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The Geography of the New Economy

R. D. Norton

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By

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SYNOPSIS

Most new-economy theories are based on the idea that computers—networked PCs—have changed things in a fundamental way. To appraise this proposition, the chapter begins with a survey of macroeconomic, microeconomic, and digital versions of the hypothesis. I conclude that there really is something new about the economy, as tends to happen every 50 years or so. As a corollary, the new economy is also a "reborn" economy. The U.S. has successfully weathered a crisis of economic maturity that only a decade ago had led most observers to predict its inevitable decline..

Central to the U.S. comeback in the 1990s is the nation's unique regional geography, a product of its continental scale. As a nation of country-sized regions at different stages of economic development, the U.S. can offer a menu of competing "economic cultures," with diverse institutions, attitudes, and business climates. Regional diversity both sparks rapid development in younger regions and generates feedback effects encouraging the older regions of the North and East to develop more pro-business policies. It has also helped encourage the formation of new firms, the shock wave of the new economy, in a process Europe and Japan are now trying to emulate.

To illustrate, Part B is a case study of the regional revolution in information technology (I.T.), as sparked by the commercialization of the microprocessor after Intel invented it in 1971. It turns out that the established, successful, vertical companies of the Northeast could not reinvent themselves to take full advantage of this new and disruptive technology. Instead, it remained for "geeks and freaks" from the western states to do so. The result was to revolutionize American computing and regain the I.T. lead from Japan.

Part C examines recent theories of urban clusters, beginning with the role of networks in cluster formation and performance over time. Economic cultures are seen as the catalyst that determines whether networks communicate. This part also compares Silicon Valley, Route 128, and other clusters prominent in the I.T. pantheon.

In conclusion, Part D considers Metaphors, Evolutions, and (Regional) Science. Regional science is a set of methods or tools to be applied to real-world tasks, rather than a unified theory. It was started 50 years ago to introduce the variables of space and location to economics. This concluding section celebrates its founders and illustrates the field's rigor and eclecticism with links to some standout regional web sites.

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A. THE NEW ECONOMY: THREE CONCEPTIONS

A magazine solicitation from the Harvard Business School begins, “Please join other pioneers in the new economy and take advantage of this Charter rate.” I’m delighted to be recognized as a pioneer in the new economy, especially by the Harvard Business School. But which “new economy” am I a pioneer in? People (and business magazines) are referring to “the” new economy all the time now, but they seem to have different models in mind.

There’s a macroeconomic version, able to keep on growing rapidly without inflation. There’s a microeconomic version, apparently driven by a new kind of firm.There’s the digital version, likely to be identified with an Information Age. Then there are variants that focus on management, labor relations, sustainable development, and other topics as well. (Here’s an aggressive version of the thesis from the economics editor at *Business Week.* And here’s economist Hal Varian’s authoritative site on the whole topic.)

What most new-economy approaches have in common is the idea that computers and in particular networked PCs have changed things in a fundamental way. That is the common denominator we will encounter as we look at the macro, micro, and digital versions of the new economy hypothesis in turn.

I conclude that there really is something new about the economy, as tends to happen every 50 years or so. Also, the new economy is in some relevant sense a “reborn” economy. That is, it has successfully weathered what could be termed a maturity crisis (or, as the British call it, a “climacteric”) and defied the predictions a decade ago of inevitable U.S. economic decline. What has helped all this along is the nation’s unique regional geography, a product of its continental scale.

But you don’t have to arrive at these same conclusions to get something out of the grand tour we’re about to take.

1. MACRO VIEWS (A): FASTER GROWTH, LOWER INFLATION

The crux of the macroeconomic version of the new economy is the idea that information technology (I.T.) creates higher productivity growth, which in turn permits faster growth in output without a rise in the rate of inflation. The awkward fact that measured productivity growth has not gone up by much is downplayed, and is sometimes viewed as an artifact of measurement problems.

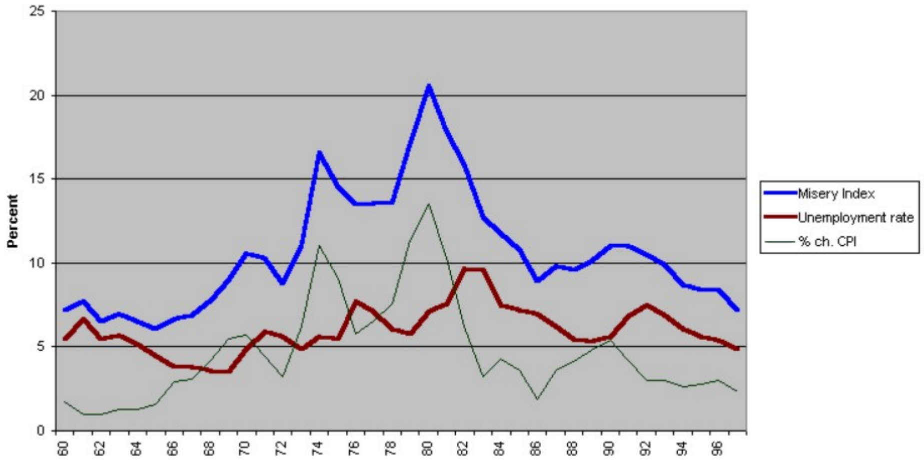
Federal Reserve Board Chair Alan Greenspan himself seems to believe that things have dramatically changed. (Clicking on the hyperlink will take you to his testimony of February 24, 1998. We quote here from paragraph 6.) In his words,

> “ . . . our nation has been experiencing a higher growth rate of productivity—output per hour worked—in recent years. The dramatic improvements in computing power and communication and information technology appear to have been a major force behind this beneficial trend.”

Indeed, in a recent report, *The Emerging Digital Economy,* the Department of Commerce presents a graph that shows I.T. reducing the rate of inflation by one full percentage point over what it would be in the absence of I.T.

There is no question that the macroeconomic picture has been a thing of beauty in the late 1990’s. A useful indicator to show the improvement is the misery index, the sum of the inflation and unemployment rates. It used to be said there was an inescapable tradeoff between the two, a tradeoff portrayed in the Phillips Curve. In the late 1990s, however, with unemployment down to 4.5% and inflation below 3%, the index for the U.S. looked better than in three decades. (FIGURE 1.)

FIGURE 1. THE U.S. MISERY INDEX: UNEMPLOYMENT PLUS INFLATION



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Generalizing, Bernard Weinstein (1997) offered the following list of new-economy attributes:

– An economy that grows without apparent threat of recession.

– An economy that continues to expand without a pickup in inflation.

– An economy constantly restructuring itself for greater efficiency and productivity.

– An economy replenishing and revitalizing itself through new technology and capital investment.

– An economy that functions without excessive debt, either public or private.

– An economy that maintains a balanced budget.

– An economy that is increasingly globalized and export driven.

Professor Weinstein concludes,

> "Not to suggest that inflation is dead, the business cycle extinct, and the stock market destined to rise forever. But, with good macroeconomic management, we believe the economy can grow virtually without interruption for the foreseeable future."

Mark Zandi of Regional Financial Associates, a forecasting firm, described the new economy at a Boston conference in May 1998. "The new economy adjusts more quickly to exogenous shocks, and it does not generate an environment that leads to recession." In his view, (1) globalization, (2) faster technological change, (3) securitization, and (4) deregulation have together introduced new variables that have yet to be included in conventional forecasting models of the economy. (Miara 1998)

TRIUMPHALISM?

Zandi offers a fuller treatment of the macroeconomics of the new economy is his "Musings on the New Economy" (in Regional Financial Associates's *Regional Financial Review*, March 1998, pp. 4-10). There he describes it as "part real and part surreal."

Similarly, many economists would conclude that the improvement in the misery index is as much as can be said for any macroeconomic version of a new economy. For example, an exchange in the May/June1998 issue of *Foreign Affairs* turns on whether America's long expansion in the1990s signals a true restoration of the nation's bygone glory.

In "A Second American Century," Mortimer Zuckerman (a real-estate developer and publisher) contends that the U.S. triumph reflects "deft managers, technological innovation, and a culture that values rugged individualism—all fueled by finance capital that can nimbly meet the needs of a globalized, rapidly changing economy" (p. 1). Accordingly, he concludes, the present U.S. lead relative to Europe and Asia will if anything increase in the next century.

Paul Krugman's rebuttal, "America the Boastful," views all this as a triumphalist caricature. As background, Krugman has long since declared the New Economy dead. Here he points out in a lucid analysis that while productivity growth may be faster than the official measurements show, that has always been true. He notes that technically, the growth of real output is limited by the sum of (1) the increase in employed workers plus (2) the rate of growth of productivity, or output per worker. Instead he sees the U.S. ascendance as the result of a sustained cyclical expansion here, which looks all the better next to difficulties in Europe, Japan, and emerging Asia. Everything could change once the U.S. has another recession, and economies elsewhere revive. He concludes, "Future historians will not record that the 21st century belonged to the United States."

Similarly, Alan Blinder speaks of "lucky shocks," as the reason for the reduction in the rate of inflation while the unemployment rate also falls. Among them are lower prices for oil and for imports generally, a slowdown in the rise of health costs, and—last but for our purposes not least—the relentless fall in computer prices. (Louis Uchitelle, "Economists Reject Notion of Stock Market 'Bubble,"' *The New York Times*, January 6, 1999, p. C2.)

A similar dismissal of the macro version of the thesis appeared in a Silicon Valley magazine, *Red Herring,* whose editor concludes,

> ...the argument for a new economy does not make sense. Digital technologies have not dramatically increased productivity; international competition doesn't have much effect on prices; and the economy cannot grow by more than the sum of the increase in productivity and the increase in new workers. (Jason Pontin, "There Is No New Economy," *Red Herring* Magazine, September 1997.)

MACRO VIEWS (B): COMPETITIVENESS

More generally, Krugman chides new economy advocates for a lack of historical perspective. His point is that there is nothing new about technological change. Now, Krugman knows what he is talking about on these questions. (For a look at his influential writings, popular and more technical, see his site, which *The Economist* Magazine recently cited as the top economist's web site in the world. Of particular interest to us at this point is "Requiem for the New Economy," from way back on 10 November 1997.)

But economic history yields an alternative view as well. In hindsight, we could say that there were two great economic questions of the 20th Century. One was about the effectiveness of communism as an economic system. That was answered decisively with the collapse of the Soviet Union after 1989.

The second great economic question of the 20th century has been the adaptability of what might be termed mature capitalism—above all as practiced in the largest mature economy, the U.S.

The big question was whether the U.S. had to endure the decline that afflicted the world's first industrial nation, Britain, at the end of the 19th century. As Moses Abramovitz asked in a Presidential Address to the American Economic Association in 1980: "Can we mount a more energetic and successful response to the challenge of newly rising competitors after 1970 than Britain did after 1870?"

INDICATORS OF A U.S. COMEBACK IN THE WORLD ECONOMY

In that light, it is precisely Britain's historical precedent that makes the U.S. comeback in the world economy such an unexpected event.

The Swiss competitiveness ranks. Consider, for example, the annual press releases from Davos, Switzerland, where an organization called the World Economic Forum publishes ratings of the world's economies in terms of their "competitiveness." Any single index of competitiveness is bound to be in part arbitrary, and this one has met its share of criticism. But in the past couple of years Jeffrey Sachs and Michael Porter of Harvard have helped refine the measure. What it shows in each recent year is a ranking for the U.S. (3rd, after Singapore and Hong Kong) higher than for any other major economy. And by the subjective appraisals of business executives polled by the Forum, the U.S. actually ranked first in both 1997 and 1998. (See Table 6 of the Executive Summary.)

Industrial output. One reason for the business leaders' view may be that the U.S. manufacturing sector has surged in the 1990s. This is not always understood, partly because downsizing and layoffs still occur and indeed accelerated in 1998. In addition there is a lingering "post-industrial fallacy," which in one version measures the sector's role by employment—or in another uses current instead of inflation-adjusted dollars to track manufacturing output as a share of GDP.

An example of the fallacy is a recent *New York Times* column: "The Economy Grows. The Smokestacks Shrink." There we read, "Manufacturing has been losing momentum for decades, with its share of the gross domestic product dwindling to just over half of what it was in 1953. . . ." (Louis Uchitelle, 29 November, 1998, 3:4.)

In real terms manufacturing's 1996 share of GDP reached its highest value in a generation, 19.1%, vs. previous peak values of 18.3% in 1989 and 18.7% in 1979. (See Table 1231 of the Statistical Abstract of the United States 1998, and the corresponding tables in earlier editions.)

At about 3% a year since 1975, manufacturing's productivity growth is much faster than in the rest of the economy. (As Table 689 of the Abstract shows, output per hour rose 65% from 1980 to 1997, vs. 21% in the non-farm private sector as a whole). Therefore manufacturing output can grow rapidly over time without adding more workers—or even with fewer workers, as in agriculture at the beginning of the century. Faster productivity gains also mean costs and prices rise less rapidly in manufacturing than in other parts of the economy. For that reason, when measured in current dollars manufacturing as a share of output lags. But the shrinkage is an illusion of prices.

U.S. productivity levels in manufacturing are the highest in the world. While the Netherlands and Sweden come close, and other countries have higher levels in specific sectors (e.g., cars in Japan), the aggregate U.S. lead remains. In 1996, output per hour worked in manufacturing was half again as high as in Canada or the U.K, and a third again as high as in Japan. (That is, the index values relative to 100 in the U.S. were 68 for Canada, 67 for the U.K., and 74 for Japan. See Tables 1374 and 1375 of the *Abstract.*)

The U.S. share of world exports in manufactures rebounded from a 10.7% share in the late 1980s to 11.5% in 1995. Faced with the rapid expansion of exports from China and the Asian Newly Industrializing Countries (NICs: Hong Kong, South Korea, Singapore, and Taiwan) other advanced economies lost ground. The former West Germany's share fell from 14.6 to 12.2%, and Japan's from 12.4 to 11.4%. (Table 1244.)

What all this adds up to is that the U.S. has had a faster expansion in industrial output since 1980 than any other advanced economy. FIGURE 2 tells the story, tracking the percentage growth in output for manufacturing, mining, and electric and gas utilities. The U.S. increase of 56% exceeded Japan's 51%, virtually all of which occurred in the 1980s. Mexico and Canada are not far behind, with Europe's major economies trailing.

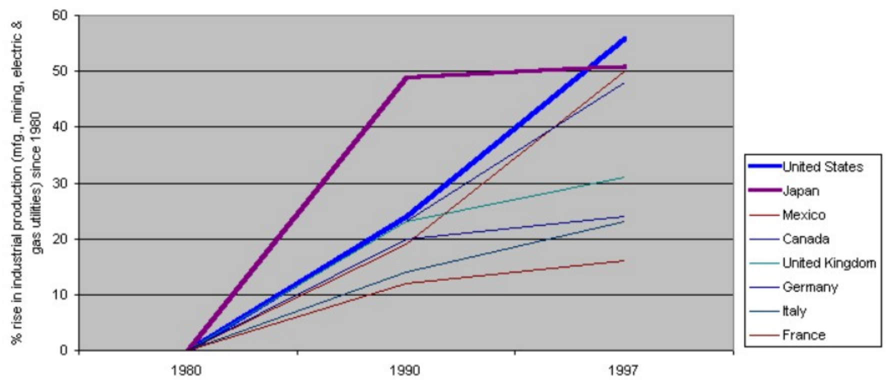
In short, it is not obvious that the U.S. has been de-industrialized, or that its manufacturing sector is shrinking relative to the rest of the economy, or that it has lost its industrial competitiveness.

LIVING STANDARDS

As a result of its economic revitalization, the U.S. continues to have the world's highest average living standards. Economists compare living standards across countries by output per person, assuming that the more output is produced per year, the more will be available for consumption by the population. The usual measure of output is gross domestic product, GDP, defined as the market value of currently produced final goods and services during one year. For any given year, then, a country's average living standards are gauged by per capita GDP.

For the U.S. in 1997, this figure, $28,740, equals a GDP of $7.7 trillion divided by a population of 268 million. I'm reading these numbers off a printout from the excellent (and recently overhauled) World Bank site, specifically from Table 1 of the statistical appendix to the Bank's *World Development Report 1998/99.* (pg. 191)

FIGURE 2. U.S. INDUSTRIAL GROWTH
LEADS JAPAN AND EUROPE, 1980-97



Source: Statistical Abstract 1998, T 1371

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Comparing per capita GDP across countries requires one more step. Except for the Euro group, which rallied around a single currency on January 1, each country has its own currency whose value depends on supply and demand in world markets. Therefore an adjustment must be made for something called "purchasing-power parity" (PPP). The adjustment corrects for any discrepancy between a currency's domestic purchasing power and its exchange rate, to give a more accurate index of living standards.

The benchmark value in their Table 1 pg. 191 is the U.S. figure in 1997 of $28,740. That placed it a close second to tiny Singapore's $29,000. The U.S. figure was, for example, 23% higher than No. 6 Japan's $23,400 and 31% higher than No. 10 Canada's $21,860.

To be sure, any such average value says nothing about income distribution, which is becoming more unequal in the U.S. and in other industrial economies. In addition, there are various other measurement and quality-of-life issues that make per capita GDP a crude yardstick at best.

The UNDP human development index. For skeptics, the United Nations Development Program provides an interesting alternative measure of well-being. Their Human Development Index (HDI) factors in not only per capita GDP but also life expectancy at birth and average educational levels. As the UNDP explains, "a composite index, the HDI thus contains three variables: life expectancy, education attainment (adult literacy and combined primary, secondary and tertiary enrolment) and real GDP per capita (in PPP$)." By this score the U.S. ranks No. 4, behind Canada, France, and Norway. (France had lower education and output values, but a higher life expectancy, 78.7 vs. 76.4 for the U.S., in 1995.) Japan ranked No. 9, the U.K. No. 14.

Revising real growth upward. How does all this square with the view that U.S. living standards have not improved much over the past quarter-century? Much has been made of the fact that after about 1973, productivity growth and the rise in living standards slowed.

But it turns out that the official numbers have given too pessimistic a picture. The distortion stems from the way the year-to-year changes in output and income are adjusted for inflation. According to the Boskin Commission (chaired by Michael J. Boskin and including the luminaries Ellen Dullberger, R.J. Gordon, Zvi Griliches, and Dale Jorgenson), inflation rates have been overestimated by about 1.1% a year for some time. The technical reasons inflation has been measured at too high a rate come under four headings: product substitution, retail outlet substitution, quality, and new-goods biases.

Thus about 1% too much has been subtracted from each year's measured per capita GDP for perhaps the past two decades. Living standards, thought to be stagnant, have actually risen by something closer to 2% a year. That would still not be as high as before 1973, but it is respectable for an economy that already had the world's highest absolute productivity levels.

For perspective, let's view the change in terms of the "rule of 72." It says that the time it takes an amount growing at compound growth rate $r\%$ to double can be found by diving 72 by r. Living standards would thus double in 36 years at 2% a year, vs. 72 years at 1%.

Labor-force outcomes. A look at labor-market conditions may be found in a recent on-line report from the Progressive Policy Institute, a Democratic Party think-tank. The report, What's New about the New Economy?, organizes a variety of useful indicators. In combination the findings (some of which are quoted directly below) suggest a less secure economy—but one teeming with opportunity:

1. Low-wage jobs are growing, but higher-wage jobs are growing even faster.

2. Manufacturing has not disappeared, it has been reinvented.

3. In the last 9 years, three million new managerial jobs have been added.

4. Fewer workers are unemployed and under-employed.

5. The increases in worker displacement remain modest.

6. The wage premium for skilled jobs is growing.

7. Increases in contingent (part-time, contract, temp) work are also modest.

8. Workers experience less job stability.

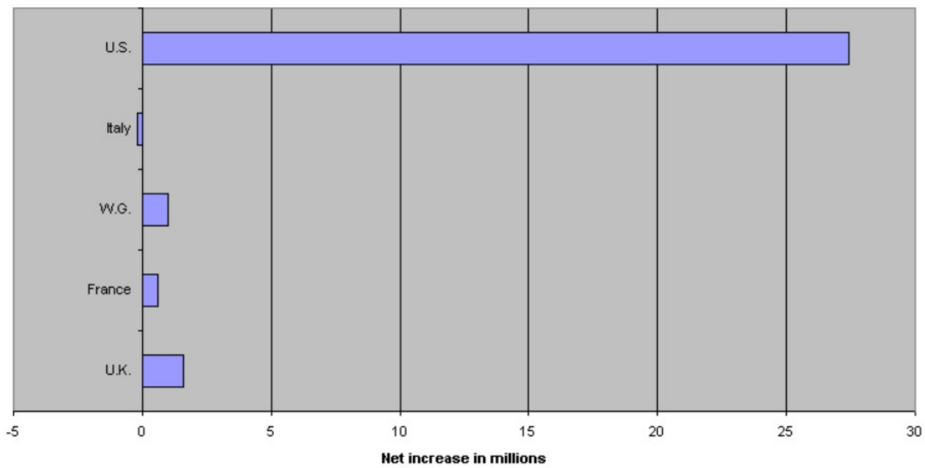
In a similar analysis, Michael J. Mandel, economics editor of *Business Week,* observes that since March, 1991, "real wages have risen at an annual rate of 1 percent," a big improvement over the 0.2% average for the expansion of the 1980s. Mandel also shows that over two-thirds of the new jobs created in the economy between 1995 and 1998 are "good jobs," in managerial, professional , and skilled-production occupations. As he puts it, "The benefits are especially apparent for young people graduating from college, who are coming into a world of soaring salaries rather than [the] dim prospects many had expected."

MACRO VIEWS (C): JOB GROWTH

Not that it is new, but we should make explicit another feature of the U.S. economy that is familiar enough by now that we tend to take it for granted.

Since 1980, the U.S. has experienced net employment growth of about 30 million new jobs. What puts this achievement in perspective is the fact that over the past generation, the major industrial economies of Europe have had virtually zero job growth. (FIGURE 3.) As a first approximation, the national economy spawns large numbers of new jobs of all types because of the rapid growth of both large and formerly small states in the South and West—not only Florida and Texas, that is, but also Arizona, North Carolina, and Washington. (MAP 1).

FIGURE 3. EMPLOYMENT GROWTH BY COUNTRY, 1980-1996



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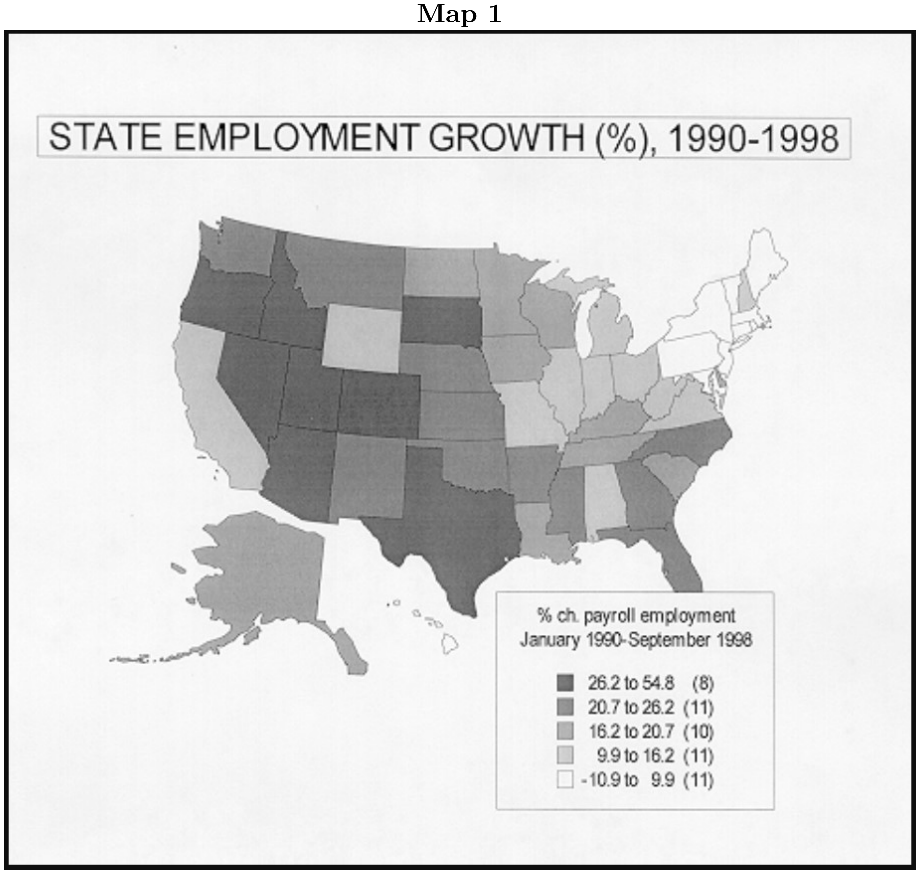
Map 1



CORE LEGACY: THE MANUFACTURING BELT AND THE PERIPHERY

For historical perspective, let's relate the Census Bureau's definitions of regions to the timing and geography of American economic development. (For data reasons, I use the Census definition of regions, with their 9 component divisions, rather than the Bureau of Economic Analysis definitions, which contain10 divisions.)

Economic geographers see the historical development of the nation's regional structure in terms of an industrial core and a less-developed periphery. We can bundle the 9 Census Bureau divisions accordingly. We start from the Census's four main "regions": the Northeast, Midwest, South, and West. As a map on the inside front cover of the *Statistical Abstract of the United States 1998* shows, there are then 9 divisions:

- Northeast: New England and Middle Atlantic divisions
- Midwest: East North Central and West North Central divisions
- South: South Atlantic, East South Central, and West South Central divisions
- West: Mountain and Pacific divisions

The three bolded divisions industrialized before the others: New England, the Middle Atlantic, and the East North Central (or Lakes) divisions. These were the matrix for America's 19th century industrial revolution before and especially after the Civil War. Accordingly, historians and geographers define the Manufacturing Belt as the super-region from Boston to Baltimore to St. Louis to Milwaukee.

The other six divisions constitute the South and West, a label masking enormous diversity. Though an approximation, this core-periphery approach has proved useful. A wide range of variables (e.g., city growth, attitudes toward unions, ethnicity) display contrasting values as between the old industrial core and the developing periphery.

For example, TABLE 1 shows that when we rank the 9 divisions by the timing of their industrialization, a standard measure of state "business climates" for the year 1980 aligns closely. Similarly, of the states with "right-to-work" laws that forbid union shops (requiring workers to join unions at unionized job sites), all 20 are in the five "younger" divisions, and not one is in the four divisions that industrialized earlier.

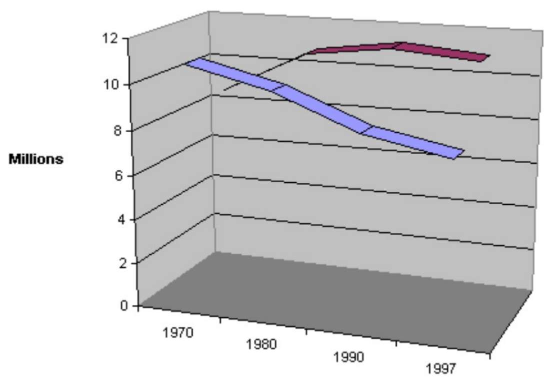
TABLE 1
REGIONAL MATURITY AND BUSINESS CLIMATES

Regional maturity, as ranked by population share in manufaturing jobs in 1909	Age rank	Business climate rank, from average of 1980 state scores (Grant Index)	No. of States with right-to-work laws
The Manufacturing Belt			
New England	9	8	0
Middle Atlantic	8	9	0
East North Central	7	6	0
The South and West			
Pacific	6	7	0
South Atlantic	5	5	5
West North Central	4	1	5
East North Central	3	3	3
Mountain	2	3	4
West South Central	1	2	3

Source: R.D. Norton, "Industrial Policy and American Renewal," *The Journal of Economic Literature*, Vol XXIV (March 1986), p.21.

Reflecting high costs and such political and institutional variables, manufacturing employment in the core has declined steadily since the late 1960s. (FIGURE 4) The core had 10.8 million in 1970, but only 7.7 in 1997. Offsetting much of that decline, the South and West gained 2 million jobs over the interval, most of it by 1980. For the U.S. as a whole, the count peaked at 21.0 million in 1979 and has dropped by one million in the 1990s, from 19.7 to 18.8 million. All in all, the U.S. has fared far better on this score than Europe (which has lost over 5 million manufacturing jobs). The reason is the job growth in new manufacturing activities in the South and West (R.D. Norton, 1997).

FIGURE 4. MANUFACTURING EMPLOYMENT TILTS SOUTH & WEST



	1970	1980	1990	1997
MFG. BELT	10.8	9.9	8.4	7.7
SOUTH & WEST	8.9	10.8	11.3	11

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Hidden from these sweeping comparisons is a remarkable industrial resurgence in the Upper Midwest. During the 1990s, after a generation of painful adjustment, the Lakes states have displayed an impressive comeback. It is based on the division's traditional cluster of "heavy-metal" and vehicles—and on another staple activity, agriculture. The effects are less evident in manufacturing than in total employment. In terms of total (non-farm) payroll employment, the triumph of the resurgent Midwest is that it has added jobs at about the national rate during the 1990s.

The Midwest recovery can be gauged in TABLE 2. It shows that the states with job growth at rates above the 15% U.S. average are all in the South and West—with two notable exceptions. Wisconsin and Michigan grew slightly faster than the national rate and together added over 1 million new jobs.

Table 2. Changes in Nonfarm Payroll Employment, January 1990-September 1997 To September 1998

State	Percent change	Absolute change	September 1998	January 1990
Nevada	55%	332,700	940,500	607,800
Utah	45%	318,200	1,027,800	709,600
Arizona	43%	624,800	2,092,900	1,468,100
Idaho	38%	143,000	519,100	376,100
Colorado	38%	563,200	2,062,000	1,498,800
Texas	28%	1,958,200	8,938,600	6,980,400
Oregon	27%	333,500	1,566,700	1,233,200
South Dakota	27%	76,800	361,000	284,200
New Mexico	26%	149,900	722,200	572,300
Montana	26%	76,500	370,100	293,600
Georgia	26%	775,700	3,752,800	2,977,100
Florida	26%	1,376,300	6,728,400	5,352,100
Washington	23%	490,500	2,603,400	2,112,900
Arkansas	23%	210,500	1,125,500	915,000
Nebraska	22%	159,500	878,800	719,300
Oklahoma	22%	258,600	1,436,700	1,178,100
Kansas	21%	227,400	1,309,200	1,081,800
Mississippi	21%	192,100	1,119,300	927,200

State	Percent change	Absolute change	September 1998	January 1990
North Carolina	21%	643,800	3,753,300	3,109,500
North Dakota	21%	54,400	317,500	263,100
Minnesota	21%	434,200	2,547,500	2,113,300
Louisiana	20%	315,600	1,884,800	1,569,200
Wisconsin	20%	452,500	2,717,000	2,264,500
Kentucky	19%	283,100	1,756,400	1,473,300
Alaska	19%	43,000	273,900	230,900
Iowa	19%	225,800	1,442,200	1,216,400
South Carolina	18%	275,000	1,804,300	1,529,300
Delaware	17%	59,300	403,100	343,800
Tennessee	17%	365,900	2,552,200	2,186,300
Michigan	16%	634,300	4,554,900	3,920,600
Alabama	16%	260,800	1,886,100	1,625,300
Wyoming	16%	31,000	226,200	195,200
West Virginia	16%	97,900	721,700	623,800
Virginia	15%	443,800	3,340,100	2,896,300
Indiana	15%	375,900	2,884,900	2,509,000
Missouri	15%	344,000	2,686,700	2,342,700
Ohio	13%	639,500	5,475,600	4,836,100
Illinois	12%	628,300	5,880,000	5,251,700
California	10%	1,246,200	13,656,000	12,409,800
New Hampshire	10%	51,400	569,300	517,900
Vermont	9%	22,700	283,700	261,000
Maryland	6%	132,100	2,298,800	2,166,700
Pennsylvania	6%	310,300	5,491,800	5,181,500
Massachusetts	5%	160,800	3,210,300	3,049,500
Maine	4%	24,300	567,900	543,600
New Jersey	4%	332,200	3,815,000	3,682,800
Hawaii	3%	14,300	531,000	516,700
Rhode Island	0%	(1,400)	455,200	456,600
Connecticut	0%	(6,600)	1,640,700	1,647,300
New York	-1%	(71,000)	8,187,100	8,258,100
D.C.	-11%	(74,700)	612,200	686,900
Source: U.S. Department of Labor, Bureau of Labor Statistics				

The divisions hit hardest in the 1990s have been New England and the Mid-Atlantic. As FIGURE 5 shows, the Northeast lagged far behind the rest of the U.S. in job growth in the 1990s. In the early part of the decade, the traditionally slow-growing Northeast was hit especially hard by (1) defense cuts, (2), corporate downsizing (which rocked the region's headquarters complex in New York City, New Jersey, and Connecticut), and (3) the rapid shift of American computing to the West.

Cuts in defense spending after 1989 had a huge impact on such states as Massachusetts, Connecticut, and New York—and on the West Coast, California. FIGURE 6 tells one version of the story. Among the six states with the largest absolute cuts in defense spending between 1984 and 1993, the states with the largest percentage cuts in defense spending had virtually no growth in total payroll employment between 1990 and early 1997. Texas, by contrast, had the smallest percentage cuts among the six and the fastest 1990s growth in non-farm payroll jobs.

FIGURE 5. 17 MILLION NEW JOBS, BY REGION
(Non-farm payroll employment, January 1990-September 1998)

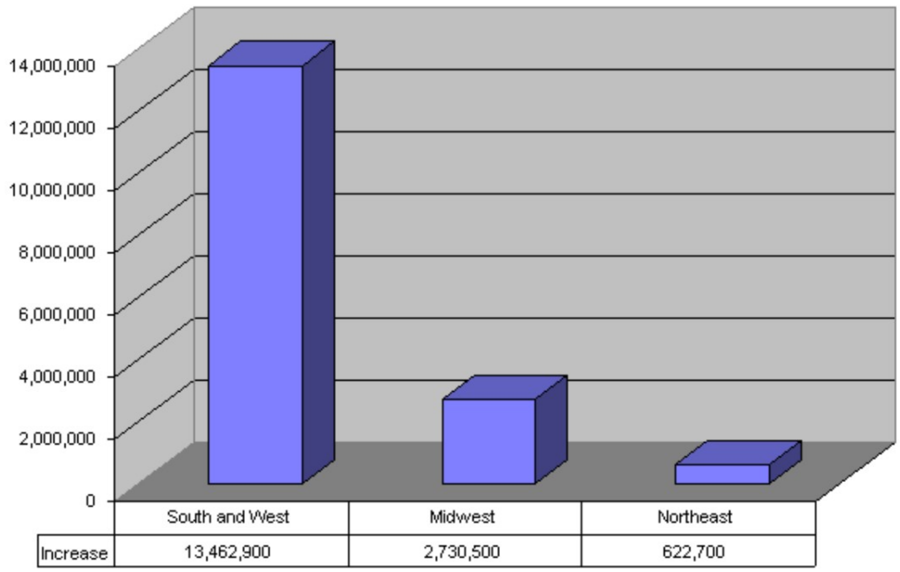

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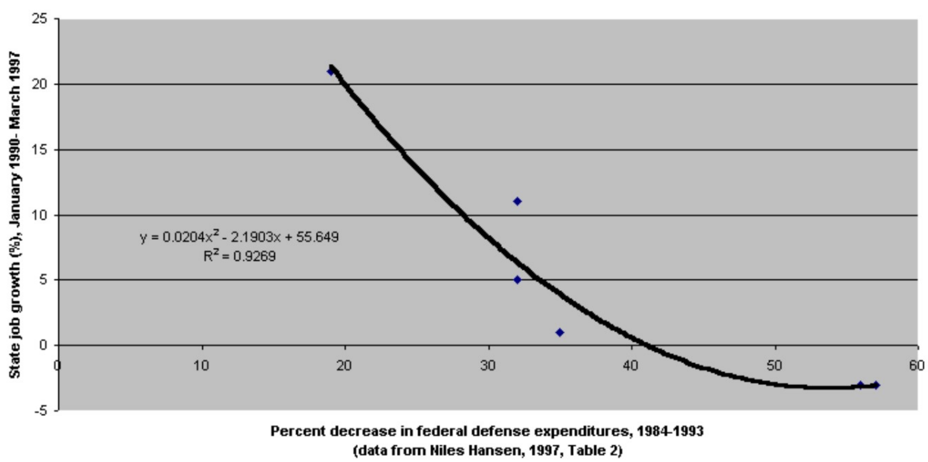
FIGURE 6. DEFENSE CUTBACKS AND STATE JOB GROWTH IN THE 1990s
(Descending: Texas, Missouri, California, Massachusetts, New York, Connecticut)



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Nevertheless, by the beginning of 1997 the state and regional job picture had reached a new stage, in which, for example, Massachusetts would add employment at about the national rate. By that point the Northeast had ridden out its various shocks, and the region's strengths in finance, health care, and software gave it a new lease on growth.

MACRO VIEWS (D): NEW DEMOGRAPHICS, NEW POLITICS?

Some 90% of the growth in the U.S. population since 1970 has registered in the states of the South and West. Each state has two U.S. senators, of course. But by the doctrine of "one man, one vote," the Constitution requires reapportionment of the House of Representatives every 10 years to reflect the changing distribution of the population.

Both regional and city-suburban shifts thus require a redistricting after every census. The result is to redistribute power from older cities and from the Manufacturing Belt—which as late as 1980 accounted for half of the House of Representatives. Since the Electoral College (which technically determines the outcomes of presidential elections) reflects congressional redistricting, presidential politics are at stake as well.

We offer now a brief overview of regional population shifts, after which we return to the question of how they change the nation's political environment.

REGIONAL POPULATION SHIFTS: A PRIMER

A valuable checkpoint for state population trends is a Census Bureau news release posted on the last day of 1998 as an update on the 1990s. It features two maps of population changes by state, one for 1990-1998, the other for 1997-1998. These are classic examples of what good maps can do. They show patterns that the numbers for individual states do not. And they allow quick visual comparisons of how the most recent year (1997-1998) aligns with or differs from the 1990-1998 pattern. You can compare the two maps now by going to the site and clicking each in turn.[1]

The 1990-1998 map shows most of the states in the South and West growing faster than the U.S. average of 8.7%. Most of the states in the Northeast and Midwest are growing more slowly. The slow-growth region sweeps from Maine to Oklahoma and up to North Dakota, which (like Connecticut and Rhode Island) actually declined. Anomalies are slow-growth Louisiana and brisk New Hampshire.

Now compare the pattern for 1997-1998. Relative to the U.S. average (as it happens, 1.0%), the basic regional pattern is unchanged. But now, for example, Alaska, Washington, and Oregon are closer to the average, and California has surged ahead. On the downside, Pennsylvania and West Virginia lost population in the most recent year.

Why, then, do the states of the South and West typically add population faster than those elsewhere? Without getting into deeper chicken-and-egg theories of job-seeking vs. amenities-induced migration, we can take a quick look at the definitional components of population growth.

For the nation as a whole, by definition

(E.1) Population Growth=the Natural Increase (Births − Deaths) + Net Immigration

Click on item 2 of the news release, State Population Estimates and Demographic Components of Population Change: April 1, 1990 to July 1, 1998. The first row shows that the U.S. population rose 21.5 million to 270.3 million between 1990 and 1998. The increase of 21.5 million=(32.9 million births − 18.6 million deaths) + 6.7 million net foreign immigrants. (The discrepancy of .5 million reflects the unlisted net gain as a result of returning U.S. military and government employees from abroad during the year.)

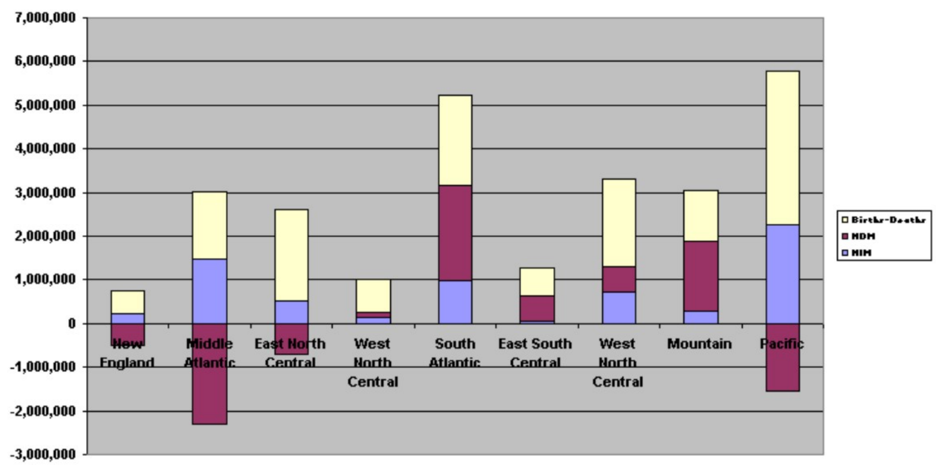
The U.S. thus adds nearly a million people a year through legal (and illegal) immigration. This, plus the higher birth-rates among recent immigrants (especially Hispanics), is what gives the U.S. higher rates of population growth than Japan or Europe.

For states and regions, we have to add domestic migration. To see why a state or region is growing at a higher or lower rate, find the natural increase (births − deaths) and then add the two migration entries. The first, as for the U.S., is NIM (net international migration). The second is NDM (net domestic migration). In practice, domestic migration has for a long time tilted the population increasingly away from the Northeast and Midwest, to the South and West.

[1] Because the press release is no longer available, these maps are no longer viewable, but similar maps can be found in more recent Census Bureau reports. In the remainder of this book similar problems exist, but instead of deleting accompanying text, we have simply removed links that are no longer active.

The effects of net domestic migration flows can be seen visually in FIGURE 7. For each of the 9 divisions you can scan the role of foreign and domestic migration. (Every division had a positive natural increase, births - deaths.) Four of the divisions lost migrants to the rest of the U.S., as indicated by their “below-the-line” bars in the chart.

FIGURE 7. COMPONENTS OF POPULATION CHANGE BY DIVISION, 1990-1998



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We can compare two divisions on the East Coast that had offsetting numbers of domestic migrants. The Middle Atlantic division attracted 1.5 million net foreign migrants but lost 2.3 million people to other U.S. regions. Its natural increase, 1.5 million (=4.5 million births – 3 million deaths), was therefore reduced by over .8 million net migrants out of the region. All in all, its net increase in population was less than 700,000, for a population growth rate of only 1.8%.

As an example of a fast-growing division, the South Atlantic (which includes Florida and North Carolina) added 5.4 million people, for a rate of 12.3%. The increase consisted of a natural gain of 2.3 million, plus net foreign immigration of 1 million, plus 2.2 million in-migrants (job-seeking and sun-seeking both) from other parts of the U.S.

In the far West, a similar comparison might be drawn between the Pacific Division, dominated by the flight from California in the early 1990s, and the Mountain states. Visually (just as with the Mid-Atlantic and South Atlantic divisions), the number of domestic out-migrants from the Pacific was roughly matched by the number of domestic in-migrants to the Mountain states.

California aside, these tendencies are broadly similar to the prior two decades, the 1970s and 1980s. A fuller treatment of population growth by state and region is in the Statistical Abstract of the United States 1998. Using the Adobe Acrobat reader provided there, you should move to Table 29, p. 31, “U.S. Resident Population, by Region and Division: 1970 to 1997.”

There you find that from 1970 to 1997 the U.S. population grew by 64.3 million, an increase of 32%. (Owing to legal and especially illegal immigration, the rate is noticeably higher than in Europe or Japan). Less than 10% of the 64.3 million additional people registered in the Manufacturing Belt: New England, the Mid-Atlantic, and the East North Central divisions. Over 90% of the increase in the U.S. population between 1970 and 1997 occurred in the South and West.

That brings us back to the politics of demographic realignments.

POWER SHIFTS

As early as 1969, the Republican theorist Kevin Phillips titled his book on electoral demographics, *The Emerging Republican Majority.*Before the reapportionment required after every decennial census, the 1980 delegation from the North in the House of Representatives was 225 (or 50% of the 450). It fell to 208 in the 1980s, and again to 193 after the 1990 census. By no coincidence, virtually every major committee in the House is chaired today by a Republican from the South or West.

Population shifts count ideologically because most states in the South and interior West are more conservative than most states in the North, the Manufacturing Belt. The South and interior West were historically less urban and industrial and today remain attached to rural and conservative values. In general, new residents not only add to a growing state's electoral count but also tend to acquire the political coloration of the new environment.

The thesis that the South and West hold decisive power in choosing presidents was formulated again in 1975. In a prescient glimpse of the Reagan Revolution yet to come, Kirkpatrick Sale wrote that the U.S. was experiencing its fifth fundamental political *Power Shift:*

- . . . first [was] the consolidation of federal control at the turn of the eighteenth century,
- . . . second. . . the introduction of Jacksonian democracy in the early nineteenth century,
- the third. . . the expansion of Northern industrialism after the Civil War, and
- the fourth [was] the establishment of Rooseveltian welfarism in the 1930s.
- The rise of the Southern Rim marks a fifth.

As a geographic concept, the "Southern Rim" may have missed the mark, but modified to the "South and West," Sale's thesis hits the target. Six successive elected presidents spanning the last 9 elections have hailed from outside the North.

Not that the regional pattern implies a one-party presidency. As Jimmy Carter and Bill Clinton proved, centrist or new or Third-Way Democrats can still get elected president. But the geographical dispersal of people and power forces Democratic candidates for president to the center of the political spectrum.

THREE ECONOMIES?

A struggle among three spatially overlapping but ideologically distinct economies has been provocatively sketched out by David Friedman, who directed the New Economy Project in California in the mid-1990s. In Friedman's words, the innovative, bureaucratic, and provincial economies display the tensions that exist between the new and old economies:

The wired [innovative] economy. The densely packed concentration of entrepreneurs and companies in America's urbanized states that generate virtually all the nation's globally competitive, high-wage industries, such as multimedia,design, software, entertainment, computers, biomedical, engineering, finance, and business services.

The Kluge [bureaucratized] economy. Slang for Rube Goldberg-like computer code that barely, if ever, achieves its purpose, the Kluge describes the economy of major media, public-sector bureaucracies and universities that dominates urban politics.

The provincial economy. The rapidly growing Southern and Intermountain Western regions of the country that now dominate national politics. (Quoted from Friedman, "The Fate of a Nation," *Los Angeles Times*, August 20, 1995, p. M1.) Regionally, both the wired and Kluge economies are centered in the urban, high-wage states of the Manufacturing Belt. These industrialized states have nearly half the nation's employment, about one-sixth of which is in the opinion-defining core bureaucratic sector: government, education, and social-service activities.

The provincial economy, in Friedman's view, occupies the South and Mountain West. It accounts for about 35% of the workforce. Despite its rapid-growth image, on the whole it specializes still in slower growing industries and the footloose incomes of, for examples, retirees.

As to party realignments, the party of the bureaucratized economy is the Democrats and that of the provincial economy is the Republicans. The innovative economy (as in the Tofflers' Third Wave model) has no clear alignment but tends to prefer Republicans as noninterventionist.

Within this imaginative (if oversimplified) framework, geographical dispersal plays a key political as well as economic role. On the one hand, the urban underclass remains concentrated in the Manufacturing Belt and in such dispersed cities as Los Angeles and Atlanta. On the other hand, the job-generators in the innovative economy can escape the political hostility and regulation of the core's bureaucratized players by heading for greener grass elsewhere.

As these comments suggest, population shifts are also reshaping the political process on another axis, not only away from the long-industrial states of the North, but from cities to suburbs. The combination of regional and suburban realignments is the subject of a 1998 policy memorandum by two consultants to the Democratic Party.

CITIES, SUBURBS, AND NEW REALITIES.

In "Five Realities that Will Shape 21st Century Politics," William A. Galston and Elaine C. Kamarck view the future of the Democratic Party through the prism of demographic and geographic change. For brevity, the five realities are synopsized here.

(1) "The New Economy Favors a Rising Learning Class over a Declining Working Class." The new economy holds new realities for party politics, away from class-based legacies of the New Deal. The new key determinant of economic position is family structure. Unions have shrunk so much that they are no longer pivotal. "In the Information Age political power will rest on the ability to compete in the marketplace of ideas" (p. 10).

(2) "The New Deal Generation Gives Way to the Skeptical Generations." Whereas the New Deal generation saw government as a solution to the problems of the industrial age, and Baby-Boomers have mixed emotions based on Watergate and Vietnam, the formative Generation-Xers hold the key to the future. They are even more skeptical than Boomers, because they have come of age in a time of economy insecurity, in which government seems as much a problem as a solution. In their view, "large-scale politics is a blunt and ineffective instrument for addressing key social problems. . . ." (p. 13.) But they can be recruited to programs for education and the environment.

(3) "Power Continues to Shift from the Cities to the Suburbs." The key comparison here is that 25 years ago, "there were roughly equal numbers of urban, suburban, and rural districts in the U.S. House of Representatives. Today, suburban districts outnumber urban districts by more than 2 to 1, and rural districts by almost 3 to 1" (p. 14). If the Democrats want to find a demographic power-base comparable to the cities in the New Deal, it will have to be the suburbs, where relevant issues will be education, crime, sustainable development, and the environment (p. 16).

(4) "More Children from More Diverse Backgrounds Will be Concentrated in a Shrinking Percentage of Households." The paradox that comes out of changes in family structure is this: "The needs of children will be increasingly central. . . but the percentage of families with minor children will continue to shrink" (p. 17). In other words, there will be an empathy problem on the part of the majority of the electorate.

(5) "A New Diversity Brings the Challenge of National Identity Politics." Whereas the old politics were about black/white divisions, immigration is changing the picture. From an immigrant low-point in the 1960s, today 11 percent of the population is Hispanic and another 3 percent Asian by birth. (This combined share of the foreign-born exceeds the African-American share, 12 percent.) Such tendencies are likely to accelerate. The challenge will be so appeal to the American Dream as a unifying message to offset the politics of ethnic identities.

2. MICRO VIEWS: NEW ECONOMY, NEW FIRM?

To sum up our exploration so far: the macroeconomic debate over a new economy is about changes in growth-inflation tradeoffs in the macroeconomy. A number of skeptical top economists (Krugman, Blinder, or Brad DeLong, for example) hold fast to what might be termed The Casablanca Rule: "The fundamental things apply, as time goes by." On the other hand, Fed Chairman Alan Greenspan, no fad-chaser himself, is a convert to the idea of a new economy.

Our topic now is the "new firm" and its regional coordinates. As background, let's take a light look at the 1998 *Forbes Magazine* list of the 400 richest people in the U.S. (TABLE 3.) This list is largely a creature of stock-market valuations at any given month or year, since truly monumental fortunes (the ones denominated in billions) in the U.S. nearly always reflect ownership of large corporations. (To see which stocks have most enriched the *Forbes* 400 recently, check The Forbes Forty.) The 1998 list appeared in the October 12 issue, when the stock market was in a temporary slump. Still, and allowing for these and other vicissitudes in the wealth estimates, the top ranks of the list tell quite a story about the American economy in the late 1990s.

TABLE 3
FORBES MAGAZINE'S ESTIMATES FOR THE 15 RICHEST AMERICANS IN 1998

	($billion)	*(Affiliation)*	*(Residence)*
1. William H. Gates III	58	Microsoft	Bellevue, Washington
2. Warren Edward Buffet	29	(Independent)	Omaha, Nebraska
3. Paul Gardner Allen	22	Microsoft	Mercer Island, Washington
4. Michael Dell	13	Dell	Austin, Texas
5. Steven Anthony Ballmer	12	Microsoft	Bellevue, Washington
6. Alice L. Walton	11	Wal-Mart	Rogers, Arkansas
7. Helen R. Walton	11	Wal-Mart	Bentonville, Arkansas
8. Jim C. Walton	11	Wal-Mart	Bentonville, Arkansas
9. John T. Walton	11	Wal-Mart	Durango, Colorado
10. S. Robson Walton	11	Wal-Mart	Bentonville, Arkansas
11. John Werner Kluge	10	Metromedia	Charlottesville, Virginia
12. Barbara Cox Anthony	7	Cox Coms.	Honolulu, Hawaii
13. Anne cox Chambers	7	Cox Coms.	Atlanta, Georgia
14. Gordon Earl Moore	7	Intel	Woodside, California
15. Sumner Redstone	6	Viacom	Newton, Massachusetts

Source: Eric R. Quinones, "Forbes 400 Richest Include 189 Billionaires," Boston Globe, 28 September 1998. (Corporate affiliations have been added by the author.)

For one thing, the top 14 people on the list all live outside the Manufacturing Belt. In general, there are no old-fashioned smokestack industrialists among the top 15 (and not many among the top 50). True, the 15th member of the list, Sumner Redstone, is from Newton, Massachusetts, but he is a media magnate (his Viacom owns Paramount, UPN, MTV, and Blockbuster Video), not an industrialist or denizen of Route 128. Except perhaps for John Werner Kluge (founder of Metromedia and developer of the nation's largest cell-phone network in the 1980s), the top 14 appear to live in the regions where their fortunes originated. (Barbara Cox Anthony's came from Cox Communications, an Atlanta media company; she lives in Honolulu.)

These fortunes emanate from I.T., Wal-Mart, and media. (Warren Buffet, the investor, is a possible exception; it would depend on his portfolio.) Five of the top15 are high-tech entrepreneurs, from Seattle, Austin, and Silicon Valley. Five are members of the Arkansas Walton family; their vast wealth derives from founding-father Sam Walton's controversial innovations in the organization of retailing. Four (Kluge, Redstone, and the Cox sisters) owe their fortunes to media empires of one kind or another. And one (ranked second with $29 billion) is Warren Buffett from Omaha.

While far from definitive, this list would seem to be consistent with the thesis of a new economy. What are its implications?

- First, the growth sectors of the U.S. economy—at least as perceived and valued by Wall Street—have shifted to new activities.
- Second, there is a preliminary suggestion here of heightened entrepreneurial performance in younger regions.
- Third, it appears that firms (Dell, say, or Wal-Mart) can spring up from nowhere and catapult to great size within the span of a generation or two.

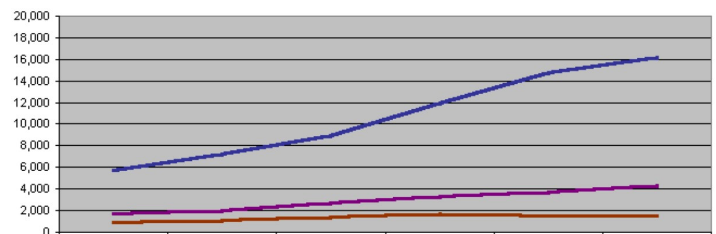
What no such list can tell us is whether something has changed about the firm, i.e., about the organization of production. Beyond management consultants' jargon about reengineering, core competencies, etc., is there a "new firm" spearheading the new economy?

To attack this question, let's first develop an introductory vocabulary on business organization in the U.S. in the 1990s. Then we can turn to a related but different topic of how firms influence the adaptations of their home regions to changing environments. We'll conclude our inquiry with a look at the notion of the network enterprise, as defined by Manuel Castells (1996).

HEADCOUNT

There were about 22 million companies (in Section 17, "Business Enterprise," of the *Statistical Abstract*) in the U.S. in the mid-1990s. (FIGURE 8.) One way to look at their makeup is in terms of the three forms of business organization described in introductory economics textbooks. These are (1) the proprietorship (a single owner), (2) the partnership (two or more owners), and (3) the corporation. As a matter of sheer numbers, the proprietorship dominates, accounting for some 16 million companies in 1994. (FIGURE 9.) Next come some 4 million corporations, a number swelled by the large number of small professional practices (doctors or accountants) incorporated for tax reasons. Third, partnerships number another 1.5 million. (These data are based on tax filings, which is why they are a few years old before they reach the *Abstract.*)

FIGURE 8.
U.S. COMPANIES BY TYPE, 1970-1994
(000)



	1970	1975	1980	1985	1990	1994
Proprietors	5,770	7,221	8,932	11,929	14,783	16,154
Corporations	1,665	2,024	2,711	3,277	3,717	4,342
Partnerships	936	1,073	1,380	1,714	1,554	1,493
Total	8,371	10,318	13,023	16,920	20,054	21,989

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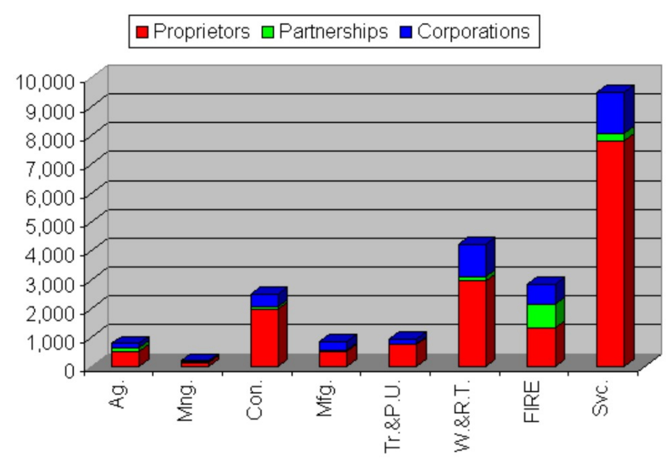
FIGURE 9. U.S. COMPANIES BY SECTOR (000) IN 1994



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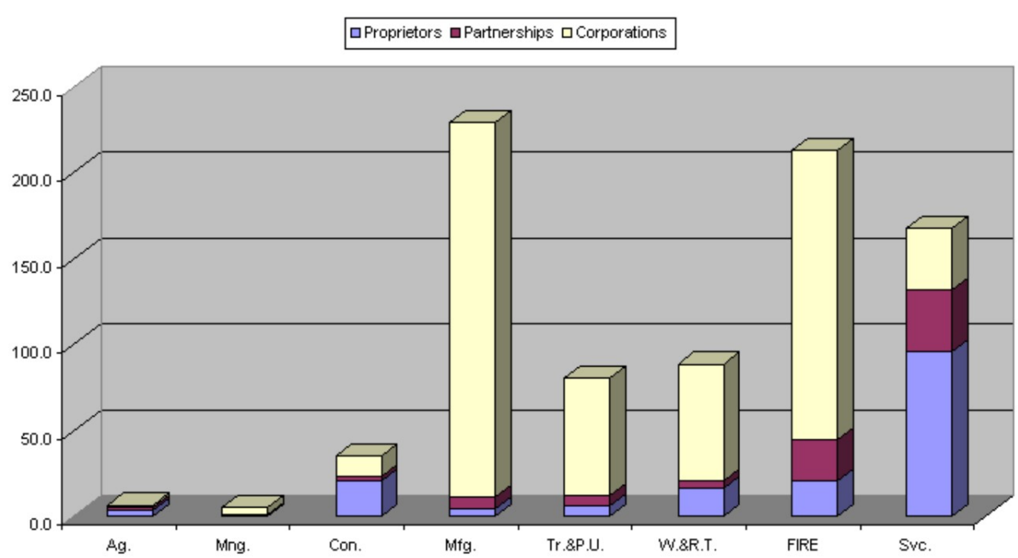
One can also describe the population of firms in terms of market structure, i.e., as examples of monopoly, perfect competition, oligopoly, or monopolistic competition.

- The **competitive** firm (selling a standardized product, in an industry with free entry and many sellers) can hardly be found outside agriculture, where small firm size and a standardized product are still observable.
- The **monopoly**, the only seller of a particular product (e.g., the local cable company or, allegedly, Microsoft), is observable but numerically rare.
- More common are **oligopolies**: firms in industries dominated by only a few sellers (because capital requirements make entry difficult) such as the U.S. auto industry or laundry detergents. Roughly speaking, these are the firms on the Fortune 500 list, or any such tabulation of the nation's largest firms.
- Nevertheless, what economists classify as **monopolistic competitors** are overwhelming the most numerous types of business organization, encompassing not only virtually all proprietorships and partnerships, but most corporations as well. These are firms like restaurants or laundries that are in industries easily entered (because it doesn't take much capital to get started), and in which each firm is somehow differentiated if only slightly (and often by its location) from its competitors. That is, it faces a downward sloping demand curve: it can raise prices without losing all its customers.

Putting it differently, most of the 22 million companies in the economy are proprietorships, 99% of them engaged in monopolistic competition. Because firms in this category are subject to competition from new entrants, profits seldom get too far above the amount required to cover the opportunity cost of capital, i.e., to keep the firm afloat. Moreover, this is where the rapid growth in the number of firms has occurred in the 1990s, for reasons both positive (opportunity) and negative (necessity). Needless to say, the failure rate is also high.

But what about the other representative category, not small business but Big Business? One way to put big business in perspective is to look at the profit (net income) figures, which are dominated by a relatively small number (fewer than 5,000, say) of corporations in (1) manufacturing, and (2) finance, insurance, and real estate (FIRE). (FIGURE 10.) In 1994, these relatively few corporations had over two-thirds of the $550 billion in total business profits in the U.S.

FIGURE 10. BUSINESS PROFITS (BILLIONS OF $) BY SECTOR, 1994



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The upshot, as a first approximation, is that we live in a dual economy of millions of small firms (a relative handful of which will become large) and a few thousand large corporations. More will be said as to how this duality plays out spatially, but for now we can settle for a comparison of large and small firms in the resurgent Rust Belt and in defense-dependent California.

HOW REGIONS ADAPT: THE MIDWEST AND CALIFORNIA IN THE 1990S

Conceptually, we can think in terms of three channels of change open to any region that has been hit by adversity (and that means every region, from the Midwest in the 1970s to Texas in the oil-bust 1980s to California in the early 1990s). To wit:

- Established firms in stable or declining industries can do the same thing as before, only better, to claim a larger share of a fixed or shrinking pie.
- Established firms can convert to new, faster-growing product lines.
- New firms can do new things, and small firms can grow rapidly.

The Midwest comeback in the 1990's illustrates the first process—which is rare! The region's resurgence flows from agriculture and a reinvigorated U.S. auto complex, led by the traditional (post-makeover) Big Three. As with half the nation's regions, the Upper Midwest experienced minimal dislocations from defense cutbacks after 1989, simply because they had benefited less from defense spending during the Cold War. In part for this reason, the erstwhile Rust Belt has actually matched the U.S. average in job growth (15%) during the 1990s, adding 2 million jobs.

At first blush, the story of the Midwest comeback is "the more things change, the more they stay the same." But things are not entirely the same, as explained in "The Midwest Turnaround: Internal and External Influences," by William Testa, Thomas Klier, and Richard Mattoon, three researchers engaged in a project on the Midwest comeback done at the Federal Reserve Bank of Chicago. In particular, while the Midwest in 1996 had four more auto plants (31) than it had had in 1979, the increase masked the closing of 9 plants and the opening of 13 others.

The technologies and organization of the workflow in the new plants bear little resemblance to what had gone before. The region's watchword today is lean manufacturing. In other words, the comeback took place only after an agonizing restructuring over the past generation, as marked in part by the adoption of Japanese techniques and practices. The result is to extend the earlier recoveries of New England and the Mid-Atlantic divisions to the western end of the old core, the Manufacturing Belt.

CALIFORNIA: CONVERSION VIA REALLOCATION OF TECHNICAL TALENT

California poses a direct test case of how a regional economy adapts to the sharp downsizing of some of its largest companies—in this case, defense cutbacks after 1989. Did existing defense firms shift to new product and service lines, the second channel of conversion? Or did conversion require new firms and the expansion of firms in other sectors, the third possibility?

In "California's Recovery and the Restructuring of the Defense Industries," Luis Suarez-Villa analyzes the state's surprisingly strong mid-decade rebound from the doldrums of the early 1990s. How important was "defense-conversion" in fostering that recovery? He concludes that it wasn't a factor. "Rather, California's recovery was a product of the upswing in the national economy, which boosted demand for many of the state's products, and of the rise of many small and medium-sized firms in a few... very dynamic sectors...." The growth-industries included civilian high-technology, wholesale trade, the film industry, and producer services.

The level at which "conversion" occurred in California was therefore less within defense firms than via the market-based recycling of technical talent from defense companies to more entrepreneuerial firms. This process is symbolized by California's striking share (25 percent) of all the nation's firms that doubled in size between 1989 and 1994. In general, such firms are known as gazelles.

Suarez-Villa concludes that conversion occurred not within firms but through the rise of new enterprises and the expansion of existing non-defense sectors. What may look like conversion at the level of the firm is typically some constructed mix of downsizing, mergers, and acquisitions.

Instead, conversion occurs as workers are released from downsized defense firms and re-employed in expanding (civilian) activities. In this process, entertainment employment in Los Angeles over the past decade has expanded rapidly enough to offset losses in the area's defense sector. More specifically, some high-skilled workers released from defense activities wound up finding high-paid jobs in the entertainment sector.

The conclusion? The links between companies and regions are diverse and not easy to summarize. From this comparison, it is tempting to conclude that "big is good, and small is good, too." On the other hand, there are deep and rich literatures that explore the connections between companies and regions, today and in the past, in the U.S. and in other nations. We return to this topic in Part C, Strategic Cities.

What can be said at this point is that companies of all sizes and in all locations are going through changes that reflect breakthroughs in communication technology.

THE GOSPEL ACCORDING TO MANUEL

> "A new economy has emerged in the last two decades on a worldwide scale."
> (Manuel Castells, 1996, p. 66.)

Perhaps the most influential guru of the new economy among scholars (especially non-economists) is Manuel Castells, a Berkeley sociology professor born in Barcelona in 1942. Following a 1989 book, *The Informational City*, Castells has written a massive trilogy between 1996 and 1998 on *The Information Age: Economy, Society, and Culture.* Volume one is *The Rise of the Network Society.* It lays out a worldview and describes "the information technology paradigm." And it contains long chapters on "the network enterprise" and "the space of flows" (i.e., as distinct from "the space of places").

Castells' logic and rhetoric are traditional, though not quantitatively analytical. (In other words, the numbers are used to illustrate, but they don't prove anything.) Without claiming to do justice to the range and ambition of Castells' magnum opus, I will sketch out the main lines of his argument on the new firm here.

In a nutshell, the new firm is the Networked Firm. As such, it is neither small nor large, neither start-up nor corporate, neither digital nor industrial. Instead, it can be any combination of the foregoing, provided it uses computer networks to adapt and compete.

FRAMEWORK: THE INFORMATION TECHNOLOGY PARADIGM

Castells offers a framework for "the material foundation of the informational society" (p. 61). The key features he lists refer not to all the influences the new technologies exert upon society, but only to economic factors, "the material foundation." Five characteristics define the information technology paradigm:

- In contrast to earlier technological revolutions, this one is about technologies that "act on information."
- Since information is a part of all human activities, all aspects of life are affected.
- Any system or organization using information technologies has a network logic, a logic which in turn has become more powerful because of computers.
- The paradigm is accordingly based on the flexibility that networks provide. As he puts it, "Turning the rules upside down without destroying the organization has become a possibility, because the material basis of the organization can be reprogrammed and retooled" (p. 62).
- The fifth property is the technological convergence of such formerly separate sectors as computers, telecommunications, and biology.

The information-technology paradigm, writes Castells, is informed by (but not the same as) "complexity theory." The descendant of the "chaos theory" of the 1980s, the complexity school is centered in the Santa Fe Institute, which derives from the nuclear laboratories at nearby Los Alamos, New Mexico (now in the news for an espionage story linked to China). A hallmark of complexity theory is its focus on how simple systems in nature and in the economy generate spontaneous order, i.e., operate as self-organizing systems. Putting it differently, a broader school of thought links not only (1) complexity, but also (2) fractals (self-replicating geometric patterns in nature, as in the leaves of a tree), (3) self-organizing systems, and (4) emergent computation. In any case, as a perspective for understanding diversity, complexity theory has a part in

Castells' paradigm—whose defining qualities he lists as "Comprehensiveness, complexity, and networking" (p. 65).

By way of distancing himself from the morality of the new information technologies, Castells concludes this discussion of his organizing framework with a famous maxim from the technologist Melvin Kranzberg. 'Technology is neither good nor bad, nor is it neutral.' (Kranzberg, 1985, p. 50, emphasis in Castells, p. 65.)

THE NETWORK ENTERPRISE

> "Networks are the fundamental stuff of which new organizations are and will be made."
> (Castells, p.168.)

Castells also posits a "new organizational logic." This he sees as common to all organizations, whereas their contexts may vary with circumstances and cultures. In his view the 1980s saw a "recapitalization of capitalism" (p. 85) that restored the preconditions for investment that capitalist economies require for growth. One hallmark was the much-heralded "transition from mass production to flexible production, or from 'Fordism' to 'post-Fordism' " (p. 154). Another is the "crisis of the large corporation, and the resilience of small and medium firms [SME's]. . . ." (p. 155). A third is a new style of management, most evidently around the Japanese practices that reduce uncertainty by opening up communication between workers and management, and between suppliers and customers.

In addition, three other sets of arrangements that give firms new flexibility derive from networks. One concerns a variety of networked relationships among SME's. Another encompasses the various practices large corporations use to subcontract and license production to smaller firms. Finally, a sixth arrangement is the "intertwining of large corporations in. . . strategic alliances" (p. 162).

From all this emerges the horizontal corporation. The organizational innovations just listed can be understood is as a response to the crisis of the bureaucratic, hierarchical corporation—the corporate dinosaurs decried in the late 1980s and early 1990s. Nor is the horizontal corporation necessarily "lean and mean," since it became clear in the 1990s that "large corporations had to become primarily more effective rather than more thrifty" (p. 164).

Instead, the meaning of the horizontal corporation within what Castells terms the informational/global economy is as a "network enterprise." Following the French theorist Alain Touraine, Castells distinguishes here between static and evolving organizations. The first type has as its goal self-reproduction. In the second type, the organization's goals lead to endless structural changes. "I call the first type of organizations bureaucracies; the second type enterprises" (p. 171).

DIGITAL DIVIDE

Many observers have believed that a developed capitalist economy tends to slow down and even stagnate over time. In that context, a "new" economy becomes a welcome thing. In hindsight, however, it turns out that new economies have emerged in the U.S. and world economies about every half-century or so. Today's New Economy, in other words, is one of a progression of new economies over the past two centuries, beginning with the high Industrial Revolution in Britain in the late 1700s.

In that light, the issue becomes, what does this new economy replace? What was the Old Economy? We might jot down a working list of some of its stylized features:

- The vertically integrated corporation, mass-producing goods within the U.S.
- Political party coalitions forged in the New Deal.
- A hyper-industrial Manufacturing Belt, shipping goods to other U.S. regions.
- After 1950, a mainframe culture: big computers in big organizations.
- A military-industrial complex.

And we might assign it a life-span of 50 years, from the beginning of World War II in Europe (1939) to the end of the Cold War (1989).

A COLD-WAR ECONOMY?

A diverse tradition in the history of economics concluded that advanced capitalist economies inevitably tend to stagnate. Stagnationists like the Marxists Paul Baran and Paul Sweezy and the Keynesian Alvin Hansen (who all witnessed the transition) may well have viewed post-World War II America as a case in point. From 1939 to 1989, military spending justified both (1) Keynesian budget deficits and (2) an implicit technology or industrial policy. Pump-priming there was, along with any number of infrastructure and RD projects justified in the name of national security.

The cold-war economy was without question a new stage of American economic development. For example, President Eisenhower was elected in 1952 on a pledge to end the Korean War—which he did in 1953. But the arms budget grew relentlessly anyway through the 1950s. Alarmed by this unprecedented "peacetime" build-up, Eisenhower uttered a famous warning on leaving office in 1961:

> The conjunction of an immediate military establishment and a large arms industry is new to the American experience. . . . In the councils of government, we must guard against the acquisition of unwarranted influence. . . by the military-industrial complex . The potential for the disastrous rise of misplaced power exists and will persist. (Dwight David Eisenhower, 17 January 1961, in T. Augarde [Ed.], *The OxfordDictionary of Modern Quotations* [London: Oxford University Press: 1991], p. 73.)

Hence stagnationists might well have concluded that the Great Depression of the 1930s marked the end of the private economy's capacity to grow steadily on its own.

And it is true that today we tend to forget the shock to the economic system that ensued with the end of the Cold War. After the post-Vietnam retrenchment, the Reagan arms build-up of the mid-1980s had given new life to the military-industrial complex. But between 1987 and 1995 defense spending fell from 6.4 to 3.9% of GDP. In those same years the U.S. lost over a million well-paid, defense-related jobs: more than one in three. Hard-hit though a few key states, were, however, by the mid-1990s the transition was complete. The proof? Today's unemployment rates below 5% in every region.

What happened to make the economic exit from the Cold War relatively smooth? A partial answer is that the private sector was more resilient than many had thought. In particular, a new core sector had been forming for some time, one capable of driving the economy to a subsequent basis for expansion.

INFORMATION GOODS AND THE NEW ECONOMY

In a 1989 essay, "The Triumph of Capitalism," Robert Heilbroner, perhaps the best known American historian of economic thought, declared the stagnation thesis dead. "The long-term process of expansion has bypassed saturation by discovering or creating new commodities." (Heilbroner, quoted in Jonathan Schlefer, "Making Sense of the Productivity Debate," Technology Review, August/September 1989, p. 33.)

What were these "new commodities," so powerful that they could swamp any tendencies the economy had toward stagnation? Today, of course, the answer is obvious. They were information goods, old and new, that can be digitized.

But how have such information goods become so prominent in the economy? The answer entails three landmark events: the invention of the microprocessor in 1971, the introduction of the IBM PC in 1981, and the commercialization of the Internet in 1994.

For purposes of understanding the transition of the 1980s, in which the old economy expired and the new one gathered its forces, we can focus on 1981.

THE PC REVOLUTION

Before that year there were three major technology industries: mainframe computers, electronic components, and medical instruments. These, plus a few other activities employing high proportions of scientists and engineers, used to constitute the "high tech" sector of the economy. The market for computers per se had only two components. Fortune 500 companies used big computers to compile databases for customer billing and employee records. The federal government (where the Defense Department and NASA relied on mainframes and supercomputers for military and space programs and the Census Bureau kept counting) was the other.

The IBM PC broadened the market from corporations and the federal government to include all manner of businesses, large and small, and households as well. The definition of I.T. changed accordingly.

> Today, due in large part to that one significant product introduction in 1981, virtually every person, company, and government is a customer for technology products. The definition of technology industries has expanded from large computers to include personal computers, software, semiconductors, semiconductor equipment, communications (both telecommunications and data communications), and medical technology (biotechnology and medical devices). (Michael Murphy, 1997, p. 47.)

In this view, the information technology sector today has seven components:

(1) large computers,

(2) personal computers,

(3) software,

(4) semiconductors,

(5) semiconductor equipment,

(6) communications, and

(7) medical technology (biotech and instruments).

What was so revolutionary about the personal computer? The microprocessor, as put to use in the Apple II and then the IBM PC, carried the world from an analog to a digital mode of representing ideas (language, numbers, images and sounds). Five basic ingredients in this change are

- **Digitization**
- **Moore's Law**
- **A law of increasing bandwidth**
- **Metcalfe's Law**
- **Packet-switching**

What is new to the Information Age, in other words, is the ability to do things in a digital way. (This elegant formulation is explained in The Big Picture, a web site and CD-ROM that provides a tutorial on the digital revolution.) Today, for example, we can sample CD's or videos on the Internet before paying for them, again on the Internet. Why? Because the sounds and images are digitized. For such generalized purposes, mainframes and minicomputers were all but irrelevant, tools from the era of mass production, automation, and top-down bureaucratic management. The coming of the PC thus rendered anything and everything subject to the power of the computer, while retaining the crucial dimensions of human scale, decentralized decision-making, customized design, and creativity.

In that light, it is striking to find that U.S. Commerce Department data (Figure 6 of the on-line version of *The Emerging Digital Economy*) on I.T.'s share of corporate investment in business equipment show sharp jumps after both the PC and the Internet. The data show the I.T. share jumping from about 10 percent in 1979 to 25 percent in 1985 and again with the Internet from about 33 percent in 1994 to 45 percent in 1996. (Department of Commerce, 1998.)

While we are at it, other indicators in the report show similar shifts in the economy toward digitized products and processes. For a quick introduction to the Commerce Department report, *The Emerging Digital Economy*, go to chapter 1, "The Digital Revolution," and check Figures 1-5.

LONG WAVES AS NEW ECONOMIES

And yet, to repeat, this is not the first or even the second or third new economy. On the contrary, and from one point of view, world development unfolds through a succession of "new economies." The roughly 50-year rhythm of the sequence can be seen in TABLE 4. The table is based on a review by Nobel-Prize-winner Simon Kuznets of Joseph Schumpeter's 1939 book, *Business Cycles: A Theoretical, Historical and Statistical Analysis of the Capitalist Process*. The waves labeled "Kondratieff" refer to Nikolai Kondratieff, the great Russian economist of the early 20th-century who first posited and explored such 50-55 year cycles—and died at the hands of Stalin. (Kuznets, "the father of national income accounting" in the U.S., was also Russian-born.)

TABLE 4. LONG WAVES OF CREATIVE DESTRUCTION

1. Industrial Revolution (1787-1842): cotton textiles, iron, steam power
2. The Bourgeois Kondratieff (1842-1897): railroadization
3. The New-Mercantilist Kondratieff (1897-1939): electricity, automobile
4. **The Cold-War Kondratieff** (1939-1989): defense, TV, mainframes
5. **The Information Age** (1989-) PC's, telecommunications, entertainment

Source: Adapted by the author and updated (in the bolded items) from Simon Kuznets, "Schumpeter's Business Cycles," *American Economic Review*, June 1940, p. 257.

The first was the beginning of the Industrial Revolution and the factory system, the second had as its symbol the railroads, the third electricity and automobiles, and the fourth (for the U.S., at least) the military-industrial complex of the Cold War. The fifth wave, the Information Age, is today's new economy. (TABLE 4.)

The series of five "new economies" corresponds in its logic to Schumpeter's theory of creative destruction. In *Capitalism, Socialism, and Democracy* (1942, 1962, p. 83), he wrote that innovation "incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one. This process of Creative Destruction is the essential fact about capitalism" (p. 83). In a footnote, he points out that the years of "comparative quiet" can make us miss out on the longer rhythm:

> These revolutions are not strictly incessant; they occur in discrete rushes which are separated from each other by spans of comparative quiet. The process as a whole works incessantly, however, in the sense that there always is either revolution or absorption of the results of the revolution, both together forming what are known as business cycles. (Schumpeter, 1942, p. 83.)

Strictly speaking, not many economists today view such long waves as technically measurable. Numerous attempts to quantify and measure price and output fluctuations to validate more formal Kondratieff Cycles have proved unsatisfying. But then the same thing is true of "business cycles" of any duration: economists have come to doubt any regular cycle of business fluctuations over time. In any case, in this softer version, as labels for distinct technology regimes through the stages of the Industrial Revolution, long waves seem useful constructs. By this I mean that they can provide a framework for understanding other seemingly autonomous (i.e., seemingly independent or free-standing) changes that catch our attention.

Consider, for example, globalization. One of the organizers of the World Economic Forum in Davos, Switzerland, sees globalization as the hallmark of the 1990s. In turn, globalization in her view awaited the end of the Cold War. When the U.S.S.R. was dissolved in 1991, she says, "That unleashed all the capital and energy that had previously been locked in this global power struggle" (Maria Livanos Cattaui, in Diana B. Henriques, "Sewing a Label on a Decade," *The New York Times*, 4 January 1998, p. C3.)

Fair enough. Globalization seems on the surface to be "what the 1990s are all about." (My phrase, not hers.) But what is it in the 1990s that has stepped up the pace of global communication? As a commentary in *Newsweek* put it in September, "Globalization has become the decade's most overused word. But at its heart, it embodies a real truth: technology has made this a planet of shared experiences." (Quoted by Seth Stevenson, In Other Magazines, *Slate,* September 1, 1998.)

Here we have it. In the 1990s, "Technology has made this a planet of shared experiences." The technology in question is digital.

The next section of the chapter is a case study on the birth of the digital economy, as it unfolded geographically. The theme to be developed now is that the presence of younger regions (regions of creativity, one might say), gave the U.S. geographical sources of rejuvenation not available to its competitors in the world economy.

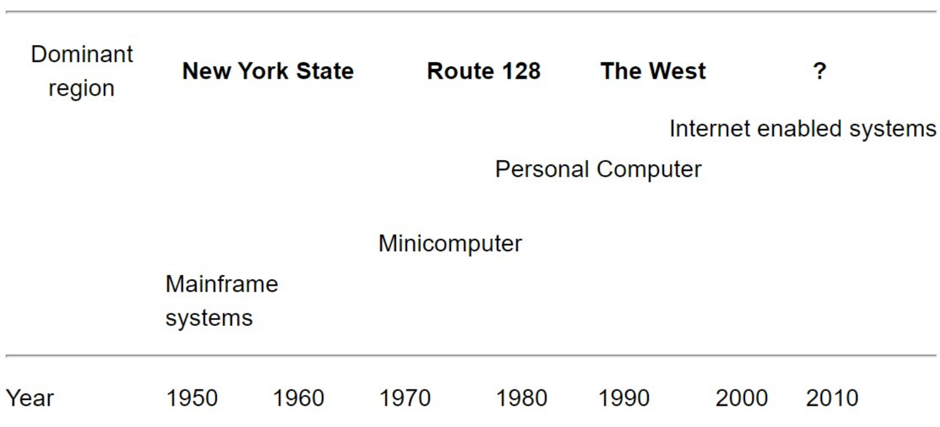
B. THE REGIONAL REVOLUTION IN I.T.: A CASE STUDY

Radical advances in technology can dislodge established regions or nations from the top ranks of wealth and power. In the late 19th century, Britain famously lost its lead to Germany and the U.S. when the key sectors in the world economy shifted from steam power and textiles to electricity and chemicals. Whatever Britain had done right in the earlier era, after about 1870 it was no longer enough to keep the first industrial nation ahead of its newcomer rivals.

Something similar happened within the U.S. when the microprocessor was invented at Intel in 1971. The outcome of that basic breakthrough would be to strike down the established information technology (I.T.) giants of the American Northeast, in favor of younger companies in such western states as California, Texas, and Washington.

As American computing evolved from the mainframe and minicomputer to the and the Internet, the centers of design, strategy, and control that were initially combined at IBM's headquarters at Armonk, New York, scattered far and wide. The sequence of industry stages in FIGURE 11 is from researchers at Morgan Stanley, an investment bank. I have added characteristic home-regions to the mainframe, mini, and PC eras. These are New York State for mainframes, Boston's Route 128 for minicomputers, and the West generally for the PC era. The current stage, Internet-Enabled Systems, began about 1994. Its home-region remains an open question. See Figure 11.

FIGURE 11
REGIONAL ADVANTAGE OVER THE LIFE CYCLES OF MAINFRAME, MINI, PC, AND INTERNET-ENABLED SYSTEMS



Source: Adapted by the author from Morgan Stanley Research Estimates as reported in Mary Meeker and Chris DePuy, *The Internet Report* (New York: Morgan Stanley, 1996), p. I-9.

Our theme is that in the PC era the younger firms in the West revolutionized world computing and in so doing won back a leadership role that was rapidly shifting to Japan. Two quick comparisons help put this idea in perspective:

- The decade after 1987, the period of the unexpected U.S. resurgence vis-à-vis Japan, saw a reversal in the market valuations of America's leading I.T. firms. (TABLE 5.) The West's Intel and Microsoft leapfrogged the Northeast's IBM and DEC (Digital Equipment Corporation). (Norris, 1997.)
- More generally, by a recent ranking 9 of the world's top10 I.T. firms are American, and 8 of the 9 are from the three western states.

TABLE 5. REVERSAL OF FORTUNES AMONG US COMPUTER GIANTS 1987-1997						
Largest U.S. corporations, ranked by market capitalization in billions $						
12 May 1997			31 August 1987			
Value $bn	Company	Rank	Value $bn	Company	Rank	Rank 1997
201	G. E.	1	102	**IBM**	**1**	9
165	Coca-Cola	2	71	Exxon	2	3
148	Exxon	3	57	G.E.	3	1
142	**Microsoft**	**4**	36	ATT	4	21
125	**Intel**	**5**	30	DuPont	5	15
112	Merck	6	29	G.M.	6	33
103	Ph. Morris	7	29	Ford	7	32
90	P.Gamble	8	28	Ph. Morris	8	7
86	**IBM**	**9**	28	Merck	9	6
83	Johnson Johnson	10	25	**Digital Equip.**	**10**	324
Source. Norris (1997). Computer companies in bold.						

This case-study links the American comeback in information technology in the 1990s to the regional realignment that marked the PC era. The module unfolds as follows:

As background, we need to recall how different the world looked a decade ago.

1. THE COMING JAPANESE CONQUEST (ca. 1989)

..."the Japanese have now embarked on "take-lead" strategies they hope will ensure that Japan will inevitably become the undisputed No. 1 in computers. This is a matter of great concern because it is difficult to find an example of any American or European industry that has successfully fought back...where the Japanese have decided to go for leadership." (Tom Forester, 1993, p. 86, emphasis added).

In 1989, Japan gave every indication of pulling away from its technological competitors. The Rising Sun seemed to herald not only a national victory but also an affirmation of the Ministry of Trade and Industry's (MITI's) strategic intervention and of industrial policy generally. A glance at several specific I.T. sectors shows how comprehensive the victory was expected to be.

(1) Semiconductors. Japan had caught the U.S. in its output of semiconductors by 1986, and by 1988 and 1989 it was supplying over 50 percent of the world market. Despite a partial captive market (e.g., IBM producing its own chips for its own computers), "merchant" memory chips for sale in the open market had been largely taken over by Japan.

That left mainly microprocessors for the U.S.—but even this creative side of semiconductor chips was being bought up by Japanese firms. According to M.I.T.'s (the university, not the Japanese ministry) *Made in America*, "Without some dramatic realignment of the American merchant industry, its decline is likely not only to continue but to accelerate." (Michael Dertouzos et al., 1989, p. 261.)

(2) Computers. The shift from desktop microcomputers to portables seemed to signal a shift toward Japanese leadership. The flat screens in laptop and palmtop computers had liquid-crystal-diode (L.C.D.) displays, a Japanese strength. (This was also another example of a U.S. discovery—at R.C.A. in 1963—which only the Japanese had seen fit to commercialize, for use on digital watch faces and video games). Hence the evolution of the industry toward laptops was thought to help Japan. Charles H. Ferguson thus wrote, "Some say: 'Japan will make the commodities and the U.S. will profit from design, software, and marketing.' This is fantasy." (1990, p. 66.) His prescription: U.S. government-industry consortia along Japanese lines.

(3) Software. Even in software, the Fifth Generation project (artificial intelligence, or AI) Japan initiated in 1982 was still being touted as a locomotive coming through the tunnel. This was the accepted outlook despite Japan's language and other handicaps in software. If MITI could make it happen in VCR's, the prevailing view then intoned, why not software too?

(4) HDTV. In 1989 lobbyists for a U.S. high-definition television (HDTV) effort to counter Japan's were making major inroads within the Executive Branch of the federal government. They converted Robert Mosbacher, the Secretary of Commerce, and Craig Fields of the Pentagon's Defense Advanced Research Project Agency, DARPA (now ARPA), to the view that the U.S. was hopelessly behind Japan and could only catch up in this "critical" (i.e, to national security) technology with help from the government. While not central to I.T., HDTV was nonetheless feared in the U.S. as an advanced technology that would permanently guarantee Japan's supremacy across consumer electronics and home entertainment generally.

But a funny thing happened on the way to Japan's inexorable conquest of the world's I.T. sector. The conquest fell apart on all fronts: chips, boxes, software, television—and , for that matter, telecommunications as well. You name it: if it required creativity and a rapid response, Japan lost it. They lost it, as a rule, to U.S. companies headquartered in the Western states, in an arc from Texas to Seattle.

Who were these companies? Why did they spring up in the western half of the U.S.? How did they defeat Japan's bid for leadership in I.T., the world's premiere growth sector?

2. THE RISE OF THE WILD WEST COMPANIES

One way to answer these questions is to list a series of examples in which old-style companies in the Northeast (call them "managerial corporations") bungled opportunities to innovate. In the vacuum, younger and more innovative firms (call them "entrepreneurial corporations") took advantage of the figurative wide open spaces of the West to move the industrial system to its next stage of development.

This section is a narrative account of the regional realignment. (Other issues of interpretation are touched upon in Section 3, in connection with cluster theory.)

CASE 1: FAIRCHILD SPAWNS INTEL (1968)

In contrast to mainframes and minicomputers, personal computers are blown up from thumbnail-sized microprocessors. Silicon Valley started with transistors, moved on to memory and logic (or microprocessor) chips, and evolved into a complex producing the whole I.T. spectrum. Its origins as a semiconductor center would ultimately give the Valley a decisive advantage over Route 128.

In this sense, it can be said that Silicon Valley is "a place that was invented one afternoon in 1957 when Bob Noyce and seven other engineers quit en masse from Shockley Semiconductor" to found Fairchild Semiconductor. This was a division of the established Syosset, New York firm, Fairchild Camera and Instrument. (Robert X. Cringely, p. 36.) The path leads from New Jersey's Bell Labs to a moment in 1968 when Noyce and crew would again leave, this time from Fairchild.

Background: The Origins of Silicon Valley. A key technological moment in the Valley's development was William Shockley's arrival in 1955 from Bell Labs. Shockley had been a co-inventor of the transistor in 1947 for Bell Labs, which would later garner him a Nobel Prize. In 1955 Shockley returned from New Jersey to his home state to start a transistor company in Mountain View, near Stanford. (Bell Labs is now Lucent.)

The original Lucent has been acquired a few times over and from what I can tell is now part of Nokia so I removed link here and other places it was mentioned and had a link. I could comment Lucent is now part of

Nokia and put the Nokia link in

He called it Shockley Semiconductor because the transistor could be switched on or off to register a 0 or 1 in binary code, depending on whether it was in a conductive or non-conductive mode. This "semiconductor" property is present in the minerals germanium and silicon. Years later, in 1971, a newsletter writer named Don C. Hoefler accordingly coined the term, "Silicon Valley." (Rogers and Larsen, 1984, pp. 25-26.)

Shockley moved west to Mountain View in part because it was his home ground and his mother still lived there. But business logic also favored the move. Two key components were already in place to create a seedbed for new enterprises. One was the Stanford Industrial Park launched in 1951 and followed in 1954 by the Stanford Research Park. The impetus was not economic development but the desire to make money from real estate the university owned yet (by the terms of Leland Stanford's gift) could not sell.

The second keystone was Hewlett-Packard, started by the two Stanford students on the eve of World War II to manufacture electronic oscillators, under the guidance of an electrical engineering professor studying negative feedback, Fred Terman. The two components had come together in 1954 when H-P took a lease in the Stanford Research Park and served as the anchor for subsequent tenants. (Rogers and Larsen, chapter 2.)

The Traitorous Eight. Shockley had barely started his semiconductor company when it foundered on a legendary spin-off, which would eventually beget Intel. It has been said that Silicon Valley is "a place that was invented one afternoon in 1957 when Bob Noyce and seven other engineers quit en masse from Shockley Semiconductor" to found Fairchild Semiconductor, as a division of the established Syosset, New York, firm Fairchild Camera and Instrument. (Cringely, 1993, p. 36.)

Fairchild's Traitorous Eight, (as Shockley saw them) share credit with Texas Instruments (TI) for inventing integrated circuits (ICs). Germanium ICs were designed by Jack Kilby at Texas Instruments (TI) in Dallas, but he lacked a method of layering transistors on a flat surface. Jean Hoerni, one of the Fairchild Eight, came up with a "planar" technique to embed rather than stack component layers.

Noyce carried the idea through to create complete circuit maps on a single silicon slice, clearing the way for photolithography (or "burning" the circuits into the slice) and thus for batch production. TI and Fairchild both announced the breakthrough in 1959. ICs came into production within two years, for use by the U.S. government at $100 apiece to miniaturize the future Apollo moon rocket's onboard computer (Palfreman and Swade, 1991, pp. 87-91).

Intel. A decade later, Noyce, Moore, and others jumped ship again to found Intel, a more egalitarian company than Fairchild's eastern owners would permit. As a minister's son from Iowa, Noyce did without dress codes, reserved parking places, closed offices, executive dining rooms, and the other status trappings of more hierarchical and bureaucratic mature U.S. corporations. The remote control thus foundered on the divergent philosophies of Syosset and Silicon Valley:

Noyce couldn't get Fairchild's eastern owners to accept the idea that stock options should be a part of compensation for all employees, not just for management. He wanted to tie everyone, from janitors to bosses, into the overall success of the company.... This management style still sets the standard for every computer, software, and semiconductor company in the Valley today.... ...Every CEO still wants to think that the place is being run the way Bob Noyce would have run it. (Cringely, p. 39.)

CASE 2: XEROX FAILS TO MARKET PARC'S DISCOVERIES

Noyce's brush with the Northeast's resistance to change was repeated at Xerox PARC, this time over bringing new products to market. In 1970, the eastern copier firm, Xerox, founded Palo Alto Research Center (PARC) as a flat organization of some 50 creative researchers whose mission was to create "the architecture of information."

As PARC'S web site puts it, they responded "... by inventing personal distributed computing, graphical user interfaces, the first commercial mouse, bit-mapped displays, Ethernet, client/ server architecture, object-oriented programming, laser printing and many of the basic protocols of the Internet." Preoccupied with copiers, however, the New York-based Xerox failed to bring any of these potentially breakthrough technologies to market. That remained for such western firms as Hewlett-Packard, Apple, and Utah's Novell.

CASE 3: IBM AND DEC IGNORE THE COMPUTER-ON-A-CHIP

Noyce and his colleagues thus formed Intel in 1968, as a spin-off (like its competitor National Semiconductor and some 50 other companies) from Fairchild. Intel made its mark on the world in November 1971 when it announced a triple breakthrough: the microprocessor, dynamic random access memory (DRAM), and erasable programmable memory (EPROM) for software. (George Gilder, 1989, p. 101.) Here was the package to make personal computers a reality.

But the big computer companies of the Northeast were not interested: "IBM and DEC...decided there was no market. They could not imagine why anyone would need or want a small computer; if people wanted to use a computer, they could hook into...time-sharing systems." (Palfreman and Swade, 1991, p. 108.) Thus microprocessors languished, scorned by the mainframe and mini- establishments—and not pushed by Intel—for another three years.

What would it take to bring the new firepower into play? The answer came with the now legendary January 1975 issue of *Popular Electronics*, whose cover showed the MITS Altair kit for a home-made microcomputer based on an Intel 8080 processor chip. Inspired, Steve Wosniak devised the Apple 1 to impress the hobbyists at the Homebrew Computer Club in Palo Alto. When Steve Jobs entered the picture the result was the Apple II, which found a ready market.

Wosniak's hardware breakthrough was matched on the software side by the 19-year-old Seattle-ite, Bill Gates. Using a DEC PDP 10 minicomputer at Harvard to emulate the MITS Altair, Gates and his high-school friend from Seattle, Honeywell programmer Paul Allen, devised a modified version of Dartmouth's mainframe BASIC programming language. Moving to New Mexico to be near the MITS facility, they formed Microsoft to market MITS BASIC, their microcomputer version of the mainframe programming language. Over the next five years, Microsoft would then develop, market, and license other languages for microcomputers, reaching $2.5 million in sales and 25 employees by the end of 1979.

In other words, the four seminal figures in the PC industry after 1975 (when IBM in New York and DEC in Massachusetts saw no future in it) were barely 21 on average and hailed from the San Francisco Bay area and Seattle.

Microsoft—like Compaq in Houston, Dell in Austin, Texas Instruments in Dallas, and WordPerfect and Novell in Utah—is a reminder that the technological transformation of American computing ranged from Texas to Seattle. If Silicon Valley was the West's capital, it sometimes followed the lead of the provinces.

The next episode was played out not in the West at all, but in Florida. Yet the theme remains the same: new territory as a spur to innovation.

CASE 4: THE PC'S ROOTS IN BOCA RATON, SILICON VALLEY, AND SEATTLE

Microsoft's initial takeoff following the New Mexico start-up brought the company to IBM's attention. In the mid-1970s, IBM had actually introduced an expensive PC-like machine that drew little response from its corporate customers and was quickly abandoned. By 1980, as microcomputer sales by Apple, Radio Shack, Atari and Commodore generated over $1 billion, IBM decided to try again.

This time IBM's development team was placed far from Armonk, New York, headquarters in Boca Raton, Florida, with a one-year project deadline. The crash-program deadline, unprecedented at IBM, forced the PC project chief, Bill Lowe, to design a machine built from other people's components—another radical departure for IBM.

Enter Microsoft. Lowe's plan for IBM was initially just to buy Microsoft BASIC, a standard feature of existing microcomputers, and to run it over a CP/M operating system from Gary Kildall's Digital Research of Pacific Grove, California. But when negotiations with Kildall misfired (because he did not show up for the meeting in Pacific Grove), Lowe turned to Microsoft for the operating system as well. Gates replied that IBM should use a 16-bit microprocessor, the new Intel 8088 chip. But since Gates had no operating system for a 16-bit processor, Microsoft now had to come up with one.

Gates' solution was to spend about $50,000 to buy an existing 8088 operating system, QDOS ("Quick and Dirty Operating System") from Tim Paterson's Seattle Computer Products and to rename it MS-DOS.

In August 1981 the IBM PC appeared on schedule, featuring MS-DOS (called "PC-DOS" by IBM), and Microsoft BASIC, with available Microsoft versions of FORTRAN, COBOL, and PASCAL.

The package was thus equal parts hardware from Boca Raton and Silicon Valley's Intel and system software from Seattle. The creative points of origin were far removed from Armonk, New York.

Such was the beginning of the IBM-Microsoft collaboration that ended in 1990 with a complete reversal of fortunes, symbolized by IBM's plummeting employment, from 395,000 in 1984 to 243,000 in 1994. Microsoft's standard-setting strategy succeeded to the point where its stock-market value, like Intel's, surpassed IBM's by 1993. (Not the least colorful aspect of the reversal is that IBM unloaded stock in Microsoft and Intel that, if retained, would have been worth $18 billion by 1996.)

In the meantime, it wasn't just IBM who took a tumble in the 1980s. Something comparable was also happening along Boston's Route 128, where the big four minicomputer companies (Digital, Wang, Data General, and Prime) had entered the 1980s as giant-killers, Davids to IBM's Goliath.

CASE 5: THE FALL OF THE ROUTE 128 MINICOMPUTER COMPLEX

The reindustrialization of New England from the early 1970s to the mid-1980s was an amazing story (one I sketched in an analysis published by the Federal Reserve Bank of Boston). The linked article, "The Role of Services and Manufacturing in New England's Economic Resurgence," is based on a simple technique known as **shift-share analysis** .

In the study I contended that (in contrast to New York City's comeback at about the same time), New England's resurgence was powered by manufacturing. The technique allowed a graphical portrayal of manufacturing's role, as initially lagging, then surging ahead on its own, then bringing other sectors along, then collapsing in the mid-1980s. It should be added that the services sector played a nonetheless crucial part in New England's reindustrialization, because two of the three key catalysts to the comeback were venture capital and higher education—service activities.

In any event, after about 1985 the two outwardly similar high-tech clusters, Boston's Route 128 and California's Silicon Valley, moved in opposite directions. Along Route 128, the "Massachusetts Miracle" (as touted by defeated presidential candidate Michael Dukakis) collapsed in a heap, wiping out tens of thousands of jobs across New England. But Silicon Valley kept on adding employment, despite California's high taxes and housing prices.

A little-noted reason for this eclipse was management failure along Route 128. All the key players in the New England complex saw the handwriting on the wall in the early 1980s. The future of computing was the PC, not minicomputers, let alone mainframes. Yet not one of the successful and profitable companies (DEC, Wang, Data General, Prime), had the boldness to cannibalize their profitable minicomputer lines to shift to a PC strategy.

What could account for this collective failure of nerve? Technologically, Route 128's minicomputers were actually mainframe computers shrunk down, not microprocessors blown up, like the PC. For that reason it was much harder for the Route 128 companies to introduce new and uncertain personal computers. Putting it differently, the economies of scope favoring Silicon Valley's microprocessor-based complex were missing along Route 128. Facing the technology barrier, managers along Route 128 stayed too long with cash-cow, proprietary (or closed) systems in minicomputers.

The long-term outcome would be a default I.T. role for Route 128 as a software and now Internet specialist, a role MIT's presence more or less guarantees. But the immediate result was for hardware production to move west, to Silicon Valley and then to Texas.

CASE 6: HOW TEXAS BECAME THE PC STATE

"End of an era. The Texans have taken over."
(David Vellante, February 1, 1998, on Compaq's purchase of DEC)

Today Texas has the two leading PC producers in the world, Compaq and Dell. How did the Lone Star State become the PC State?

Texas Instruments. Compaq's provenance traces a fairly precise lineage of industrial evolution. In the 1930s engineers with a new instrumentation technology for seismographic oil exploration came from the Northeast to Dallas to found Geophysical Services. In 1951, the original firm gave way to Texas Instruments (TI). As we have seen, the technologies TI employed led naturally to semiconductor research and in 1959 to the co-discovery of the integrated circuit by Jack Kilby, a TI engineer. Military and space contracts from the federal government spurred the company's ascent to one of the top semiconductor manufacturers in the U.S. by the 1970s.

Compaq. In 1982 four TI engineers from the company's Houston facility broke away to form a spin-off. Their leader was Rod Canion, and the company was Compaq. The breakaway team patiently reverse-engineered the then new IBM PC, so that it could legally invent its own BIOS (or interface) chip to emulate the PC for 100-percent software compatibility. Their success created Compaq's breakthrough as the legitimate king of the PC clone-makers. Compaq rose from its inception to Fortune 500 status in only four years—a record Dell would itself later break.

What is the meaning of the TI-Compaq story? The link between resource endowments and innovative capacity. Historically, the development of technological strength in an American region can typically be traced to the region's resource base. (Perloff and Wingo, 1961.) A given resource endowment either generates or fails to spark a related set of resource-processing activities that in turn encourage the development of new skills and technologies. (Norton and Rees, 1979.) The link between iron and coal endowments and metalworking, via the machine tools industry, was how the Manufacturing Belt of the Northeast and Upper Midwest became the nation's seedbed for innovation in the century from 1850 to 1950. The 60-year path from oil exploration to Compaq's world leadership in PC production displays a similar logic.

Dell. In contrast, Dell's meteoric rise in the 1990s has no such precisely traceable lineage. Instead, Michael Dell's strategy has been to devise a new distribution system to "mass-customize" the PC to order and to get the product delivered in a matter of days through the mail. "Because Dell holds very little inventory, it takes advantage of lower component costs and is always selling a fresher product, which can command a higher profit margin." (Fisher, 1998.)

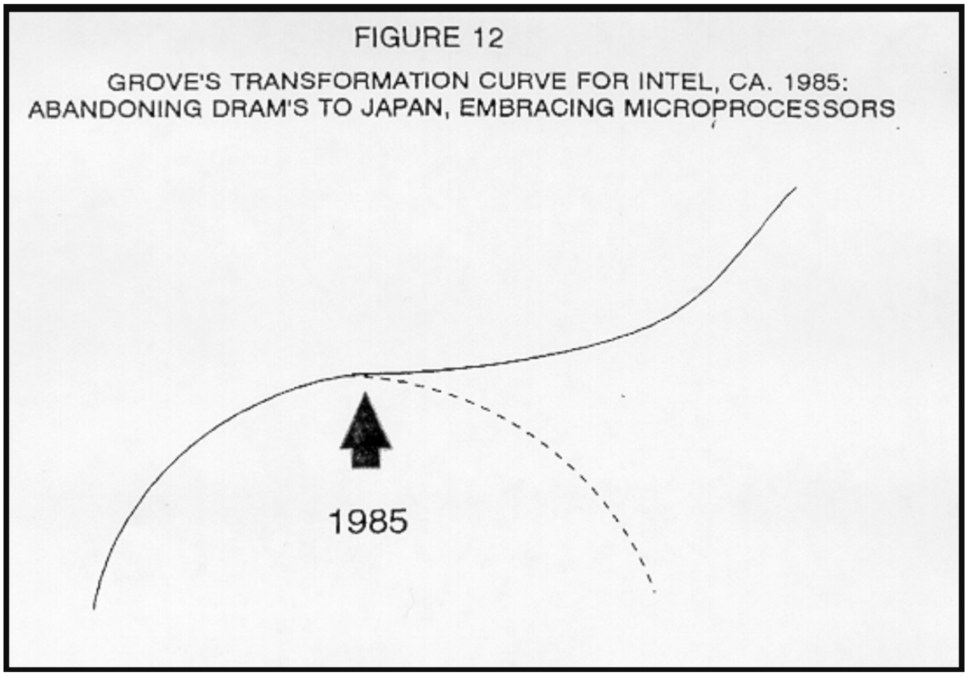
This comment by a journalist in August 1998 accompanies robust earnings announcements that show Dell moving into the position of No. 2 desktop computer seller in the U.S., i.e., moving ahead of IBM and Hewlett-Packard. (Compaq remains in first place.) It would be hard to find a better illustration of the triumph of the Texas PC producers over their rivals in other regions.

"THE BREAK-UP OF THE OLD COMPUTER INDUSTRY" (1985-1990)

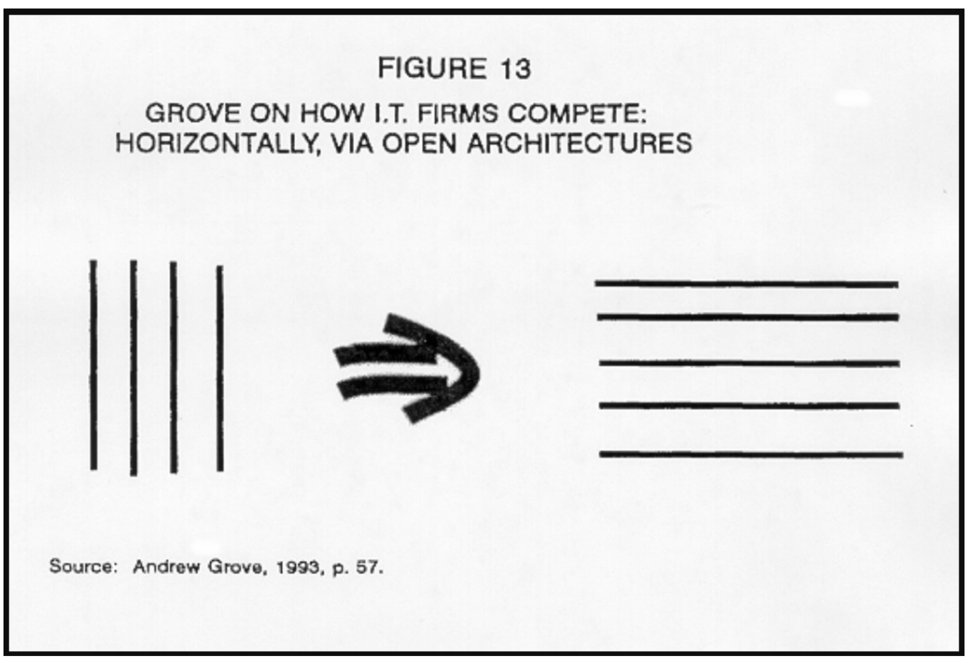
To recap, Intel's invention of the microprocessor in 1971 set the stage for the PC—which the Northeast's computer firms then failed to develop. That task was left to newcomers, adolescent or 20-ish prodigies from California and Washington State. After several failures, IBM finally managed to emulate Apple's success, but only by moving the PC project's design far from Big Blue's headquarters, to Boca Raton in Florida, and only by using components from Intel and Microsoft.

By the mid-1980s, as Japan moved into the I.T. passing lane, IBM summoned its PC management back to its Armonk headquarters, where the PC was smothered—partly by jealous competition from IBM's mainframe managers! Meantime, the initial outsourcing to Intel and Microsoft meant that clones using the same components were now taking away larger and larger shares of the PC market. IBM was about to fall, and Japan was ready.

Moreover, Japan had by the mid-1980s seemingly wrested the semiconductor lead from Intel. Intel had lost money in 1983 and 1984 in the face of heightened Japanese competition in DRAM memory chips. Andrew Grove, Intel's Hungarian-refugee CEO has since said, "There is at least one point in the history of any company when you have to change dramatically to rise to the next performance level. Miss the moment and you start to decline." (Andrew Grove, 1993, p. 58.) At Intel the moment came in 1985. (FIGURE 12.) The company surrendered memory chips to Japan and turned solely to microprocessors (at the time, 286s).



What happened between Intel's company-saving decision and 1990 Grove describes as "The breakup of the old computer industry... [which] gave Intel its chance and made the mass-produced computer possible." The change can be described in terms of Grove's sketch of vertically integrated companies vs. new horizontal tiers differentiated by component. (FIGURE 13.) The old system had self-contained, relatively closed and proprietary systems a la Route 128 and IBM. "These vertically integrated companies would compete against [each other]...and buyers had to commit to the whole package of one manufacturer or another." (Grove, p. 57.)



OPEN SYSTEMS

By contrast, the new model of competition is based on open (i.e., published) technical standards and full compatibility between every component-maker's products and every other's. In FIGURE 13, for example, each horizontal line represents a product axis along which companies in a particular segment of the market (systems software, monitors, printers, software applications, etc.) compete. The products from each segment must be fully compatible with those on every other horizontal tier--or customers will not buy them. This new system Grove terms "industrial democracy," in the sense that "It resists central guidance. Nobody can tell anyone else what to do." (P. 57.) In contrast to the old regime, choices abound and competition drives prices down.

Consumers also benefit from an accelerated pace of technological change. In a demonstration of the "Arrow effect," IBM had notoriously restricted the pace of technological change with a view to maximizing its profits over time. Its mainframe installations were known for "golden screwdriver" techniques, in which a demand for more performance (at higher rental rates) would prompt a visit from an IBM technician who would insert a few lines of code into existing software and unlock new power in the machine. (James Carroll, 1993, p. 217.) Similar restrictions of hardware potential marked IBM's missteps with its PC-AT in the mid-1980s.

The new rules force the pace of technological change and translate lab potential into product. Grove's analogy is skis. "Any ski boot works with any binding. Any binding fits any ski. That permits innovation to take place independently in boots, bindings, and skis." (Grove, p. 57.)

STANDARD-SETTING

But who makes the profits required for high levels of sustained RD? Charles Morris and Charles Ferguson contend that the key to profitability is to control the standards, protocols, and formats by which the different parts of an information system are linked. Put the other way around, we find a (perhaps belated) recognition that Japan is only human.

Scale, friendly government policies, world-class manufacturing prowess, a strong position in desk-top markets, excellent software, top design and innovative skills—none of these, it seems, is sufficient, either by itself or in combination with each other, to ensure competitive success in this field. (Charles R. Morris and Charles H. Ferguson, 1993, p. 87.) The key, in their view, is proprietary control over a dominant open system. Examples were Microsoft in system software, Novell in network software, Sun in network hardware and software, Adobe and Hewlett-Packard in printer protocols, and Intel in microprocessors. These Wild West companies managed to make the codes and standards for their products established as industry norms. Then the proprietary, company-specific control of the open system gave the company in question an edge in the race to pump out new products.

As Grove observes, "A leading-edge product requires leading-edge manufacturing capability, and you can't buy it." (Grove, pp. 57-58.) It requires massive investment, which requires massive profits, which come from competition via standard-setting.

That is the puzzle the successful Wild West firms solved in the 1990s. In turn, their ability to handle the pace of innovation given by Moore's Law while still maintaining continuity of standards created shock waves worldwide. It gave the U.S. a second wind as the race with Japan carried into the 1990s.

4. THE U.S. COMEBACK, 1989-1994

In every one of the four I.T. sectors sketched in the introduction to this case, what actually happened was more or less opposite what most people had expected in 1989.

(1) Semiconductors. Timelines show Japan taking the lead in 1985, pulling far ahead by 1989, then being overtaken by 1993. Not only has U.S. pressure from the high-markup microprocessor end of the chip spectrum hurt Japan. Korea has attacked from the commoditized memory-chip end, in a bid reminiscent of that country's success vis-a-vis Japan in steel and shipbuilding.

(2) Computers. Computer "boxes" have also displayed a surprising U.S. resilience since 1989. One indicator is the failure of Japanese microcomputers to make much of an inroad into the U.S. market. Following a jump

from 9 to 13 percent between 1989 and 1990, Japan's U.S. share fell back to 6 percent in 1991. Commenting on this reversal, Steve Jobs observed in 1992 that "The United States computer manufacturers have re-invented themselves and are holding on to the most desirable market in the world." (Quoted in Markoff, 1992.) The result finds Japanese firms supplying U.S. computer makers with flat screens and memory chips, but struggling to sell the U.S. markets the actual computers.

(3) Software.As to software, point one is the demise of Japan's Fifth Generation project. After 10 years, MITI gave up the ghost in mid-1992. "The problem for Japan is that the computer industry shifted so rapidly that the technological path the Fifth Generation took—which seemed a wise choice in 1982—turned out to be at odds with the computer industry's direction by 1992." (Andrew Pollack, 1992.) The lack of interest in the software that resulted led MITI to give it away free, though few took them up on the offer.

Equally important is the triumph of Microsoft's Windows platform, an exercise in cumulative standard-setting that has given an edge to U.S. computer companies relative to, say, NEC or Toshiba, which were late to commit to the standard.

(4) HDTV. As with the Fifth Generation project's commitment to the wrong technological trajectory, so too with HDTV. U.S. companies have developed digital approaches that appear to have leapfrogged Japan's analog approach. Thus "...enlightened federal regulation, rapidly advancing digital technology and cooperation between competing organizations have combined to vault the late-starting United States into a clear lead in the race to develop practical high-definition television." (William J. Cook, 1992, p. 14.)

In 1994 the director general of broadcasting in Japan's Ministry of Posts and Telecommunications conceded as much. He created a furor by revealing that his ministry was contemplating withdrawing support for Japan's HDTV program. The announcement was taken to signal "The triumph of American-style HDTV, something almost unimaginable five years ago...." (Andrew Pollack, 1994.)

CAN INDUSTRIAL POLICY HURT COMPETITIVENESS?

These four distinct sectors suggest that industrial policy can retard change in a dynamic technological environment. Pollack comments that the HDTV episode is especially telling: "...Japan's plan for HDTV showed the drawbacks in this country's system of Government-backed cooperative industrial development. **The system** allows for great staying power and steady progress down a particular path, but **does not adjust well when the technological road turns**." (Emphasis added.)

By the mid-1990s, such second thoughts about MITI and the role between Japan's bureaucrats and its giant firms had become widespread. The failure of the Fifth Generation software project and of the HDTV campaign, combined with Japan's distant lag in its over-regulated telecommunications sector—all these stand in contrast to the diversity and dynamism of the U.S. technological landscape. What had seemed to work so well for Japan in the automotive and consumer-electronics sectors in the 1970s and 1980s looked strangely dated today.

LESSONS

We have considered six examples of tensions between the old computer industry of the U.S. Northeast and more entrepreneurial actors in the South and West. We also compared the dismal 1989 prospects and startling U.S. comebacks during the 1990s in computers, software, semiconductors (more specifically, microprocessors), and HDTV. The counterparts were surprising setbacks for Japanese efforts in each of the four components of Information Technology, as well as in the related sector of telecommunications.

The logical link between these two sets of events is what Andrew Grove termed "the breakup of the old computer industry" between about 1985 and 1990. The relentless drumbeat of 18-month product cycles for chips given by Moore's (and Joy's) Laws required quick responses by players throughout the I.T. sector. The technology's momentum in effect required entrepreneurial agility. Agility's nemesis is bureaucracy—which in the mainframe culture of IBM would slow decision-making to a standstill as Microsoft heated up the system-software design wars of the 1980s. In a parallel quest, Intel's radical bet-the-company reinvention after 1985 wrested standard-setting leadership for microprocessors away not only from IBM but from Japan as well.

The new business model that took hold after 1985 spawned competition via open (published) systems, compatible components, and uniform technical standards across vendors. In addition, the characteristic PC firm was specialized in a particular slice of the sector:

. . . the PC industry from its earliest beginnings adopted a purely horizontal supplier structure. Companies such as Intel, Microsoft, Novell, Lotus, Compaq, Seagate, Oracle, 3com, Electronic Data Systems, and many others thrived by being specialists in particular layers of a newly emerging IT industry value chain. By focusing on just one technology area, the horizontal companies moved with a speed, deftness, and openness that the older systems companies simply couldn't match. (David Moschella, 1997, pp. x-xi.)

The competitors that succeeded under the new rules were not only American, but from the West. "From a global perspective, this change in vendor business models led to an even more dominant U.S. competitive position. **Most of the companies that mastered the horizontal model turned out to be American, usually from the western half of the country**." (Moschella, p. xi, emphasis added.)

Without the regional realignment, the history of the U.S. computer sector would have remained the preserve of IBM and Route 128 (the aging upstarts). Japan would likely have taken outright leadership in the I.T. sector from the U.S. Its great electronics companies, notably Fujitsu and Hitachi, but also Toshiba and NEC, gave every indication in the 1970s of knowing how to catch and overtake Big Blue. Instead, that would fall to such standard-setters as Intel and Microsoft.

To be sure, some observers still viewed the U.S. resurgence as only temporary. Eamonn Fingleton, for example, wrote a 1995 book with the uncompromising title, *Blindside: Why Japan Is Still on Track to Overtake the US by the Year 2000.* But as 2000 approaches, the forecast seems a bit strained. Perhaps a more plausible comment on the state of the world's I.T. sector today came from a Czech computer expert commenting on software in March 1996. "Americans are showing an unbelievable burst of creativity. By relying on sophisticated tools, Americans have shifted the competitive arena from sweat labor to imaginative design."

With the arrival of the Internet in 1994, the creativity factor would play an even larger role.

5. NEW COMPANIES IN THE INTERNET ERA (1994-)

> "Put simply, the story of computer industry competition has been one of new waves of technology, led by new waves of vendors, rapidly overpowering much of the existing order. . . . [T]he network-centric era will result in market and supplier restructuring every bit as great of those of the PC revolution." (Moschella, 1997, pp. vi-vii.)

In a useful simplification, the Internet or network-centric era can be dated from 1994, the year the barriers finally came down to the creation of a "network of networks." The Defense Department's ARPANET had been around since 1969. By the mid-80s the National Science Foundation had helped it evolve into a university research network based on the Pentagon's software standard, Transmission Control Protocol/Internet Protocol (TCP/IP). In 1989 Tim Berners-Lee, a British scientist working at the physics research lab CERN in Switzerland, had devised the hyperlink system of document linkage and access—an example of which you are now reading. The problem remained, however, how to hook up and standardize the numerous proprietary networks (e.g., ATT and MCI) competing for corporate and consumer business.

The problem was effectively solved in 1993 by programmers at the University of Illinois (the source also of the widely used free e-mail program, Eudora). Headed by Marc Andreeson, they came up with a good graphical-user-interface (GUI) browser, MOSAIC. Then Andreeson decamped for Silicon Valley and helped launched Netscape Navigator for profit in 1994.

At this juncture Metcalfe's Law kicked in. To repeat: the costs of adding users to a network increase linearly, while the benefits expand quadratically. If a network's users increase in number from 99 to 100, for example, the costs to the network go up by the incremental cost per node, the same as if the number increased from two to three users. But the number of additional two-way connections go up by 99, vs. only 3 more when a third subscriber is added. The larger the network, the greater the value to existing users of new members.

The smaller, isolated proprietary networks of the 1980s had failed to break through to the threshold that was now accessible via the Internet and a Mosaic-class browser. After 1994, any such constraints would be rent asunder. The shockwaves are with us still, as the new communications links redefine every sector of the economy.

NEW FUNCTIONS, NEW COMPANIES

The Internet permitted a blending of computing, communications, and entertainment in the mid-90s that, like the PC before it, changed the rules of the I.T. game. As to the pattern of regional advantage, one indicator of the new regime is the appearance of new companies. Another is the re-making of existing ones.

To get a sense of these tendencies, we can turn to a recent list of the world's top I.T. firms, then look at specific firms and their locations.

The July 1997 PC Magazine list of the world's 100 "most influential" I.T. firms appears as TABLE 6. The criteria for the list are subjective, but plausible. Perhaps the main caveats are (1) the list is American, and biased to that extent, and (2) these are the top firms from the perspective of a PC magazine, not from the standpoint of mainframes, telecommunications, or biotechnology. The list may well be open to debate as to exact ranks of companies, and its makeup and rankings will change from one year to the next. For our purposes, however, it appears sufficiently reliable to serve as a roadmap for the new geography of I.T.

TABLE 6

PC MAGAZINE'S 100 MOST INFLUENTIAL PC COMPANIES IN THE WORLD IN 1997

1	Microsoft Corp.		51	Seiko Epson Corp.	Japan
2	Intel Corp		52	Xerox Corp.	
3	IBM corp.		53	Iomega Corp.	
4	Netscape Communications		54	Dialogic Corp.	
5	Sun Microsystems Inc.		55	Samsung/AST Research	Korea
6	Compaq Computer Corp.		56	Logitech International SA	
7	Hewlett-Packard Co.		57	Matsushita Electric Industrial	Japan
8	Cisco Systems Inc.		58	National Semiconductor Corp.	
9	Oracle Corp.		59	PC Connection Inc.	
10	Toshiba Corp.	Japan	60	Sharp Corp.	Japan
11	Dell Computer Corp.		61	Fujitsu Ltd.	Japan
12	Apple Computer Inc.		62	Hitachi ltd.	Japan
13	Adobe Systems Inc.		63	NEC Corp	Japan
14	Gateway 2000 Inc.		64	Borland International Inc.	
15	Novell Inc.		65	Meta Tools Inc.	
16	3Com Corp.		66	Matrox Graphics Inc.	Canada
17	Corel Corp.	Canada	67	Sybase Inc.	
18	America Online Inc.		68	MCI Communications Corp.	
19	PointCast Inc.		69	Motorola Inc.	
20	Packard Bell NEC Inc.		70	Hayes Microcomputer Products	
21	Softbank Corp.	Japan	71	Adaptec Inc.	
22	Intuit Inc.		72	Philips Electronics NV	Netherlands
23	Digital Equipment Corp.		73	Western Digital Corp.	
24	Silicon Graphics Inc.		74	Activision Inc.	
25	Symantec Corp.		75	Cirrus Logic Inc.	
26	U.S. Robotics Corp.		76	Cabletron Systems	
27	Canon Inc.	Japan	77	ATI Technologies Inc.	Canada
28	Progressive Networks Inc.		78	Aimtech Corp.	
29	Macromedia Inc.		79	Computer Discount Warehouse	
30	id Software Inc.		80	Quarterdeck Corp.	
31	Seagate Technology Inc.		81	CompuServe Inc.	
32	Advanced Micro Devices Inc.		82	idealab!	
33	S3 Inc.		83	DeLorne Mapping Co.	
34	Acer Group	Taiwan	84	Informix Software Inc.	
35	Marimba Inc.		85	Lexmark International Inc.	

TABLE 6
PC MAGAZINE'S 100 MOST INFLUENTIAL PC COMPANIES IN THE WORLD IN 1997

36	McAfee Associates Inc.		86	Madge Networks Inc.	U.K.
37	Micron Technology Inc.		87	Broderbund Software Inc.	
38	Autodesk Inc.		88	Phoenix Technologies Ltd.	
39	Bay Networks Inc.		89	Power Computing Corp.	
40	Creative Technology Ltd.	Singapore	90	Be Inc.	
41	GT Interactive Software Corp.		91	Number Nine Visual Technologies	
42	Ascend Communications Inc.		92	Eastman Kodak Co.	
43	Sony Corp	Japan	93	The Santa Cruz Operation Inc.	
44	Cyrix Corp.		94	View Sonic Corp.	
45	Diamond Multimedia systems		95	Rockwell Semiconductor Systems	
46	CUC International Inc.		96	SAP AG	Germany
47	Computer Associates Intl.		97	The Learning Company Inc.	
48	AT&T Corp.		98	Tektronix Inc.	
49	Texas Instruments Inc.		99	Yahoo! Inc.	
50	International Data Group		100	Firefly Network Inc.	

The impact of the Internet can be gauged by the fact that 15 of the most influential 100 I.T. firms in 1997 had not existed in 1989. (TABLE 7.) In addition to Netscape, these included such firms as PointCast , U.S. Robotics, DeLorme Mapping (Maine), Progressive Networks (Ohio), Yahoo! and Firefly Network (Massachusetts). Eight of the 15 new firms from the 1990s were located in California, three in the Northeast, two in the Midwest, one in Texas, and one in Kentucky.

TABLE 7
THE FOUNDING DATES OF THE 100 TOP IT FIRMS

Founding date	Company by age	City	State/Nation (number of companies)	Primary activity
1875	Toshiba Corp., Japan	Tokyo	Japan (10)	hardware
1880	Eastman Kodak Co.	Rochester	NY (6)	software
1885	AT&T	New York	NY	telecommunications
1891	Philips Electronics NV, Netherlands	Hoofddorp	Netherlands (2)	software/hardware
1899	NEC Corp., Japan	Woodland Hills	CA	hardware
1906	Xerox Corp.	Stamford	CT (2)	hardware
1910	Hitachi Ltd., Japan	Tokyo	Japan	semiconductors
1912	Sharp Corp., Japan	Yao	Japan	hardware
1914	IBM Corp.	Armonk	NY	hardware/software
1918	Matsushita Electric Industrial, Japan	Tokyo	Japan	hardware
1928	Motorola Inc.	Schaumburg	IL (3)	semiconductors
1935	Fujitsu Ltd., Japan	Tokyo	Japan	semiconductors/hardware
1937	Canon Inc., Japan	Tokyo	Japan	hardware
1939	Hewlett-Packard Co.	Palo Alto	CA (47)	hardware
1946	Tektronix Inc.	Wilsonville	OR	hardware
1946	Sony Corp., Japan	Tokyo	Japan	semiconductors
1951	Texas Instruments Inc.	Dallas	TX (5)	semiconductors
1957	Digital Equipment Corp.	Maynard	MA (4)	hardware/software
1959	National Semiconductor Corp	Santa Clara	CA	semiconductor
1960	idealab!	Pasadena	CA	(internet)
1962	Seiko Epson Corp., Japan	Torrance	CA	hardware
1964	International Data Group	Framingham	MA	media
1968	MCI Communications Corp.	Washington	DC	internet
1968	Intel Corp.	Santa Clara	CA	hardware/semiconductor
1969	CompuServe Inc.	Columbus	OH (2)	internet
1969	Advanced Micro Devices Inc.	Sunnyvale	CA	semiconductors
1970	Western Digital Corp.	Irvine	CA	semiconductor (software)

TABLE 7
THE FOUNDING DATES OF THE 100 TOP IT FIRMS

Founding date	Company by age	City	State/Nation (number of companies)	Primary activity
1972	SAP AG, Germany	Walldorf	Germany	internet
1973	CUC International Inc.	Stamford	CT	software
1975	Microsoft Corp.	Redmond	WA	software
1975	Matrox Graphics Inc., Canada	Montreal	Canada (3)	semiconductors
1976	Computer Associatees International Inc.	Islandia	NY	software
1976	Apple Computer Inc.	Cupertino	CA	hardware
1976	Acer Group, Taiwan	San Jose	CA	hardware
1977	Hayes Microcomputer Products Inc.	Norcross	GA (2)	telecommunications
1977	Oracle Corp.	Redwood Shores	CA	software
1978	Seagate Technology Inc.	Scotts Valley	CA	hardware
1978	Micron Technology Inc.	Boise	ID	semiconductor
1979	3Com Corp.	Santa Clara	CA	internet/hardware
1979	Activision Inc.	Santa Monica	CA	software
1979	Phoenix Technologies Ltd.	San Jose	CA	software
1979	The Santa Cruz Operation Inc.	Santa Cruz	CA	internet
1980	Informix Software Inc.	Menlo Park	CA	software
1980	Broderbund Software Inc.	Novato	CA	software
1980	Iomega Corp.	Roy	UT	software
1980	Samsung/AST Research, Korea	Seoul	Korea	semiconductor
1981	Silicon Graphics Inc.	Mountain View	CA	hardware
1981	Adaptec Inc.	Milpitas	CA	semiconductor
1981	Softbank Corp., Japan	Tokyo	Japan	software/internet
1981	Logitech Internationa SA, Switzerland	Freemont	CA	hardware
1982	Number Nine Visual Technologies Inc.	Lexington	MA	telecommunications
1982	PC Connection Inc.	Milford	NH (3)	distribution
1982	Sun Microsystems, Inc.	Mountain View	CA	software
1982	Adobe Systems Inc.	San Jose	CA	software
1982	Symantec Corp.	Cupertino	CA	software
1982	Autodesk Inc.	San Raphael	CA	software
1982	Diamond Multimedia Systems Inc.	San Jose	CA	media
1982	Quarterdeck Corp.	Marina Del Ray	CA	internet/software
1982	Rockwell Semiconductor Systems	Costa Mesa	CA	semiconductor
1982	Compaq Computer Corp.	Houston	TX	hardware
1983	Dialogic Corp	Parsippany	NJ	semiconductors
1983	Intuit Inc.	Norcross	GA	software
1983	Novell Inc.	San Jose	CA	software
1983	Borland International Inc.	Scotts Valley	CA	software
1983	The Learning Company Inc.	Fremont	CA	software
1983	Dell Computer Corp.	Round Rock	TX	hardware
1983	Creative Technology Ltd., Singapore	Singapore	Singapore	media
1984	Computer Discount Warehouse	Vernon Hills	IL	distribution
1984	Cisco Systems Inc.	San Jose	CA	internet
1984	Macromedia Inc.	San Francisco	CA	internet
1984	McAfee Associates Inc.	Santa Clara	CA	software
1984	Sybase Inc.	Emeryville	CA	software
1984	Cirrus Logic Corp.	Fremont	CA	semiconductor
1985	Aimtech Corp.	Nashua	NH	software
1985	America Online Inc.	Dulles	VA	software
1985	Bay Networks Inc.	Santa Clara	CA	(network)
1985	Gateway 2000 Inc.	Sioux City	SD	hardware
1985	ATI Technologies Inc., Canada	Toronto	Canada	semiconductors
1985	Corel Corp., Canada	Ottowa	Canada	software
1986	Madge Networks Inc.	Hoofddorp	Netherlands	telecommunications

TABLE 7
THE FOUNDING DATES OF THE 100 TOP IT FIRMS

Founding date	Company by age	City	State/Nation (number of companies)	Primary activity
1987	Packard Bell NEC Inc.	Sacramento	CA	hardware
1988	Cabletron Systems	Rochester	NH	internet
1988	Cyrix Corp.	Richardson	TX	semiconductor
1989	Ascend Communications Inc.	Alameda	NY	internet
1989	S3 Inc.	Sanata Clara	CA	semiconductors
1990	DeLorme Mapping Co.	Yarmouth	ME	software/internet
1990	Be Inc.	Menlo Park	CA	software
1990	ViewSonic Corp.	Walnut	CA	hardware
1991	Lexmark International Inc.	Lexington	KY	hardware
1991	id Software Inc.	Mesquite	TX	software
1992	PointCast Inc.	Sunnyvale	CA	internet
1993	GT Interactive Software Corp.	New York	NY	software
1993	U.S. Robotics Corp.	Skokie	IL	telecommunications
1993	Power Computing Corp.	Cupertino	CA	hardware
1994	Progressive Networks Inc.	Mayfield Village	OH	media/internet
1994	Netscape Communications Corp.	Mountain View	CA	software/internet
1994	Yahoo! Inc.	Santa Clara	CA	internet
1995	Firefly Network Inc.	Cambridge	MA	internet
1996	Marimba Inc.	Mountain View	CA	software
1997	Meta Tools Inc.	Carpinterid	CA	software

In addition, a number of other companies on the list are labeled as telecommunications- or Internet-related. They include ATT, idealab!, MCI, CompuServe, SAP AG (Germany), Hayes, 3Com, Santa Cruz, Number Nine Visual Technologies, Quarterdeck, Creative Technology (Singapore), Cisco Systems, Macromedia, America Online, Bay Networks, Madge Networks (the Netherlands), Cabletron Systems, and Ascend Communications (recently acquired by Lucent).

It is important to recognize that every company on the list of 100 (like most companies regardless of industry) experiences the Internet as a revolutionary technology. Tables 6 and 7 are more specific. They include companies that either sprang into existence to take advantage of the Internet or that qualify as I.T. companies because they have expertise in communications or media.

Beyond these two sets of firms, of course, the firm that leads the list, Microsoft, did a drastic change of course after 1995 to try to catch up with and overtake Netscape in the browser market. Without going into the antitrust case now being heard, we should nevertheless touch upon one aspect of the Microsoft vs. Netscape-AOL-Sun Microsystems conflict that is now taking shape.

FROM ILLINOIS TO SILICON VALLEY TO VIRGINIA

Has the Internet had much impact on the pattern of regional specialization in I.T.? The events of late 1998 offer a new angle on this question, in that they reveal the inability of Silicon Valley companies to set the agenda for the Internet era.

Not only is PC production centered in Texas. Not only has Microsoft set the software standards for the world to follow. Now it turns out that the struggle for commercial leadership on the Internet will take place between a Seattle-area firm and one based in Virginia: America Online. That is the implication of AOL's $4 billion takeover of Netscape, as bolstered by the Valley's Sun Microsystems.

As a columnist for the San Jose Mercury News observes,

Before Marc Andreesen co-founded Netscape Communications Corp. in 1994, he'd moved from Illinois to Silicon Valley. . . . It is the nerve center of visionary technology. But it sometimes lacks vision, or the ability to sustain it. . . . Silicon Valley has long disdained AOL as an East Coast pretender. . . . But America Online is not a technology company. It is a media company, and an online shopping mall. . . . Every person, and place, has limitations. It's no slam on Silicon Valley to note that its imagination has sometimes been limited to techno- whizzery. (Dan Gillmor, November 23, 1998.) By implication (though certainly not a meaning intended by Gillmor), the world needed Microsoft as a successor to IBM to set uniform standards for I.T. Intel aside, Silicon Valley is a fluid assemblage of technology, creativity, and capital that at the same time never produced a strategic grandmaster on the order of Bill Gates or Steve Case.

Now we are on the eve of legal (antitrust) and technological (Open-Systems software, exemplified by Linux) challenges that seem likely to destroy Microsoft's position as a standard-setting natural monopoly. Would it be too nostalgic to recognize the possibility that the PC and the Internet explosion benefited from the Windows standard that Microsoft created—and from the Wintel duopoly Microsoft and Intel shared?

6. THE LOCATION OF THE TOP 100 I.T. FIRMS IN 1997

One way to sum up the impact of the regional realignment of information technology is to say that for the moment, Seattle, Silicon Valley, Texas, and now Virginia make the rules, and the rest of the world adapts to them. That statement used to hold for IBM. Then, in the late 1980s, it looked to everyone as if Japan's great electronics companies would replicate earlier triumphs in home electronics and automobiles. But that did not happen. Once again the U.S. holds a clear lead in I.T. The difference is that the sector's dynamism comes not from a company with a dress code (IBM), but from a variegated spectrum of younger enterprises in the West.

As we said, Silicon Valley dominates the list numerically—but not strategically. TABLE 8 shows the distribution of the 81 American firms on the list among U.S. regions. Within the U.S., 54 of the 81 are in the West. Numerically, 44 of the 53 western entries are from California. In terms of ranks, Washington (whose only firm on the list, Microsoft, leads it) and Texas (with 5 entries, but two in the top 11), are also prominent. (The absence of Amazon.com, another Seattle-area firm, must be an artifact of the timing of publication of the list, in mid-1997.)

TABLE 8
THE FOUNDING DATES OF THE 100 TOP IT FIRMS, BY REGION

Founding date	Company, by region	City	State	Primary activity
	Northeast (17)			
1880	Eastman Kodak Co.	Rochester	NY (6)	software
1885	AT&T	New York	NY	telecommunications
1906	Xerox Corp.	Stamford	CT (2)	hardware
1914	IBM Corp.	Armonk	NY	hardware/software
1957	Digital Equipment Corp.	Maynard	MA (4)	hardware/software
1964	International Data Group	Framingham	MA	media
1973	CUC International Inc.	Stamford	CT	software
1976	Computer Associatees International Inc.	Islandia	NY	software
1982	Number Nine Visual Technologies Inc.	Lexington	MA	telecommunications
1982	PC Connection Inc.	Milford	NH (3)	distribution
1983	Dialogic Corp	Parsippany	NJ	semiconductors
1985	Aimtech Corp.	Nashua	NH	software
1988	Cabletron systems	Rochester	NH	internet
1989	Ascend Communications Inc.	Alameda	NY	internet
1990	DeLorme Mapping Co.	Yarmouth	ME	software/internet
1993	GT Interactive Software Corp.	New York	NY	software
1995	Firefly Network Inc.	Cambridge	MA	internet
1961	(Regional Average			
	Midwest (5)			
1928	Motorola Inc.	Schaumburg	IL (3)	semiconductors
1969	CompuServe Inc.	Columbus	OH (2)	internet
1984	Computer Discount Warehouse	Vernon Hills	IL	distribution
1993	U.S. Robotics Corp.	Skokie	IL	telecommunications
1994	Progressive Networks Inc.	Mayfield Village	OH	media/internet
1974				

TABLE 8
THE FOUNDING DATES OF THE 100 TOP IT FIRMS, BY REGION

Founding date	Company, by region	City	State	Primary activity
	South (5)			
1968	MCI Communications Corp.	Washington	DC	internet
1977	Hayes Microcomputer Products Inc.	Norcross	GA (2)	telecommunications
1983	Intuit Inc.	Norcross	GA	software
1985	America Online Inc.	Dulles	VA	software
1991	Lexmark International Inc.	Lexington	KY	hardware
1981				
	West (54)			
1939	Hewlett-Packard Co.	Palo Alto	CA (47)	hardware
1946	Tektronix Inc.	Wilsonville	OR	hardware
1951	Texas Instruments Inc.	Dallas	TX (5)	semiconductors
1959	National Semiconductor Corp	Santa Clara	CA	semiconductor
1960	idealab!	Pasadena	CA	(internet)
1968	Intel Corp.	Santa Clara	CA	hardware/semiconductor
1969	Advanced Micro Devices Inc.	Sunnyvale	CA	semiconductors
1970	Western Digital Corp.	Irvine	CA	semiconductor (software)
1975	Microsoft Corp.	Redmond	WA	software
1976	Apple Computer Inc.	Cupertino	CA	hardware
1977	Oracle Corp.	Redwood Shores	CA	software
1978	Seagate Technology Inc.	Scotts Valley	CA	hardware
1978	Micron Technology Inc.	Boise	ID	semiconductor
1979	3Com Corp.	Santa Clara	CA	internet/hardware
1979	Activision Inc.	Santa Monica	CA	software
1979	Phoenix Technologies Ltd.	San Jose	CA	software
1979	The Santa Cruz Operation Inc.	Santa Cruz	CA	internet
1980	Informix Software Inc.	Menlo Park	CA	software
1980	Broderbund Software Inc.	Novato	CA	software
1980	Iomega Corp.	Roy	UT	software
1981	Logitech Internationa SA	Freemont	CA	hardware
1981	Silicon Graphics Inc.	Mountain View	CA	hardware
1981	Adaptec Inc.	Milpitas	CA	semiconductor
1982	Sun Microsystems, Inc.	Mountain View	CA	software
1982	Adobe Systems Inc.	San Jose	CA	software
1982	Symantec Corp.	Cupertino	CA	software
1982	Autodesk Inc.	San Raphael	CA	software
1982	Diamond Multimedia Systems Inc.	San Jose	CA	media
1982	Quarterdeck Corp.	Marina Del Ray	CA	internet/software
1982	Rockwell Semiconductor Systems	Costa Mesa	CA	semiconductor
1982	Compaq Computer Corp.	Houston	TX	hardware
1983	Novell Inc.	San Jose	CA	software
1983	Borland International Inc.	Scotts Valley	CA	software
1983	The Learning Company Inc.	Fremont	CA	software
1983	Dell Computer Corp.	Round Rock	TX	hardware
1984	Cisco Systems Inc.	San Jose	CA	internet
1984	Macromedia Inc.	San Francisco	CA	internet
1984	McAfee Associates Inc.	Santa Clara	CA	software
1984	Sybase Inc.	Emeryville	CA	software
1984	Cirrus Logic corp.	Fremont	CA	semiconductor
1985	Bay Networks Inc.	Santa Clara	CA	(network)
1985	Gateway 2000 Inc.	Sioux City	SD	hardware
1987	Packard Bell NEC Inc.	Sacramento	CA	hardware
1988	Cyrix Corp.	Richardson	TX	semiconductor
1989	S3 Inc.	Sanata Clara	CA	semiconductors
1990	Be Inc.	Menlo Park	CA	software
1990	ViewSonic Corp.	Walnut	CA	hardware

TABLE 8
THE FOUNDING DATES OF THE 100 TOP IT FIRMS, BY REGION

Founding date	Company, by region	City	State	Primary activity
1991	id Software Inc.	Mesquite	TX	software
1992	PointCast Inc.	Sunnyvale	CA	internet
1993	Power Computing Corp.	Cupertino	CA	hardware
1994	Netscape Communications	Mountain View	CA	software/internet
1994	Yahoo! Inc.	Santa Clara	CA	internet
1996	Marimba Inc.	Mountain View	CA	software
1997	Meta Tools Inc.	Carpinterid	CA	software
1980				
	Non-U.S. (19)			
1875	Toshiba Corp., Japan	Tokyo	Japan (10)	hardware
1899	NEC Corp., Japan	Woodland Hills	CA	hardware
1910	Hitachi Ltd., Japan	Tokyo	Japan	semiconductors
1912	Sharp Corp., Japan	Yao	Japan	hardware
1918	Matsushita Electric Industrial, Japan	Tokyo	Japan	hardware
1935	Fujitsu Ltd., Japan	Tokyo	Japan	semiconductors/hardware
1937	Canon Inc., Japan	Tokyo	Japan	hardeware
1946	Sony Corp., Japan	Tokyo	Japan	semiconductors
1981	Softbank Corp., Japan	Tokyo	Japan	software/internet
1962	Seiko Epson Corp., Japan	Torrance	CA	hardware
1927				
1975	Matrox Graphics Inc., Canada	Montreal	Canada (3)	semiconductors
1985	ATI Technologies Inc., Canada	Toronto	Canada	semiconductors
1985	Corel Corp., Canada	Ottowa	Canada	software
1982				
1891	Philips electronics NV, Netherlands	Hoofddorp	Netherlands (2)	software/hardware
1986	Madge Networks Inc.	Hoofddorp	Netherlands	telecommunications
1972	SAP AG, Germany	Walldorf	Germany	internet
1983	Creative Technology Ltd., Singapore	Singapore	Singapore	media
1976	Acer Group, Taiwan	San Jose	CA	hardware
1980	Samsung/AST Research, Korea	Seoul	Korea	semiconductor

In keeping with the theme of the new firm—the entrepreneurial vs. the managerial corporation—the ages of the 100 firms become younger as we move west. The firms founded before 1960 are more likely to have a location in the Northeast or outside the U.S. In the Far East (as it were), among Japan's 10 entries, 8 were founded before World War II, and the average founding date is 1927. (The remaining elder statesman on the list is Philips Electronics of the Netherlands, founded in 1891.)

While they made the list, few among these mature firms could be said to thrive in the new game. The only two stars from among the19 are IBM (which has risen from the grave in a new incarnation) and Hewlett-Packard—which is also the sole California firm among those on the list founded before 1960. Many of the other entries on the vintage list are struggling. In particular, three of the four great Japanese electronics combines are losing money in 1998, an unprecedented sign of weakened competitive positions.

It is surprising how extensive the U.S. comeback in I.T. has been. Only 19 of the top 100 firms are from outside the U.S., and Toshiba, at number 10, is the highest ranking of them. Indeed, 43 of the top 50 are American. The role of U.S. firms is thus even more dominant than the 81 percent share suggests, since most of the 19 non-U.S. firms ranked below number 50. (TABLE 6.)

The nationalities of the 19 firms are mainly Asian, with Canada and Europe hosting three each. Japan accounts for 10 listings: Toshiba (number 10), Softbank (21), Canon (27), Sony (43), Seiko (51), Matsushita (57), Sharp (60), Fujitsu (61), Hitachi (62), and NEC (63). Canada has three: Corel (17), Matrox Graphics (66), and ATI Technologies (77). Europe has three (the Netherlands' Philips Electronics, the U.K.'s Madge Networks, and Germany's SAP), but none in the top 50. In Asia, Taiwan's Acer is ranked at 34, Singapore's Creative Technology at 40, and Korea's Samsung/AST Research at 55. Of all the companies mentioned, perhaps the only one that today strikes fear and envy in the U.S. is Germany's SAP ("systems analysis and program" development). (Deborah Claymon, 1998.)

7. EUROPE'S POTENTIAL IN THE NET-CENTERED ERA

How does this episode in the history of technology relate to earlier crises of national competitiveness? One way to interpret the issue is to view the U.S. as a nation of country-sized regions at different stages of economic development. In that light, the I.T. sector experienced an internal, regionally focused maturity crisis in the Northeast a la 19th-century Britain. (R. D. Norton, 1986.) The difference was that the newcomer companies, created by entrepreneurs in younger regions, were still American.

By the same token, one reason for the eclipse of Europe's I.T. sector seems to be the smaller role played by entrepreneurs, relative to mature firms. The result, as Lester Thurow (1998) observes, is that Europe dropped behind Japan and the U.S. in the world's growth industries:

> When breakthrough technologies occur, it is very difficult for old large firms to lead. They have to cannibalize themselves to save themselves, and that is simply very difficult to do. If one looks at the 25 biggest firms (based upon stock market capitalization) in the United States in 1960 and again in 1997, six of America's twenty-five biggest firms either did not exist in 1960 or were very small. In contrast, in Europe all of the twenty- five biggest firms in 1997 were big in 1960. In the past four decades Europe has been able to grow no new big firms that could lead the world technologically.

To that extent, the changes now occurring in Europe may help open up new possibilities for entrepreneurial creativity. More generally, a strong case can be made for a resurgence of European companies as the Internet era proceeds, during the next five or six years. Indeed, it appears now that Europe collectively has better prospects in the I.T. race than Japan. This prognosis rests on an analysis in Moschella (chapter 12).

One characteristic of the transition is the shift in what he terms supplier structure away from the current horizontal value chain toward a communications chain. Apace with this he sees a corresponding shift in supplier leadership from U.S. made components to national telecommunications carriers. In other words, he assumes that national governments will retain control over major telecommunications suppliers, preventing complete globalization in this sector. The upshot is a localization of the present unified global market in which competitive advantage is gained through sheer design or cost efficiency.

In an ingenious application of Michael Porter's diamond model of national competitiveness, Moschella assigns number grades (in the form of stars) to the U.S., Japan, and Europe in a variety of categories he deems important for the next few years. The detailed evaluations are listed in TABLE 9 (below).

TABLE 9. COMPETITOR SCORES ON COMPONENTS OF PORTER'S DIAMOND IN I.T.

	EUR.	JAPAN	U.S.
AVERAGE SCORE	**3½**	**2½**	**4½**
Factor conditions (telecom. infrastructure.)	4	3	5
Related industries	3	3½	4½
Demand sophistication	3½	2	4
Domestic rivalry	3	2	4½
Source: compiled from ratings in Moschella (1997), chapter 12.			

The bottom line is a better outlook for Europe than for Japan. Summing over Porter's categories of (1) factor conditions, (2) related industries, (3) demand sophistication, and (3) domestic rivalry, Moschella computes aggregate ratings. The scorecard finds the U.S. with 4 1/2 stars (out of a maximum of five), Europe 3 1/2, and Japan 2 1/2. By this reading, however preliminary, we are about to turn the page to a new chapter in which Europe plays a larger part.

So much for the regional origins of the digital economy. Our next step is to interpret the geography of innovation and entrepreneurship from the standpoint of metropolitan areas, or clusters.

C. STRATEGIC CITIES

The ultimate irony in the placeless world is that some places organize the rest.
Manuel Castells 1998, p. 188

In 1967, at the crest of the Old Economy's development, John Kenneth Galbraith declared the individual entrepreneur obsolete, saying "only the group has the information that decision requires" (Galbraith 1967, 1985, p. 104). Today, in the light of history, we see things differently. In retrospect, "the group" in the traditional managerial corporation looks more like a stultifying bureaucracy, where the safest tactic was the non-decision. (Larry Farrell 1993.)

By the same token, the I.T. case study in Part B was intended to show the vital role played by newcomers, acting as entrepreneurs, to overthrow the established order and blast through the tendencies toward stagnation that past success seems to breed. From that standpoint, the difference between the U.S. economy, on the one hand, and those of Japan or France or Germany, on the other, has seemed to lie in the superior opportunities the U.S. has afforded newcomers—geeks, freaks, immigrants, and other outsiders.

Yet the basis for Professor Galbraith's verdict remains of interest. New technologies are not necessarily easier to understand today than in 1967. Group (or, in today's parlance, "team") cooperation, consulting, and coordination are often as crucial to product development and innovation today as they were then.

What has changed, it would seem, is the legitimacy of hierarchy. A primary lesson of the last third of the 20th century was that hierarchy is antithetical to the free and open flow of strategic information, "the information that decision requires." This, as many people have observed, is the impression one might glean from the fates of the U.S.S.R. and of U.S. corporate dinosaurs (like Sears or General Motors) alike.

More recently, of course, the proliferation of computer networks both within and between organizations has also made hierarchy less tenable. As a result, the 1990s saw powerful tendencies toward flatter organizations; burgeoning alliances between large and small firms; and deepening networks between firms and venture capitalists, universities, and governments.

Information flows remain vital, in other words. But now PC networks and spatial proximity provide increasingly complementary channels for the horizontal transmission of strategic information. One result, as manifested most vividly in the U.S. in perhaps a dozen large and mid-sized cities, is a new system of innovation, driven by partnerships between knowledge workers and venture capitalists.

That is our current point of departure.

The purpose of this section, then, is to consider which large American cities (more specifically, metropolitan areas) are spearheading the New Economy's next round of development—and to ask how they have emerged as centers of innovation.

Naturally, any such inquiry needs to begin with a deep bow to Silicon Valley.

CULTURES OF COMMUNICATION

In "The Valley of Money's Delight" (*The Economist*, March 29, 1997), John Micklethwait cites economic cultures as the catalysts that determine whether networks communicate. As he observes, "Research has increasingly concentrated on clusters—places (such as Hollywood or Silicon Valley) or communities (such as the overseas Chinese) where there is 'something in the air' that encourages risk-taking."

He lists 10 features of Silicon Valley's economic culture that help explain the area's dynamism:

1. Tolerance of failure
2. Tolerance of treachery.
3. Risk-seeking
4. Reinvestment in the community.
5. Enthusiasm for change.
6. Promotion on merit.
7. Obsession with the product.
8. Collaboration.

9. Variety.
10. Anybody can play.

This list points up the fluidity of the Valley as an economic environment. One of the qualities it conveys is a sense of loyalty to the place, rather than to the firm. By extension, it suggests a milieu conducive to spin-offs and start-ups—an environment that can be termed "Economy 2." (Martin Kenney and Urs Von Burg 1999.)

Linked background sketches on cluster theory offer further observations on the connection between information flows and spatial access. A first module surveys neoclassical approaches to cluster theory, those focusing mainly on spatial externalities. The second, on what I term post-neoclassical models, considers network-based industrial systems, path dependency, increasing returns, and dynamic agglomeration economies. As a reminder that any such hard-and-fast dichotomy between neoclassical and post-neoclassical views is fraught with peril, a sidebar locates cluster theory within the spectrum of urban growth paradigms. A useful set of links on cluster-based state economic development policies appears in the Hubert H. Humphrey Institute's list at the University of Minnesota.

That said, we can turn directly to a range of diverse views as to the role of large cities in the American economy. The goal is to discern which specific cities are best positioned at the Millennium to facilitate the information flows likely to promote innovation.

THE U.S. SYSTEM OF CITIES: COMPETING VISIONS

A few framing points about the U.S. system of cities can be offered now. The unifying theme is the role of history as help or hindrance to a metropolitan area's economic performance. From the standpoint of evolutionary economics, this is an issue of path dependence. From the standpoint of cluster theory, it overlaps with the question of specialization vs. diversity.

(1) City Roles in the World Economy

In a conference announcement from the University of Newcastle (England) in 1998, the organizers proposed a typology of cities based on 10 distinct city types. The conference theme was "Cities in the Global Information Society," so the taxonomy can be understood in that light. Here is the list, along with examples suggested by the organizers:

1. Old-industrial
   (e.g., Newcastle, Pittsburgh, Essen)

2. Global
   (London, New York, Tokyo, Singapore)

3. 2nd Tier regional and national capitals
   (Amsterdam, Dublin, Milan, Taipei, Toronto, Sydney)

4. Newly-industrializing
   (Pearl River Delta)

5. Former communist
   (Moscow, Warsaw, Budapest)

6. Globally marginalized
   (Soweto, sub-Saharan Africa generally)

7. Information-processing
   (Sunderland, Bangalore, Kingston [Jamaica])

8. Resorts and tourism
   (Palma, Orlando)

9. Logistics
   (North Carolina [sic], Rotterdam)

10. New planned
    (Malaysia's Multimedia Corridor and Japan's technopoles)

With a couple of obvious modifications, a similar taxonomy could be applied to the U.S. system of cities, using, say, categories 1-3 and 7-9.

In particular, asking which of America's largest cities are "industrial" in origin (type 1) is a fruitful exercise.

(2) American Metropolitan Evolution (Revisited)

For example, TABLE 10 links changes in manufacturing employment after 1970 to the mid-century industrial legacies of 30 large U.S. areas. It reveals a record of large losses by industrially specialized areas.

TABLE 10
1950 EMPLOYMENT STRUCTURE AND POST-1970 INDUSTRIAL GROWTH (000)

	Metro. area by 1910 population	% of workforce in mfg. In 1950	Manufacturing 1969/1970	employment 1998	Absolute change	Percent change
1	N.Y.-Nassau	30.8	1086	428	-658	-61%
2	Chicago	37.7	983	657	-326	-33%
3	Philadelphia	35.6	583	306	-277	-48%
4	Boston	28.7	322	224	-98	-30%
5	Pittsburgh*	38	292	140	-152	-52%
6	St. Louis	33.8	278	195	-83	-30%
7	San Francisco*	19.4	80	78	-2	-3%
8	Baltimore	30.9	206	100	-106	-51%
9	Cleveland*	40.5	316	201	-115	-36%
10	Buffalo*	39.7	107	77	-30	-28%
11	Detroit	46.9	637	439	-198	-31%
12	Cincinnati	33.4	173	142	-31	-18%
13	Los Angeles	25.6	881	668	-213	-24%
14	Washington	7.4	104	103	-1	-1%
15	Milwaukee	42.9	213	179	-34	-16%
16	Kansas City	24.5	127	108	-19	-15%
17	New Orleans	15.6	56	49	-7	-13%
18	Seattle*	19.8	198	228	30	15%
19	Indianapolis*	33.1	128	107	-21	-16%
20	Atlanta	18.3	154	221	67	44%
21	Denver	16.8	95	93	-2	-2%
22	Columbus	25	100	104	4	4%
23	Memphis	20.5	61	64	3	5%
24	Nashville	22.9	72	96	24	33%
25	Dal.-Fort Worth*	18.4	235	363	128	54%
26	San Antonio	11.6	38	52	14	37%
27	Houston	21.4	158	220	62	39%
28	Jacksonville	13.1	29	40	11	38%
29	San Diego	15.7	70	127	57	81%
30	Phoenix	10.4	75	170	95	127%
	U.S.		20167	18772	-1395	-7%

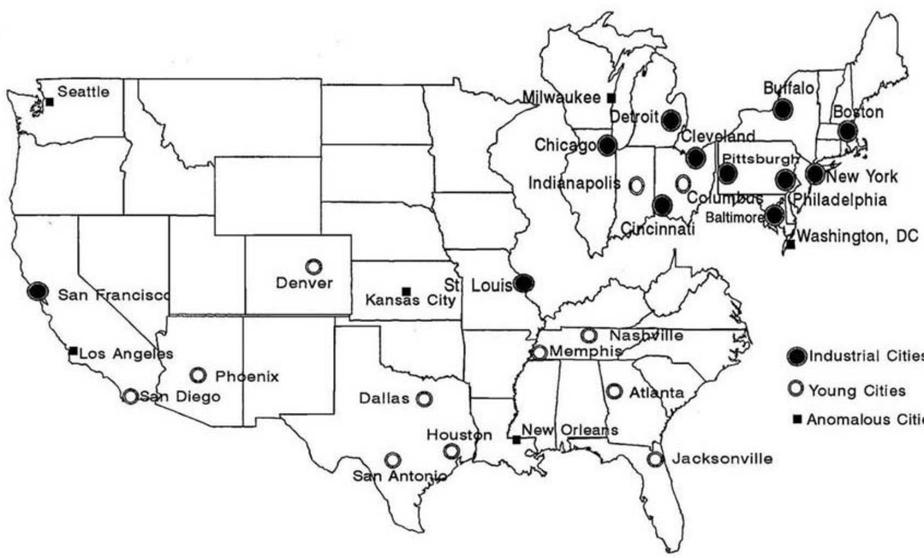
*Area had a major discontinuity in territorial definition. Figures listed are for incomplete timespan.
SOURCE: R.D. Norton 1979, p.19; U.S. Bureau of Labor Statistics, "Selective Access" on-line at http://www.bls.gov/sahome.html

The 30 metro areas contained the 30 largest cities in 1970, when large-scale losses of manufacturing jobs were about to begin. The areas are ranked by their population sizes in 1910, at the end of the nation's heavy industrialization and before the automobile or electricity had had much impact. This historical approach (introduced in Norton 1979) owes much to the geographer John R. Borchert's proposed sequence of technology epochs in a classic 1967 article, "American Metropolitan Evolution."

The dozen areas that had reached the largest size by 1910 can be termed "industrial." The dozen then smallest were deemed "young." In between, such areas as Los Angeles, Washington, D.C. and Seattle are "anomalous," in that much of their growth had occurred after 1910 but before 1950. Among the variables that then align by age-class are (1) population density, (2) industrial structure, and (3) unionization rates. (Norton 1979.)

Regionally, 11 of the industrial areas were in the Manufacturing Belt, and 10 of the younger areas outside it. (See MAP 2, which is adapted from Norton 1979, p 25.) At mid-century, the dozen industrial areas still had an average 35 percent of their 1950 workforces in manufacturing jobs. In contrast, the dozen termed younger had an average of only 19 percent.

MAP 2
THE REGIONAL CLUSTERING OF THE OLD CITIES



Source: Norton 1979, p. 25.

Their roles as exporters of industrial goods to the rest of the U.S. and abroad left the mature metro areas vulnerable to huge losses in manufacturing employment after 1970. The combined manufacturing job losses from four of them—New York (down 658,000), Chicago (326,000), Philadelphia (277,000), and Detroit (198,000)—exceeded the entire U.S. loss (1,395,000). Most younger areas added manufacturing jobs over the period, including a few (Atlanta, Dallas-Fort Worth, Houston, San Diego, and Phoenix) with sizable absolute gains.

As to changes in total employment, the contrasts between industrial and younger areas are milder, but still pervasive. The U.S. added 55 million payroll jobs from 1970 to 1998, for a percentage gain of 78 percent. Relative to this national rate, three points about the 30 areas might be made:

- A few industrial areas (New York, Pittsburgh, Cleveland, Buffalo) had extremely low job growth—below 10 percent.
- The median figure for the 11 older areas in the Manufacturing Belt, 35 percent (for Chicago), was less than half the U.S. rate.
- The median for the 10 younger areas of the South and West was 157 percent, twice the national rate. Atlanta, Dallas, Houston, and Phoenix added more than 1 million jobs (as did a now resurgent Chicago, Los Angeles, and Washington).

Even in the late 1990s, with brisk job growth nationwide, the older areas still lagged. As FIGURES 14 and 15 document, aggregate job growth from 1995 to 1998 remained only about half the rate in most older areas as in most younger ones.

FIGURE 14.
BRISK LATE 1990'S JOB GROWTH IN OLDER AREAS STILL LAGS...

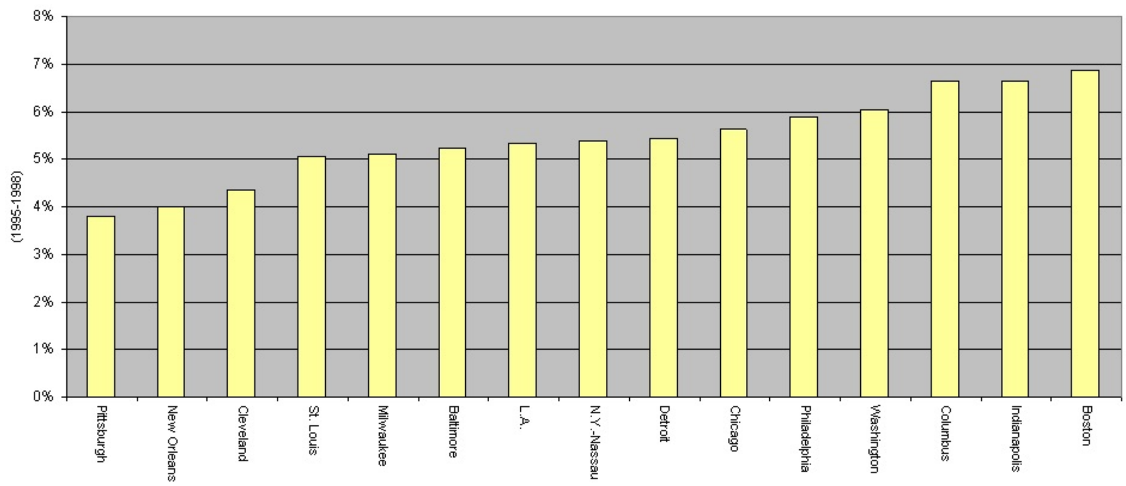
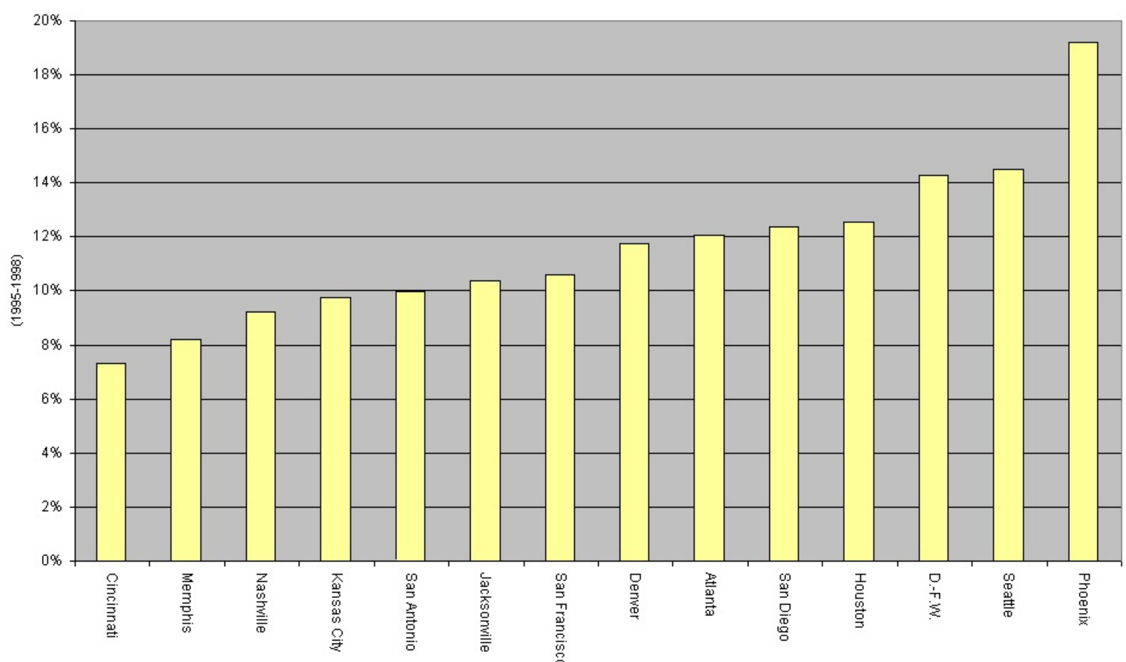


FIGURE 15 .
...THE FASTER EXPANSION OF YOUNGER AREAS
(B.L.S. TOTAL PAYROLL EMPLOYMENT, 1995-1998)



In sum, the specialized industrial roles of the mature areas led to large-scale losses of manufacturing and sluggish growth in total employment. While not exactly news, this remains point number one in any overview of the system of U.S. cities.

From the standpoint of cluster theory, we might put all this a different way: Specialization can be good for city growth—or not! It all depends on the nature of the activity, the pattern of demand from the rest of the world, and the chemistry between the activity and "learning" on the part of the city's workforce and knowledge base.

(3) The Ladder of Influence

An opposite view comes from David Warsh, who writes an economics column for the Boston *Globe*. Prompted by the purchase of the Los Angeles *Times* by the Chicago *Tribune* in early 2000, Warsh proposed an informal ranking of the leading centers of U.S. influence. His admittedly impressionistic list refers to "education, finance, and media industries. . . and the capacity to absorb the latest streams of immigration. . . ." (Warsh 2000, p. E1.) By this reckoning, the three largest cities, New York, Chicago, and Los Angeles, are also the three most influential, the places where U.S. opinions and attitudes are shaped.

Then there are "the other American cities of international importance—Washington, D.C., Boston, Miami, San Francisco and, possibly, Seattle. . . world centers in certain fields." In this reckoning, Washington qualifies only because it is the capital. Boston and San Francisco make the top 8 by virtue of their financial and university strength. Miami qualifies as the gateway to Latin America and the Caribbean, and Seattle as a "high-tech nursery." Global cities in specialized realms, these five fall just below the top three, New York, Chicago, and Los Angeles.

Warsh's conclusion? "This is not to rob a dozen other U.S. cities of their significance. . . . But the hierarchy is well-established, and here, as in Europe, the oldest cities tend to remain at the top." (Warsh, p. E1, emphasis added.)

This curious generalization may have some relevance to media and entertainment. But it completely misses the dynamic of renewal by which younger centers have restored the American economy to global leadership. A sense of that dynamic can be seen in the recent upheavals in the U.S. system of cities—indexed not only by job growth, but also migration choices and I.T. roles.

(4) Tech-Poles: The Milken Institute List

Consider, for example, the Milken Institute's 1999 ranking of "Tech-Poles." These are the U.S. metropolitan areas that stand out by virtue of their size and specialization in a broad range of high-tech activities. (DeVol 1999, p. 67.) When an area's percentage share of U.S. high-tech output is multiplied by its high-tech output location quotient, the result finds San Jose Silicon Valley) the runaway leader, followed by Dallas, Los Angeles, Boston, and Seattle. The next five are Washington, D.C., Albuquerque, Chicago, New York, and Atlanta.

In other words, four of the top five areas are from the South and West, as are three of the next five (once we recognize that the Washington, D.C., area's high-tech center of gravity is northern Virginia). That adds up to six of the top seven metropolitan areas from the South and West, as measured across the gamut of high-tech activities.

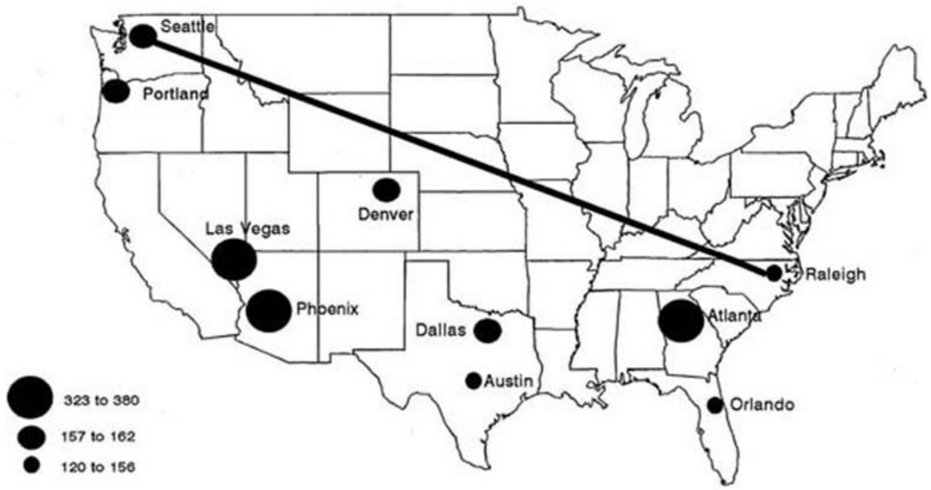
A still sharper regional watershed can be seen for domestic migration.

(5) Magnet Metros: The Seattle-Atlanta Line

Niles Hansen contends that domestic migration flows in the 1990s give a clean read on the economic opportunities offered by major metropolitan areas. (Hansen 2000.) In part this view is based on the observation by Glaeser that domestic migration flows offer a better indicator of an area's success than per capita income growth, because the latter may include a "bribe" component in wages to offset urban disamenities.

The areas with the largest 1990-1997 in-flows can be found below what Hansen terms the Seattle-Atlanta line. (See MAP 3, which is based on data presented in Hansen 2000, Table 2.) The numbers range from over 300,000 in Atlanta, Phoenix, and Las Vegas to gains between 120,000 and 162,000 in Seattle, Portland, Dallas, Denver, Austin, Raleigh (which is just north of the line), and Orlando.

MAP 3
THE 10 METRO AREAS WITH LARGEST NET DOMESTIC IN-MIGRATION (000), 1990-97



Source: Data from Hansen 2000, Table 2.

In terms of size, all the "magnet metros" had fewer than five million residents in 1995. The largest was Dallas, with 4.7 million resident. The next largest were Atlanta, 3.6 million, Seattle, 3.4, and Denver, 2.3. That meant that no magnet metro was as large as any of the 8 largest areas: New York, Los Angeles, Chicago, Washington, San Francisco, Philadelphia, Boston, and Detroit. Each of these 8 largest had over five million people, and each had net domestic outflows.

The map serves as a visual reminder that size is but one of several linked variables. It portrays a regional realignment from high-density, high-cost, older areas in the Manufacturing Belt and California to younger, low-density centers. In turn, this shows up in the data as a move from larger to smaller cities.

The net effect, Hansen concludes, "has been a definite shift downward in the urban hierarchy in terms of where Americans want to live and work." (Hansen 2000, p. 12.) And as he demonstrates, the shift is not only from the largest to mid-sized metros, but also from the Manufacturing Belt and California to younger areas in the diagonal band between them.

(6) The Perils of Specialization, Continued: I.T. Hardware

Just as specialized roles proved a heavy load for industrial metros after 1970, so too did high profiles in computer production and electronics between 1986 and 1996. (TABLE 11.) The precipitants were declining U.S. employment in computer production (SIC 357), slow job gains in electronics (SIC 367), and decentralization of both to rural states.

Thus the three areas with the greatest initial specialization in computer and electronics production accounted for over half of all hardware jobs lost nationwide from 1986 to 1996. (See Equation 1.) Phoenix, Boston, and Los Angeles combined for hardware losses of 73,000 jobs.

How different is the lesson here from that of the de-industrializing "industrial" cities after 1970? The two cases seem closely related, and not only because the I.T. hardware losses are one component of the larger losses in manufacturing employment in older areas. In each story, initial production centers specialized in sectors that would add little or no employment nationally, a scenario that tends to be accompanied by rapid dispersal to competing domestic sites, including non-metro locations.

Put the other way around, one of the ways the U.S. as a geographical entity retains employment relative to offshore locations is by offering both competing centers of innovation and lower-cost (including non-metropolitan) environments.

TABLE 11
IN HARDWARE, SPECIALIZED AREAS LOST MOST
(Absolute change in SIC 357 + SIC 367, 1986-1996)

Area	Hardware L.Q., 1986	Employment ch., 1986-1996
Phoenix	3.7	-13864
Boston	3.0	-25952
San Diego	2.1	-1327
Los Angeles	1.6	-33314
Dallas-Fort Worth	1.2	5887
Chicago	0.8	-5172
Philadelphia	0.8	-8304
Kansas City	0.8	-3427
San Francisco	0.6	-3881
Seattle	0.5	2752
NY-Nassau	0.4	-8304
Milwaukee	0.4	415
Houston	0.3	3765
Pittsburgh	0.3	666
Cincinnati	0.3	-49
Washington	0.3	-1676
Columbus	0.3	-200
San Antonio	0.3	-1190
Detroit	0.3	-365
St. Louis	0.2	1400
Cleveland	0.2	497
Baltimore	0.2	155
Buffalo	0.2	450
Indianapolis	0.2	315
Denver	0.1	482
Nashville	0.1	408
Atlanta	0.1	48
New Orleans	0.1	150
Jacksonville	0.1	-40
Memphis	0.0	821
Total, 30 areas		-88854
Exhibit: Silicon Valley	7.7	-22940
Total, 31 areas		-111794
U.S. total		-126123

Source: Machine-readable *County Business Patterns* data for 1986 and 1996. Area definitions are available on request from the author.

In any case hardware was only half the story of metro I.T. growth during "the break-up of the old computer industry" (Grove 1993, p. 57).

(7) In Sum: Diversity and Adaptive Capacity

We are exploring the geographical origins of the New Economy in the U.S. Regionally, the PC revolution had largely western coordinates, as Part B showed. As the New Economy moved into high gear in the mid-1990s around the Internet, a different geographical logic took over. The underlying forces shaping place competition increasingly came to include media and finance, not just I.T. Accordingly, the creation of technology-based start-ups would now depend on resources available to a few of the most diversified of the faded industrial centers, the industrial cities identified in Map 2.

From either perspective, that of the U.S. resurgence during the PC revolution or the Internet explosion of the late 1990s, the diversity of the system of cities may well have added to the U.S. economy's adaptive capacity. As Clem Tisdell observes, "Industrial diversity (more generally diversity of driving attributes in dynamic systems) can have value in increasing the likelihood that an economy (or system) can jump to a superior state." (Tisdell 1999, p. 163.)

>By extension, we might surmise that continentality and regional diversity aided the U.S. immeasurably in its shift from mature industries and cumbersome managerial corporations to new forms and sources of growth.

SEEDBED CLUSTERS

Now we come to the third basic tendency transforming the U.S. system of cities. The first point has been the influence of history—known in the cluster literature as path-dependence—in the economic performance of the 30 large areas we are monitoring. The second is domestic migration flows, as shaped by the influences that make mid-sized younger centers from Seattle to Atlanta "magnet metros." The third is the agglomeration of knowledge workers in a dozen or so major areas blessed by a favorable mix of venture capital firms, universities and research institutes, and a crackling atmosphere—typically a high-amenity location where ideas and possibilities are, in Alfred Marshall's term, "in the air."

Where, then, did concentrations of I.T. workers grow most rapidly between the mid-1980s and the mid-1990s? In light of the stagnant job growth in computer and electronics hardware employment, the answer turns largely on software and other computer services.

We will find that the geography of job growth in software had a logic opposite that of hardware. That is, the places that specialized most in software and other computer services in the mid-1980s would then go on to record the largest software job gains over the next decade. Since software and other computer services added jobs at a rapid clip during this interval, for most of the 30 areas the employment gains easily outweighed computer hardware losses. (Exceptions were two hardware centers, Los Angeles and Phoenix.)

In turn, some of the initially specialized areas saw software expansion interact with the local venture-capital base to spur new technology-based business creation, as measured by initial public offerings (IPOs). The result for Boston and New York, "industrial cities" in terms of the timing of their industrialization, has been a dramatic comeback in the innovation race, fueled in good part by specializations in higher education, finance, and media.

Hence the spatial chemistry for innovation to be documented now. The indicator to be used is the IPO, the issuance by a privately held company of common stock to the general public. While 600,000-800,000 new businesses are formed each year in the US, only about 400 companies reach the moment of an IPO. To that extent, IPOs can be viewed as survivors of a selection process to single out elite start-up companies promising investors high profits because they can do something new—Schumpeter's touchstone for innovation.

Part Real, Part Surreal: The Internet Gold Rush

At the same time, this may be the dimension to the New Economy best described my Mark Zandi's term, "part real, part surreal" (Zandi 1998). Realistically, an IPO can be viewed as an attempt on the part of promoters to "sell" a new idea to the investment community. During the Internet Gold Rush of 1998 and 1999 some IPOs have had more hype than content, as the shakeout of dot-com's in April 2000 demonstrated. To that extent, IPOs are an imperfect measure of innovation—an indicator of market fads as well as of genuine new ideas.

For now, suppose we view IPOs as a rite of passage for an idea-based start-up firm, a moment of truth when the firm's defining premise is put to the test of the market. The question is, where are such new ideas most likely to occur, to be put into practice, and to reach the stage of going public?

As a working hypothesis, we might surmise that IPOs in the late 1990s were most frequent where knowledge workers could hook up with venture capitalists—the suppliers not only of money, but of management expertise of the kind most technology-based start-ups lack.

Accordingly, the topics to be explored now are (1) the new lineup of software centers, where I.T. workers are concentrated; (2) the prominence of venture capital (VC) firms in the 30 areas; and (3) the rate of IPOs in an area per million residents.

Software Centers

As noted, software centers had employment gains that swamped their losses in hardware. (TABLE 12.) For example, of the 30 large areas, Washington, D.C., was most specialized in SIC 737 (computer services) in 1986. Thanks in large part to the explosion of software and telecommunications in northern Virginia, the D.C. area also had the largest gain in computer services employment, over 50,000. At the other end of the spectrum, the least specialized area in 1986, New Orleans, had the smallest increase in computer services employment.

TABLE 12
IN SOFTWARE, SPECIALIZED AREAS GAINED MOST
(Employment changes in SIC 737)

Are column headings correct Area	Software L.Q., 1986	SIC 737 employment change, 1986-1996	
Washington	5.0	122.5%	51293
Atlanta	2.9	88.9%	12729
Boston	2.4	134.8%	38239
Dallas-Fort Worth	2.2	120.6%	27461
Detroit	2.1	52.4%	11134
Denver	2.1	101.5%	10561
San Diego	1.9	91.7%	7613
Chicago	1.6	58.7%	19105
Baltimore	1.3	108.9%	4834
Philadelphia	1.3	113.1%	17937
Los Angeles	1.3	71.5%	28109
St. Louis	1.3	129.6%	7183
Houston	1.2	93.7%	9431
San Francisco	1.2	225.3%	10113
Seattle	1.1	239.3%	13178
Cincinnati	1.1	108.9%	3985
San Antonio	1.1	22.0%	655
NY-Nassau	1.0	80.4%	23046
Jacksonville	0.9	145.7%	3002
Indianapolis	0.9	141.2%	4218
Kansas City	0.8	230.7%	7508
Phoenix	0.8	187.1%	9783
Columbus	0.7	278.2%	6871
Pittsburgh	0.7	177.8%	6662
Cleveland	0.7	101.7%	4191
Milwaukee	0.6	204.1%	5128
Nashville	0.5	152.4%	2205
Buffalo	0.5	102.4%	1461
New Orleans	0.5	36.4%	478
Memphis	0.0	(not app.)	3833
Total, 30 areas			351946
Exhibit: Silicon Valley	2.7	170.3%	45270
Total, 31 areas			397216
U.S. total			713231

Note: Negligible base-year value precludes percent change for Memphis.
Source: Same as for Table 11

Here we have a stylized dichotomy, which in this case may be accurate. The contrast is between two southern centers, the National Capital Region (with its abundance of government agencies, including the Pentagon, the outsourced private contractors, the media covering the federal government, the spectrum of universities, and the tradition of intellectual conflict and ferment) and New Orleans—a city whose chief claim to fame is the Marti Gras. The first led the list in terms of job growth in computer services. The second came in last.

How general was this tendency? To find out, we can test changes in employment from 1986 to 1996 against initial location quotients. (A "location quotient" expresses the proportion of a sector like I.T. in a place's total employment, relative to the same proportion for the U.S. Hence location quotients above unity would indicate that the area is more specialized in the activity than the nation as a whole.)

Equation 2 indicates that a difference of one point in 1986 location quotients between areas was associated with an increment of 10,000 computer-services jobs over the decade after 1986. Whatever the bundle of variables represented by the initial location quotients, together they account for nearly 60 percent of the variation in job gains.

In contrast to hardware jobs, then, this was an example of virtuous specialization. In a rapidly growing employment sector nationwide, initial centers tended to grow as rapidly in percentage terms as others, hence scoring larger absolute gains.

Does Venture Capital Stay Local?

Now we come to the financing mechanism. The starting point is that lead VC firms tend to "stay local." The reason is their need for routine face-to-face contact with supported early-stage firms. As a Silicon Valley journalist notes, "If you need to meet with a company every week or other week to get it off the ground, you don't want to have to jump on a plane and cross three time zones to do it—especially if you generate high returns off companies based in your own proverbial backyard." (Shawn Niedorf, "New Yorkers Not Talk of Town," San Jose *Mercury-News*, on-line, March 7, 2000.)

At the same time, Niedorf's qualifier ("especially...") points up the key premise in her argument. What if you cannot find promising companies right in your backyard? Which comes first, the VC chicken or the start-up egg? At this point a word about the origins of VC—and its migration west—may come in handy.

Venture capital was invented in the form of Boston's American Research and Development (ARD) at the end of World War II as a deliberate attempt to incubate new activities to offset the decline of New England's ancient industries. By the 1960s, venture capital also took hold in Silicon Valley, where Shockley Semiconductor had enhanced the presence of Hewlett-Packard and the Stanford Research Park. Both Boston and Silicon Valley would go on to become the nation's primary VC centers and hotbeds of technology-base start-ups.

On the other hand, New York or Chicago venture capitalists may take part in syndications, through "co-investments" with lead VC firms elsewhere—Silicon Valley, Massachusetts, or more recently Texas, for example. This was the tendency documented in a 1992 study of VC's role in 8 major centers. The authors classified 8 VC centers as technology-oriented (Silicon Valley and Denver), financial-oriented (New York and Chicago), or hybrids of the two (Boston, Minneapolis-St. Paul, Texas, and Connecticut). (Florida and Smith 1992, p. 201.)

At that time they found that "just 7 percent of the investments made by New York venture capitalists were made in-state," vs. 70 percent in-state in California. In between was Massachusetts, whose VC firms made 40 percent of their placements in-state, and 30 percent to California start-ups. (Florida and Smith, p. 193.) (A different angle on the feasibility of long-distance relationships, as facilitated by airline connections between emerging and established centers, appears in a recent study of innovation in Texas cities.)

Florida and Smith's study of the 8 VC centers appeared in 1992. In the meantime some things have changed, such as the rise of New York City's "Silicon Alley," which specializes in media-based Internet start-ups. One might therefore expect to find deepening ties between Wall Street venture capitalists and Silicon Alley entrepreneurs.

VC "Funds" as an indicator of Local Supply

The hypothesis, then, is that the frequency of IPOs in an area will increase, the greater the supply of venture capital in the area. How, then, should be measure "supply"? Lacking more precise data, a good indicator of the size of an area's venture capital base is the number of separate *funds* being maintained by the area's VC firms. Each fund in a VC firm's "portfolio" represents a separate sector (e.g., biotech, network software, or e-commerce). And each has a separate and finite duration (perhaps five or 10 years), to be liquidated at maturity. (TABLE 13.)

TABLE 13.
THE NUMBER OF VENTURE CAPITAL FUNDS ACTIVE IN 1999

Area	No. of funds
Silicon Valley/San Francisco	500
Boston	351
New York	190
Minneapolis	62
Chicago	61
Los Angeles/Orange County	50
D.C., Maryland, Virginia	47
Dallas	42
Philadelphia	26
Denver	19
Seattle	18
Charlotte	14
Austin	13
Pittsburgh	8
Detroit	8
Cleveland	7
Kansas	6
Portland, Me	6
Greenville, S.C.	6
Indianapolis	5
New Orleans	5
San Antonio	5
Tampa	5
Total	1454

NOTE: Areas not among the 30 metros are italicized
Source: PriceWaterHouseCooopers Money Tree Survey

Note that this indicator measures where placements originate—not where they land. Since the purpose of a VC placement is to bring the early-stage firm to a successful IPO, linking IPOs to where placements land would be tautological, explaining nothing. (That is, when a Chicago venture capitalist has a placement in Silicon Valley, the IPO is all but certain to occur in the Valley.) In contrast, we are testing Shawn Niedorf's maxim: lead or solo VC firms prefer, in effect, to stay home because of the need for frequent face-to-face contact with supported start-ups.

In short, the premise is that start-ups in a given metropolis are more likely to find VC financing and assistance if more VC funds are being run there.

An IPO a Day: 1996-1999

A word about the IPO data. From May 1996 to November 7, 1999, 1,532 IPOs were launched in the U.S. That averages over 400 per year, or more than one a day. The three and a half years surveyed is the interval covered by the data-base in Hoover's on-line IPO directory (http://www.hoovers.com/ipo/)). The data-base permits counts by industry, by state, and by metropolitan area.Web address works but still correct?

Over that interval from mid-1996. about three-eighths of the total count have been in some sense "digital," linked to computing, semiconductors, software, networks, or e-commerce. (The proportion rose sharply in 1999, as the Gold Rush gathered speed, to about 60 percent.)

In absolute terms a handful of areas dominated the metro landscape for IPOs over the period from July 1997 to late October 1999. New York and Silicon Valley each were home to about 200 IPOs. Adding Los Angeles's 94 and Route 128's 90 gives a figure for the four top metros of over half of the 30-area total—and about 40 percent of the U.S. total (TABLE 14). Like its progenitor venture capital, IPO activity thus tends to be concentrated in a few major centers.

TABLE 14.
IPOS IN 30 LARGE METROPOLITAN AREAS, JULY 1996-OCTOBER 1999

Area	All IPOs	Digital IPOs	IOPs/mil.	Dig./mil.
New York CMSA	199	83	10.9	4.5
Chicago CMSA	48	13	5.6	1.5
Phil. CMSA	48	14	8.1	2.4
Boston	90	47	15.5	8.1
Pittsburgh	10	4	4.2	1.7
St. Louis	7	3	2.7	1.2
S.F.-San Jose	196	142	29.3	21.2
Baltimore CMSA	17	6	6.8	2.4
Cleveland CMSA	8	1	2.8	0.3
Buffalo	1	0	0.8	0.0
Detroit CMSA	18	1	3.3	0.2
Cincinnati CMSA	7	1	3.7	0.5
Los Angeles CMSA	94	35	6.0	2.2
Washington PMSA	59	28	12.8	6.1
Milwaukee CMSA	5	1	3.1	0.6
Kansas City	12	3	7.1	1.8
New Orleans	1	0	0.8	0.0
Seattle CMSA	35	22	10.3	6.5
Indianapolis	8	2	5.3	1.3
Atlanta	43	15	11.9	4.2
Denver CMSA	37	20	16.1	8.7
Columbus	5	0	3.3	0.0
Memphis	3	0	2.7	0.0
Nashville	6	0	5.5	0.0
Dal.-F.W. CMSA	45	14	9.6	3.0
San Antonio	2	0	1.3	0.0
Houston CMSA	61	9	14.2	2.1
Jacksonville	6	1	6.0	1.0
San Diego	31	10	11.5	3.7
Phoenix	13	4	4.6	1.4
Total, 30 areas	1115	479		
Total, U.S.	1532	575	5.7	2.1

SOURCE: Hoovers on-line IPO data base

In addition, the large number of IPOs for the New York area suggests a sharp increase in start-up activity, triggered in part by media-linked Internet firms. No longer does money raised by venture capitalists in New York all go to other regions.

At the same time, some unexpected places also have high IPO rates, once we discount the effect of absolute population size.

IPO Rates by Area, Relative to Population

Standardized for population, how do individual areas compare to the U.S. averages, i.e., about six IPOs of all kinds, and about two "digital" IPOs, per million residents? (To repeat: digital offerings include not just Internet issues, but any that relate to computers, electronics, or software.)

For IPOs generally, the highest rate was Silicon Valley (approximated by combining the San Francisco and San Jose metropolitan areas). It had nearly 30 IPOs per million residents, about twice the rate of any other area. As in the Milken Institute ranking of high-tech output noted above, the San Jose/San Francisco region is in a class by itself.

A dozen other areas on the list came in above the U.S. average. Other entries include second-place Denver (above Boston or New York), Seattle, Atlanta, San Diego, Baltimore, and Philadelphia.

In contrast, both the smaller areas in the South and West and the more "heavy-metal" areas of the Midwest lagged the national averages.

For digital IPOs per se, the top five entries in TABLE 15, are Silicon Valley, Denver, Route 128, Seattle, and Washington, D.C. (i.e., including northern Virginia). By contrast, Philadelphia, Houston, Kansas City, and Chicago are less prominent digitally than for IPOs in general.

TABLE 15
DETERMINANTS OF IPO FORMATION RATES IN LARGE METRO AREAS

Area	IPOs/mil	DIG./mil.	FUNDS99	SOFTSHARE	%DSOFT
S.F-San Jose	29.3	21.2	98	0.025	225
Denver CMSA	16.1	8.7	13	0.024	101
Boston	15.5	8.1	64	0.037	135
Seattle CMSA	10.3	6.5	16	0.017	239
Washington PMSA	12.8	6.1	23	0.064	122
New York CMSA	10.9	4.5	55	0.012	80
Atlanta	11.9	4.2	14	0.029	89
San Diego	11.5	3.7	11	0.018	92
Dal-F.W. CMSA	9.6	3	13	0.026	121
Phil. CMSA	8.1	2.4	27	0.017	113
Baltimore CMSA	6.8	2.4	23	0.015	109
Los Angeles CMSA	6	2.2	18	0.014	72
Houston CMSA	14.2	2.1	8	0.012	94
Kansas City	7.1	1.8	0	0.015	231
Pittsburgh	4.2	1.7	5	0.011	178
Chicago CMSA	5.6	1.5	31	0.015	59
Phoenix	4.6	1.4	0	0.011	187
Indianapolis	5.3	1.3	2	0.011	141
St. Louis	2.7	1.2	3	0.016	130
Jacksonville	6	1	0	0.012	146
Milwaukee CMSA	3.1	0.6	5	0.010	204
Cincinnati CMSA	3.7	0.5	1	0.011	109
Cleveland CMSA	2.8	0.3	4	0.008	102
Detroit CMSA	3.3	0.2	7	0.019	52
Buffalo	0.8	0	3	0.006	102
New Orleans	0.8	0	1	0.004	36
Columbus	3.3	0	1	0.014	278
Nashville	5.5	0	2	0.007	152
San Antonio	1.3	0	1	0.007	22

SOURCE: Same as for Tables 12, 13, and 14

Digital IPO Rates as a Function of the Two Variables

Denver aside, we seem to have arrived back to a list of "the usual suspects" for clusters of innovation. To what extent does this outcome reflect the proposed explanatory variables—the supply of venture capital and the relative size of an area's software sector? Two measures of the latter influence have been found relevant. One refers to the share of an area's total employment in software jobs in 1996. Another refers to the rate of growth of employment in computer services between 1986 and 1996.

It turns out that three-fourths of the differences among areas in digital IPO rates per million residents can be statistically explained in this framework. (In Equation 3, in other words, the adjusted R^2 is .75.)

The implication is that the five areas just mentioned have unusually high rates of IPO activity because large numbers of technically talented people are concentrated in places offering relatively easy access to venture capital—including not only the funding, but the management expertise that comes with it.

Still, given the element of hucksterism that permeated IPOs during the Internet Gold Rush of the late 1990s, it seems advisable to compare the IPO results to more traditional measures.

PATENTS: OLD ECONOMY?

The obvious question, in other words, is whether we might find a better indicator with which to monitor changes in innovative performance in the U.S. system of cities.

An approach that is sometimes advanced is to compare patent rates in competing metropolitan areas. For example, O'hUallachain (1999, p. 613) observes, "Innovation is not the product of lone individuals nudging technology forward, but encompasses many interdependent people, firms, and institutions working within networks of social and economic relations." It turns out, however, that the article is not about innovation at all, but about patents, tabulated relative to population in U.S. metropolitan areas in 1996.

In a similar spirit, Varga observes, "This chapter, using a large data set of US patents, presents the first industrially and spatially detailed analysis of recent trends of innovative activity in the United States" (Varga 1999, p. 230).

Patents Measure Invention, Not Innovation

Unfortunately, and apart from any other limitations of patent data, patents do not measure innovation. Formally, of course, patents are granted by the U.S. Patent Office when it accepts applications to register new ideas, whether for business procedures (as in the recent Amazon single-click case) or for new hardware or industrial processes—or (notoriously, of late) for a chemical formula to be used by pharmaceuticals companies. The patent then confers monopoly rights to the holder, normally for a period of 20 years.

Innovation is a separate step: the commercialization of invention. In a Schumpeterian framework, for example, the four key processes are invention, innovation, emulation, and diffusion. The invention, which may or may not get patented, is the initial idea. The innovation is the process of putting the idea into practice for a profit. Emulation is what happens when competitors "swarm" to provide the same product at a lower price, subject to patent restrictions (as when Compaq reverse-engineered BIOS chip for the IBM PC in the mid-1980s, opening the doors to clones). "Diffusion" refers to the time interval required for an innovation to become widely adopted.

In case the difference is not clear, consider the potentially unnerving case whereby British Telecom is considering pressing a claim that it had applied for (in 1980) and received (in 1989) a patent for a process closely resembling if not identical to the hyperlink. This realization occurred by accident only in the year 2000, when someone stumbled upon an old patent record. (Bray 2000, p. D1.) If such a patent exists and proves valid, the question arises—what happened? A certain rough justice might be served, in that hyperlinks were first joined to the Internet by an Englishman, Tim Berners-Lee, in a project at CERN, the European particle physics consortium in Switzerland, in 1990.

The point here, however, is that the idea was never put into practice by British Telecom, who seem not to have known what to do with it. If so, they had plenty of company in the numerous U.S. managerial corporations who came up with ideas and then had no clue how to proceed. The classic example, among many, is Xerox, whose Palo Alto Research Center (PARC) came up with a dazzling series of revolutionary PC ideas, not one of which Xerox ever commercialized—because they did not improve Xerox's position in the copier market.

In organizational terms, patents can perhaps best be understood as a running tabulation of what happens in corporate R&D labs, as a look at the U.S. Patent Office's top 10 patenting organizations will tend to confirm. In 1996, for example, the 10 U.S. organizations with the largest number of patents were IBM, Motorola, the U.S. government, General Electric, Eastman Kodak, Xerox, Texas Instruments, 3M, AT&T, and Hewlett-Packard (O' hUallachain, p. 624). Only two of these, T.I. and H-P, are from the South or West, and they are both anomalies in their own regions by virtue of their relatively advanced age.

How accurate are patents as indicators of corporate and other invention? A recent study by Cohen, Nelson, and Walsh (2000) points up the indicator's limitations. Surveying 1478 R&D labs in U.S. manufacturers in 1994, they found that of the several ways firms "protect the profits due to invention. . . patents tend to be the least emphasized by firms in the majority of manufacturing industries and secrecy and lead time tend to be emphasized most heavily." By the same token, when patents were employed, it was not necessarily to protect a new discovery but alternatively to attain negotiating leverage, to block other firms' patents of related discoveries, or to prevent suits.

Even as measures of inventive activity, in short, patents leave something to be desired.

What Do Patents Show about the Geography of R&D or Inventive Activity?

Taken on their own terms, what do such studies of the geography of patent activity reveal? As might be expected, adding location as a dimension creates new measurement issues.

One concerns the location of the discovery itself vs. the location of the patent's ownership. Tabulations that locate patent activity according to where the patent is owned, not where the inventor (or R&D lab) is located, tend to distort the picture, as when the 23 percent of Arizona's patent activity attributable to a Motorola facility there in 1996 might have been credited to the parent company's state, Illinois. Another is that patents have traditionally not covered software code, which instead comes under copyright laws. To that extent, patent counts will tend to slight metros specializing in I.T. (Both these cautionary points are made by O' hUallachain, p. 628).

Such quibbles aside, what do the two recent patent studies reveal about the U.S. system of cities? Both tend to bring out the "inventiveness" of traditional metros in the Manufacturing Belt. O' hUallachain, for example, finds that the 87 metros of the Manufacturing Belt accounted for half of all metropolitan patents in 1996, when they had only 44 percent of the metropolitan population. Accordingly, "Metropolitan residents in the manufacturing belt remain the most industrious inventors" (p. 613).

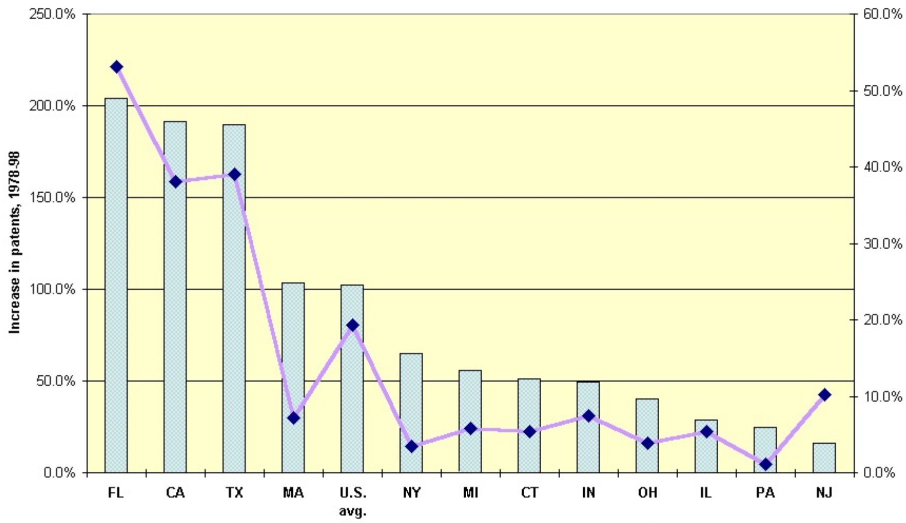
Varga's findings differ because he monitors changes in patent activity over time, from 1983 to 1992. He finds a general shift in patent activity from the metros of the Manufacturing Belt to areas in the South and West, led by patents registered for I.T. On the other hand, some centers in the Belt retained strong presences in chemicals and pharmaceuticals, and in high-technology machinery. Philadelphia, for example, remained strong in the former, and Chicago in the latter—indeed, Chicago ranked second in 1992 among all areas in terms of high-technology patents. (Varga, p. 225).

The Stellar Patent Performance of the Three Super-States, 1978-1998

Relying purely on patent data, then, the two studies together suggest that the strong performance of Manufacturing Belt metro areas in 1996 may have been a legacy effect. This impression holds up when we perform a new comparison of state patent data over time. We can begin with the 10 states that had most patents in the late 1970s. Seven were from the Manufacturing Belt, and the other three were California, Florida, and Texas, the proverbial "super-states" when it comes to population and employment growth. (The data set has been compiled and provided by Brian Ceh, who also alerted me to the increasing prominence of the latter three states.)

Among the 10 major states in terms of late-1970s patent activity, we can compute the increase in patents generated over the next 20 years. The national count doubled (from 44,762 to 90,676, up 103 percent). But counts roughly tripled in Florida, California, and Texas. As FIGURE 18 shows, Massachusetts came in at the national average, while the remaining six states had increases of less than two-thirds the U.S. pace.

FIGURE 18.
PATENT GROWTH RATES, 1978-98, IN THE 10 STATES WITH THE MOST 1978 PATENTS



Source: Based on patent data kindly provided by Brian Ceh and population data from the U.S. Bureau of the Census.

A line is also included in Figure 18 to show state population changes over the same interval. With the possible exceptions of Massachusetts (where patents "outperformed" population, as it were) and New Jersey (where the opposite can be seen), the two indicators show a remarkable correspondence.

The conclusion? For inventive activity no less than for population, the U.S. experienced a pronounced shift away from the Manufacturing Belt in the 1980s and 1990s. On average, in other words, the three "super-states" had increases in patent activity at least triple that of such traditional industrial states as New York, Michigan, Ohio, Illinois, Pennsylvania, and New Jersey.

This brief look at patents, though hardly definitive, suggests four plausible conclusions:

1. The results reveal that "per capita inventiveness" as a measure is likely to underestimate the speed of the regional transformation, because both patent activity and population have shifted at a rapid pace.
2. The widely noted U.S. comeback in patent activity during the 1990s (which defied predictions by analysts such as Michael Porter) has depended directly on the supercharged patent performance of the growing states in the South and West, as symbolized here by Florida, Texas, and California.
3. In the end there is not much difference in the geographical implications as between IPOs and patents as indicators of the geographical dispersal of creativity over the past few decades. Both indicators, the one of innovation, the other of inventiveness, point up the growing prominence of younger metros and regions within the economy as sources of technological advance.
4. The greatest exceptions to point (3) are the two resurgent industrial cities, New York (a major IPO seedbed) and Chicago, buoyed by "high-tech" (but not I.T.) patent activity. Here the indicators give different results, and each must be respected.

STRATEGIC CITIES

"Large urban places are not anachronisms in the information age, they are the dominant places in the information age" (Drennan 1999, p. 314). But which ones, specifically, emerge from among our working list of 30 of the largest U.S. metropolitan areas? In Galbraith's telling term, which have emerged as strategic cities, places offering "the information that decision requires"? In light of the indicators we have considered, the first 10 or so areas come quickly to mind, although the exact order remains subjective:

- San Francisco/Silicon Valley, of course.
- These days, (2) Boston and Route 128 (again).
- Washington, D.C., which thanks to northern Virginia is almost as prominent in telecommunications as in government.
- Dallas, especially when understood as the center of the emerging complex of Texas cities.
- Seattle, as symbolized by the world's largest philanthropy, the Bill and Melinda Gates Foundation.
- Los Angeles, like New York a media-rich location in an age of convergence between content and the Internet.
- Denver, a relatively unknown powerhouse and a regional capital.
- New York, by virtue of finance and media.
- Chicago, another "industrial city" like New York and Boston, and a standout in terms of Old-Economy high-tech patents.
- Either Atlanta, by the indicators and as a regional capital, or
- San Diego, an amenity center now liberated from but still technically enriched by its long-time military dependency.

But I see that this top-10 list, loosely based on the empirical indicators we have surveyed, omits such obvious smaller candidates as Albuquerque, Austin, Boise, Miami, Minneapolis, Orlando, Portland (Oregon), or the North Carolina complex—on the basis of size alone. Needless to say, such smaller centers are increasingly prominent in national and global networks of research, production, and innovation.

Come to think of it, recognizing that some other highly innovative cities have been omitted from our list is as good a way as any to do justice to the energizing geography of the New Economy.

D. METAPHORS, EVOLUTIONS, AND (REGIONAL) SCIENCE

In a 1996 book, *The Future of Capitalism,* Lester Thurow makes skillful use of two metaphors from the natural sciences. The first is the concept from biology of punctuated equilibria . The second metaphor is the image of tectonic plates, the geological layers whose largest versions are continental in scale, which lie beneath the surface of the earth and drift an inch or two a year, causing the earthquakes and volcanoes that are visible to us.

Thurow's argument is that the world economy has arrived at a moment of sudden change, marked by five "tectonic" underlying forces. To wit:

(1) the end of communism,

(2) the arrival of a truly global economy, owing to communications advances,

(3) the end of America's technological advantage relative to the rest of the world,

(4) the end of America's economic, military, and diplomatic leadership, and

(5) demographics including migration and the aging of the world's populations.

Time has not been kind to Thurow's diagnoses of America's weakness. But our interest concerns not his predictions but his evolutionary metaphors. (For more in the way of geological metaphors in particular, see his 1998 *New York Review of Books* essay, Asia: The Collapse and the Cure.)

1. BIOLOGICAL ANALOGIES: FROM MARSHALL TO SCHUMPETER

Thurow is not the first economist to use a biological analogy to chart capitalism's trajectory. The logic of punctuated equilibria accords with Joseph Schumpeter's famous chapter, "The Process of Creative Destruction" in his *Capitalism, Socialism, and Democracy* (1942, 1962, pp. 81-86). "The essential point to grasp," he wrote there, "is that in dealing with capitalism we are dealing with an evolutionary process (p. 82)." The driver he saw was innovation—not only technological, but organizational as well. "The fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumers' goods, the new methods of production or transportation, the new markets, the new forms of industrial organization that capitalist enterprise creates" (p. 83).

The biological metaphor lies at the core of Schumpeter's vision of capitalism. In addition to technological innovations in the steel industry, in energy conversion, and in transportation,

> The opening up of new markets, foreign or domestic, and the organizational developments from the craft shop to such concerns as U.S. Steel illustrate the same process of industrial mutation—if I may use that biological term— that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one. This process of Creative Destruction is the essential fact about capitalism (p. 83).

Well before Schumpeter, Alfred Marshall had also embraced biological and in particular evolutionary imagery. His famous textbook, *Principles of Economics*, which went through 8 editions until the last one in 1920, had the Latin motto on the title page, "Natura non facit saltum." This translates (I gather) as "nature does not work in leaps." Or, as he explained in another of his standard works, *Industry and Trade* (1923, p. 6), The idea that, "Nature does not willingly make a jump. . . is specially applicable to economic development." (Cited in Laurence Moss, 1982, p. 3.)

In "Biological Theory and Technological Entrepreneurship in Marshall's writings," Laurence Moss has shown that Marshall's fondness for evolutionary imagery had a finite life-cycle. As Moss writes in beginning his account, "it is instructive to begin with Schumpeter's views on economic development because Alfred Marshall's views are exactly the opposite" (Moss, p. 3). As we noted, Schumpeter believed that nature (economic nature at least) moved not only in leaps, but in revolutionary bursts of creative destruction, driven by entrepreneurial innovation.

The story Moss tells us reveals a great deal about the politics of evolutionary metaphors. Darwin's theory of evolution via natural selection implied long, smooth, continuous adaptations of a species to its natural environment. When this view was challenged in the early years of the 20th century by Mendel's earlier genetic experiments, Marshall lost his appetite for evolutionary metaphors.

By that time, Darwin's notion of survival of the fittest had long since been snatched by Herbert Spencer to provide a justification for the extreme inequalities of wealth that accompanied the Industrial Revolution. Spencer propounded a theory of Social Darwinism, i.e., to the victor belong the spoils. The victor, in this context, is the industrialist best adapted to his economic environment. John D. Rockefeller, Andrew Carnegie, and the other Robber Barons were rich because they were best endowed. (From a subsequent perspective, that of Schumpeter, the Robber Barons were also entrepreneurs, hence authors of creative destruction, the engine of progress.)

The political thorn in Social Darwinism cuts more deeply when it strikes the system's losers, ordinary people. In Spencer's scheme of things, they were less suited to the environment, but, alas, that was nature's way, as it were. To this extent, Spencer accepted the ideological baton from Thomas Malthus, whose policy message in works such as his at first anonymous *Essay on the Principle of Population* (1798) was that it is useless to help the poor, since they will only reproduce themselves in larger numbers. On the scale of the world economy, similar reasoning justified imperialism, and the domination of "inferior races" by whites (and in Asia, by Japan).

What, then, was Mendel's heresy that dislodged Marshall from his love of (Darwinian) evolutionary metaphors? In retrospect, the answer is surprising. While Mendel's genetic "laws" modified Darwinian "natural selection" in basic ways, nothing in Mendel's genetic laws is necessarily "mutationist." Instead, what Moss notes is that an interpreter of Mendel's theory, one Hugo de Vries, pushed the mutationist emphasis because it suited his tastes. The mutationist (and therefore discontinuous) interpretation of Mendel popularized by de Vries seems to have put a chill on Marshall's interest in biology.

What is clear is that Marshall backed away. In a footnote quoted by Moss, Marshall distances himself from the vulgarity of a "great-man" theory of economic change as follows:

> This conclusion... will remain valid even if further investigation confirms the suggestion, made by some Mendelians, that gradual changes in the race are originated by large divergences of individuals from the prevailing type. For economics is a study of mankind, of particular nations, of particular social strata; and it is only indirectly concerned with the lives of men of exceptional genius or exceptional wickedness and violence. (Marshall, 1920, p. 844.)

In other words, Marshall saw fit to reject biological analogies once they seemed to permit mutationist disruptions. In contrast, such disruptions (or discontinuities) are just what Schumpeter's entrepreneur inflicts upon the world.

Not that contemporary biology still holds to a mutationist view of evolutionary change. As summarized by Daniel Levinthal in a 1998 article (p. 218):

> The modern perspective, introduced by Gould and Eldredge... hinges not on single mutational event but on speciation—the separation of reproductive activity. The initial speciation event is minor in the sense that the form does not differ substantially from its predecessor. However, as a result of a separate reproductive process driven by genetic drift and a possibly distinct selection environment, the speciation event may trigger a divergent evolutionary path.

To explain evolution, then, (1) Darwin advocated natural selection (giraffes with long necks being better adapted to reach the leaves on higher branches), (2) Mendel introduced the science of genetics, which was interpreted later to highlight the role of mutations, whereas a school of contemporary biologists highlight (3) speciation.

2. MODELS AND METAPHORS TODAY

Why does any of this matter for our purposes? The metaphor is being used to help us understand the way technologies evolve. As Levinthal writes, "These ideas are applied here to provide insight into the pace and nature of technological change." In his view, "As in the process of punctuation in the biological context, the critical factor is often a speciation event, the application of existing technological know-how to a new domain of application" (p. 218).

In turn, the application of the metaphor can reveal something about human agency, the role of entrepreneurs in advancing the pace of technological change. That, at least, is the goal. As Levinthal observes, "The process of 'creative destruction' occurs when the technology that emerges from the speciation event is successfully able to invade other niches. . . ." (p. 218). The case he explores is the development of wireless communication technology. His conclusion, consistent with the speciation theme, is that the great events in the 20th century history of wireless were not dramatic technical breakthroughs but rather applications of existing techniques to new commercial domains.

IS THE NEW ECONOMY A BIOLOGICAL ECOSYSTEM? (PROBABLY NOT)

On the other hand, metaphors can mislead. Or they can obfuscate. (Come to that, watch out for fabricated quotes attributed to an imaginary Darwin.)

Kevin Kelley's useful book, *New Rules for a New Economy*, advocates the use of biological metaphors to understand the new economy:

> Change in technological systems is becoming more biological. This will take a lot of getting used to. Networks actually grow. Evolution can really be imported into machines. Technological immune systems can be used to control computer viruses. This neobiologicalism seeps directly into our new economy. More and more, biological metaphors are useful economic metaphors (p. 114).

Examples are used throughout the book. Consider this simile (not strictly a metaphor, but at least a trope): "[Life evolved] from globular organisms into fantastic beings, just as networks allow place-based firms to blossom into fantastic spaces." P. 95.)

This rhetoric helps Kelley explore the ramifications of Metcalfe's Law. Recall that the law says that (unlike costs, which are linear) benefits to the N users of a network increase quadratically (N x N) as the number rises. The threshold effects that result lead to images of increasing returns, meaning not the economist's increasing returns to scale, but positive feedback. As Kelley puts it, "In networks we find self-reinforcing virtuous circles. Each additional member increases the network's value, which in turn attracts more members, initiating a spiral of benefits" (p. 25).

Kelley's book is worthwhile, and a real clarification of some of the preliminary ideas that appeared in the on-line version at Wired, where he is the top editor. For example, he has reduced his controversial "12 rules for the New Economy" to 10:

1. Embrace the Swarm (Embrace "the decentralized points of control.")

2. Increasing Returns (As in Metcalfe's Law, with positive feedback added.)

3. Plenitude, Not Scarcity (Software and net firms can have low variable costs.)

4. Follow the Free (Software, e.g., with zero marginal costs, can be given away.)

5. Feed the Web First ("Unless the net survives, the firm perishes.")

6. Let Go at the Top (Be ready to cannibalize your success and go for it again.)

7, From Places to Spaces (We see disintermediation and "new mid-size niches.")

8. No Harmony, All Flux (Keep innovating to survive.)

9. Relationship Tech (As in "high tech, high touch": the winning mix.)

10. Opportunities before Efficiencies (Do the right thing, not just things right.)

On the other hand, a book like Michael Rothschild's *Bionomics: Economy as Ecosystem* (1990) is for some tastes, at least, over the top. The metaphor permits countless biological examples that may or may not shed light on economic relationships. Mostly, by my reading, they do not. But many business people seem to find his comparisons useful as an aid for thinking about competition (as in survival-of-the-fittest).

Two points about metaphors are worth making in this context. One is that, as just noted, they can stimulate new thinking. "A metaphor achieves its effect by holding in tension two incompatible meanings that reveal some new insight." Or, "A metaphor expresses an is/is not tension that creates meaning." (Both quotes are in a spectacularly constructive essay on deconstructionism and post-modernism by William Grassie.)

The second point is more elusive. It is that metaphors are mental models, just as mathematical models are in a sense metaphors. You will recall from high-school English classes that a metaphor is one form of "trope," or figure of speech. It says that one thing is something else, so as to make a point. A simile, in contrast, says that one thing is *like* something else. Either trope, metaphor or simile, is intended somehow to get at an as yet undefined property of an object, relationship, or idea.

Mathematical models in science have the same function. We need not go into this point here, as later in this textbook you will find an abundance of beautiful mathematical models to help you test your visions of the world. Suffice it here to tell you Paul Krugman's punch-line when he addressed the European Association for Evolutionary Political Economy in November, 1996. "In short, I believe that economics would be a more productive field if we learned something important from evolutionists: that models are metaphors, and that we should use them, not the other way around."

As a student of the "real" evolutionary literature, Krugman can also be scathing about the mis-use of evolutionary metaphors. And yet it would hard to find a more informative exploration in the field of complexity theory (based on the study of pattern in nature) than his 1996 book, *The Self-Organizing Economy.* This lively little book, a counterpoint to Brian Arthur's work, reappraises much of urban economics and recasts it using models of self-organizing systems.

Someone has said that the history of mathematics can be understood as progressing from place to pace to pattern. "Place" refers to Euclidean geometry in the ancient world. "Pace" refers to the discovery of calculus by Newton and Leibniz in the 17th century. "Pattern" is the current mode in science, as buzzwords and phrases like chaos, complexity, emergent properties, and self-organizing systems make clear. It is just this new emphasis on pattern (as distinct from formal hypothesis-testing using simple refutable statements to be tested with data) that makes metaphor an increasingly prominent instrument in science.

ECONOMIC GEOGRAPHY AS A STUDY IN "THE FALL OF SCIENCE"

What was the scientific method? In a 1996 book, the geographer Trevor J. Barnes highlights the dance between logic and evidence:

> From the 1920s to the late 1950s and early 1960s, the received view within the philosophy of science was the hypothetico-deductive model of explanation. Before then the inductivist model prevailed. But because of a fatal logical flaw first recognized by David Hume—that an empirical regularity observed in the past need not logically continue into the future—inductivism was supplanted by a deductive model at the turn of the century. It was not until 1948, though, that the H-D method was formally codified in a well-known paper by Hempel and Oppenheim. They argued that all scientific explanation is characterized by the same logical structure, one combining hypothesized laws with the deductive syllogism.

Barnes' book is called *Logics of Dislocation: Models, Metaphors, and Meanings of Economic Space.* (Barnes, 1996.) He recounts the rise and fall of "the scientific method" in geography using the story of David Harvey, who performed "the most famous about-face in geography" (Barnes, p. 103). In 1969, Harvey's book, *Explanation in Geography*, advocated the H-D (hypothetico-deductive) philosophy of science and advanced the cause of mathematics within the field.

Within four years, Harvey reappeared as a full-blown Marxist geographer, advocating an almost completely different system of thought. Eventually, in 1989, the year the Cold War ended, Harvey would move on to a post-Marxist stance, in *The Condition of Postmodernity: An Inquiry into the Origins of Cultural Change.* In Barnes' view, Harvey's 1969 version of the scientific method was already dated when it appeared, having been eclipsed by the "strong program" in the sociology of scientific knowledge (SSK) at the University of Edinburgh, a view that makes knowledge claims in science a matter of social relations.

Harvey's 180-degree transformation could be described in the cliché as a "paradigm shift." The word paradigm derives in practice from a hugely influential 1962 book by Thomas Kuhn, *The Structure of Scientific Revolutions.* The concept has been extended in academic circles to mean that "all belief-systems are arbitrary," artifacts of one's socially derived framework and implicit assumptions. That Kuhn himself was in some fundamental way confused is suggested in a powerful recent downgrading of his book, Steven Weinberg's 1998 essay, "The Revolution that Didn't Happen.*"*

The upshot is that to an outsider, at least, economic geography today appears polarized as between pragmatic empiricism and ideological abstraction. Consider in this regard a recent working paper on "The New Regionalism," posted on the site of The Economic Geography Research Group. John Lovering of Cardiff University, in "Theory Led by Policy: The Inadequacies of 'The New Regionalism' in Economic Geography Illustrated from the Case of Wales," critiques the "New Regionalism in Thought." That is, he disputes "that sub-set of ideas in policy-related economic geography which converge on the claim that 'the region' is displacing the nation-state as the 'crucible' of economic development." (p. 5).

Lovering contrasts Sophisticated New Regionalism and Vulgar New Regionalism:

Sophisticated New Regionalism concerns itself with the logical implication of assumptions, and operates in a theoretical space carved out by the invention of ideal-types. As such, it is unaffected by claims concerning the real world. Its purpose is to point out theoretical possibilities (such as the possible role of economic interactions or relations of 'Trust' in territorial 'clusters' of industry). The sophisticated version, he continues, is sophisticated by virtue of its distance from empirical claims that might be readily refuted.

> By the same token, Vulgar New Regionalism lends itself to refutation: (VNR) assumes or implies that theoretical categories can be read-across to real-world empirics. It derives its force from concrete empirical claims, and its vulgarity arises from the fact that many of these are crude, over-generalised, or just plain inaccurate. In other words, regional development in the case in question is not in reality shaped by the processes upon which it focuses, but is in fact shaped by other factors altogether.

3. REGIONAL SCIENCE: OPEN, MULTIDISCIPLINARY, TECHNICAL, PRAGMATIC

So when it comes to evidence and belief, it depends on what you are trying to do.

Regional science can be understood as a tolerant safe haven for people from other, more formally controlled or method-constrained disciplines—such as neoclassical economics.

Yet from its inception in 1956 at the University of Pennsylvania, regional science has had a hard-scientific bent to it. The Penn Ph.D. program in regional science began when Walter Isard and Benjamin Stevens came there from MIT, where Isard had been Stevens' dissertation supervisor. (You can read this story in a more graceful version in a biography written by Ronald Miller, who for many years edited the discipline's flagship journal, *The Journal of Regional Science,* along with Isard and Stevens.) A snapshot of Ben (in the hat) and Walter at a regional science conference a few years ago has kindly been provided by Robert C. Douglas, who took the picture. the link to the picture does not work. How should I handle this - Put the picture in the appendix I created for other materials not in the body of the book or simply delete the line referencing the picure?

Stevens was a renegade scion of the J.P. Stevens textile empire. After a year at Cornell, followed by a year working in a factory in Mexico (at local wages), he came back to Georgia Tech for a degree in mechanical engineering. He arrived in 1952 at MIT's Economics Department (then as now, as good as it gets) fully credentialed in the quantitative arts.

Now one might ask why, when Stevens showed up mathematically legitimate at the nation's top economics department, he got a degree instead from MIT's planning program. The answer, perhaps, is that economics as then practiced in the very best departments had no room for space as a variable. As Paul Krugman has said recently,

> The first big effort to get space into economics came in the 1950s, under the leadership of the redoubtable Walter Isard. Isard was and is a man of huge energy and vast learning; he performed an invaluable service in making the previously inaccessible German tradition available to monolingual economists like myself; and he created an interdisciplinary enterprise, regional science, which has been of considerable practical importance in the real world. But the aim he set himself in his magnum opus, Location and Space Economy, to bring spatial concerns into the heart of economic theory, was never attained.
> (Paul Krugman, 1995, Development, Geography, and Economic Theory, p. 55.)

The reason, Krugman believes, is that economic theory in that day was dependent on the assumptions of constant returns to scale and perfect competition. Only much later, when a newly formalized model of monopolistic competition was introduced by economists Avinash Dixit and Joseph Stiglitz in 1977, was the way cleared for what Krugman sees as a more unified theory of location and spatial structure, which he has now described as "the new economic geography." (Paul Krugman, "Urban Concentration: The Role of Increasing Returns and Transport Costs," *International Regional Science Review*, 1996, 19, p. 6.)

What needs to be understood is that regional science began as a science. Ron Miller's biography on the Stevens site observes that in 1957 Stevens added space to the domain of linear programming just as Isard had already done with input-output analysis: In the earlier mention of Benjamin Stevens Memorial it referenced a site which I could not find but did find a memoriam written by Ronald Miller so referenced that. That memoriam does not mention linear programming but there is a link to the article about linear programming by Stevens. Should I link "the domain of linear programming" to that article?

> His first published article . . . "An Interregional Linear Programming Model". . . infused the linear programming framework with a spatial dimension in rather the same way that Isard's article on regional input-output analysis had done for input-output models some seven years earlier. . . . Ben continued to explore the ways in which mathematical developments in economics, operations research and related disciplines could enrich the field of regional science.

The result, says Miller, was to extend "a sound quantitative foundation for the still-young field of regional science." This foundation would eventually be extended to include other formal models in location theory.

What, then, is regional science today? Krugman's conclusion is on target:

> . . . what Isard ended up creating was an eclectic applied field: regional science. Regional science is not a unified subject. It is best described as a collection of tools, some crude, some fairly sophisticated, which help someone who needs an answer to practical problems involving spatial issues. . . . (p. 57).

Open, multidisciplinary, technical, and pragmatic—all these, combined with an orientation to space and location, are the hallmarks of the discipline.

I could not find the site referenced below

In putting together the Stevens memorial site, I had occasion to compile two sets of links to do justice to the discipline that Isard and Stevens and Miller created. One list is long, a kitchen sink. The other I dubbed Supersites in regional science. It is short and selective: a dozen sites that are intended to convey the range and power of the discipline. Someone else could come up with a different list, perhaps an entirely non-overlapping one. In any case, this selection may give you a place to start your explorations.

Have fun!

APPENDIX

CLUSTER THEORIES (1):SPATIAL EXTERNALITIES

A recent *New Yorker* magazine piece on the bunching of new restaurants in a particular block in Brooklyn invokes Alfred Marshall's century-old theory of industrial districts. (Marshall 1890, 1920, pp. 267-277.) Whether for restaurants today or for Manchester's cotton mills in the 19th century, the same processes can be seen.

> Marshall's basic point about why companies in the same industry congregate still holds: *industrial districts enjoy the same economies of scale that only giant companies normally get.* Specialized suppliers arrive. Skilled workers know where to come to ply their trade. And everyone involved benefits from the spillovers of specialized knowledge. As Marshall put it, "The mysteries of the trade become no mysteries, but are as it were in the air." (James Surowiecki 2000, p. 68, emphasis added.)

Four Advantages of Localization

Something "in the air," the first of the four ingredients in Marshall's district theory, can be construed to refer to knowledge spillovers (as in conversations between people working for different companies). A second ingredient is the common pool of the factors of production the local cluster uses, especially labor. The greater their supply, the lower the costs for each firm in the industry. Third, as inputs become more specialized, they tend to become more productive, a la Adam Smith's legendary pin factory.

On these three supply-side counts each firm in the area will have lower costs than if it operated in isolation. But in addition, and on the demand side, comparison shopping becomes easier for the customer when the retail firms are bunched—as in the Brooklyn restaurants.

All this is above and beyond any savings in transportation costs between suppliers and buyers. When we combine the two sets of forces, Marshall's spatial externalities and the savings on transportation costs when activities are concentrated, the result can be combined under the heading of *agglomeration economies.* (See Chapter 5 of "An Introduction to Regional Economics" by Hoover and Giarratani.)

Localization in Marshallian industrial districts happened on both side of the Atlantic in the late 19th century. In a masterful essay on Marshall, Paul Krugman points out that a special 1900 Census monograph, "The Localization of Industries," identified 15 specific concentrations in the U.S., among them

> Collars and cuffs, localized in Troy, New York; leather gloves, localized in the two neighboring New York towns of Gloversville (sic) and Johnstown; shoes, in several cities in the northeastern part of Massachusetts; silk goods, in Paterson, New Jersey; jewelry, in and around Providence, Rhode Island; and agricultural machinery, in Chicago. (Krugman 1991, p. 61.)

He observes that in seemingly every example, localization resulted from a combination of an initial accident in a particular location, after which "cumulative processes took over." (Technically, by the way, this is the non-neoclassical language of positive feedback and path-dependency.)

A Neoclassical Update

A good update on spatial externalities comes from Mills (1992). A skeptic on labor pooling, he lists three other families of causation, which I paraphrase here:

(1) *Input-output clustering*. With or without economies of scale, if firm A's input is used to produce firm B's output and is costly to ship, cost savings can be attained by proximity, and it would be natural to find both A and B locating in the same metropolis. Whether labor can be viewed in this context is open to question. Natural resources (A) and resource-processing (B) qualify. Consider climate, as illustrated by aircraft production in places with mild

climates. In contrast, oil and gas are cheap to transport, so processing can occur far from oil and gas fields.

(2) *Comparison shopping clusters.* In New York's high-fashion garment district, buyers converge from all over the country to examine the wares and negotiate face-to-face over a whole range of price, design, and production details. While it might seem that such communication could be done via information technology, something about the cluster makes it advantageous for buyers to come in person.

(3) *Information clusters* Firms that deal with similar kinds of information may cut costs or maximize their access to information by locating in the same metropolis. This arises when information has public-good attributes (with zero marginal costs) or is a joint product linked to supplier-customer communications. Another set of issues concern the distinctions between (a) quantitative vs. qualitative and, more cogently, (b) ambiguous vs. unambiguous information.

Ambiguous information in Mills' view is information that requires face-to-face access and hence contributes to clustering. It is any information that must, in effect, be "negotiated" to establish its meaning.

This point is fundamental in that it establishes a continuing need for face-to-face access, despite the coming of the Internet.

The Difference a Century Makes (Not Much)

Now, just for the record, let's go back and compare Marshall and Mills on two of these three advantages of localization. Look what Marshall had to say about comparison shopping, an issue virtually never (except in Mills) cited in the voluminous literature:

> So far we have discussed localization from the point of view of the economy of production. But there is also the convenience of the customer to be considered. He will go to the nearest shop for a trifling purchase; but for an important purchase he will take the trouble of visiting any part of the town where he knows that there are specialty good shops for his purpose. Consequently shops which deal in expensive and choice objects tend to congregate together; and those which supply ordinary domestic needs do not. (Marshall 1920, p. 273.)

And what about conversations? For Mills, face-to-face access is a must when the information to be communicated is ambiguous, a matter of calibration or negotiation. What kinds of information did Marshall think benefited from proximity? "When an industry has thus chosen a locality for itself," Marshall writes,

> . . . The mysteries of the trade become no mysteries; but are as it were in the air, and children learn many of them unconsciously. Good work is rightly appreciated, inventions and improvements. . . have their merits promptly discussed: if one man starts a new idea, it is taken up by others and combined with suggestions of their own; and thus it becomes the source of further new ideas. (Marshall, p. 271.)

Trust?

The next point to be noted concerns the uncertain role of trust between competing firms as a factor conducive to spatial clustering.

In *The Second Industrial Divide,* Piore and Sabel (1984) highlighted "flexible specialization" as the developmental stage succeeding "Fordism" or mass production. They emphasized the virtues of the "Third Italy" and its industrial clusters specializing in high-fashion, design-intensive goods. They saw *virtuous networks emerging among rival firms, which manage to cooperate* around activities of mutual benefit such as training, marketing, and research.

By the same token, Bennett Harrison concluded that the difference between Marshall's model and this Italian version was trust—an outgrowth of experience. As he put it, this interpretation of the new wellsprings of regional growth in Italy proceeded "from proximity to experience to trust to collaboration to enhanced regional growth."

The Italian studies inspired scholars to look for parallels in clusters in other countries. A recent study of Danish textiles, for example, finds another industry cluster marked by trust and cooperation. (Sven Illeris 2000.) In Europe, it seems, trust based on experience may permit rival firms in the same industry to cooperate on certain common fronts.

In the U.S., however, the parallels have proved elusive. Did Silicon Valley measure up to Harrison's criterion? Alas, no. The spectacle of Valley firms such as Intel suing each other at every opportunity (usually over intellectual property rights) rules this particular cluster out as an example of post-neoclassical trust and harmony. In Harrison's view, firms that rely on each other through informal agreements and cumulative collaboration do not wind up in court.

Similarly, a companion chapter in this textbook points out that clusters in The Third Italy may be culture- or country-specific. As Bergman and Feser observe in Chapter 2 of "Industrial and Regional Clusters: Concepts and Comparative Applications", trust is relatively easy among firms and their suppliers. A much rarer phenomenon—except in Italy—is trust between competitors. On this and other counts Bergman and Feser designate the Italian clusters as a distinctive type, which they dub *Italianate*.

Localization vs. Urbanization Effects

A controversy in the cluster literature concerns the roles of localization economies (a la Marshall) and the more diverse urbanization economies that come with large city size, often identified with Jane Jacobs (1969, 1984).

For example, Mills' 1992 account outlined above had been prompted in part by the findings of Henderson (1988) and O hUallachain and Satterthwaite (1988) "that localization economies are more important than urbanization economies. That means that growth of employment within a sector tends to depend more on the size of the sector than on the size of the metropolitan area" (Mills 1992, p. 3).

As it happened, an influential journal article by Glaeser et al. that same year (1992) reached an opposite conclusion. The authors found that "industries grow slower in cities in which they are heavily over-represented" (p. 1129). These findings tended to cast doubt on localization economies as a source of growth. By implication, they also supported Jacobs' arguments for diversified cities as seedbeds for innovation and rapid growth.

The resolution of this issue can be found in a product-cycle or industry-maturity perspective. As a recent *World Development Report* puts it,

> Whether an industry benefits most from urbanization or localization economies depends on how innovative it is. New, dynamic industries are likely to locate in large urban centers where they can benefit from the cross-fertilization provided by diverse actors. Older, mature industries concentrate in smaller, more specialized cities, where congestion costs are low and localization economies can be high. (World Bank 2000, p. 117.)

When an industry matures, in other words, its initial centers become vulnerable to competition from newcomers and specialization becomes not an advantage but a burden.

Porter: Rivalry and Information Flows

By the same token, however, innovation can maintain a specialized cluster's competitive advantage. This is a useful light in which to view Porter's influential version of cluster theory, as introduced in *The Competitive Advantage of Nations* (1990) and refined in two more recent articles. (Porter 1998, 2000.) The approach derives from management theory, but it retains a neoclassical emphasis on competition and rivalry rather than trust.

As Porter puts it, "Successful firms are frequently concentrated in particular cities or states with a nation" (1990, p. 29). Offering detailed maps of the Italian and German cluster landscapes (pp. 155-156), he cites these additional examples as well:

> British auctioneers are all within a few blocks in London. Basel is the home base for all three Swiss pharmaceutical giants. Danish windmill producers are centered in Herning. In America, many leading advertising agencies are concentrated on Madison Avenue in New York City. Large-scale computer manufacturers Control Data, Cray Research, Burroughs (now part of Unisys) and Honeywell all are headquartered in or near Minneapolis, Minnesota. Pharmaceutical and related companies. . . are based in the New Jersey/Philadelphia area. (Porter 1990, p.155.)

Porter explains such agglomerations in terms of his "diamond." Its four corners are demand, factor conditions, rivalry-strategy, and industry clusters. That is, an industry becomes internationally competitive because of

- favorable home conditions in the markets it sells to,
- the quality of its factor inputs,
- the competitive pressures encouraging excellence within its industry, and
- the supplier and customer linkages specific to the industry, which in practice are often traced out within specific urban agglomerations.

On this last point, a tight geographical locale intensifies (1) information flows and (2) rivalry between competing firms. Local media, banks, universities, bars, and eateries enhance communication. The spatial proximity of rivals—whether they communicate and cooperate or not—spurs competition and innovation. Trust between rivals does not enter into it.

In the spirit of Porter's emphasis on information flows, financial services in London and New York City provide convincing evidence of the continuing value of face-to-face communication.

London as a Financial Cluster

In a May 1998 article, for example Ben Edwards assessed London's staying-power as a financial center. ("Capitals of Capital: Financial Centres Survey," *The Economist*, 347:8067, p. 8.) Some of his analysis smacks of Marshall's writings a century ago on the industries of northern England, highlighting the role of specialized skills. "Developing financial markets requires a wide range of talents, and clusters make it easier to co-ordinate them. Lawyers must ensure... Accountants must check.... As long as these people prefer to meet in person to co-ordinate their work, there will be a need for financial centres."

Even more to the point: "But even if business must be done centrally, why do it next to your competitor?" (Edwards, p. 8.)

The answer to this question, a matter of localization economies, not urbanization economies, draws on Porter's theme of information flows. Being near your competitors and mutual suppliers enhances your knowledge of their operations, a prod to innovation on your part. It also permits raids on their employees, who may have just the skills you are looking for. ("So, in New York, Wall Street investment banks routinely poach credit analysts from their rating-agency neighbors, Standard & Poor's and Moody's. . . .")

Two distinct logics of location are emerging in London and other financial centers. One image is *hub-and-spoke*. The image refers not to the relationships between large and small firms, but to the location of activities within a firm. "Hub businesses are centralised: strategic planning, project management, product development, and risk-taking activities such as trading and cooking up exotic financial derivatives. Spoke activities—such as sales, marketing and company analysis—keep the business in touch with the customer and with good information. With globalisation and improved communication, spoke operations are becoming leaner."

The second location principle is to scatter whatever operations can be scattered to lower-cost sites. In a classic pattern reminiscent of Raymond Vernon's 1960 analysis of New York City, *back-office* (i.e., administrative and number-crunching) activities can be housed in remote locations where wages and land rents are low and commuting is easy. Only the functions requiring frequent face-to-face contact (mergers and acquisitions, raising capital, fund management) must be kept in the center. A mixed case is trading, which in the age of the Internet is up for grabs.

Can Clustered Firms Also Be Less Adaptive?

Two questions can be posed here about Porter's cluster analysis. One concerns the potential perils of clustering for member firms, the other the role of government.

On the first matter, Porter himself now recognizes that participation in an established cluster may not always help a firm adapt to new circumstances. In this recent passage, for example, it is hard to miss the influence of Porter's Harvard Business School colleague, Clayton Christensen (1997):

> When a cluster shares a uniform approach to competing, a sort of groupthink often reinforces old behaviors, suppresses new ideas, and creates rigidities that prevent adoption of improvements. Clusters also might not support truly *radical innovation*, which *tends to invalidate the existing pools of talent, information, suppliers, and infrastructure*. In these circumstances, a cluster participant. . . .might suffer from greater barriers to perceiving the need to change. . . . (Porter 2000, p. 24, emphasis added.)

This is a pivotal issue. Proponents of cluster-based development strategies tend to assume that fostering specialized clusters is good for an area's growth prospects. But students of industrial history might well differ.

After all, what became of Marshall's prototypical industrial district, 19th century Manchester? The answer, in a phrase, is that "Industrial evolution is a history of cruel fates." (Rothschild 1973, p. 191.) Marshall's "something in the air," in other words, may have become an obstacle to change.

The list only begins with textiles in Manchester or steel in Pittsburgh, mature centers that failed to meet the challenge of new competitors located elsewhere. (Chinitz 1961.) More recent episodes include Boston's Route 128 in the 1980s. Its minicomputer firms proved blind to the need to move on to PCs. Similarly, in the Porter passage quoted earlier we find Minneapolis cited as the home of Cray, Burroughs, and Unisys. But just as with minicomputers, "big-iron" supercomputing proved to be a shaky base.

For both Route 128 and Minneapolis-St. Paul what has proved decisive to future development is the capacity to shift from dying bases to new sources of growth, as given by universities and financial institutions at least as much as by existing firms.

Clusters, Industrial Policy, and Targeting

A second ambiguity is Porter's attitude toward government policy. On the one hand, he applauds state, local, and national initiatives informed by cluster theory. (See Table 1 in Porter 2000, p. 31.) In his view, "clusters should represent an important component of state and local economic policy." (Porter 2000, p. 29.) And indeed they do. The influence of cluster theory for policy design can be seen in this useful set of links on policies in individual states, as compiled by the Humphrey School of Public Policy at the University of Minnesota.

But in the same article, Porter takes pains to differentiate cluster strategy from industrial policy—which is bad, he writes, because it entails picking winners, a zero-sum game. "Although industrial policy aims to distort competition in favor of a particular location, cluster theory focuses on removing obstacles. . . . The emphasis in cluster theory is not on market share but rather on *dynamic improvement*." (Porter 2000, p. 28, emphasis added.)

This will strike some readers as a fine distinction. To skeptics, cluster theory sometimes looks like a vehicle for state and local government officials in search of a targeting rationale.

For example, Terry Buss offers "The Case Against Targeted Industry Strategies." His view: "Targeted industry studies use poor or inappropriate data, deeply flawed social science methods, and simplistic mathematical models in producing targets. Targets themselves tend to be dubious" (Buss 1999, p. 343).

Why, Buss asks, are targeting strategies, including cluster-based targeting, so widely practiced? Not because of their scientific merit, but for political reasons. Impressive analytics can be drummed up on demand to justify inherently political proposals. And why, when so many targeted industry strategies have failed, do states and localities continue to rely on them? Partly because they have the appearance of scientific backing, but mainly because of a herd effect. Once some states and localities develop targeting strategies, others feel compelled to follow suit.

Implicit in any such critique of targeting is the view that when it comes to new-enterprise development, market forces provide the best mechanism for picking winners and weeding out losers. Elementary as that proposition sounds, it remains a useful touchstone for sorting out economic from political dimensions in state and local economic development policies, including cluster-based strategies.

Dynamic Perspectives

Skepticism about targeting is the context for Porter's distinction between generalized cluster strategies and local industrial policies. But what does it mean to say as he does that a cluster-based strategy aims not for market share but for "dynamic improvement"?

Static spatial externalities depend on proximity among knowledge workers in a given setting at a given time. "It is argued that knowledge for innovations resides in the communication between skilled (knowledge) workers, and that this is dependent on their geographical proximity." In other words, as studies of static externalities tend to confirm, "the capacity to receive knowledge spillovers is influenced by distance from the knowledge source." (Echeverri-Carrol and Brennan 1999, p. 29.)

But while the effects may register over time, the analysis can be viewed as inherently static.

Nothing that has been described in this module on neoclassical perspectives treats history as anything but a prologue. To that extent, the conversation remains open to other approaches, whether from evolutionary economics, path-dependency perspectives, increasing-returns models, or network theories.

In particular, what are dynamic agglomeration economies? How do they shape the positions of competing centers of innovation? And how do they condition the relative importance of proximity and long-distance networks?

Such questions are explored in the companion module on post-neoclassical cluster theories.

New Growth Theory and Increasing Returns

According to new or endogenous growth theory, economic growth can be understood as a process of learning-by-doing, within a firm, within an industry, and within a metropolitan area as well. (Arrow 1962, Romer 1986, 1993, Lucas 1988, Krugman and Obstfeld 1997.)

By way of counterpoint, what might be termed "exogenous growth theory" sees rising output per capita as resulting from externally given increases in the quantities of labor and capital. This in outline is the constant-returns-to-scale approach modeled by Dale Jorgenson. In Jorgenson's growth accounting (a classic example of what intricate model refinements can accomplish), virtually all U.S. economic growth in the 20$^{\text{th}}$ century can be statistically explained by the increases in *quantities* of the factors of production—when the "quantity" of labor is specified in ways that include increasing education for workers. This, as if there were no technological or organizational change, no economies of scale, but only constant returns in an environment altered solely by investment and labor-force growth.

In endogenous growth models, on the other hand, growth over time entails increasing returns to scale for a metropolis or a national economy. A proportionate increase in labor and capital gives rise to more than proportionate gains in output. The explanation lies in better "recipes," as Romer terms innovations, and in spillovers that operate over time, enhancing skill and productivity levels throughout the economy.

Learning-by-doing within a firm means that current unit costs are a function of experience (as measured by the firm's total cumulative past output). Given the learning curve for a single firm, then imitation of successful firms on the part of other firms in the industry spreads the "learning" around, such that the industry can benefit from falling-forward supply curves. The process links unit costs to cumulative industry output within a country. The ease of imitation and learning then increases within spatial agglomerations—which in turn can be understood as "little nations" (my phrase) benefiting from increasing returns. (Krugman and Obstfeld 1997, p. 154.)

In sum, interpreted variously in terms of Arrow's learning curves, Romer's recipe for growth, or Lucas's vector-autoregressive (VAR) time-series specifications, the key ideas are learning-by doing and cross-fertilization over time.

POST-NEOCLASSICAL VIEWS

Most neoclassical approaches to clusters highlight the static spatial externalities or knowledge spillovers made possible by geographical proximity. The typical transmission medium assumed for communication within a given metropolitan area is the workforce made up of engineers, scientists, and other knowledge workers.

However, several criticisms can be made of cluster research that purports to measure information flows within the static-externality framework.

One might be termed "the invisibility problem," as described by Krugman:

> Knowledge flows. . . are invisible; they leave no paper trail by which they can be measured and tracked, and there is nothing to prevent the theorist from assuming anything about them she likes. So while I am sure that true technological spillovers play an important role in the localization of some industries, one should not assume that this is the typical reason—even in the high technology industries themselves. (Krugman 1991, p. 54.)

The literature contains numerous studies claiming to find empirical validation of neoclassical static externalities as a source of localization—when such evidence can often be interpreted equally well as showing increasing returns. In Krugman's phrase, when it comes to invisible information flows, "there is nothing to prevent the theorist from assuming anything about them she likes."

A second criticism focuses on the assumption that firms must rely on face-to-face communication to remain efficient or innovative. "Despite these claims, there is in fact abundant evidence that information and knowledge networks that influence business efficiency can be and often have been widely diffused geographically." (Hansen 2000, p. 4.) Hansen, among others, believes that competing firms within a given cluster or region often try to maintain secrecy locally, while networking aggressively with distant partners or allies.

A third type of criticism about proximity as a sufficient or measurable condition for competitive advantage comes from Annalee Saxenian. She disavows the neoclassical notion of spatial spillovers in favor of a related but distinct concept of regional industrial networks among non-hierarchical firms.

Network-Based Industrial Systems

As noted in the sketch of neoclassical cluster theories, the first round of non-neoclassical theorizing began with Piore and Sabel (1984). What distinguished the New Industrial District (NID) theory they launched were twin emphases on (1) Italianate trust and (2) flexible or post-Fordist production systems.

Saxenian contrasted Silicon Valley's adaptability with Route 128's decline in the 1980s as a minicomputer center. Her 1994 work, *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*, highlighted differences in communications patterns between the two clusters. A useful image for her thesis (as in earlier accounts of the Valley) is the Wagon Wheel, a Santa Clara "watering hole" where engineers and other technical types from sometimes competing companies gather to drink and talk shop. No such oasis was detected in Route 128's more buttoned-down, up-tight corporate landscape.

Rejecting external economies as a way to understand clusters, Saxenian contends that "this approach cannot account for the divergent performance of" Route 128 and Silicon Valley in the 1980s. (Saxenian, 1996, p. 42.) She continues, "The simple fact of spatial proximity evidently reveals little about the value of firms to respond to the fast-changing markets and technologies that now characterize international competition" (p. 44).

What does explain the divergent performance of the two clusters in her view is the relative importance of regional information networks. In contrast to Route 128, the Valley's "dense social networks and open labor markets encourage entrepreneurship and experimentation" (p. 45).

To develop this argument, she compares two start-ups (Apollo from Route 128, Sun from the Valley) and two mature firms (Digital Equipment Corporation and, in the West, Hewlett-Packard). Each pair started from similar positions in the early 1980s, but in each the Silicon Valley firm opted for the open-systems (non-proprietary) approach that would fit in with the then-unfolding PC revolution. The result: Sun triumphed over Apollo and H-P over DEC in work-stations and servers.

The lesson Saxenian draws is that regions should be viewed "as networks of relationships rather than as collections of atomistic firms" (p. 57). Accordingly, she views the Valley as a "network-based industrial system." The term refers to a project-oriented adaptive mode of production that may be seen not only in Silicon Valley but also to the south, in Hollywood. As she put it in a 1998 interview,

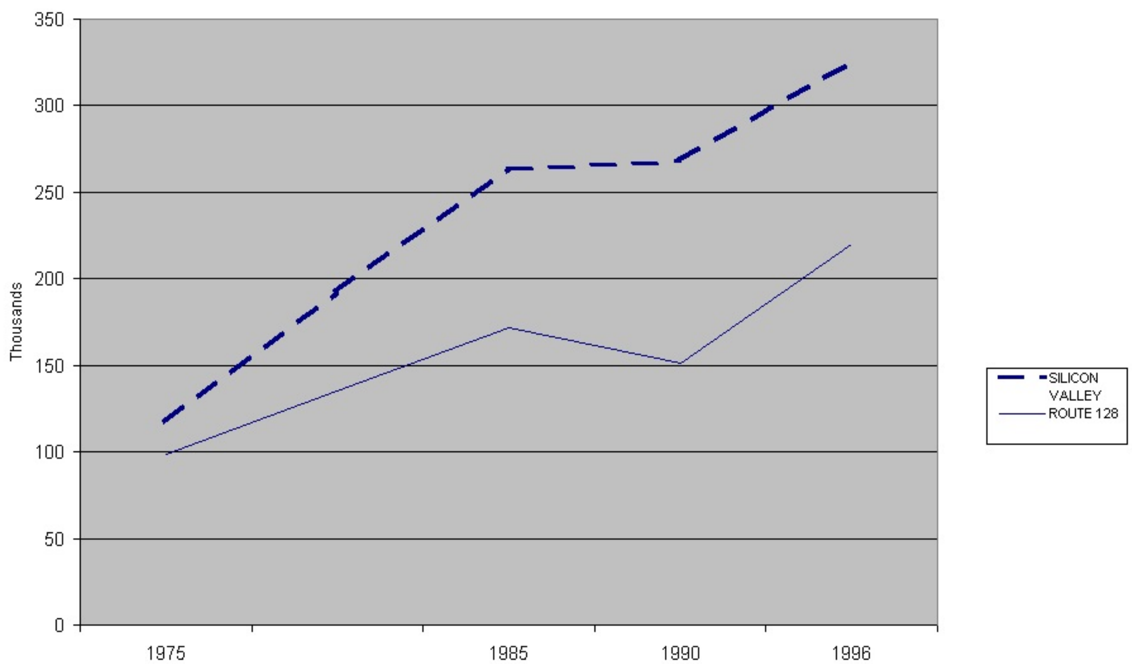
> You have these very fluid labor markets and these communities of highly skilled people who recombine repeatedly. *They come together for one project--in this case a new film, in Silicon Valley it would be a new firm--and then they move on.* The system allows a lot of flexibility and adaptiveness. Information about new markets and new technologies flows very quickly. This sustains the importance of geographic proximity, despite the fact that, theoretically, the technology allows you to be anywhere. (Cassidy 1998, p. 125.)

Don't Know Much about the Rise and Fall. . .

Still, the debate over Route 128's failure after 1985 has been overtaken by events. The reason: the Boston area achieved an impressive comeback around software and other advanced services in the 1990s.

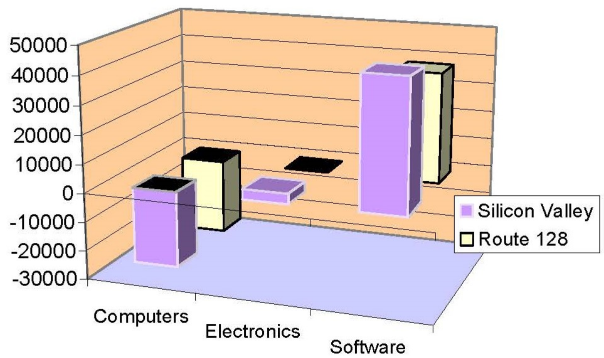
Two charts reveal the timing and dimensions of the Boston area's comeback. FIGURE 16 shows that across a broad spectrum of high-technology activities, the two clusters each registered employment growth of about 14 percent between 1990 and 1996. FIGURE 17 narrows the focus to three core I.T. lines (electronics, computers, and software) and finds surprisingly similar patterns of structural change in each area.

FIGURE 16.
HIGH-TECH JOB GROWTH IN ROUTE 128 AND SILICON VALLEY, 1975-1996



Employment in SIC codes 283, 348,357,361-367,369,376,379,381-387,737,871,873. (1980 interpolated)

FIGURE 17.
SOFTWARE DOMINATES I.T. JOB GROWTH IN BOTH ROUTE 128 AND SILICON VALLEY, 1986-1996
(SIC 357, 367, AND 737)



Source: County Business Patterns, 1986 and 1996.

The implication is that Route 128 has managed to convert from the devastating collapse of its minicomputer sector and to rebuild around software and Internet activities. Between venture capital and MIT, the Boston area has seen two radical make-overs in three decades: minicomputers in the 1970s, and a broader base of elite services in the 1990s: software, medical, and financial.

Saxenian's question can thus be turned on its head. She asked why Route 128 failed to adapt in the 1980s. The new question becomes, how did it manage to overcome that failure and move on?

This is the question addressed by Martin Kenney and Urs von Burg in the March 1999 issue of *Industrial and Corporate Change*. They present a mild and detailed presentation of a path-dependency explanation—an account rejected categorically by Saxenian (1999).

Path Dependency and Techno Lock-Ins

In "Technology, Entrepreneurship and Path Dependence: Industrial Clustering in Silicon Valley and Route 128," Kenney and von Burg begin with the following observation about critical technologies:

> The evolution of each region displays path-dependent characteristics as Route 128 evolved into the center of the minicomputer industry and Silicon Valley became the center of the semiconductor industry. The semiconductor would become the fundamental input to every product with an electronics function, whereas the minicomputer was a much more limited artifact. (Kenney and von Burg 1999, p. 68.)

In other words, minicomputers evolved from traditional mainframe technologies. By contrast semiconductors and the microprocessor in particular constituted a seminal all-purpose capability with open-ended possibilities. The IBM PC debuted in 1981, using Intel's microprocessor. Nevertheless, Route 128's mini makers thought they could still compete using the fading but still profitable technology and vertical business model of the mainframe industry. That myopia prevented DEC, Wang, Prime, and Data General as a group from facing the need to cannibalize their existing operations and to shift to PC production (Norton 1996).

Nor, for all its rigidities, was the collective failure of vision by the Route 128 minicomputer complex an isolated exception. Christensen's account of the effects of disruptive innovations like the microprocessor generalizes to any number of industry examples. Sears in retailing, Xerox in copiers, integrated steel companies relative to mini-mills, disk-drive makers, producers of mechanical excavators—all offer examples of respected companies at the top of their industries that failed to withstand competition at the low end from newcomer adopters of disruptive innovations. (Christensen 1997, Foster 1986.) Kenney and von Burg's analysis can thus be understood as a spatial application of Christensen's negative lock-in.

Economy 2: Capitalizing on "Market Discontinuities"

Kenney and von Burg introduce a distinction between what they term Economy 1 (established firms and their supporting institutions) and Economy 2 (the institutions nurturing new-firm formation). Saxenian's account of Silicon Valley's superior performance in the 1980s emphasized better information flows among the Valley's more open firms. The authors observe, "Undoubtedly, information sharing and interfirm cooperation have been important in Silicon Valley's success, as they were in Route 128. [But this view] does not address *the ultimate reason for the industrial success of both regions—new firm formation*" (emphasis added, p. 71).

The formation of new firms depends on the effectiveness of Economy 2. In a nutshell, the participants in Economy 2 have as their goal "discovering market discontinuities created by technological advances." (Kenney and von Burg, p. 95.) Start-ups can be viewed as Economy 2's products. Start-ups contain "discrete packets of knowledge," which can be brought to the test of market profitability with the help of Economy 2's institutions (p. 73).

Venture Capital in Economy 2

The central players in this drama are entrepreneurs and venture capitalists. In addition, other supporting institutions are specialized law firms, consulting firms, investment banks—and even consultants to coach heads of firms about to go public in the art of the pre-IPO "road show" (Kenney and von Burg, p. 75).

Venture capital was invented in the Boston area at the end of World War II with the formation of American Research and Development (ARD). ARD represented a conscious effort by Boston capitalists to spawn new industries to offset the decline of textiles and other mature industries in New England. (Adams 1977, chapter 9.)

By about 1960 venture capital firms were also created in the Valley. When the famous "traitorous eight" (who would eventually found Intel in 1968) resigned from William Shockley's semiconductor company in 1957, they obtained funding from Fairchild Camera and Instrument Company and started Fairchild Semiconductor in the Valley.

Among the spin-offs that would in turn branch out from Fairchild Semiconductor were local venture capital firms. These local partnerships then replaced East Coast venture capitalists in financing area start-ups (Kenney and von Burg, p. 84). That localization of financing resources was probably as decisive an advance for Silicon Valley as Shockley's arrival there in the 1950s.

In retrospect, the emergence of a local venture-capital industry gave the Valley a system that enabled it to continue to reproduce itself around new activities. From another vantage point, the result can be interpreted as unlocking a sequence of increasing returns or dynamic externalities.

Dynamic Externalities: Can There Be Only One Silicon Valley?

Recent news stories about the $500,000 median house price in Santa Clara County—and about chronic congestion and labor shortages—have brought any number of predictions that Silicon Valley's days of glory are numbered.

If so, the fall of the Valley will override the powerful built-in advantage the Valley has attained from its pooled, accumulated knowledge. This is one implication of a study on networks and dynamic agglomeration done recently from the perspective of firms in rising Texas cities.

Elsie L. Echeverri-Carroll and William Brennan ask, "Are Innovation Networks Bounded by Proximity?" (1999.) Their answer turns on two distinctions. One concerns static vs. dynamic externalities. The second is the difference between established and newcomer clusters, as illustrated by Silicon Valley on the one hand and the Texas cities on the other.

The authors asked managers in establishments in the major Texas cities to rate themselves as more innovative than average in their individual industries or not more innovative, with respect to both products and processes. They tabulated the answers (more innovative, or not) relative to the importance of local agglomeration economies (the labor force, local university programs and technical graduates, etc.) and, alternatively, to the links the establishments had outside the locality.

When it comes to static externalities, "It is argued [i.e., by other researchers] that knowledge for innovations resides in the communication between skilled (knowledgeable) workers, and that this is dependent on their geographical proximity. In this view, the capacity to receive knowledge spillovers is influenced by distance from the knowledge source."

The authors are more interested in dynamic externalities. For a given cluster dynamic externalities are given by accumulated knowledge, a result in turn of the total volume of past production of the output by establishments in the cluster. (Krugman and Obstfeld 1997, pp. 147-155.) The reasoning resembles that of a learning curve (or more precisely an experience curve), in which unit costs fall not with scale but with the total amount of all past output in a firm. In this view, "dynamic externalities deal with the role of *prior* knowledge accumulation on *current* innovations" (Echeverri-Carrol and Brennan, p. 29, emphasis in the original).

Cities in the study are stylized as either "upper rank" or "lower rank" on the basis of cumulative production and knowledge. The authors hypothesize that the innovativeness of firms in lower-rank centers depends on the flow of information from upper-rank urban centers (pp. 29 and 30). They interpret the survey results as confirming this hypothesis:

> [T]he evidence shows that the knowledge necessary for innovations is *not* bounded by proximity. In fact, as indicated by all the managers in our interviews, knowledge is found wherever it is available (p. 42). . . . [I]nnovations in firms located in cities with a relatively small accumulation of knowledge depend on relationships with universities and other high technology firms (mainly suppliers and customers) located elsewhere. . . ." (p. 47).

In contrast, the local area provides managers in the Texas cities the agglomeration economies that are not directly knowledge-related. These include technical labor and related local firms that help attract labor with the right skills from elsewhere.

The exception is Silicon Valley, the preeminent local cluster at the top of the hierarchy and hence blessed with its own, localized dynamic externalities.

More generally, the distinction between static and dynamic agglomeration as an explanation for Silicon Valley's prominence fits readily into the larger paradigm of endogenous or New Growth Theory identified with Romer, Lucas, and others.

REGRESSIONS FOR METROPOLITAN GROWTH AND IPO RATES

Equation (1)

The 1986-1996 absolute change in hardware employment (SIC 357 and SIC 367), DHARD, as a function of the initial, 1986, location quotient in the same variable, for the 30 metropolitan areas:

$$\underset{}{\text{DHARD}} = \underset{(0.7)}{1078} - \underset{(4.5)}{6273}\ \text{LQHARD86},$$

$$N = 30, \text{ adjusted } R^2 = .41,$$

where the parenthesized terms are the t-ratios of the coefficient estimates.

(Source: Same as for Table 11.)

Equation (2)

The 1986-1996 absolute gain in computer services employment (SIC 737), DSOFT, as a function of a metropolitan area's location quotient in the same variable (LQSOFT86) in 1986:

$$\text{DSOFT} = \underset{(0.6)}{-1395.4} + \underset{(6.4)}{9775}\ \text{LQSOFT86},$$

$$N = 29, \text{ adjusted } R^2 = .59,$$

where the parenthesized terms are the t-ratios of the coefficient estimates and Memphis is excluded for reasons of non-comparable data.

(Source: Same as for Table 12.)

Equation (3)

The number of digital IPOs per million area residents, 1996-1999 (DIGRATE), as a function of (1) LOCALVC, the number of active VC funds in the area in the third quarter of 1999; (2) DSOFT, the 1986-1996 percentage increase in computer services employment; and (3) SOFTSHARE, the 1996 share of total payroll employment in computer services jobs:

$$\text{DIGRATE} = \underset{(2.0)}{-2.07} + \underset{(7.3)}{.14}\ \text{LOCALVC} + \underset{(2.1)}{1.4}\ \text{DSOFT} + \underset{(1.7)}{.65}\ \text{SOFTSHARE}$$

$$N = 29, \text{ adjusted } R^2 = .75.$$

(Source: Same as for Tables 12, 13, and 14.)

URBAN GROWTH PARADIGMS: A PRIMER

One way to classify theories of metropolitan development is to divide them into demand-side and supply-side perspectives The taxonomy that follows is decisively informed by Mills and McDonald 1992; they are not responsible for my amendments and updates.

On the demand side, traditional *export-base theory* covers the vast range from simple Keynesian multiplier models to elaborate input-output models. The great appeal of export-base theory and its myriad offshoots is the precision with which it can be mathematically modeled. But it leaves unasked the question of *why an area's exports are demanded by the rest of the world*, and why such demand changes over time.

These are the questions to be explained by the supply-side paradigms, among which cluster theories are tantalizingly interwoven.

Cluster Theory as a Supply-Side Sport

Cluster theory, in short, is mainly about the supply side. (A possible exception, however, is comparison-shopping, a demand-side story, and a reason for localization of specialized vendors.) As such, it overlaps in its numerous versions with neoclassical abstractions, technology life-cycles, legends of class conflict, and applied economic-development strategies.

Given this embarrassment of riches, the following list is inevitably incomplete and perhaps arbitrary as well. Consider it a first approximation, subject to your revision:

> 1. Neoclassical cluster theory. Focusing on an area's supply side, neoclassical theory concerns itself with capital, labor, technology, and agglomeration economies. In turn, agglomeration economies are comprised of *localization* economies (which are industry-specific) and the more general *urbanization* economies, which derive from size and a diversified base. Either way, a distinction must be drawn between *level* and *growth* effects.
>
> 2. Product cycle theory. Informed by economic history, product-cycle (or long- wave or profit-cycle) theory invokes *entrepreneurship* and *innovation* as keys to an area's ability to offset industrial life cycles. It tries to explain the redistribution of science-based and high-tech activities to younger areas and regions. To that extent, it highlights the decline of established clusters and the formation of new ones.
>
> 3. New Industrial District theory. The NID school includes Piore and Sabel (1984) and the cooperative models of The Third Italy, as well as Annalee Saxenian's (1994) networked industrial systems approach to Silicon Valley. It differs from neoclassical approaches in its emphasis on trust and cooperation. This branch of cluster theory has been greatly advanced by European scholars in particular.
>
> 4. Michael Porter's innovation-based clusters. This can be seen as a variant of product-cycle theory, but one that emphasized the role of innovation as an antidote to the dispersal of mature industries. Based on competition rather than trust (and hence neoclassical in flavor), specialized clusters in Porter's "diamond" paradigm represent one source of competitive advantage for a nation within the world economy, especially through information flows.
>
> 5. Dynamic disequilibrium (positive feedback) theories. Richardson (1985) advances cumulative causation models as the main rival to neoclassical theory, contending that they allow increasing returns to scale, in contrast to the constant-returns assumption typical of neoclassical approaches. It makes plausible persistent differences in growth rates, rather than convergence. Subsequent explorations by Brian Arthur (collected in Arthur 1994) and others develop this perspective via formal models. Paul Krugman refers to increasing-returns models as heralding "the new urban economics."

What does not come through in this barebones list is the flavor and diversity of the more applied side of the burgeoning cluster literature, especially as practiced by economic development agencies. Fortunately, a companion Chapter 2 in "Industrial and Regional Clusters: Concepts and Comparative Applications" by Bergman and Feser in this text provides a thorough survey of such applied branches.

GLOSSARY

Digitization. The process through which all information (text, numbers, images, and sounds) can be reduced to 0's and 1's, represented by on-off states on transistors, which in turn can be lodged on semiconductor chips at a rate that doubles every 18 months (see Moore's Law).

Gazelles – New and small businesses that have rapid job growth (e.g., the ones that doubled their employee count between 1989 and 1994). In general, such firms account for job growth far out of proportion to their numbers.

Information Goods – According to Varian and Shapiro (1999), information goods (1) typically display economies of scale in their production, (2) are "experience goods" that may need to be tried out before they are bought, and (3) may need to conform to a technology standard, which means that "network economies" are likely to come into play.

Law of Increasing Bandwidth. A tendency for telecommunications carrying capacity to double regularly as speeds approach fiber-optic or near light-speed transmission. For example, a cable modem has roughly 50 times the "bandwidth," or "width of the pipe" as a telephone modem. Hence it is 50 times as fast and is one step in the progression.

Metcalfe's Law. Costs of expanding a network increase only linearly, while benefits in the form of access points expand with the square of the number of users.

The Military-Industrial Complex. In 1961 a departing President Eisenhower described the military-industrial complex as "The conjunction of an immediate military establishment and a large arms industry," a phenomenon he described as "new to the American experience" and one that tended toward "the acquisition of unwarranted influence. . . ."

Moore's Law. The amount of digitized information that can be stored on a microchip doubles every 18 months. Formulated by Gordon Moore of Intel. Joy's Law is similar but refers to the speed of the microprocessor, not storage capacity.

Packet-Switching. A digital transmission technique of the kind used on the Internet, in which messages sent from one point can be broken up into many different packets, each of which is sent individually at higher speeds, to be reassembled upon delivery.

Punctuated Equilibria. An influential 1972 article by Niles Eldredge and Stephen Jay Gould spelled out the thesis that natural evolutions, while typically gradual in character, are marked from time to time by moments of sudden change, as when dinosaurs became extinct. This view of evolution stands in contrast to the "gradualist" view. The distinction looms large in discussions of economic and technological change, where evolutionary metaphors abound.

The Rule of 72 – The time it takes an amount growing at compound growth rate $r\%$ to double can be found by dividing 72 by r. Living standards would thus double in 36 years at a 2% gain each year. By the same token, the rate r required for a given amount to double in some desired period of N years can be found by the equation, $r = 72/N$.

Shift-Share Analysis. A simple technique that breaks down a city or region's growth into (1) a "share effect," based on the rate of national growth; (2) the "mix effect," which adjusts for the individual growth rates of the region's component industries; and (3) the "shift" or "competitive effect" given by the difference between the region's actual growth and that predicted from its share and mix effects. A positive shift effect thus reflects a faster rate of growth for a region over time than can be accounted for by its share of national growth or the specific mix of its industrial base.

The Stagnation Thesis. The view held by some Keynesian (and Marxist) economists that mature capitalism faced a vanishing of profitable investment opportunities. Once business investment slowed, the private sector as a whole would bog down in a chronic slump, constantly in need of pump-priming expenditures from government. This is the thesis Robert Heilbroner said in 1989 had been disproved by the introduction of new commodities. (See Information Goods.)

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