FRBSF WEEKLY LETTER

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# The Product Life Cycle and the Electronic Components Industry

Since the early 1980s, many observers have worried that Silicon Valley may be losing its position as a leader in high technology industries. They suggest that high costs in Silicon Valley have driven firms to shift production to less costly sites. These concerns are consistent with the views of some economists, who argue that the factors affecting firms' location decisions may vary during a product's life cycle. In this view, innovation in a particular industry tends to be concentrated in a region that offers access to technological expertise, even if costs in that region generally are high. As the market for the new product grows and production technologies are standardized, proximity to the innovating region becomes less important, freeing firms to seek lower costs elsewhere. Thus, according to this theory, infant industries may be concentrated in high-cost regions, while mature industries are more likely to be located where production costs are low.

At first glance, recent trends in electronic components employment among the western states appear to be consistent with the hypothesis that lower-cost regions are gaining ground at the expense of innovating regions such as Silicon Valley. For example, between 1982 and 1987, employment in the electronic components industry in California fell 1.8 percent and rose by more than 75 percent in three low-cost western states, Idaho, Nevada, and Utah.

This *Weekly Letter* examines the broader geographical trends of activity in the electronic components industry since 1977 to determine whether the concerns about movement to low-cost regions are in fact justified.

**The product life cycle**

The product life cycle theory emphasizes the changes in the importance of various factors in firms' location decisions during a product's life cycle. The first stage of the product life cycle is innovation, which is characterized by geographic concentration. Innovations may be more likely to occur in some regions than in others, because a critical mass of related activity can increase the efficiency of each plant in the industry. For one thing, a region with a cluster of related activities is likely to have the business service and financial infrastructure in place to serve firms with similar needs. Moreover, workers with appropriate skills are likely to be more plentiful in such a location, and if these skills are relatively unusual in the general population, the location will be particularly appealing to firms. For innovations in which work force characteristics and local infrastructure are critical, proximity to these factors is likely to outweigh other cost considerations in the innovation stage. Therefore, an initial cluster of activity could occur even in a location where the general level of costs is high.

After the innovation comes a stage of transition, in which increased demand for the product makes investment in production technology feasible, and the technology of production can be transferred from one location to another. At this point, firms are not tied to the site of the original innovation as closely as they were in the first stage. Nevertheless, the continued need for technological expertise as the production process is refined may lead the firm to confine its site search to a smaller region than it might otherwise explore. Thus, in the second stage, the industry may spread out somewhat from its initial concentration of activity.

The third and final stage of the product life cycle is standardization, when technological innovations are complete. At this point, production is "footloose" and the research activities that were concentrated in the innovating region are no longer crucial to the production process. Therefore, site location decisions can be based primarily on the costs of production that are not related to innovation.

If these factors have been at work in the electronic components industry, which makes such

products as semiconductors and printed circuit boards, and if the initial production was concentrated in high-cost areas, wages and other direct costs should have become more important locational determinants over time, while attributes associated with technological expertise should have become less important.

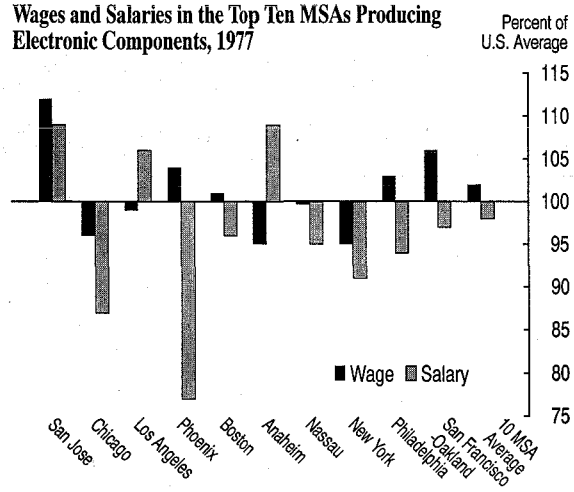
While these kinds of changes seem plausible, there are reasons for skepticism about whether they have in fact occurred for electronic components makers. Most importantly, the pace of technological change has been so rapid that even the "standardized" components change every few years. "Standard" memory chips, for example, have grown in their memory capacity with stunning frequency. With products changing so often, production processes and equipment change frequently. This suggests that technological expertise may continue to be important to production, thus limiting the extent to which standardized production processes can be implemented.

**Characteristics of innovating regions**

The characteristics of the innovating regions also will affect how the location of production activity will change over time. If there were an incentive to shift activity away from these regions since 1977, labor costs in these cities would be expected to have been relatively high. The Chart plots labor costs for the ten metropolitan areas that were the most important electronic components producers in the U.S. during 1977. The Chart shows that labor costs in the San Jose area (which includes Silicon Valley) were indeed relatively high, with the average hourly wage and average annual salary in the electronic components industry well above the national average. The high costs in the area around Silicon Valley do appear to have provided firms with the incentive to shift activity to lower-cost regions.

However, for these ten cities as a group, costs were not particularly high. In fact, the average annual salary for nonproduction electronic components workers actually was lower for these cities than it was nationally. These figures suggest that, even if production and nonproduction activities become less closely linked over time, as the product life cycle theory suggests, the shift of activity away from these innovating regions may not in fact occur.

**Wages and Salaries in the Top Ten MSAs Producing Electronic Components, 1977**




**Trends in U.S. activity**

Indeed, the data on regional market share do not indicate a significant exodus of activity from the innovating regions. Data from the Census of Manufacturers reveal that the ten metropolitan areas that were the most important electronic components producers in 1977 experienced only a small decline in their share of U.S. activity by 1987, from 38 percent to 37 percent. The single most important metropolitan area, San Jose, actually increased its share during the decade, from 10 percent to 11½ percent. Information on the years since 1987 is more spotty, but suggests that if there was a decline in these regions' share of total U.S. activity, that decline probably was relatively small.

Statistical analysis of U.S. data suggests that firms in the electronic components industry did not become more sensitive to high costs during the 1977 to 1987 period. Indeed, the statistical relationship between wages and employment is positive across the entire sample of electronic components producing regions, rather than negative as one would expect if firms were seeking low labor costs without regard for the productivity of the workers they hire.

The product life cycle theory also predicts that the link between production and nonproduction activities should weaken over time. Statistical analysis does suggest that the linkage between production and nonproduction activities probably has become looser over time. However, the

other evidence suggests that this change is not due to firms' shifting away from high-cost regions.

**International comparisons**

Many have noted that producers of electronic components seem to have pursued lower costs by shifting production overseas. If this is so, then the U.S. share of world electronic components production should have fallen over time. No consistent production activity data are available across countries, but some suggestive information is available. According to the Semiconductor Industry Association, the share of U.S.-based companies in total world semiconductor production fell quite dramatically during the 1980s. U.S.-based companies accounted for 67 percent of world semiconductor production in 1977, but that share fell to 60 percent in 1982, 45 percent in 1987, and 38 percent in 1988. It is likely that these numbers understate the decline in the share of production taking place in the U.S., since the U.S.-based companies moved some of their production offshore during this period.

It is worth noting that even though the U.S. share of the world market has fallen substantially, the level of activity in the U.S. continues to be much higher that it was during the late 1970s. The value of 1987 sales (adjusted for inflation) by U.S.-based semiconductor makers was almost twice the value of sales in 1977. In addition, between 1977 and 1987, total U.S. employment in the electronic components industry grew 53 percent, although it fell 3½ percent between 1987 and 1991.

**Conclusions**

This *Weekly Letter* has examined geographic trends in the electronic components industry, to see whether they have been consistent with expectations based on the product life cycle theory. According to this theory, as the market for a new product grows and production becomes standardized, locations with low labor and land costs should become increasingly important to production activity, while costly innovating regions should see a decline in activity. For the electronic components industry, this suggests that high-tech centers such as Silicon Valley should have shrunk over time, while most of the industry's activity should have shifted to low-cost production sites.

The evidence presented in this *Weekly Letter* suggests that there has not been a major exodus of electronic components activity from innovating regions in the United States. The regions that were important producers in 1977 remain so today, and despite a modest decline in recent years, now have a far higher level of activity than they did then. The rapid growth in low-cost states such as Idaho, Utah, and Nevada does not necessarily contradict these findings, because those states' employment bases were so small in 1977 that the actual number of jobs added in these states has been relatively modest. These findings reflect the facts that the pace of technological innovation in electronic components has been rapid enough to limit the extent of standardization in the industry, and that most of the important innovating regions in the U.S. were not particularly high-cost locations to begin with.

At the same time, though, the decline in U.S. producers' share of world production has been dramatic. This suggests that the lure of lower costs abroad has been an important force in the industry, and that if the forces described by the product life cycle theory are at work, they are working in an international rather than a domestic context. Still, these forces have not yet been strong enough to pull production away from the industry's initial innovating regions.

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