Route 128 and Environs

Silicon Valley and Environs

INTRODUCTION: LOCAL INDUSTRIAL SYSTEMS

▶ During the 1970s Northern California's Silicon Valley and Boston's Route 128 attracted international acclaim as the world's leading centers of innovation in electronics. Both were celebrated for their technological vitality, entrepreneurship, and extraordinary economic growth. With common origins in university-based research and postwar military spending, the two were often compared. They were also widely imitated. As traditional manufacturing sectors and regions fell into crisis, policymakers and planners around the world looked to these fast-growing regions and their "sunrise" industries as models of industrial revitalization and sought to replicate their success by building science parks, funding new enterprises, and promoting links between industry and universities.

This enchantment waned during the early 1980s, when the leading producers in both regions experienced crises of their own. Silicon Valley chipmakers relinquished the market for semiconductor memory to Japanese competitors, while Route 128 minicomputer companies watched their customers shift to workstations and personal computers. Both regions faced the worst downturns in their histories, and analysts predicted that they would follow the path of Detroit and Pittsburgh to long-term decline. It appeared that America's high technology industry, once seen as invulnerable, might not survive the challenge of intensified international competition.

The performance of these two regional economies diverged, however, in the 1980s. In Silicon Valley, a new generation of semiconductor and computer start-ups emerged alongside established companies. The dramatic success of start-ups such as Sun Microsystems, Conner Peripherals, and Cypress Semiconductor, and the continued dynamism of large companies such as Hewlett-Packard and Intel, were evidence that Silicon Valley had regained its former vitality. Route 128, in contrast,

showed few signs of reversing a decline that had begun in the early 1980s. The once-hailed "Massachusetts Miracle" ended abruptly, and start-ups failed to compensate for continuing layoffs at the region's established minicomputer companies, Digital Equipment Corporation, Data General, Prime, and Wang. By the end of the 1980s, Route 128 producers had ceded their longstanding dominance in computer production to Silicon Valley.

Silicon Valley is now home to one-third of the 100 largest technology companies created in the United States since 1965. The market value of these firms increased by $25 billion between 1986 and 1990, dwarfing the $1 billion increase of their Route 128–based counterparts.[1] Although the two regions employed workforces of roughly the same size in 1975, between 1975 and 1990 Silicon Valley firms generated some 150,000 net new technology-related jobs—triple the number created on Route 128 (see Figure 1). In 1990 Silicon Valley–based producers exported electronics products worth more than $11 billion, almost one-third of the nation's total, compared to Route 128's $4.6 billion.[2] Finally, Silicon Valley was the home of 39 of the nation's 100 fastest-growing electronics corporations, while Route 128 claimed only 4. By 1990 both Southern California and Texas had surpassed Route 128 as locations of fast-growing electronics companies.[3]

Why has Silicon Valley adapted successfully to changing patterns of international competition while Route 128 appears to be losing its competitive edge? Despite similar origins and technologies, these two regions evolved fundamentally distinct industrial systems after World War II. Their different responses to the crises of the 1980s revealed differences in productive organization whose significance had been unrecognized during the rapid growth of earlier decades—or had been seen simply as superficial disparities between "laid back" California and the more "buttoned up" East Coast. Far from superficial, these differences illustrate the importance of the local determinants of industrial adaptation.

Silicon Valley has a regional network–based industrial system that promotes collective learning and flexible adjustment among specialist producers of a complex of related technologies. The region's dense social networks and open labor markets encourage experimentation and entrepreneurship. Companies compete intensely while at the same time learning from one another about changing markets and technolo-

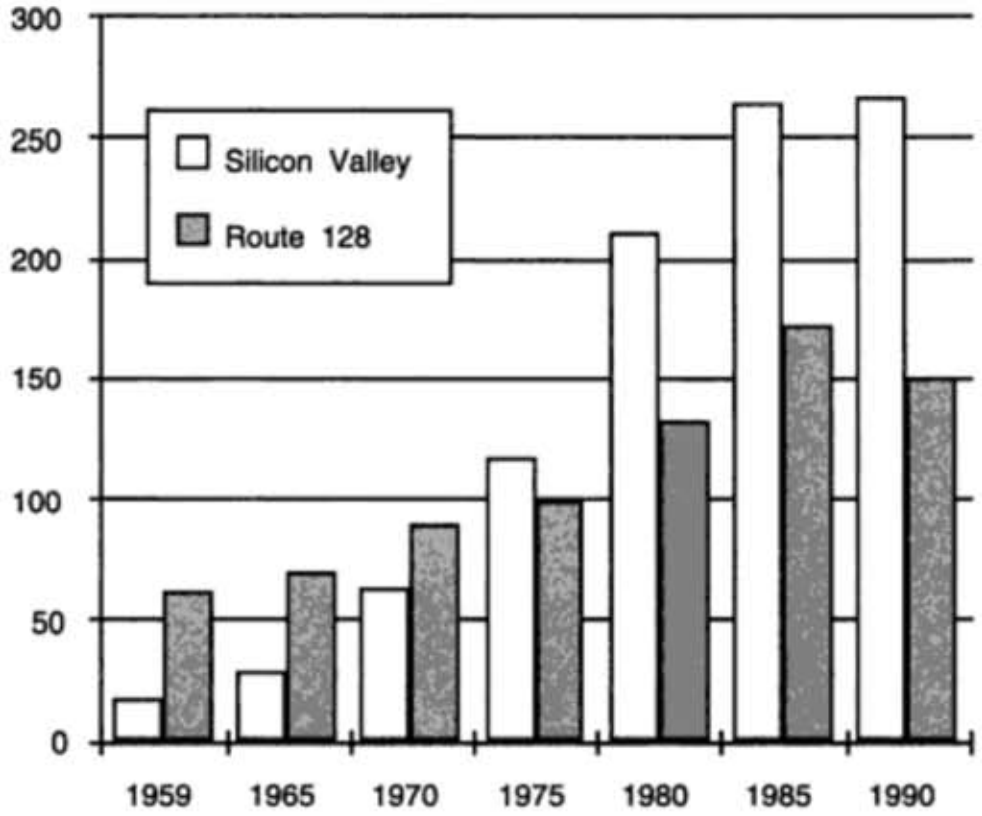

Figure 1. Total high technology employment, Silicon Valley and Route 128, 1959–1990. Data from *County Business Patterns*.

gies through informal communication and collaborative practices; and loosely linked team structures encourage horizontal communication among firm divisions and with outside suppliers and customers. The functional boundaries within firms are porous in a network system, as are the boundaries between firms themselves and between firms and local institutions such as trade associations and universities.

The Route 128 region, in contrast, is dominated by a small number of relatively integrated corporations. Its industrial system is based on independent firms that internalize a wide range of productive activities. Practices of secrecy and corporate loyalty govern relations between firms and their customers, suppliers, and competitors, reinforcing a regional culture that encourages stability and self-reliance. Corporate hierarchies ensure that authority remains centralized and information tends to flow vertically. The boundaries between and within firms and

between firms and local institutions thus remain far more distinct in this independent firm–based system.

Networks versus Independent Firms

The Silicon Valley and Route 128 economies are not isolated examples of the two types of industrial systems. Independent firm–based systems dominate the industrial geography of the United States and large parts of Europe. They are typically associated with capital-intensive industries such as oil, rubber, machinery, and automobiles, and they have been analyzed by students of the large-scale corporation. These analyses have little to say about the organization of regional economies, however, primarily because the traditional vertically integrated corporation tends to internalize most local supplies of skill, technology, and other resources. As a result, even when regional theorists examine large corporations, few link the social, institutional, and technical fabrics of different localities.[4]

There is, in contrast, a growing literature on the dynamics of regional network–based industrial systems, which have been identified in many parts of the world and in many historical periods.[5] In these systems, which are organized around horizontal networks of firms, producers deepen their own capabilities by specializing, while engaging in close, but not exclusive, relations with other specialists.[6] Network systems flourish in regional agglomerations where repeated interaction builds shared identities and mutual trust while at the same time intensifying competitive rivalries.

The most studied contemporary examples of regional network–based systems, the small-firm industrial districts of the Third Italy, specialize in traditional industries such as shoes, textiles, leather goods, furniture, and ceramic tiles. Germany's Baden-Württemberg is known for its mix of small and medium-sized makers of machine tools, textile equipment, and automobile components alongside giant electronics corporations. Similar flexible industrial clusters have been identified in Denmark, Sweden, Spain, and Los Angeles.[7] While each of these variants of network systems reflects distinctive national and regional institutions and histories, their localized social and productive interdependencies are comparable to those in Silicon Valley.

The successes of Japanese industry are similarly attributable, at least in part, to network organizational forms. The Japanese corporation is

more internally decentralized and more open to the surrounding economy than the traditional large American corporation. Producers of electronics, autos, and machine tools, for example, rely on extensive networks of small and medium-sized suppliers, to which they are linked through ties of trust and partial ownership. Although Japan's large firms historically exploited suppliers, many increasingly collaborate with them, encouraging them to expand their technological capabilities and organizational autonomy. Like their Silicon Valley counterparts, these producers tend to be geographically clustered and depend heavily on informal information exchange as well as more formal forms of cooperation.[8]

As the case of Japan suggests, there are large- as well as small-firm variants of network-based systems. Large corporations can integrate into regional networks through a process of internal decentralization. As newly independent business units are forced by competition to achieve the technical and productive standards of outsiders, they often draw on the social and technical infrastructure of the local economy and collaborate with external suppliers and customers.[9]

Of course all economic activity does not cluster within a single regional economy. Firms in network systems serve global markets and collaborate with distant customers, suppliers, and competitors. Technology firms, in particular, are highly international. However, the most strategic relationships are often local because of the importance of timeliness and face-to-face communication for rapid product development. Moreover, nonlocal suppliers succeed in part by integrating into regional economies that specialize in similar lines of business. Paradoxically, the creation of regional clusters and the globalization of production go hand in hand, as firms reinforce the dynamism of their own localities by linking them to similar regional clusters elsewhere.

Regional Advantages

The experience of Route 128 and Silicon Valley in recent decades suggests that there are important regional sources of competitive advantage. Neither standard accounts of industrial adaptation as a national or a sectoral process nor traditional theories of regional development, which treat Silicon Valley and Route 128 as comparable concentrations of skill and technology, can account for Silicon Valley's superior adaptive capacity during the 1980s. Producers in these two

regions compete in the same technology-related markets and are located in the same nation, yet they have fared quite differently in the competitive turmoil of recent decades. Their differences in performance cannot be explained by approaches that view firms as separate from the social structures and institutions of a local economy.[10]

Historical evidence emerging from the United States and other advanced industrial nations confirms that variations in local institutions and corporate forms shape regional capacities for adaptation.[11] The recognition that differences in economic performance within nations can be as great as those between nations has spurred growing interest in regions. However, the concepts traditionally used to analyze regional economies provide little assistance in accounting for the differences in performance of Silicon Valley and Route 128.

Students of regional development rely on the concept of external economies to assess the sources of comparative advantage that lie outside the individual firm.[12] They view Silicon Valley and Route 128 as classic examples of the external economies that derive from industrial localization: as cumulatively self-reinforcing agglomerations of technical skill, venture capital, specialized suppliers and services, infrastructure, and spillovers of knowledge associated with proximity to universities and informal information flows.[13] But the concepts of agglomeration and external economies cannot explain why clusters of specialized technical skill, suppliers, and information produced a self-reinforcing dynamic of increasing industrial advance in Silicon Valley while producing stagnation and decline along Route 128.[14] The simple fact of spatial proximity evidently reveals little about the ability of firms to respond to the fast-changing markets and technologies that now characterize international competition.

The notion of external economies assumes that the firm is an atomistic unit of production with clearly defined boundaries. Treating regions as collections of autonomous firms has led some observers to conclude that Silicon Valley suffers from excessive, even pathological, fragmentation.[15] This view overlooks the complex of institutional and social relationships that connect the producers within the region's fragmented industrial structure. Although the broadest interpretations of technological external economies recognize that firms learn from one another through flows of information, ideas, and know-how, they do so only by denying the initial theoretical distinction between internal and ex-

sufficient business strategies despite a regional culture that promoted open exchange and informal cooperation.

Differing combinations of the three dimensions of an industrial system are possible, although they tend, in practice, to become reinforcing components in coherent regional economies. Dense networks of social relations play an important role in integrating the firms in Silicon Valley's fragmented industrial structure. Elsewhere, however, the small, specialized firms in regional clusters remain isolated, linked only by arms-length market relations.[20] Moreover, apparently analogous institutions can play different roles in different industrial systems. Universities, for example, are widely viewed as sources of knowledge and information for their regional economies. But Stanford University, which actively promoted local technology start-ups during the years following World War II, is far more deeply integrated into its surroundings than the Massachusetts Institute of Technology (MIT). Thus it is not sufficient to consider institutions in isolation; they too are parts of the broader industrial systems in which they are embedded.

Adapting to Change

Understanding regional economies as industrial systems rather than as clusters of factors of production, and thinking of the two regions as examples of the two models of industrial systems—the decentralized regional network–based system and the independent firm–based system—illuminates the divergent trajectories of the Silicon Valley and Route 128 economies since World War II. The histories of these two regions also provide a striking illustration of the relationship between regional networks and the process of industrial adaptation.

Silicon Valley's producers continued to adapt to the leading edge of electronics technologies, while Route 128 companies repeatedly stumbled—often losing out to the West Coast. In the early 1960s Silicon Valley established itself as the nation's center of semiconductor innovation, overtaking Route 128's initial leadership in transistors and other solid state devices. Although several large Route 128 companies eventually began producing semiconductors internally, the region never developed an independent semiconductor business.

A second opportunity emerged for Route 128 when it became a center of minicomputer production in the late 1970s. Most observers at the time described an emerging division of labor between Silicon

Valley and Route 128, with the former specializing in semiconductors and the latter in computers. But Route 128 producers failed to make the transition to smaller workstations and personal computers, and in the late 1980s the locus of innovation in computing shifted from the East to the West, just as it had in semiconductors two decades earlier.

In a network-based industrial system like that in Silicon Valley, the region—if not all the firms in the region—is organized to adapt continuously to fast-changing markets and technologies. The system's decentralization encourages the pursuit of multiple technical opportunities through spontaneous regroupings of skill, technology, and capital. Its production networks promote a process of collective technological learning that reduces the distinctions between large and small firms and between industries or sectors.

The independent firm–based industrial system flourished in an environment of market stability and slow-changing technologies because its leading producers benefited from the advantages of scale economies and market control. It has been overwhelmed, however, by changing competitive conditions. Corporations that invested in dedicated equipment and specialized worker skills find themselves locked in to obsolete technologies and markets, while hierarchical structures limit their ability to adapt quickly as conditions change. Their inward focus and vertical integration also limit the development of a sophisticated local infrastructure, leaving the entire region vulnerable when the large firms falter.[21]

In the case of semiconductors and again with computers, Silicon Valley's network-based system supported a decentralized process of experimentation and learning that fostered successful adaptation, while Route 128's firm-based system was constrained by the isolation of its producers from external sources of know-how and information. Route 128 firms continued to generate technological breakthroughs but were not part of an industrial system that would have enabled them to exploit these successes as a region. In Silicon Valley, as in comparable localities elsewhere, regional networks promote the collective technological advance that is increasingly essential to competitive success.