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### Title

A Global Reshaping of the Computer Industry

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# Research Report

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## A Global Reshaping of the Computer Industry

Foreign trade is playing an increasing role in the transformation of California industries. Many of the state's most rapidly expanding sectors are growing globally, both in sales and in production locations. This type of growth is met with excitement in some quarters but raises concerns in others. While the export of product strengthens California firms, the production abroad, for foreign or domestic sales, raises fears of weakened employment opportunities within the state.

As part of a larger study on the role of foreign trade in California's economic growth, the Fisher Center for Real Estate and Urban Economics conducted a case study of the computer cluster, examining how global linkages, including export opportunities, import competition, foreign production, and the use of imported inputs, affect growth and structure of the industry.

### The Computer Cluster Defined

We examined California's computer industry as a cluster of different sectors, including the makers of computers and their hardware components and peripherals, and the software developers whose products are integral to the operation of computers and peripherals. By our definition, the core of the computer cluster in California is composed of eight sectors. These include electronic computers, computer storage devices, computer peripheral equipment,

printed circuit boards, and computer software (computer programming services, prepackaged software, and computer integrated systems design). The software component of this cluster accounts for almost half of the employment in these eight sectors, as shown in Figure 1. (Semiconductors are also linked to this cluster, but we did not include this sector in our study).

California dominates US employment in many of these sectors. The state has over one-fourth of US employment in computer and office equipment manufacturing overall, and between 30-40% of employment in the specialized categories of electronic computers, computer storage devices, and computer peripherals. At least

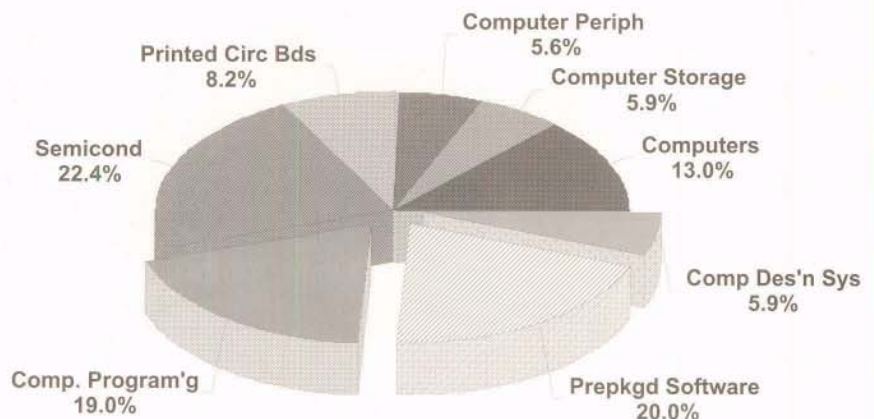
one-fourth of US employment in electronic components such as printed circuit boards and semiconductors is located in California. The state has a somewhat smaller share of US employment in computer and data processing services overall (16%), but accounts for almost 30% of US employment in prepackaged software.

### Sales Outpace Employment Growth

Computer sales have expanded strongly, but the employment change has been uneven, with the largest share of growth occurring in the services portion of the cluster, rather than in manufacturing sectors. As reported by the Annual Survey of Manufacturers, the value of computer

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Figure 1  
Distribution of Employment within the Computer Cluster  
California, 1994



Source: County Business Patterns 1994.



shipments has grown sharply in California, with sales rising by 89% between 1987 and 1995, before adjusting for inflation. (See Figure 2.) Because computer and component prices have *dropped* over this period, per unit output has more than doubled. Productivity gains have also been large. With the growth in productivity, despite revenue gains, employment in the primary computer manufacturing sector, computer and office equipment, shrank between 1987 and 1994, dropping from 103,000 to 83,000, according to California Employment Development Department data. Employment has grown since 1994 (by 2.4% in 1995, by 5.2% in 1996, and by an estimated 6.8% in the first 8 months of 1997), to about 95,000 in 1997, but is still below levels of a decade ago. (Sales and value added data are not yet available beyond 1995.)

Detailed California data are not available for the segment of the computer cluster classified as computer and data processing services. At the US level, sales in computer and data processing services almost tripled between 1987 and 1995, while

employment grew by close to 75%. California employment grew more rapidly than US employment. Based on County Business Patterns data, California had over 160,000 employed in this sector in 1994 and, by our estimates, over 180,000 in 1995. Sales data for California computer services are available only from the Census of Services, for 1987 and 1992. For that period, sales in computer and data processing services grew by 91%.

### A Shifting Trade Balance

The trade balance picture is quite different for computer hardware and software. While detailed data are not available for computer exports and imports at the statewide level, it is clear that foreign trade plays a major role in the industry. Nationwide, exports were 45% of the value of 1995 shipments in computer and office equipment. In California, industrial equipment (a larger category including computers) is the state's second largest export category, after electronic equipment (also a computer related category which includes peripherals and semiconductors).

California accounted for 23% of US 1995 industrial equipment exports and for 31% of electronic equipment exports.

Despite the large export base of the computer industry, its imports are now greater than its exports. The computer and office equipment sector went from a positive trade balance of \$2.2 billion in 1989, to a negative balance of \$17.2 billion in 1995 (see Figure 3). The services component of the cluster, computer and data processing, has maintained a growing positive net trade balance, but this is still too small to offset the negative balance of the computer hardware sector. (For accounting reasons, it is possible that the trade figures underestimate the role of trade in computer and data processing services.)

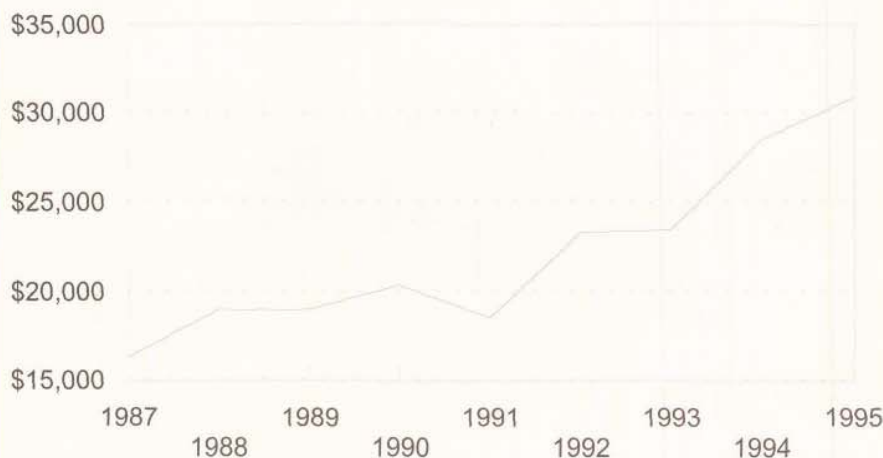
Foreign imports also can play an important role in the domestic computer manufacturing process. Our estimates for 1992 (the latest date for which data is available) show that computer manufacturers import 18% of inputs, and component manufacturers import 14-15% of inputs.

### A Multidisciplinary Approach to Analysis

To understand the impacts of trade on California in general, and the computer cluster in particular, we conducted several different types of analyses. Our methods included:

- descriptive statistics of the computer sectors,
- detailed interviews of a sample of computer cluster firms,
- econometric analyses of the role of exports and imports in determining growth of output and employment levels in California 3-digit sectors,
- an econometric analysis of the effects of imported inputs on the proportions of blue collar to white collar workers in a sector,

**Figure 2**  
**Value of Shipments, Computer Manufacturing California, 1987-1995 (\$ millions)**



Source: Annual Survey of Manufacturers and Census of Manufacturers



- estimates based on extrapolation techniques of the indirect effects of price decreases on computer cluster employment.

In our results, we address the issues of how individual firms respond to and make use of the global market, how employment within the manufacturing sectors changes as a result of increasing global interactions, and more broadly, how employment growth is affected by these changes. We also examine policy concerns that may affect California's computer industry in the future.

### Computer Cluster Firms in Multinational Settings

Interviews with computer firms brought out the complexities of operating in a global market. Many firms began operations in California at a single production site. Output might be sold either domestically or in global markets, and input might come from domestic or overseas producers, but the firm's core production was in California. Two different types of forces may lead a computer firm to expand beyond state (and often US) borders.

First, many segments of the computer industry face stiff competition from other US firms and from abroad. For the hardware portion of the industry, California producers compete with many foreign producers in production of computers, peripherals, and components. To maintain cost competitiveness, many California computer hardware producers have located a portion of production activity overseas, primarily in Asia, but also in parts of Europe and in Central and South America. The move overseas is often part of expansion, with a portion of production as well as much of the administrative and research and development (R&D) activity retained in California.

In some cases, the overseas site or sites produce inputs to products still assembled in California.

Second, firms seek overseas production sites as a way of obtaining better access to overseas markets. Many of the European production sites of California computer firms are not in low cost areas, but are well-located for access to European markets.

A very small proportion of hardware firms maintain the bulk of their production in California. These are Silicon Valley firms that alone produce more than half of the product sold in their market niche (often because they are working with new technologies), and where product customizing for the needs of the buyer is an important aspect of production. In these firms, the bulk of the "production" workforce is educated at a college level.

While virtually all hardware firms have a portion of production at overseas sites, software firms show more variation in production ap-

proaches. Small, rapidly growing software firms rely primarily on their California labor force, and are the least likely to have outside production sites (unless they have acquired an out-of-state company as part of their growth). More established software firms with broader market areas are more likely to do some production overseas. Disk production and packaging are the most likely overseas operations for software firms, while technical work is generally related to tailoring products for foreign markets.

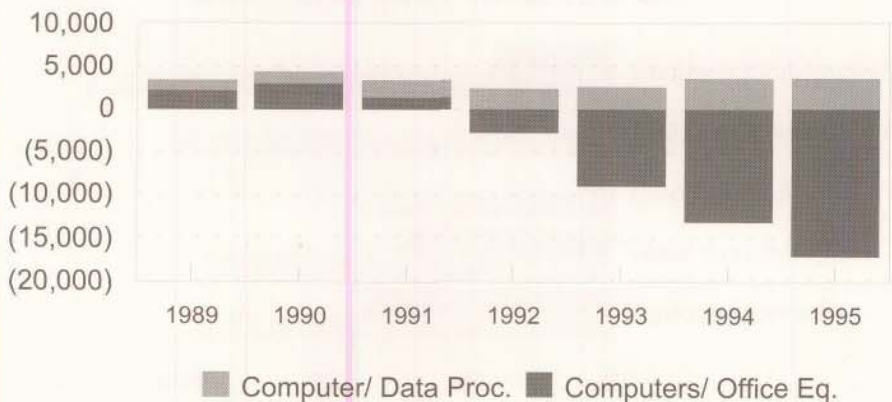
### Global Impacts on Firm Structure at Home

As firms grow globally, the portion of production that remains in California and in other parts of the US also undergoes change. To the extent that operations remain in California, the use of imported inputs rises. For example, between 1987 and 1992, segments of the computer and office equipment industry saw the proportion of inputs that are imported increase from a range of 1-8% in

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**Figure 3**  
**Net Exports in Computer Hardware and Services**  
**1989-1995**

Net Exports (Exports-Imports), Millions



Source: Annual Surveys of Manufacturing and Services, U.S. trade data.



1987 to a range of 7-18% in 1992 (as shown in Figure 4).

Methods of expansion have also changed. A number of the firms interviewed describe their growth process as a series of acquisitions of start-up companies and of competitors. Acquisition of competitors is the means by which a number of hardware, network, and software firms have become multi-state or multinational. The opportunity to identify and acquire start-up firms is a factor keeping some growing firms in Silicon Valley.

### Labor Force Restructuring

Both econometric analysis and firm interviews suggest that as companies stretch globally, their labor force needs in California shift. An econometric analysis across over 400 different California manufacturing sectors for the period from 1987 to 1992 shows that the proportion of white collar workers in an industry's employment mix rises with the proportion of inputs imported from abroad. The computer industry, with increasing use of production abroad, has among the highest proportions of

white-collar workers in its labor force.

The technical analysis is consistent with the labor force mixes found in firms interviewed. The great majority of firms had significant sales operations, production, and some technical assistance employees located overseas. In most cases, the profile of employees at California locations was quite different from employees out-of-state or overseas. For most firms, 30-40% of workers at the California locations were in professional and technical occupations, while workers at overseas locations were primarily in production and sales occupations.

In some cases, this geographic variation in labor force mix was mirrored among locations within the state. A few firms had significant production operations at lower cost sites within California, such as the Sacramento area, while the great majority of computer cluster firms have headquarters, administrative, and research and development activities centered in Silicon Valley.

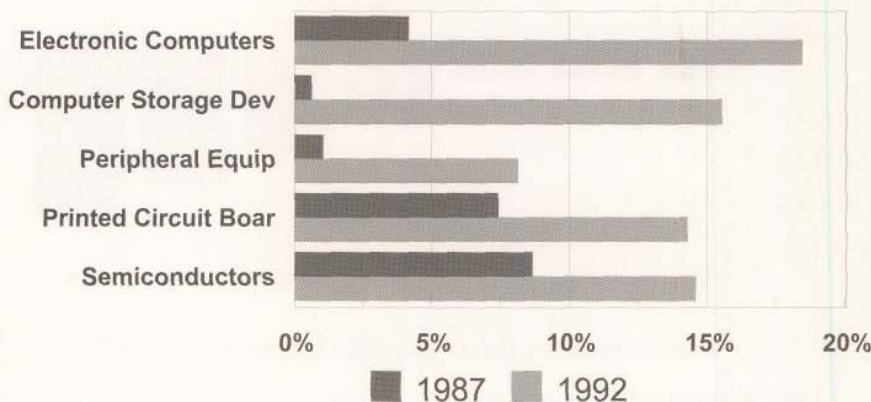
### Employment Shifts among Sectors

The above descriptions suggest that much of the manufacturing employment growth from computer production is not occurring in California, and as a result, the California labor force has not fully felt the benefits of expansion into global markets. Certainly, the growth in manufacturing jobs is much less than might be expected from the greatly expanded revenues in the industry. However, two elements of our analysis suggest that the job consequences of trade activity on the computer cluster are more positive than is evident in the manufacturing experience alone.

A statistical analysis comparing California manufacturing sales and employment levels with trade activity indicates that in aggregate, exports increase both employment and sales, while imports do not necessarily have the "expected" negative effect on employment and sales growth. The neutral effect of imports might arise from their dual role as items of final consumption and as intermediate inputs. A look at the computer industry provides some further hypotheses concerning the effect of imports on the state's employment.

Within computer manufacturing, the competitiveness of the industry, in which foreign producers play a significant role, has contributed to steady improvements in the product accompanied by large reductions in price. Figure 5, for example, shows the price index for office, computing and accounting machines for 1984, 1995, 1996 and 1997, with prices overall in the industry down by over 40% in the past decade and a half. When increases in computer capacity are taken into account, the real price change may be far greater. The decrease in price has had a broaden-

**Figure 4**  
**Percent of Inputs Imported**  
**US Sectors, 1987 and 1992**



Source: Computed from Annual Survey of Manufacturers data



ing effect on the market; between 1984 and 1993, the share of households with computers increased from 8-23%.

Increased computer sales, of both imports and products produced in the US, has the potential for increasing sales in related sectors, particularly in computer software. To the extent that foreign imports have contributed to price reductions, and thus the expansion of sales, imports are also contributing to the growth of the software industry and of other industries providing services to computer users. Under very conservative assumptions about the role of foreign imports in computer price reductions and about the impacts of price reductions on sales, we estimate the number of jobs added to the computer software industry as a result of this process comes close to replacing all of the jobs lost in computer manufacturing in California since the sector's 1987 peak. Under more realistic assumptions, up to 50,000 additional jobs (beyond those lost in manufacturing) may have been added to the software industry as a result of the foreign import contribution to the expansion of computer sales.

Our conclusions, then, are that the global linkages in California's computer industry, in foreign sales, production, and imports, are integral to the growth and strength of the industry in California. These forces also influence the type of job growth and the geographic location of growth.

### Location Choices and Policy Concerns

Global restructuring in the computer cluster is contributing to the changing geographic patterns of the industry. As firms expand operations throughout the world, to what extent will California, and in particular

Silicon Valley, maintain its dominance? Interviews with computer firms highlighted some of the factors that influence the decision to remain in California or move parts of operations elsewhere, as shown in Figure 6.

For computer firms centered in Silicon Valley, the skilled labor pool and professional networks, supported by university research and academic programs, were the primary factors leading the industry to maintain its base in Silicon Valley and to expand some activities to other parts of California. Firms mentioned the flow of information, proximity to investors, the flow of new ideas and the opportunity to acquire start-ups as advantages of being part of the California computer network. Firms also cited other proximity advantages for California—to west coast and overseas markets and suppliers. The California quality of life was cited by about half of the computer firms in the study.

While there are strong advantages keeping computer cluster firms in the state, there are other factors that make operating in California a challenge. For

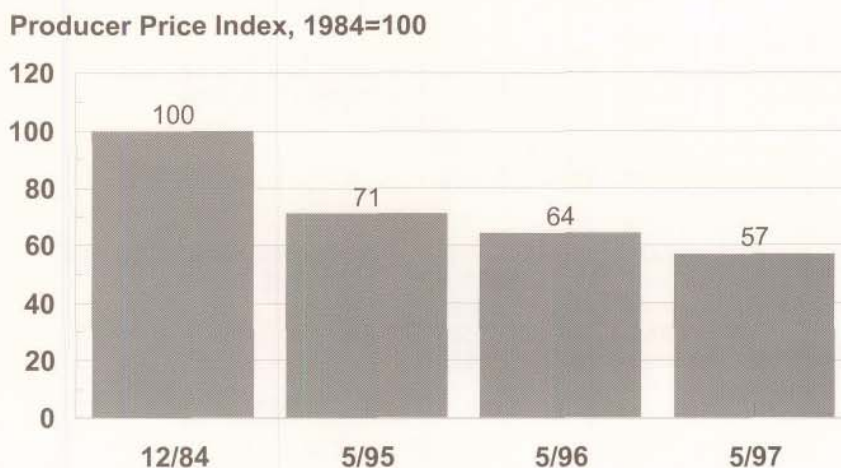
computer firms, costs and congestion were the greatest concerns; housing costs are far higher than in other parts of the US, while labor costs would be much lower in many overseas locations. As with many business centers, traffic congestion is an increasing issue in Silicon Valley, contributing to the problems of access to affordable housing and labor. Taxes and government regulation were seen as making it more difficult to do business in the state. Many firms complained of the cumbersomeness of environmental processes, rather than the standards set or technical costs of meeting those standards, as being most burdensome.

Computer firms rarely used state promotional resources to help expand export sales. Instead, these firms indicate broader concerns regarding competitiveness including:

- The need to maintain a strong education system and to improve K-12 education
- The need to simplify regulatory processes.
- The need to anticipate and plan for infrastructure and real estate for expanding industries (for example,

*(Continued on page 6)*

**Figure 5**  
**Office, Computing and Accounting Machines**  
**Producer Price Index**



Source: Bureau of Labor Statistics web page

