and Motor Vehicles & Equipment.

Table 5
The Fastest-Growing New England Industries and Their Betas

2-Digit Industry	1975 Employment Share (Percent)	1988 Employment Share (Percent)	1975–88 Growth in Employment Share (Percentage Points)	Beta
Business Services	2.87	6.33	3.46	.47
Special Trade Contractors	2.62	3.72	1.10	2.01
Real Estate	1.54	2.57	1.03	1.72
Miscellaneous Services	1.41	2.16	.75	1.65
Eating and Drinking Places	4.08	4.82	.74	.94
Health Services	6.50	7.23	.73	−.07
General Building Contractors	1.11	1.79	.68	3.84
Social Services	.94	1.59	.65	2.20
Personal Services	1.53	1.93	.41	.99
Banking and Credit Agencies	1.74	2.12	.38	.56

ing that it reduced overall portfolio variance. Both business services and health services have grown fast, have large weights, and are among the twenty industries with the lowest betas. Three of the fastest-growing industries that increased portfolio variance were primarily tied to the real estate boom, special trade contractors, general building contractors, and real estate.

Analysis of the portfolio variance of New England employment is relatively encouraging. Many of the service industries in which the region is overrepresented and which employ a large percentage of the work force, such as insurance carriers, health, and education, have low betas and are not particularly sensitive to changes in employment in high technology industries. While the industries tied to real estate grew rapidly through 1988 and have large betas, many other fast-growing industries such as business services and health services decrease portfolio variance.

IV. Conclusion

New England is known for manufacturing, and particularly its high technology industries. Employment in some of these industries has declined since the mid 1980s and may decline further, as a result of cuts in defense spending and competition from firms outside the region. The extent of the difficulties in these industries will depend on how quickly they produce new products and how much demand for high technology products increases with changes occurring in the rest of the world. While problems in these industries may restrain employment growth in New England, the slowdown is not likely to be as severe as that experienced in the 1980s by regions dependent on natural resources. The major reason for this optimism is the greater diversity in the New England economy.

While New England has a larger share of its work force in manufacturing than the rest of the country, it is also overrepresented in many service industries such as educational services, health services, and insurance carriers. These industries contribute little to portfolio variance in total employment, are relatively uncorrelated to high technology industries, and are not particularly sensitive to movements in the national economy.

New England is likely to benefit from future national trends. The service sector has been growing rapidly nationwide and New England is no exception. Health and business services have been among the fastest growing industries in the region and they tend to reduce the variance of employment. New England should be well positioned to apply high technology innovations to service industries.

Unlike resource-dependent regions, the New England economy closely tracks the national economy. This will provide vital support to the New England economy while high technology industries adapt to changes in their markets. New England's close relationship to the nation also means, however, that a national recession would cause significant problems for its economy, which has already experienced considerable slowing in employment growth.

Appendix 1: Entropy as a Measure of Dissimilarity

The measure of entropy used in previous studies such as Kort (1981), is summarized in equation 1A.

$$\text{(1A)} \qquad ENT = \sum E_{NE_{it}} \ln\left(\frac{1}{E_{NE_{it}}}\right)$$

where: ENT = entropy measure, and
$E_{NE_{it}}$ = New England employment share of industry i.

If New England had only one industry, ENT would be zero. If employment is equally divided among n industries, ENT reaches a maximum value of ln(n). Use of entropy as a measure of diversification has been criticized by Conroy (1975) and Wasylenko and Erickson (1978) because industrial classifications are arbitrary, making particularly tenuous any assumption that diversification is synonymous with equal distribution of employment across industries. This article uses a variant of the entropy measure summarized in text equation 2. Rather than assuming a diversified region would have equal distribution of employment across industries, it assumes that a diversified region would have the same industrial composition as the United States. It therefore uses the same underlying assumption about diversification as the goodness of fit test. Both the entropy measure and the goodness of fit measure compare industrial composition of a region to that of the country, but do not measure diversification in a way consistent with finance theory.

Appendix 2: Portfolio Variance

The relative variance of employment in New England is

$$\text{(2A)} \qquad PV = \frac{1}{N-2}\sum_{t-1}^{N}\left[\frac{Y_t - \hat{Y}_t}{Y_t^*}\right]^2$$

where: N is the number of observations,
Y represents the total employment in period t,
$\hat{Y}_t$ represents the predicted level of total employment for period t based on a quadratic time trend equation estimated by ordinary least squares regression, and
Y* represents the arithmetic mean of the total employment time series.

The variance of employment can be disaggregated so that each industry's contribution to portfolio variance can be established. New England has 67 industries. For each industry it is necessary to calculate the variance of that industry's employment and the 66 covariances with the other industries. The 67 × 67 elements of the variance-covariance matrix can be calculated from equation (3A).

$$\text{(3A)} \qquad \sigma_{ij} = \frac{1}{N-2}\sum_{t-1}^{N}\left[\frac{Y_{it} - \hat{Y}_{it}}{y_i^*}\,\frac{Y_{jt} - \hat{Y}_{jt}}{y_j^*}\right]$$

where: Y_{it} and Y_{jt} represent the observed levels of employment in industries i and j, respectively, during period t,
$\hat{Y}_{it}$ and $\hat{Y}_{jt}$ represent the predicted levels of employment in industries i and j, respectively, for period t based on a quadratic time trend equation estimated separately for each industry by ordinary least squares regression, and
Y_i^* and Y_j^* represent the arithmetic means of the individual industry employment time series.

The covariance is a measure of the degree of association between employment in industries i and j. The covariance is positive if deviations of y_i and y_j from their respective expected values tend to have the same sign, and it is negative if the deviations tend to have opposite signs. If no correlation is found between deviations in employment in the two industries, the covariance is zero.

The weighted sum of the 67 × 67 components of the matrix is called the employment portfolio variance, computed in equation (4A).

$$\text{(4A)} \qquad PV = \sum_{j=1}^{67}\omega_j^2 VAR_j + \sum_{i=1}^{67}\sum_{\substack{j=1\\ j\neq i}}\omega_i\,\omega_j\,COV_{ij}$$

where: ω_i and ω_j represent the mean employment share of industries i and j, that is, y_i/Y and y_j/Y respectively.

By summing all the weighted elements of the variance-covariance matrix we achieve the same portfolio variance as calculated in equation (2A) on total employment. The advantage of equation (4A) is that it is possible to see each industry's contribution to the portfolio variance.

The contribution of a particular industry to the total portfolio variance is the sum of the industry's variance and the 66 covariances with other industries. In other words, it is the weighted sum of the column for industry j of the 67 × 67 variance covariance matrix. By comparing industry j's contribution to portfolio variance to total portfolio variance, we get beta.

$$\text{(5A)} \qquad B = \omega_j^2 VAR_j + \sum_{i=1}^{66}\omega_i\,\omega_j\,COV_{ij}$$

The sum of all the industry betas equals 1. Thus, an individual industry with a value of beta equal to or greater than 1 increases the portfolio variance, and an industry with a value of beta less than 1 reduces portfolio variance.

[1] Ideally we would compare employment in the region with that of the world, but because of measurement problems we instead compare New England employment to that of the nation.

[2] This article used U.S. Bureau of Economic Analysis (BEA) industrial classifications, which are based on the U.S. Bureau of Labor Statistics (BLS) 2-digit SIC code industrial classifications for 1972. Three of the industries are a combination of several BLS industries: "other nondurable goods" combines petroleum and coal products, and tobacco; "other transportation" includes railroad, water, pipelines, and transportation services; "other durable goods" combines furniture and fixtures, and motor vehicle equipment. The employment numbers used by the BEA make some adjustments to BLS employment numbers, such as including college students and proprietors and partners.

[3] A comparison of federal government workers by region will be distorted by the very large concentration of federal government workers in the greater Washington, D.C. area, resulting in all other areas appearing to be underrepresented. However, in 1988 civilian government workers were 1.98 percent of all employees in the United States excluding Maryland, Virginia, and the District of Columbia, compared to only 1.65 percent in New England.

[4] Note that substitution can occur between public and private employment. In a region with many private hospitals and private colleges, the government may decide to provide fewer public hospitals and public colleges.

[5] Fomby and Hirschberg (1989) use a slightly different goodness-of-fit test. Rather than assuming the theoretical distribution is U.S. employment shares, their test assumes the theoretical distribution is U.S. employment shares excluding the region under consideration, here New England. We also calculated the Fomby and Hirschberg (1989) goodness-of-fit measure for New England, which generated a curve with the same shape as the one shown in Figure 1.

[6] Consider the following employment in industries A and B.

	Region 1	Region 2	Region 3	Nation
A	25	50	25	100
B	25	25	50	100
Total	50	75	75	200

The employment shares are:

Industry	Region 1	Region 2	Region 3	Nation
A	.50	.67	.33	.50
B	.50	.33	.67	.50

GF and ENT are:

	Region 1	Region 2	Region 3
GF	0	.12	.12
ENT	0	.06	.06

[7] GF and ENT use employment shares of the United States in the denominator of equations 1 and 2. This is appropriate when comparing a region to the United States; over time, however, cross-regional comparisons can be misleading because the measures are not symmetric. Thus, differences in industries where the United States has smaller shares result in a larger effect on the measures than in industries where the United States has larger shares.

[8] R^2 is the explained sum of squared residuals divided by the total sum of squared residuals. It can be written as

$$R^2 = \alpha_1^2 \left(\frac{S_x^2}{S_y^2} \right)$$

where: α_1 is the estimated slope coefficient,
S_x^2 is the sample variance of the independent variable
S_y^2 is the sample variance of the dependent variable.

Therefore, even if α_1 is large, R^2 will be low if the S_x^2 is small relative to S_y^2.

[9] Correlation coefficients are calculated as the covariance between industry i and industry j divided by the standard deviation of industry i times the standard deviation of industry j. The standard deviations and the covariances are calculated from the variance-covariance matrix used in calculating portfolio variance, so they are all corrected for time. Note that a 0 correlation implies no linear relationship but a relationship may exist; for example, the data may fit a curve rather than a line.

[10] The nine census regions include the following states: New England: CT, ME, MA, NH, RI, VT. Mid Atlantic: NJ, NY, PA. South Atlantic: DE, D.C., FL, GA, MD, NC, SC, VA, WV. East North Central: IL, IN, MI, OH, WI. East South Central: AL, KY, MS, TN. West North Central: IA, KS, MN, MO, NE, ND, SD. West South Central: AR, LA, OK, TX. Mountain: AZ, CO, ID, MT, NM, NV, UT, WY. Pacific: AK, CA, HI, OR, WA.

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