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Silicon Chips and Spatial Structure: The Industrial Basis of Urbanization In Santa Clara County, California

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FOREWORD

In the 1970s, as the industrial regions around the world languished and the energy regions boomed, regional theorists began to look beyond regional boundaries for the explanation of regional economic fortunes.

Pioneered by Doreen Massey and Richard Meagan (1978), a new approach emerged which emphasized industrial restructuring as the prime agent in regional change. They demonstrated for Britain how innovation and cost-saving initiatives in certain industries accounted for locational shifts in manufacturing and consequent changes in the regional demand for labor. Similarly, Frobel, Heinrichs and Kreye (1980) argued that the restructuring of manufacturing in general and textiles in particular resulted in enclave growth of low-wage manufacturing in developing countries while severely curtailing production in Germany and other industrialized countries. In pioneering the industrial restructuring approach for the U.S., Bluestone and Harrison (1980) studied eleven industries significant for the New England economy and documented how shifts in employment could be traced to changes within these sectors. Each of these studies showed compellingly the regional consequences of industrial restructuring and each succeeded in proferring at least some of the causes.

What such studies have not done to date is trace the intra-regional spatial consequences of industrial restructuring. This is the task that AnnaLee Saxenian takes on in the present work. Her research demonstrates how the labor force requirements of the electronics industry have resulted in a bifurcated residential pattern in Santa Clara County, California, the infamous Silicon Valley that is every declining region's envy.

Residential segregation of these two classes of labor--highly skilled managers and engineers and low skilled manufacturing and assembly workers--has created a highly differentiated urban/suburban landscape, with severe fiscal imbalance across the fifteen municipal governments involved. Most metropolitan location studies have not been able to trace, as Saxenian does, the relationship of differential land use and fiscal status directly to the industrial base of the region.

Saxenian's work also closes the circle by showing how the contradictions of this spatial form translate into significant costs that in turn encourage the industry to restructure yet again. Particularly, the high costs of housing, the congestion caused by high levels of commuting, and the pollution caused by auto emissions have all adversely affected the industry's ability to recruit additional workers, particularly in the higher salaried positions. In response, the industry is increasingly decentralizing its assembly and advance manufacturing processes in order to keep firm headquarters, research and development, and experimental work in the Valley.

Saxenian's approach may prove difficult to apply to other metropolitan regions. Her Santa Clara case was ideally suited for exposing the casual link between industry and spatial structure because the electronics industry is so dominant in the region. However, her work poses a challenge to other students of regional structure by elucidating a relationship which can no longer be ignored. For she has shown us, that while people do follow jobs and jobs do follow people, what matters most are the kinds of jobs created and residential and commuting patterns of the people who occupy them.

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IURD

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I. <u>INTRODUCTION</u>

The Santa Clara Valley is
To those who hold it dear
A veritable Paradise
Each season of the year.
One loves it best in April
When the fruit trees are in bloom;
And a mass of snowy blossoms
Yield a subtle sweet perfume.

When orchard after orchard
Is spread before the eyes
With the whitest of white blossoms
'Neath the bluest of blue skies.
No brush could paint the picture
No pen describe the sight
That one can find in April
In "The Valley of the Heart's Delight".

"The Valley of the Heart's Delight"
Clara Louise Laurence, 1931

"Urbanists cite it as the archetypical slurb, a sprawling confusion of look-alike houses, shopping centers and filling stations, crisscrossed by freeways that whiz shopper and workers away from a once-bustling downtown business district."

"Correcting San Jose's Boomtime Mistakes" <u>Business Week</u>, September 19, 1970.

In 1940, Santa Clara County was a peaceful agricultural valley. By 1960, the electronics industry had taken root and it had become one of the fastest growing urban areas in the country. By 1970, it had gained its reputation as Silicon Valley, the world capital of the semiconductor industry. Today the county is plagued with urban problems which are driving out the very electronics firms which brought its phenomenal growth.

This thesis explores the implications of the evolution and restructuring of the electronics industry for patterns of regional growth and urban development through an examination of the experience of Santa Clara County, California, over the past forty years. The underlying argument is that the electronics industry is distinguished primarily by the social structure which it generates. Electronics is a science, and the industry's growth is dependent upon continuous innovation, refinement and application of scientific technologies and processes. This technological-base of electronics sets it apart from other industries because of the large numbers of highly educated scientists and engineers who are integral to the production process. Electronics manufacturing requires both unskilled labor and a sizable proportion of professional and highly skilled workers. The behavior of the industry is thus governed by a unique set of imperatives, imperatives driven by the need to attract and retain intellectually qualified manpower, while at the same time having access to substantial pools of unskilled labor. Thus, while the speed with which Santa Clara County grew is a reflection of the rapid growth of the electronics industry, the urban contradictions that have evolved in the county are consequences of the social structure generated by the industry.

Analytical Approach

The approach to the process of regional change presented here differs significantly from those taken by traditional location and regional growth theories. Location theory, using neoclassical economics as a foundation, explains firms' location decisions as the profit-maximizing allocation of activity with respect to the given distribution of markets and factors of production (e.g. Weberian cost-minimization or revenue-maximization in central place theory). It isolates these locational factors (factor supplies and market locations) from all other economic forces, and explains firm behavior solely as a function of comparative costs and revenues. While an understanding of the way in which different firms select among locations for investment is crucial to an understanding of regional change, traditional location theory is sadly deficient in this undertaking. Little insight is given into forces underlying shifts in the comparative factor costs in a region, or into other forces which influence the locational calculus and overall spatial distribution of firms, such as the changing nature of industry-specific processes of production, ownership patterns, market structures and competitive dynamics (Walker and Storper, 1980). Finally, social and political factors which greatly influence firm location decisions often are not reflected at all in the price/cost mechanism.

Regional growth theory, on the other hand, sees regions as the basic analytic unit, and seeks to explain their growth (or lack thereof) as a function of their specific characteristics. Supply-based growth theories (e.g. agglomeration and growth-pole theories) look to the existing supply of inputs in a region (land, labor, capital and entrepreneurship) as the determinants of economic growth. Demand-based theories of growth (e.g. export-base theory) focus on the role of external demand for a region's output, and thus see economic growth as a function of the existing composition of the industrial base. These approaches to growth all see the region as a pre-defined spatial unit, and actually elevate individual regions to the role of actors or entities with dynamics in and of themselves. By viewing regions in geographic and economic isolation from the rest of the economy, growth theory fails to include the crucial role of external and macro-economic forces in regional change, and thus confines causality to the qualities of the region itself (Massey and Meegan, 1978). Again, insufficient attention is given to the impact of the changing behavioral motivations, characteristics of production and locational strategies of individual firms and industries on the growth or decline of regions.

A more fruitful tack for understanding the process of regional growth is suggested by Benjamin Chinitz (1960). In contrasting the processes of agglomeration in New York and Pittsburgh, he suggests that the magnitude of agglomeration pull created in a region depends upon the character and specific structure of the industries which originally triggered development (with size held constant). He stresses the need to examine the supply side and the implications of industrial structure for the creation of external economies and diseconomies, and thus for regional growth.

The approaches of traditional location and growth theory thus fail to satisfactorily illuminate the processes of regional change which have occurred in Santa Clara County. Neither provides an adequate framework for understanding the electronics industry's original location and agglomeration in the county and the resulting unprecedented rates of regional growth (including dramatic changes in the composition of the industrial base and the effects of a vast immigration of workers and capital). Most importantly, these approaches are inadequate in explaining the current transformation of the region because they do not allow examination of the processes spurring the dispersion of investment out of the county. Only an examination of the evolution and changing needs of the electronics industry and its historical interactions with the geography of the region allows clarification of these processes occurring in Santa Clara County.

The analytic approach which is applied here thus sees regions and spatial differentiation within them as the outcome of processes of accumulation and industrial change. In the tradition of recent regional research by D. Massey, it assumes that existing regions can only be seen as the product of complex historical processes of industrial development, and their specific characteristics as products of the past and present location and investment strategies of firms (Massey, 1978; see also Western Regional Development Project, 1979).

The focus of this sort of analysis is on the evolving characteristics and needs of production and the way in which economic activity responds to geographic variations in the conditions for accumulation. Industry decisions are thus seen as the key causal force in regional change, and industry logic the foundation of analysis.

Within this analytical framework, Massey (1978b) and Massey and Meegan (1978) have examined the implications of the restructuring of the UK electrical engineering and electronics industries for the changing distribution of employment between depressed and prosperous regions of the country, and for the decline of the old industrial inner cities. Focusing on the technological changes and reorganizations of the production processes which were undertaken to enable reductions in the cost of labor in the face of declining profitability, they trace the changing spatial and regional distribution of activity to underlying macro-economic forces.

Bluestone and Harrison (1979) undertake a similar analysis in a series of individual industry studies which examine the transformation of the New England region of the U.S. They describe developments in the industry-specific ownership patterns, competitive dynamics, technology and production processes and market structures which underlie shifting investment decisions, and which are seen as the basic determinants of the changes in employment and income levels in the region.

These writers also examine the causes of industrial disinvestment and their consequences for the fate of particular communities and regions (Bluestone and Harrison, 1980). Noting the historically increasing mobility of capital resulting from technological advances in transportation and communications, the growing concentration and centralization of production, the role of the "product cycle" and of international political and economic forces, they argue that labor militancy and unionization in more developed regions have been the prodominant force spurring regional shifts of investment.

While these analyses are highly illuminating for understanding the processes of regional change in the cases examined, they fail to examine the impact of investment on the patterns of urban development and thus they tend to view industrial relocation solely as a response to the economic contradictions of past regional concentration. This thesis attempts to demonstrate that production affects not only the economic growth of regions, but also determines the local class structure and the specific organization of space, and that these impacts eventually feed back into production and the locational calculus of industry. In other words, the process of industrial evolution shapes both regional geography and patterns of urban development, and each of these configurations, as they evolve historically, will in turn influence the course taken by industry (Massey, 1978a).

A comprehensive study of regional change must thus incorporate the specific effects and contradictions created by the impact of industrial development on the local social and spatial structure, as well as the contradictory effects generated by regional economic growth. To put it simply, the process of capital accumulation both creates new regions and over time alters (1) regional rates of growth, and (2) local class and spatial structures. The latter eventually feed back into the accumulation process and thus influence future industrial location and regional growth patterns.

The case of Santa Clara County highlights the importance of analyzing the specific structure, evolution and changing needs of industry and its historical interaction with patterns of spatial development. I will argue that the recent history of Santa Clara County can be understood only through an examination of the impacts of the electronics industry on the local urban structure and the subsequent feedback effects which the evolution of this spatial form has had on industry behavior. In this instance, the key force underlying the dispersion of the industry out of the region is the obstacle to production created by the evolution of the local spatial structure and intensified by regional agglomeration. (This contrasts with the role of labor militancy and unionization as the key force spurring industrial dispersion in the previously cited studies.)

The Case Study

Santa Clara County is a unique case for examining the impacts of production on regional growth and local spatial structure. The electronics industry is virtually the sole industry in the county and, prior to its arrival, the region was almost completely agricultural. Most of the region's recent growth can thus be directly attributed to the evolution of this sector. Likewise, as there was little urban development in the county before the growth of electronics, the patterns of urban development in the county can be traced to the structures of production and class generated by electronics. While these relationships between production, regional growth and local geography occur everywhere, it is rare to find such a clear-cut case in which regional and spatial outcomes are so directly attributable to the characteristics of an individual industry.

This study focuses on the semiconductor industry in particular. Along with the definitional and statistical difficulties of dealing with the entire electronics industry, this narrowing of attention to the production of semiconductors is justifiable for three reasons.[1] To begin with, the semiconductor industry (sometimes referred to as "microelectronics") is the fastest growing and most dynamic sector of electronics today. Semiconductors have replaced conventional electronic compoenents (such as vacuum tubes) and are now at the heart of nearly all electronic products.[2] The development of semiconductor technology has permitted the continual miniaturization of components which perform increasingly complex electronic functions at ever higher speeds and ever lower costs. This in turn has allowed the rapid spread of electronic technology to almost all realms of production, communication and transportation. The pace of technological innovation has been remarkable. By the 1970's an individual semiconductor on a one-quarter inch chip could embrace more electronic functions than the most complex piece of electronic equipment built in 1950.

Second, the semiconductor industry is the predominant segment of the electronics industry in Santa Clara County, and it is the sector which has accounted for the majority of the county's phenomenal growth. The county is now acknowledged as the world capital of the semiconductor industry, and it has been nicknamed Silicon Valley after the major ingredient in semiconductor chips. Today five of the seven largest semiconductor firms in the United States are based in Santa Clara County.

Finally, it would be impossible in this space to discuss the entire electronics industry with the desired degree of specificity. Despite this narrowing of the focus, much of the basis analysis and the general conclusions presented here apply to other segments of the electronics industry as well.

This is a case study of the impacts of the semiconductor industry on the growth and urban development of one particular region. It does not attempt to explain the overall spatial distribution of the industry, nor to examine inter-regional dynamics, except as they related directly to the fate of Santa Clara County. One important sub-theme on a broader scale does emerge from this investigation of the case of Santa Clara County. Originally all phases of semiconductor production were concentrated within the county. During the time period covered in this study, a gradual process of decentralization has occurred whereby two separate phases of the production process have spun-off and been relocated to regions outside of the county. (Assembly was spun-off in the early 1960's and the relocation of advanced manufacturing began in the late 1970's.) Thus an examination of the evolution of semiconductor production in Santa Clara County also highlights the emergence of an international and inter-regional territorial division of labor in the industry as a whole. The underlying causes and timing of these spin-offs will be related to the changing dynamics of the industry, and the implications of this newly emerging locational hierarchy of production for Santa Clara County in particular will be discussed.

Methodology

The research for this study involved the gathering of information from a wide variety of sources. The primary source of data and insights was a series of personal interviews conducted with management representatives from Santa Clara County electronics firms and with representatives of a variety of local interest groups. (See Appendix A for a listing of the interviews conducted.) Further information on Santa Clara County was drawn from attendance at community forums and open governmental meetings, from the publications of the County Planning Department, from the county's main newspaper, the San Jose

Mercury, and from a variety of local, state and federal documents. Information on the electronics industry was also obtained from the local industry associations: the Semiconductor Industry Association, the American Electronics Association, and the Semiconductor Equipment Manufacturing Institute, as well as from the industry trade journals, business journals, and firms' annual reports. Many other secondary sources of information on the electronics industry were also consulted.

The industry interviews were conducted with representatives of eleven local electronics firms. (Appendix B lists the firms interviewed, their employment and sales levels, products, year established and the location of existing and planned facilities.) The firms were chosen to represent a range of firm sizes, a variety of products and differing ownership structures. Large firms are disproportionately represented in this sample, as their behavior has a far greater impact on employment and growth in the county. Further, the majority of firms in the sample are semiconductor firms, as the semiconductor industry is the most dynamic and the fastest growing sector of the industry, the vast majority of the other activity in the county either provides equipment, inputs or services to the semiconductor industry, or uses semiconductors as final products.

Altogether, the firms studied employ a total of 35,880 workers in Santa Clara County, thus representing approximately one-third of the total electronics workforce in the county.[3] Further, the semiconductor firms for which interviews were conducted represent 23,610 workers, or almost two-thirds of the total county employment in semiconductor manufacture.[4] The individuals interviewed were the most knowledgeable person available to discuss factors underlying location decisions for their firm.

These interviews were based on a structured underlying agenda with a sequence of specific questions designed to illuminate the factors influencing past, present and future location decisions in the industry. They were conducted in a conversational manner and generally began with the reasons for the firm's original location in the county, and the historical growth of the firm and production in the county. Next, the changing nature of production technology and automation in the industry, the changing nature of competition and the newly evolving structure of ownership were addressed. Questions were then focused on the specific implications of the urban spatial structure for their operations in the county, especially the cost and shortage of housing, and the transportation congestion, as well as the role of the county's no-growth movement and their attitudes towards unionization. The current trends in dispersion of manufacturing were then addressed in detail, in order to clarify the differing locational needs of the various phases of production in the industry, with a special emphasis on the factors which dominate decision-making in the selection of new sites for advanced manufacturing.

Interviews were also conducted with individuals who represent a variety of institutional interests and the major citizens' groups in the county. They included representatives of local labor, housing, and environmental groups, industry associations, Stanford University, and local planners. These interviews focused on the processes of regional growth and urban development in the county and the nature of the interrelationship of each individual and his or her specific group with the growth of the electronics industry in the county. They were intended to gain insights into the social and political impacts of rapid regional growth in the county, and to illuminate the implications of the urban spatial development and its contradictions for various sectors of the population. Particular attention was given to the local no-growth movement, a social-political manifestation of the evolving urban contradictions.

Outline

In order to demonstrate the historical interactions between the evolution of the semiconductor industry, the region's growth and the pattern of spatial development, the material is presented here very schematically. A historical periodization and separate levels of analysis help to clarify the important effects and feedbacks, although they also simplify quite complex and continuous processes.

The argument is presented in two major sections. In the first section, The Growth Era, the early growth and nature of production in the young semiconductor industry are examined, followed by a discussion of the industry's original location in Santa Clara County and a description of the social and spatial structure which the industry generated in the county. The final part of the first section describes how the evolution of these regional, spatial and social processes created urban contradictions which became serious obstacles to continued production in the county.

The second section, The Era of Consolidation and Decentralization, traces the restructuring of the semiconductor industry and the changing nature of production which has allowed resolution of the local urban contradictions through alteration of the locational behavior of the industry. The implications of this geographic restructuring of the industry for the nature of future growth and urban development in Santa Clara County as well as for regional growth elsewhere are then explored.

The overall progression is thus symmetrically ordered to show: (1) the original effects of the industry on the region and its social and spatial structure, and the subsequent evolution of urban contradictions; and (2) the response of the industry and its feedback effects on the region and on other regions.

Footnotes

1. Continuous technological innovation and the diversity of realms into which electronic technology has diffused make the "electronics industry" very hard to generalize about. There are almost as many definitions of the industry as there are sources of information on it. Van Nostrand's Scientific Encyclopedia (1976), The U.S. Department of Commerce, the Electronic Industries Association, and the Dictionary of Electronics and Nucleonics (Hughes, 1970) each provide a slightly different definition of the industry.

   See Bacon and Remp (1967) for a detailed discussion of the definitional problems and the shortcomings of the Commerce Department Standard Industrial Classification System (SIC) for gathering statistics on the industry.

2. Electron tubes alter an electric current as it passes through the space enclosed by the tube (usually a vacuum), while semiconductors use solid-state materials (usually silicon crystals) for current alteration. The advantages of using solid-state for electronic functions, rather than tubes, are improved reliability, performance versatility, vastly reduced size and weight, reduced power requirements and lower price.

   As their name implies, semiconductors are not full conductors of electricity (as is a piece of copper wire), but rather have properties between those of metals and insulators.

Transistors, diodes and rectifiers are all semiconductors. Integrated circuits combine these active components with passive components (which impede or store the flow of electricity) inseparably within a silicon crystal.

3. The Project on Health and Safety in Electronics (PHASE) has estimated a total of 111,635 workers in the county's major electronics firms in 1979 (Axelrad, 1979).

4. The same PHASE study estimated 37,870 employees of semiconductor firms.

II. THE GROWTH ERA

Birth of an Industry

The birth of the semiconductor industry. The semiconductor industry came into being in the early 1950's. In its first decades, the industry was distinguished by the pervasive influence of the federal government in its development, and by an ongoing proliferation of small, intensely competitive firms, an unsurpassed pace of technological change and phenomenal growth rates. These characteristics of production in the young semiconductor industry are key to understanding the nature of the regional growth and urban development which it generated in Santa Clara County.

The industry's birth is generally associated with the invention of the solid-state transistor at AT&T's Bell Laboratories in 1948, (although the first generation of active components, electron tubes, had actually existed since the 1920's). Western Electric, an affiliate of Bell Labs, began the first commercial production of transistors in 1951. Soon thereafter, under the pressure of a lengthy anti-trust case, Bell Labs held a series of symposia revealing the unique properties and applications of transistors as well as the principles underlying their manufacture.[1] Simultaneously, they established an extremely liberal licensing policy for their semiconductor technology. These actions allowed Bell to escape the potentially damaging charges of monopolizing or attempting to dominate the new industry, and at the same time, they publicized and provided easy access to the new technology. Such developments stimulated immediate and widespread interest among the scientific community in semiconductor technology, and induced enormous expenditures on research and development in the field. Likewise, many of the old electron tube firms soon took licenses from Bell and began producing transistors themselves.[2]

In 1954, prompted by the needs of the military for an electronic device with higher temperature and power handling capabilities, Texas Instruments developed the silicon transistor. In 1959, the integrated circuit was developed at Fairchild Semiconductor and Texas Instruments. This miniaturization vastly broadened the applications for electronics technology and allowed considerable cost savings.[3] With the subsequent evolution of silicon technology the manufacturing process for semiconductors began to stabilize, permitting greater mechanization, improved performance and reliability, increased production and still lower unit costs. Lower prices in turn improved sales volume.

Thereafter, with the entry of large numbers of new firms and rapidly expanding demand for its products, the semiconductor industry grew at unprecedented rates.[4] Less than fifteen years after its birth, there were already one hundred establishments in the industry; by 1967, there were 177, and by 1972, there were over 300. (See Table 1.) The total value of shipments of U.S. semiconductor firms skyrocketed from $5.1 million in 1954 to over $500 million in 1960. In 1970 it reached $1.5 billion and by 1977 had surpassed $5 billion (1977 Census of Manufacturers, 1979).

The dizzying pace of technological innovation fueled the industry's rapid growth. Between 1956 and 1962, 6,000 different types of transistors were introduced. Within its first twenty years of existence the industry had already completed the full life-cycle for three

TABLE 1.

HISTORIC GROWTH OF THE SEMICONDUCTOR INDUSTRY (SIC 3674)
1963 - 1977

Year	Total Establishments	Value of Shipments ($ m)	Total U. S. Employees
1963	108	687.8	56,300
1964		716.4	55,300
1965		911.7	67,400
1966		1,123.7	82,200
1967	177	1,141.0	85,400
1968		1,317.2	87,400
1969		1,572.9	98,800
1970		1,501.2	88,500
1971		1,599.6	74,700
1972	325	2,704.8	97,600
1973		3,647.7	120,000
1974		4,305.1	133,100
1975		3,276.9	96,700
1976		4,473.8	102,500
1977	547	5,238.2	112,900

Source: U. S. Bureau of the Census. Annual Survey of Manufacturers 1964-1976 and Census of Manufacturers 1963, 1967, 1972, 1977. (Washington, D. C.: U. S. Government Printing Office) Volume II, Industry Statistics.

generations of semiconductor products (Chang, 1971). While one silicon chip contained only a single circuit (and thus a single electronic function) in 1956, during the 1960's and early 1970's, the number of component elements were steadily increased to where 30,000 circuits were being processed onto a single chip. Today, with Very Large Scale Integration (VSLI) technology, up to 75,000 functions are possible.

The role of technology. The semiconductor industry is a child of technological innovation and the technological base of production remains its key distinguishing characteristic. The young industry was thus dependent above all else on highly educated engineers and scientists. This dependence on brain power as a resource was fundamental to the industry's original location and clustering in Santa Clara County.

Scientific research and technological development have been integral to three aspects of semiconductor production: (1) innovations in basic scientific concepts and the underlying electronic technology have contributed to the increasing capability and sophistication of semiconductor components; (2) the improvement of manufacturing process technologies and production techniques has dramatically reduced the costs of production and thus enabled mass production of semiconductors; and (3) the adaptation of existing technologies and processes to new products and to the improvement of old products has generated the increasing application of electronic technology to many realms of activity and production.[5]

Basic research in solid state physics and other disciplines has produced the fundamental technology which underlies all semiconductor devices. Applied research then leads to the first laboratory model of a particular device. Both basic and applied research have been concentrated almost exclusively in universities (MIT and Stanford) and the research labs of a few of the largest firms in the industry (most notably AT&T's Bell Labs, IBM and Texas Instruments), as such research requires enormous amounts of capital investment and the highest calibre of professional scientists and engineers. In fact, much of the early development of the industry can be attributed to the massive support which the federal government provided for basic and applied research.

As a result, technological innovations in the semiconductor industry have tended to be highly concentrated. Before 1968, Bell Labs produced 56% of the major process innovations in the industry. In 1968, three of the industry's largest firms, Fairchild, Texas Instruments, and IBM, together accounted for 44% of all product patents (Tilton, 1971). Despite their original concentration, however, new innovations diffused very rapidly through the industry, thereby preventing innovating firms from gaining a competitive advantage through the monopolization of innovations.

With basic research concentrated in these large institutions, the realm in which most semiconductor firms invest is the application of existing technology to the innovation of new products and the development of improved manufacturing process technologies to allow more efficient high volume production. Most firms devote a very high percentage of total revenues to research and development, generally ranging from about 8 to 10%. As one industry represnetative noted, this kind of R & D is "little R and big D".

Product development involves (1) original conception (which includes ascertaining that there is a need/demand for it), (2) extremely complex design and engineering of circuits to meet the given product specifications, and (3) prototype production in order to refine and correct the design and to adjust the manufacturing process so that it will produce satisfactory yields. Only then is the product ready to be removed to a factory for production. This initial product development or R & D phase of production thus requires a firm's most highly skilled scientists and design engineers, along with some technical assistance, and it is generally conducted in a firm's special development laboratory.

During the industry's first decades, failure to keep up with the latest technological developments often meant death to a small firm. Success in the industry was thus linked to the quality of a firm's R & D laboratories. R & D expenditures relative to total sales were the highest during the earliest days of the industry (when the government contributed vast sums, and when sales were lower), e.g., 18% in 1959 and 27% in 1958. Yet they were maintained at a very high level throughout the Sixties and Seventies, generally between six and seven percent of total sales (Tilton, 1971).

The industry's dependence upon professional and technically skilled labor is evident in the composition of the work force. The semiconductor industry has among the highest percentage of non-production workers of all industries. Forty percent of the total workforce in 1972 was classified as non-production workers, as compared with sixteen percent in the production of motor vehicles and only thirteen percent in the apparel industry (Mutlu, 1979). According to occupational breakdowns, a full thirty four percent of total semiconductor employment was in professional (21%) and technical (13%) occupations (U.S. Department of Commerce, 1971). Furthermore, virtually all new enterprises (except for the branches of large diversified firms) have been started and headed by scientists and engineers, who have Ph.D.'s but little or no past business experience.

The role of the federal government. The federal government played a massive role in the early development of the semiconductor industry. In fact, the industry's emergence and record setting growth can only be understood in light of extensive government intervention and support during and after World War II. The industry would never have emerged when it did, nor grown as rapidly as it did without the vast impetus to innovation and production generated by military and aerospace demand for semiconductors and the vast government support for semiconductor research and production facilities. Furthermore, the nature and location of government activities were critical determinants of the spatial patterning of the industry, and especially of its development in Santa Clara County.

The government market for semiconductors was critical in fostering the industry's early growth as the military (and later NASA) both provided an identifiable demand for new semiconductor devices and formed the dominant market sector. In fact, production for the defense market grew from $15 million to $294 million between 1955 and 1968. The government market peaked in 1960 when it accounted for fully one-half of total U.S. semiconductor sales. Between 1955 and 1963, production for defense ranged from 35% to 50% of total U.S. semiconductor production (Tilton, 1971). The armed forces provided continuous demand for new devices to meet their latest requirements, and imposed very high quality standards on the products. (In the military, cost is secondary to performance and reliability.) The constant promise of a large guaranteed market with high prices and good profits provided an ongoing incentive for firms to develop new high quality semiconductor devices. Since such new semiconductors were typically far too expensive for use in industrial or consumer electronic products, the military formed the initial markets for new products. Only after production experience allowed reductions in the price of components, did applications for these products broaden.

By creating an identifiable source of demand and essentially underwriting the otherwise prohibitive original investment and production costs of new products, these military purchases also spawned the development of many new small semiconductor firms. The Defense Department was also often willing to buy semiconductors from new and untried firms. At the same time, military demand sheltered these new firms from the older electronic giants by reducing or eliminating altogether the need and expense of marketing.

Along with defense procurements, government funding for R & D and for production preparedness programs also spurred innovation and growth in the semiconductor industry. Between 1958 and 1974, various branches of the federal government (predominantly defense and aerospace related) pumped $930 million into the industry for R & D, nearly equal to the $1.2 billion total the firms themselves spent on R & D (Linvill and Hogan, 1977). In addition, huge contracts were given for building production equipment so that firms would have the capability to produce large quantities of new devices. By covering all of the engineering design and development costs, the Army, Air Force and Navy in essence underwrote the costs of new production lines for which firms otherwise would not have had the resources, nor have been willing to take the risk to build themselves.

Further, some of the government appropriations for new weapons systems were passed on by prime contractors to semiconductor firms. Substantial amounts of government money also went to university operated basic and applied research on semiconductor technology and related fields of science.

Industry structure. Within a decade after commercial introduction of the transistor, the number of firms producing semiconductors had increased dramatically. The firms that made up the young semiconductor industry can be divided into four distinct categories. American Telephone and Telegraph, the old established electronic and electric giant, with its research arm, Bell Labs, and its manufacturing arm, Western Electric, stands in a class by itself. Not only did AT&T invent the transistor, but it also produced a disproportionately large share of subsequent major product and process innovations in the semiconductor field. Along with an enormous commitment to R & D, the company set industry-wide precedents with its licensing policies and its attitudes towards the interfirm mobility of engineers and scientists. AT&T is unique because it cannot sell in the commercial market, though it still produces for the government and for its own needs.

A second group of firms, which began commercial production of semiconductors almost immediately after Western Electric, is the old vacuum tube firms. These firms were already large diversified electrical and electronic companies, and thus their survival was not dependent upon any one product. However, their receiving tube operations were clearly threatened by the rise of semiconductor technology and thus their entry was a defensive move to protect their markets. This category of firms includes the three giants, General Electric, RCA and Sylvania, along with the smaller Raytheon, CBS, Tung Sol and Westinghouse.

This third category includes all those pre-existing firms which were newcomers to the production of electronic components. This group includes the firms which were already large diversified companies when they entered the semiconductor industry, such as IBM, Motorola and Hughes. As vertically integrated producers of electric and electronic equipment and systems, these firms initially began producing semiconductors for in-house use. Later, some began production for outside markets as well. IBM rapidly attained its position as the country's largest single producer of semiconductors, which it has retained up to the present. IBM still produces solely for in-house use. Motorola on the other hand has become one of the top producers in the commercial market. Texas Instruments also belongs in this category. It was a small geophysical services company when it began producing semiconductors. Within less than a decade, it had become the largest commercial producer of semiconductors in the country. (In 1977, Texas Instruments and Motorola led the industry in production for commercial markets, wtih 17% and 14% of total market share respectively. Financial Times, 10/17/78.)

The fourth category includes all of the new firms which were formed specifically to produce semiconductors and it is these firms which sprang up in Santa Clara County. These companies were almost exclusively founded by scientists and engineers with Ph.D.s and academic positions, and began as small enterprises with extremely limited capital resources. The majority of these firms started with only a couple million dollars in seed money, and grew through the reinvestment of earnings and later through public offering of stock. Almost all were products of the spin-off process, whereby ambitious or disgruntled scientists left older and already established semiconductor firms to try their own hands at the business. Between 1952 and 1967, no less than 15 firms had spun-off from Bell Laboratories, one of them being its even more prolific grandchild, Fairchild. Texas Instruments, Motorola, Sylvania, RCA, Philco, Hughes and others have also experienced similar defections (Tilton, 1971). This spin-off process was greatly facilitated by the free mobility of people between firms in the industry. In fact, the poaching and inter-firm movement of scientists has become so commonplace in the industry that it is rare to find an individual who has worked at only one firm, and many have worked at more than three (Interviews).

The importance of these newly formed semiconductor firms to the development of the industry transcends their individual size. They have been far more successful than the older, established receiving tube firms in terms of growth rates and in the exploitation of new innovations. While the new innovations of the industry's first decades were generated mainly by Bell Labs and the receiving tube firms, these new smaller firms often were the first to actually exploit them in production because of the flexibility which their smallness allowed. By the late Sixties, the older electronic companies had relinquished dominance in the industry to the young semiconductor upstarts.

This turning of the tables resulted from a combination of factors. To begin with, during the Fifties and early Sixties, semiconductors (mainly transistors at that time) offered little serious competition to vacuum tubes. They were used mainly in military applications, and did not pose an immediate threat to the tube industry. Traditional electronic equipment (especially consumer items such as radios and televisions) still commanded a huge market; receiving tube production peaked in both volume and value between 1955 and 1957, while the semiconductor market remained quite small by comparison. From 1954 to 1956, only 28 million transistors worth $55 million were sold, whereas over 1,300 million receiving tubes with a sales value of $1 billion were sold (Mutlu, 1979). Thus, there was scarcely enough pressure on these receiving tube producers in terms of either markets or profits to warrant serious redirection of resources and efforts towards semiconductor production.

Furthermore, even when semiconductor development and production was commenced by these older established firms, the inflexibility and monolithic organizational structure that characterizes firms in a more mature industry, became an obstacle to the rapid change required to remain competitive in this new industry. The accelerated pace of technological innovation during these first decades prevented established firms (or any firms for that matter) from using their sizable resources to gain significant market shares and create an oligopolistic market structure.

These old firms also suffered because they could not provide the rewards needed to retain innovative individuals in an industry where having the highest calibre of scientists and researchers was essential to success. The greatest promise for innovators in the industry lay in forming their own companies and exploiting their ideas themselves. Thus, the old established firms with traditional means of compensation were rarely able to attract, let alone retain, truly top-notch scientists. The receiving tubes suffered the most from this problem, but it was not limited to them. All companies, large and small, old and new, were hurt by the fact that there were always higher potential rewards elsewhere for a truly innovative individual. The result was an unceasing movement of individuals between firms as well as a continuing proliferation of new firms.

Entry conditions. Unusually low barriers to entry formed the basis for a highly competitive market structure. During the industry's first decades, rapid technological innovation, the absence of scale economies, the speedy diffusion of innovations and the ready availability of finance capital made entry remarkably easy. These characteristics also made the spatial clustering of firms highly advantageous.

The pace of technological change dictated very short production runs and product life cycles and thus prevented the emergence of significant economies of scale in production. It also perpetuated very low levels of automation, as any investment in costly machinery would have tied a firm to a specific technology which was very likely to become obsolete before sufficient returns on the investment could be reaped. (The irony of this is that while electronics has done so much to automate other industries into high technology, computerized processes, its own manufacturing techniques lagged significantly behind.)

There was a notable lack of economies of scale in marketing as well, due to the limited number of potential semiconductor users. In fact, throughout the Sixties there were only about two dozen important customers for the industry. Until it began in-house production in 1964/65, IBM was the single largest customer of every American semiconductor company. Less than a dozen other computer firms accounted for another 30% of the market. The Minuteman Missile was the industry's second largest customer (with readily identifiable contractors) (Mutlu, 1979).

This absence of scale economies in production and marketing resulted in very low initial capital requirements and easy entry. Throughout the Sixties, a mere $1 million was sufficient to start a small semiconductor firm. Transitron was launched in 1952 with a $1 m. investment and Advanced Micro Devices and Advanced Memory Systems were both founded wtih $1.5 m. in 1968. While most of these newcomers and spin-offs grew rapidly, they generally remained as small or medium sized enterprises, with sales of $100-200 million. A few exceptions, however, provided phenomenal success stories, and continued to lure hopeful entrepreneurs. Most recently, Intel, which started in 1968 with a $2 million stake by a venture capitalist increased its sales more than one-hundred fold in a single decade--from $4 million in 1969 to $663 million in 1979, thus joining the ranks of the top five producers in the industry (Interviews).

The rapid diffusion of technological innovations further insured easy entry of new firms into the industry. This diffusion process was facilitated by a combination of liberal licensing policies, second-sourcing, the outright imitation of innovations and the inter-firm mobility of professionals. The liberal licensing policies of Bell Labs, established to avoid anti-trust difficulties, set a precedent which was later followed by the rest of the semiconductor industry. Not only has it allowed new firms to use patented technology, but it has facilitated its transfer.

Second-sourcing, a practice originally imposed on firms by the military, involved a procedure whereby innovating firms allowed other manufacturers to produce their new products. Formal agreements as to the specifications of a device were used so that the products of the firms would be interchangeable. Later, small innovative companies were often forced to second-source to larger companies because they lacked the marketing resources or the scale of production to produce the product in sufficient quantities themselves. Civilian users also began to demand second-sourcing as well, to insure a guaranteed supply. Finally, simple copying or pirating of a rival firm's innovations, or gaining access to the new technology through the poaching of key scientists from other firms, have become widespread. More often than not, second-sourcing is done today without the original manufacturer's permission or cooperation.

Finally, the entry of many small semiconductor firms was facilitated during the 1960's by the provisions of the 1958 Small Business Investment Act that established asymmetrical tax treatment of capital gains and losses from investment by private venture capital firms in small enterprises. By allowing capital losses to be deductible from personal income, investment in small semiconductor companies became an almost risk-free proposition, and many investors were attracted by the promise of capital gains from these small ventures.

Dynamics of competition. During the early growth decades, the semiconductor industry was characterized by small, intensely competitive firms. In 1963, there were already 108 establishments and by 1972 the total had tripled to 352 firms (U.S. Bureau of the Census, 1977). The competitiveness of the market structure is revealed by the industry's concentration ratios. Between the years 1958 and 1972, the four largest firms in the industry accounted for 39% to 53% of the total value of shipments (U.S. Bureau of the Census, 1977), as compared with the automobile industry in which a single firm held 50% of the market during the same period, and the computer industry, in which IBM accounted for between 67% and 75% of the value of shipments (Mutlu, 1979). Further, these concentration ratios are somewhat misleading as to the level of competition in the commercial market because in 1972, IBM, which produced solely for in-house consumption, alone accounted for 23.6% of total semiconductor shipments.

Furthermore, the industry structure during this period was characterized by dynamic fluctuations in the market share held by individual firms. The rapid pace of technological innovation meant that there were rarely products with stable enough process technologies or long enough production runs to enable the stabilization of market shares. Maintaining market shares therefore depended upon a firm's ability to introduce process innovations and new products at opportune times. This accounts for the decline of some of the industry's early leaders like Raytheon and Transitron. Transitron was the industry's second largest semiconductor producer in 1960, with one highly successful product and 10% of the market, but it invested little on R & D, and failed to keep up with the new process innovations of the early 1960's. Within three years, the firm dropped to eleventh place in the market with a mere 3% share. Conversely, the dramatic rise to prominence of formerly insignificant firms like Motorola, Fairchild and Intel was clearly due to the timely introduction of innovations and new products.

Since these dynamic fluctuations in market share resulted from the rapid generation of innovations, there was a premium on having access to information concerning the latest development--never published until too late--in the industry. Thus, for small firms in particular, locating in close proximity to one another was essential, as it allowed the informal interchange of information and enabled the firms to monitor and respond to new developments (Interviews).

Price manipulation has been the dominant form of competition in the semiconductor industry, and the industry's pricing policies have been quite unique. They too are a result of the industry's technological-basedness, as it is the scientific nature of the manufacturing process that underlies the learning economies (the "learning curve") characteristic of the industry. Learning economies derive from improving the production process for a given product through experience and experimentation in refining the process and thereby raising yield levels. The general experience has been that the average cost of production for a new device falls between 20% to 30% with each doubling of output.

Pricing strategies are directly related to learning economies. Typically, cream (or monopoly) pricing is used for the introduction of a new product. This allows innovating firms to recoup some of their R & D expenses by marketing only to customers willing to pay the high price of an innovative device. Once a product has reached its growth phase, a policy of penetration pricing is used, in which the price is rapidly reduced, often to levels below the cost of production. The aim of this penetration pricing is simple, to capture a dominant or significant share of the market during a product's growth phase. The amount of future profits to be reaped depends on emerging with a sizable market share. Sometimes, if the new product or technology is easily imitated, or the anticipated market very large, a firm will forego the cream pricing phase and initiate penetration pricing immediately upon the product's introduction. (Conversely, cream pricing is most advantageous if the new product involves a breakthrough in process technology which cannot be imitated by competitors or if the anticipated market is very small.) Once a product reaches maturity, production levels off, market shares stabilize, and prices stabilize. This is the stage when R & D costs are recovered and profits are realized, as the production costs continue to decline because of learning economies. Finally, as new products are introduced to supercede the older one, demand declines and often the costs of production rise (given that overhead costs are distributed over a smaller volume of output and learning economies have been exhausted). Prices will often rise and eventually the product is phased out.

This learning curve pricing is typified by the case of the Fairchild Planar Transistor, which involved a basic breakthrough in process technology. The price of a single transistor declined from \$150 to \$75 between February and August, 1958, and then to \$45 by January, 1959, at which time the volume was ten times greater than it had been in August, 1958. By July, 1959, the price had declined still further, to \$28.50, and in February, 1960, it was levelling off at \$22.70 (U.S. Department of Commerce, 1979).[7]

This form of severe price competition, based on penetration pricing and the existence of learning economies, created intense pressures on firms to reduce their costs through the use of low cost labor in areas outside of the U.S. (as capital costs were essentially the same for all, and labor the major component of production costs). In order simply to preserve existing market shares, even the smallest firms were soon pushed by these competitive pressures to establish offshore assembly plants. This internationalization of production--the first stage in the emerging territorial division of labor in the industry--will be discussed in more detail after a brief discussion of the process of production itself.

The process of production. The unique process of manufacturing semiconductors provides yet another manifestation of the industry's science-basedness. Semiconductor manufacturing (or wafer fabrication) has been described as the most complex production process adapted to mass production, requiring the constant attention and presence of trained professional and technical employees.

The production process involves three discrete phases: (1) mask making, (2) wafer fabrication, and (3) assembly and testing. Mask making is actually the final step in the initial development and design (or R & D) phase of production discussed above. It involves representing the circuit design for a new semiconductor device in artwork, reducing it from the master drawing of the pattern (which is usually 200 to 300 times the desired size), and reproducing it onto glass plates, or photomasks. The photomasks are then used to transfer the circuit design onto silicon material.

Wafer fabrication is the most complex and sensitive phase of the manufacturing operations.[8] It is basically a batch process with a large number of precise mechanical, chemical and electrical operations performed in sequence. First, the photomask circuit design is transferred onto a thin silicon wafer (originally two to three inches in diameter) through such methods as the use of high intensity light (photolithography). Selective impurities are then introduced into the silicon to impart the desired electrical conducting properties. This begins with ion implantation and other chemical processes inside of a high temperature furnace, and is followed by a series of metallization, passivation, oxidation, washing, etching and diffusion processes. Each process step produced irreversible changes in the silicon wafer, so that any error in the overall sequence generally means that the entire batch must be discarded. Errors are not uncommon. High purity materials, thin layers, small dimensions, low concentrations and other extremes of conditions, and uniformity of temperature, extreme cleanliness and precise dimensional control are all essential to the fabrication process. Once prepared, the wafers are individually tested with computerized test equipment, then divided into thousands of identical chips. A yield of under 5% is quite common in the early phases of a product's life, while later, as process technologies improve, yields also improve dramatically (the learning curve process).

The delicate nature of wafer fabrication underlies the industry's dependence upon a reliable supply of energy for air conditioning, heating furnaces, testing and other chemical and mechanical processes. Manufacturing is vulnerable to any interruption of electrical energy by power plants. A short interruption in power supply or a brownout can destroy part of a day's output, and a sudden power loss destroys not only the materials in process but also causes expensive damage to the production equipment itself.

The complexity of the fabrication process also means that the initial transfer of new products from the development laboratory is often extremely difficult. What was being done by highly skilled engineers on a prototype basis must be adapted to factory conditions for volume production by workers who are generally not acquainted with the principles underlying what they are doing. Even after this has been achieved, semiconductors cannot be produced routinely by unskilled workers in a factory with the guidance of only a few managers, in the way that most manufactured products can. A large number of skilled engineers and technicians who are versatile with the scientific principles involved must always be on hand in order to adjust and control the various processes. In particular, process engineers must measure and control the variables at each stage, making sure that the overall sequence is in order. Quite often the variables needed are in such tiny areas that they are not accessible to measurement (tolerances of up to one seventy-five millionth of an inch are not uncommon), or the act of measurement itself is destructive. Yet if some calculated estimate is not made and a processing error results, the money spent on the remaining processing is wasted as well. Thus the judgment of skilled process engineers is crucial to wafer fabrication.

While closely controlled by engineers, this process still requires a large number of unskilled and semi-skilled production workers to perform routine loading, monitoring, processing and cleaning tasks. Thus wafer fabrication requires a workforce which consists of both skilled and unskilled workers in a ratio of about 1 to 2.

The third phase of the manufacturing process is the assembly. Assembly of semiconductors involves the highly routine process of hand-bonding very fine wire leads or connectors to the chips (under a microscope), and the final sealing of the chips in ceramic, metal or plastic protective packages. This assembly process is identical for all of the different product lines, the only variation for different products is the number of wires to be welded. The final testing and sorting of the chips is a highly capital intensive, often computerized process. No prior training or education is required for assembly workers, and thus the assembly workforce is entirely unskilled.

The two basic phases of semiconductor manufacturing, wafer fabrication and assembly, thus require very different kinds of labor and vastly different capital expenditures. Wafer fabrication is heavily capital intensive and requires the constant attention of highly skilled workers , while the assembly process involves minimal capital investment and large amounts of unskilled labor. Furthermore, each of these operations is a completely discrete step in the production process which can be physically separated from the other without technical difficulties. It is these unique characteristics of the wafer fabrication and assembly phases of production that have allowed their spatial separation, and facilitated the early internationalization of semiconductor production.

In addition, the industry is virtually unconstrained, or "footloose" as far as transport costs are concerned. Semiconductors have a very low weight relative to value, and the packing density is extremely high. While for conventional electron tubes the packing density was only 1 unit per cubic inch, with transistors it was 20 to 30; with microassemblies in the 1960's, it was 100, and in the early 1970's with LSI's it had reached one million (Mutlu, 1979). With such high, and increasing, packing densities, transport costs over even the longest distances are an insignificant part of the total cost of delivery for semiconductor devices.

The internationalization of production: offshore assembly. Internationalization through the establishment of offshore plants in low wage areas of Asia and Latin America was clearly a result of the pressure to reduce labor costs in an industry characterized by intense price competition. Since the pace of technological innovation prohibited automation of the labor intensive assembly process, the severe competition based upon learning economies and penetration pricing to gain a large market share propelled firms to locations where assembly could be performed more cheaply.

Fairchild established the industry's first offshore assembly operation in Hong Kong in 1961. Soon thereafter, the firm introduced dramatic price reductions which allowed a dramatic expansion of its market share. In order to survive and simply preserve existing market shares, even the smallest semiconductor firms were soon pushed by the competitive pressures to establish assembly plants in low wage areas. By the early 1970's, every established U.S. semiconductor firm was engaged in some offshore assembly (Chang, 1971; Interviews).

Low wage rates are clearly the primary attraction of the countries selected for offshore assembly operations. The average hourly wages for semiconductor assembly in third world countries are between one-fourth and one-twentieth of the wage rate in the U.S.[9] Offshore assembly operations have been concentrated predominantly in Eastern and Southeastern Asian countries (Hong Kong, Singapore, Korea, the Philippines, Taiwan, Indonesia, and Malaysia) and in Mexico. These offshore plants are almost all wholly owned subsidiaries, for reasons of control and coordination. A few smaller firms with limited resources have attempted joint-ventures and subcontracting, but these remain exceptions.

By 1974, U.S. semiconductor companies had established approximately 103 offshore assembly operations, including ten subcontracting operations, with the majority in Mexico, Malaysia, Singapore and Hong Kong (U.S. Department of Commerce, 1979). This rapid internationalization of production was facilitated by the fact that transportation is an insignificant part of total costs. Also important are the United States Tariff Items 806.3 and 807 which allow U.S. manufacturers to export products for assembly abroad and to pay duty only on the value added abroad. This means that the semiconductor firms do not pay for the value of the imported chips themselves, only for the costs of the wires and frames, and the assemblers' wages. This allows U.S. producers to minimize costs on a world scale and to maintain competitiveness by exploiting low wage labor outside the country.

Along with wages, considerations that seem important in selection of offshore sites are accessibility by air, political stability, receptiveness of the government to foreign investment (including provision of incentives such as special tax treatment, infrastructure and facilities as in the Export Processing Zones, the EPZ's, of Asia and Mexico), and labor market conditions other than wages, i.e. minimal, if any, labor union activity (Chang, 1971).

Employment in offshore plants increased so dramatically during the late 1960's that by 1971 it had surpassed total employment in the industry within the U.S. Between 1966 and 1970, estimated offshore employment grew from 8,600 to 66,700, while total domestic employment increased only 7.7%, from 82,200 to 88,500. Notably, the number of domestic production workers increased only 2.0% during the same period, from 59,100 to 60,300 (Mutlu, 1979). Similarly, between 1966 and 1976, total domestic employment grew by 20,300, while the number of production workers increased by only 600.[10] Thus while employment in the industry grew steadily in the U.S., the number of production workers remained stable due to the export of assembly jobs (Snow, 1980).

The structure of employment. The semiconductor industry requires large amounts of manpower, and is distinguished by its dependence upon highly skilled scientific and engineering manpower for production.

R & D requires the highest calibre scientists and engineers, along with a small percentage of technical and clerical employees. Advanced manufacturing requires approximately one-third skilled engineering staff and technicians and two-thirds low skilled production workers. Assembly requires almost exclusively unskilled workers. Since virtually all assembly operations have been exported to the third world, domestic employment is divided almost evenly between the engineers, scientists and technicians engaged in research and development and in wafer fabrication process control, and the minimally skilled production workers employed in wafer fabrication. The result is a highly segmented and dichotomized domestic workforce, with the highly educated professional, administrative and technical employees on one end and increasing as a percentage of total employment, low skilled production workers on the other end, and a small group of clerical employees in between.

In 1971, 40% of the industry's total domestic workforce were classified as professional, technical, executive, administrative and marketing personnel; 48% were listed as production and maintenance workers, and the remaining 12% were in secretarial and clerical occupations. This contrasts with 1964 employment figures, which show only 24% in the first category, 69% in production and maintenance, and 7% clerical. Table 2 shows these occupational breakdowns in more detail. This highly bifurcated labor force is key to understanding the social structure which was generated by the industry and thus underlies the nature of urban development in Santa Clara County.

Some additional characteristics of employment should be noted. From the very start, women and minorities have been disproportionately

TABLE 2.

Occupational Structure of the Semiconductor Workforce: 1964 and 1971

Occupation	Percent of Total Workforce					
	1964			1971		
EXECUTIVE, ADMINISTRATIVE, PROFESSIONAL AND TECHNICAL	24			40		
Executive		2			5	
Administrative, Marketing and Supervisory		6			8	
Professional and Technical		16			27	
Engineers and Scientists			9			15
Technicians, Draftsmen, etc.			7			12
SECRETARIAL AND CLERICAL	7			12		
PLANT AND CUSTODIAL WORKERS	69			48		
Skilled		8			9	
Processing Workers			1			2
Technicians and Repairmen			2			3
Plant Maintenance			1			1
Other			4			3
Semiskilled and Unskilled		61			39	
Assemblers			29			26
Inspectors and testers			9			4
Materials, handling and storage			4			1
Custodial Workers			2			1
Other			17			7
TOTAL	100					

Source: U. S. Department of Commerce, A Report on the U.S. Semiconductor Industry (Washington, D. C.: U. S. Government Printing Office, 1979) Table 2.10, p. 31.

placed in low-skill production jobs. According to a Bureau of Labor Statistics Industry Wage Survey, women account for over 70% of the industry's production workforce (Bureau of Labor Statistics, 1979). Within production jobs, women are concentrated in the categories requiring the lowest skills and receiving the lowest wages.

Semiconductor production also remained overwhelmingly labor intensive during the first decades. Despite the transfer of the most labor intensive assembly operations overseas, labor costs accounted for an unusually high percentage of total costs in the industry. In 1975, the cost of payrolls as a percentage of total value of output was 38.3% for the semiconductor industry, as compared with the average of 18.3% for all manufacturing in the same year (U.S. Department of Commerce, 1979).

The semiconductor industry remains virtually unorganized. Only about one-fifth of the workers nationwide are employed in establishments that are unionized, and the vast majority of the unionized workers are in the older firms, such as GE, located in the Northeast (Bureau of Labor Statistics, 1979). As a result, semiconductor production workers have remained one of the most poorly paid groups of industrial workers in the country, with an average wage in 1976 of $4.46 an hour, compared with an average of $5.43 an hour for all U.S. manufacturing.

Footnotes

1. United States v. Western Electric Company, Inc., and the American Telephone and Telegraph Company, was initiated by the Justice Department in 1949.

2. Meanwhile, in the 1956 consent decree that culminated the antitrust case, AT&T was enjoined from selling semiconductors in the commercial market. In return for this and other concessions, AT&T persuaded the Justice Department to drop its efforts to sever Western Electric from the AT&T system. It is still free, however, to sell semiconductors in the military and space market, and to produce for its own needs (Tilton, 1971).

3. An integrated circuit consists of tens, hundreds, thousands or more transistors on a single silicon chip less than a quarter inch square. It eliminated the need for masses of separate transistors and mechanical connections in an electronic system and since the production process is the same for a single transistor as for a chip containing thousands, considerable cost-savings are realized by integrating many transistors onto one chip.

4. According to the U.S. Office of Management and the Budget definition, which will be used hereafter, the Semiconductor and Related Devices Industry (SIC 3674) includes all "establishments primarily engaged in the manufacture of semiconductors and related solid

state devices such as diodes, transistors, rectifiers, solar wells, integrated microcircuits and light sensing and emitting semiconductor devices" (U.S. Office of Management and the Budget, 1972).

5. These three areas of technological development also correspond chronologically to three separate phases in the historic evolution of technology in the industry. While each could be performed at any time, the major advances in the basic technology of semiconductors were made during the first decade, innovations in process technology were dominant during the Sixties and early Seventies, and during the recent period most attention has been devoted to innovative applications for semiconductor devices.

6. Some firms employ designers who live in resort spots such as Lake Tahoe and Reno, Nevada. As a firm's fate depends upon attracting top-notch designers, they are among the best paid in the industry, and there is no need for them to be located where the rest of the firm is. Intel now has design centers in Japan and Israel, reportedly to take advantage of the high quality engineering talent there.

7. These learning economies are also cumulative for the industry as a whole, and the average prices of semiconductor components have

declined sharply as yields in manufacturing have improved. For example, the average selling price of an integrated circuit (in constant 1972 dollars) declined from $24.84 in 1964, to $11.21, $6.58, $4.20, $2.76 and $1.88 in the five following years. By 1975, it had reached $0.63, and production volume had grown from 2 million units in 1964 to 1,375 million in 1975 (U.S. Department of Commerce, 1979). These price reductions cannot be entirely attributed to learning economies, however, as off-shore assembly in low wage areas also significantly reduced costs.

8. Wafer fabrication might be more appropriately termed "advanced manufacturing" to distinguish it from the routine assembly phase of manufacturing.

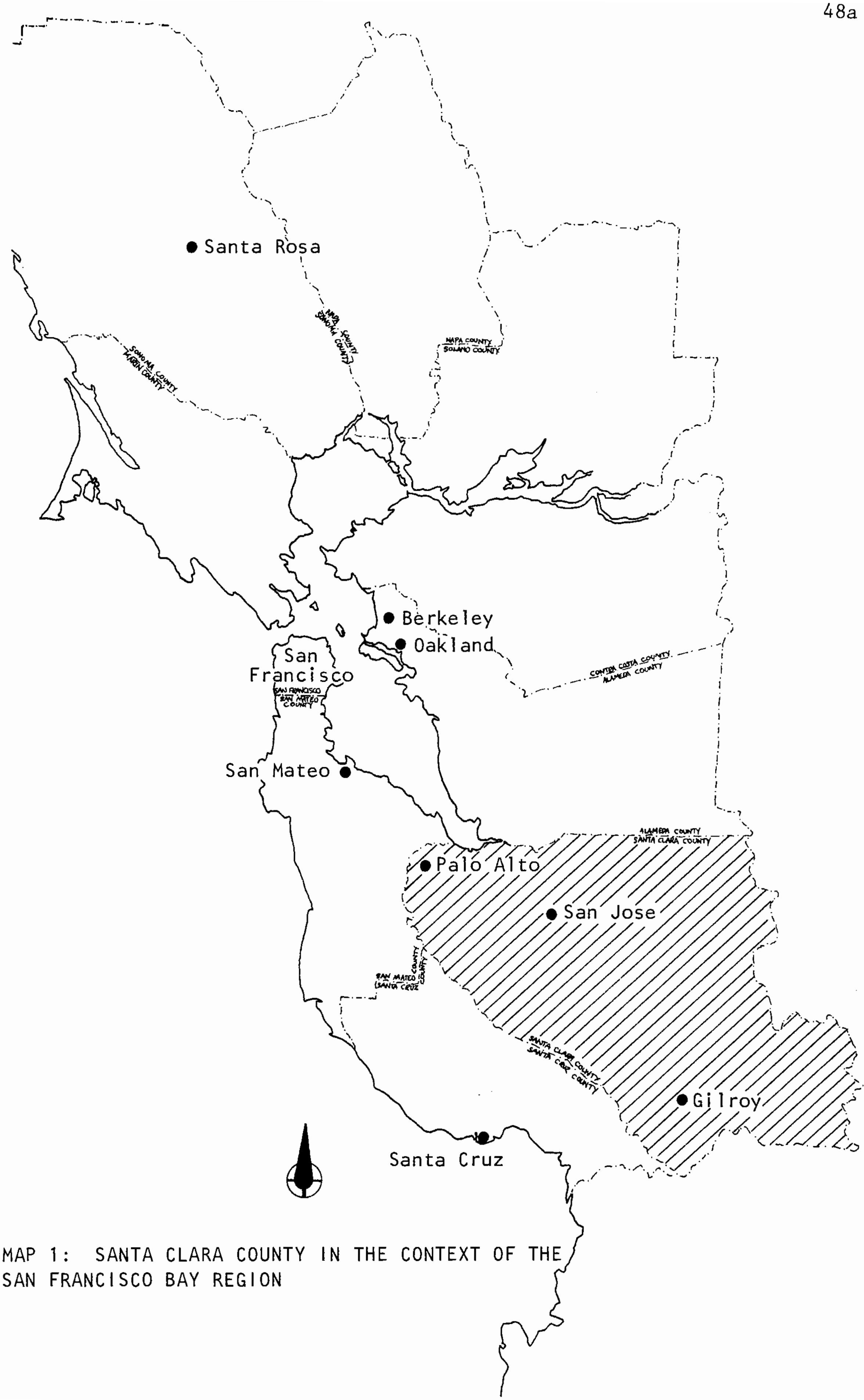
9. Wages in Asia are the lowest. In 1976, average hourly wages for unskilled workers ranged from 17 onets in Indonesia to 62 cents in Singapore. In Mexico they were slightly higher, at 78 cents an hours, still a drastic savings over the average hourly pay for a U.S. components assembler of $4.00 an hour (Volk, 1978).

Regional Economic Boom: The Accelerated Growth of Santa Clara County

Historical overview of Santa Clara County. Santa Clara County was transformed from an agricultural community into one of the most rapidly growing urban centers in the nation in less than two decades. A confluence of historical forces created an environment in Santa Clara County in the post World War II era that was particularly appropriate for successful electronics and semiconductor production. In the early 1950's a few fledgling electronics firms located in the county, and by 1970 the region had gained international fame as Silicon Valley, the capital of the semiconductor industry and the densest concentration of high technology and electronics enterprises in the world. This section examines the processes underlying the rapid growth of Santa Clara County between 1950 and 1975.

Santa Clara County lies at the southern tip of San Francisco Bay. About 1,312 square miles in size, it encompasses a valley flanked by low mountains of the Coastal Range. The valley itself constitutes approximately one-third of the total area of the county, or about 436 square miles.

The valley is extremely fertile, and thus from its settlement by the Spanish colonizers in the late 1700's, an agrarian economy was highly successful. Intensive agricultural development was undertaken in Santa Clara County throughout the late 19th and early 20th centures. By 1940, the region had developed into a fully integrated agricultural community, boasting about 100,000 acres of orchards, roughly 8,000 acres of more traditional vegetable crops and over 200,000 food processing plants. At that time, the county was ranked as one of the 15



MAP 1: SANTA CLARA COUNTY IN THE CONTEXT OF THE SAN FRANCISCO BAY REGION

most productive agricultural counties in the country and it accounted for one-third of California's annual crop of plums, cherries, pears, and apricots (Belser, 1970). It is remembered by old-timers as a bucolic agricultural haven, as the "Valley of the Heart's Delight".

World War II was a major turning point for this peaceful agricultural valley. To begin with, the war greatly stimulated California's economy and generated a massive influx of population into the region for the rapidly expanding war-related industries. Local industries, from canned vegetables to shipbuilding, geared up for the Pacific War. San Jose's Food Machinery and Chemical Corp. (FMC), for example, transformed its factories from the assembly of tractors to tank production. California's young research based aircraft manufacturing capability was also being geared up to meet the war needs. (Many large aircraft firms such as Litton Industries and North American Aviation had been established in the state to take advantage of the good weather conditions which allowed year-round testing of aircraft and reduced costs since some of the assembly activities could be performed outdoors.) Another significant wartime development for Santa Clara County was the genesis of a technological watershed at Stanford University through the initial flow of federal funding to Stanford's laboratories for the development of electronic components and equipment for use by the military. With the nearby San Francisco harbor and port as the gateway to the Pacific theater, the proximity to the military installations and industrial centers of Richmond, Oakland and San Francisco, and the large Moffet Field naval air station in the northern part of the county drawing in thousands of of military personnel for training, the foundations were laid for the future growth of Santa Clara County.

As the Second World War drew to a close, events in Santa Clara County began to pick up momentum. The population swelled with the influx of returning military personnel who had passed through the Bay area en route to posts in the Pacific.

Frederick Terman, a far-sighted and ambitious electrical engineering professor at Stanford (later to become dean, provost and Vice President) returned from administering a major military project at Harvard, determined to improve the university's then primitive electrical enginnering program.[1] He actively sought government and business funding for this purpose, with the promise that it would bring new indigenous industry to the West to balance its agricultural resources. He contended that universities needed to develop a new relationship with the new genre of science and technology-based industries which were dependent upon brain-power as their main resource. Terman spoke of the "community of interest between the University and local industry" and promoted his vision of an academic-industrial complex around Stanford. As he put it,

> If western industry and western industrialists are to serve their own enlightened and long-range interest effectively, they must cooperate with western universities and, wherever possible, strengthen them by financial and other assistance.
>
> (Blakeslee, 1977)

Terman's success in this is clear. In 1955, gifts from corporations to Stanford had reached half a million dollars annually; by 1965, they exceeded $2 million; and in 1976 they had reached $6.9

million. Most importantly for the development of the local electronics industry, through Terman's careful attention to faculty building, Stanford rapidly attained the reputation as one of the two best electrical engineering programs in the country (along with MIT).

In addition, the Stanford Research Institute (SRI) was founded in 1946 at Stanford University. SRI had a broad charter which emphasized performing research to help stimulate West Coast business (SRI International, 1980).

The outbreak of the Korean War and the ensuing "Cold War" period guaranteed a continuing flow of funds to Stanford and firms in the area for basic electronics research and development, as well as creating a large and identifiable demand for new high technology electronic products. The development of the ballistic missile system, in particular, dramatically boosted the west coast aircraft and missile industries, creating a large and guaranteed demand for prototype components from the young semiconductor industry. During this period, most of the local aircraft firms diversified themselves into production for the space industry. Terman reportedly used the government and academic contacts he had made during the war to attract a large proportion of the Pentagon's research and procurement dollars to the Stanford area. Between 1950 and 1954, military prime contracts awarded to California totalled about $13 billion, or 14% of all such awards nation-wide (SCC Planning Dept., 1967).

During the 1940's and 1950's a number of already well-established electrical and electronics related firms also moved operations into Santa Clara County to take advantage of the proximity to the war-related aircraft, missile and aerospace markets. Sylvania, Fairchild Camera and Instrument, General Electric, Philco-Ford, Westinghouse, Itel, and Kaiser all established manufacturing branch plants in the county.

Some large national firms also located research and development facilities in the county during this period. The biggest and most important of all was the research facility of the aerospace giant Lockheed, which was founded in the Stanford Industrial Park in 1956. IBM established a research center in San Jose in 1952. ITT, Admiral and Sylvania also set up R & D laboratories in the county.

Further, the development of the Stanford Industrial Park in the early 1950's represented the culmination of Terman's vision of an academy-industry partnership. It was one of the first industrial parks in the country, and Terman called it "our secret weapon". Established on 660 acres of land adjoining the Stanford campus, leases in the park were granted only to high technology firms which might be beneficial to Stanford University (Blakeslee, 1977). The leases were granted for 99 years, and the 75 resident firms now pay only rent enough to cover property taxes alone.

A pattern of industrialization was thus consolidated in Santa Clara County during the decade following World War II which provided the underpinnings for the future burgeoning of electronics and semiconductor enterprises in the area. While the war stimulated the region's economy and subsequently the development of aerospace and electronics production and research in the region, Stanford's engineering school had begun to provide a substantial supply of high calibre scientists and engineers. By the middle 1950's the region was distinguished by a rich and supportive educational and technological milieu consisting of high quality universities, research institutions and older technology-based firms. Santa Clara County had become an ideal environment for innovative, science-based industry.

Location of the semiconductor industry in Santa Clara County. The development of the semiconductor industry in Santa Clara County is notable in that it was almost entirely due to the formation and growth of new firms and spin-offs rather than to the location or relocation of the facilities of older firms into the region. In 1955, William Shockley established Santa Clara County's first semiconductor firm. Shockley, one of the three original inventors of the transistor, returned to Palo Alto soon thereafter to establish Shockley Transistor, thereby establishing one of the original spin-offs from Bell Laboratories. In 1957, eight of Shockley's best scientists in turn broke off themselves and gained financial backing from Fairchild Camera and Instrument to start their own firm. By 1965, ten new Santa Clara County semiconductor firms had spun-off of Fairchild, and the Santa Clara Valley had replaced Boston as the center of gravity for new electronic firm locations. Between 1959 and 1979, Fairchild Semiconductors spawned an amazing total of fifty new companies in the county. Virtually every established semiconductor firm in the valley can trace its genealogy back at least indirectly to roots at Fairchild.[2]

By the mid 1950's, Santa Clara County had already become one of the best possible locations in the country for the formation and growth of new semiconductor firms.[3] The region's two distinguishing characteristics were the unusually large supply of scientific and engineering manpower coming out of the universities, research institutions and laboratories in the area, and the huge markets for semiconductors generated by the defense and aerospace contracts and subcontracts directed to the region. Further, Stanford University was extremely responsive to the needs of companies in the area, and actively worked to promote conducive conditions for local high-technology industry. Finally, once a few firms like Fairchild had succeeded, there was easy access to venture capital for the founding and expansion of new firms in the area due to the county's proximity to San Francisco, the financial center of the west (Mutlu, 1979).

An indication of Santa Clara County's bountiful supply of scientific and engineering manpower is the rapidly increasing number of advanced degrees granted in electrical engineering by the local universities. Between 1950 and 1954, Stanford awarded 67 doctoral degrees in electrical engineering, between 1960 and 1964 it awarded 185, and for 1970 to 1974, 242. Meanwhile, the University of California at Berkeley awarded 19, 72 and 202 for the same time periods (Mutlu, 1979).

In the early 1960's, the number of Ph.D.s granted yearly by Stanford exceeded the number granted by MIT. Since 1960, U.C. Berkeley and Stanford combined were granting twice as many Ph.D.s as MIT yearly in electrical engineering (Mutlu, 1979). This large supply of university graduates made it easier for small firms in the area to recruit engineers. It also provided a larger pool of potential entrepreneurs, as most new semiconductor firms were started by university Ph.D.s and faculty members.

Further, local research institutions (SRI and NASA's Ames Research Center) and the R & D laboratories of the older electronics firms (especially IBM, ITT, Admiral and Sylvania) and major aerospace contractors (Litton Industries, Lockheed, Westinghouse, General Telephone, Intel, Kaiser Industries, Philco-Ford, General Electric and Precision Equipment) all recruited engineers nationally, thus providing an even larger supply of high calibre engineering manpower for small new firms to draw upon. Quite often these small firms were able to simply steal top employees from the larger firms. As the electronic component in aerospace and military products grew, the number of engineers employed in these firms grew dramatically. Lockheed, for example, employed a full 2,200 research scientists in 1962 (Mutlu, 1979). In sum, significant external economies had been created in the Santa Clara Valley which benefitted small semiconductor companies with respect to manpower sources. No other area in the United States provided such a rich concentration of technologically skilled labor.

The most decisive factor underlying the initial rapid growth of semiconductor firms in Santa Clara County was the amount of government spending directed to the region. The government market for electronics in California grew steadily after World War II until the state's share of military and space markets for semiconductors was greater than any other state in the country. The prior concentration of aircraft and aerospace firms gave California a significant edge over all other parts of the country, as the main customers for young semiconductor firms during this period were military prime contractors and their subcontractors. (Even Massachusetts lacked the concentration of major aerospace contractors which Santa Clara County possessed.)

As the semiconductor component of missiles and defense systems grew, and their complexity increased, a premium was put on the spatial proximity of the semiconductor firm to its electronic subsystem prime contractors. The need for interaction and collaboration between aerospace firms and their semiconductor producing subcontractors grew rapidly as the complexity of integrated circuits increasingly required custom-made designs. Spatial proximity between the components manufacturers and the subsystem producers economized on R & D personnel and time, and reduced communication costs. Since most semiconductor firms were very small in the 1960's, they had limited ability to interact over long distances. Thus those new firms which located close to prime contractors and subsystem manufacturers had a definite advantage over other small firms located further away.

Throughout the years of the Second World War, military prime contracts to the Pacific Region totalled $25.5 billion annually, or 12.3% of the total awarded in the U.S. During the Korean War years, the share going to the region had grown to 17.9% of the total nationwide, or $17 billion annually. By 1961, the Pacific region led the country with a full 27.5% of the total military prime contract awards. (See Table 3, Bacon and Remp, 1967.) These awards included a rapidly increasing amount of semiconductors. During the 1960's California received 20% of all defense-related prime contracts of $10,000 or more, and 44% of all National Aeronautics and Space Administration (NASA) subcontract awards. By that time, 15 - 20% of the cost of an aircraft was accounted for by electronic equipment, and at least 30% of missile systems was accounted for by electronics (Mutlu, 1979).

Finally, the Pacific region received an overwhelming share of federal Research and Development obligations. In 1964 it topped the nation with 36.5% of all Defense Department R & D expenditures and a full 47.5% of all NASA R & D obligations. The region also received 23.0% of all Atomic Energy R & D obligations (Bacon and Rempp, 1967).

As previously noted, Stanford University has had a long interest in the formation and growth of high technology firms in its vicinity. Stanford's activities played a significant, though secondary, role in drawing new firms to the county. The programs provided by Stanford included the honors program, whereby employees of local companies could attend the university during evenings or on company time in order to obtain advanced degrees in science and engineering; and a cooperative program of industry-university research sharing and seminars. By 1961, there were already 32 companies participating in the honors program, with approximately 400 employees attending courses at the university. Such programs were invaluable for small firms and their employees in an industry characterized by rapidly changing technology and dependent upon highly qualified R & D personnel. While larger firms, such as AT&T with Bell Labs, had the resources to provide graduate level training in science and technology for their employees, for the small companies that dominated the young semiconductor industry, proximity to a university was crucial.

The opening of the Stanford Industrial Park was also seminal in encouraging new company formation in the county. The ready availability of space and facilities assisted small new firms with limited resources. By 1961, the park already housed 25 high technology firms with a total employment of nearly 11,000. Later, other communities in the area also established industrial parks, which further enhanced company formation and growth in the region.

During its first decades, local industry was also liberally financed with venture capital. Once Fairchild had succeeded, financial support for new and expanding firms was easily obtained. The San Francisco milieu consisted of a large pool of wealthy individuals and families with discretionary incomes, and management consulting houses which provided advice and evaluative services. Of course, it had all the services and assets which proximity to a major financial center provides to local business.

Thus small new semiconductor firms flourished in Santa Clara County during the 1950's and 1960's. Propelled by the combined force of agglomeration and the industry's rapid growth, the county soon achieved the reputation as Silicon Valley, the densest concentration of electronics and semiconductor companies and highly skilled technological talent in the world.

Agglomeration in Silicon Valley. By the mid-Sixties, the composition of markets had changed and military demand had declined significantly in importance relative to the newer computer and industrial markets (see Table 4), but the original concentration of semiconductor production in the county acted as a powerful centripedal force for the continued clustering of new semiconductor and electronics firms.[4] An enlargened supply of manpower, specialized inputs and services, and a social, cultural and educational environment which was particularly appropriate to semiconductor production had been generated by a decade of prior spatial concentration by the industry. Thus virtually all spin-off firms chose to locate only a short distance from parent companies in the county and older firms continued to expand production locally.

As the industry grew, local education institutions instituted programs to meet the specific needs of the local firms. U.C. Berkeley and Stanford expanded their master's degree and Ph.D. programs, and many community colleges and vocational schools in the area instituted engineering and training programs. Santa Clara College, for example, provides courses in semiconductor production technology. A study of San Jose's junior college system in its formative years reported that more than half of all job placements for graduates of San Jose Junior College were as electronics technicians in the industrial and service sectors of the county economy (Keller, 1979). Thus the educational system was shaped to meet the occupational needs of the local economy.

Industrial growth also incuded massive immigration into the county. With under 200,000 people in 1940, the population of Santa Clara County more than doubled between 1950 and 1960, and then had nearly doubled again by 1970 when it surpassed the one million mark (see Table 5.) Well over 75% of this growth was due to in-migration,

TABLE 4.

Distribution of U.S. Semiconductor Sales By End Market: 1960 - 1975

Year	Percent of Total Semiconductor Sales Going To: Computer	Consumer	Government	Industrial	Percentage of Integrated Circuit Production Going To Space and Defense
1960	30	5	50	15	
1962					100
1963					94
1964					85
1965					72
1966					53
1967					43
1968	35	10	35	20	37
1970	28	22	24	26	n.a.
1973	28	25	18	29	
1974	32	22	16	30	
1975	33	23	15	29	

Sources: Mutlu, Servet. Unpublished doctoral thesis, Department of City and Regional Planning University of California, Berkeley (1979) Table VII. 2, p. 79.

Tilton, John E. International Diffusion of Technology: The Case of Semiconductors (Washington, D.C.: The Brookings Institution, 1971), p. 91.

U. S. Department of Commerce. U.S. Semiconductor Industry (Washington, D.C.: U.S. Government Printing Office, 1979), Table 3.4, p. 44.

TABLE 5.

Population Growth and Components of Increase
Santa Clara County, California. 1940-1980

Year	Total Population	Interval	Total Increase Number	%	Components: Natural Increase	Net Immigration
1940	175,000					
		1940-1950	115,500	66.8	n.a.	n.a.
1950	290,500					
		1950-1960	351,815	121.1	23%	77%
1960	642,315					
		1960-1970	442,998	65.8	28%	72%
1970	1,065,313					
		1970-1980	184,687	17.3	57%	43%
1980	1,250,000					

Source: County of Santa Clara Planning Department: INFO No. 660, "Components of Yearly Population Increase, 1950-1979, Santa Clara County" (February, 1980).

much of it being workers displaced by mechanization from agriculture, along with newly arrived immigrants from Mexico and Asia (Santa Clara County Planning Dept. Info No. 660). Thus there was a substantial and continually growing supply of unskilled labor available for production in the industry.

Supplies of specialized inputs and services were also guaranteed in Santa Clara County as a result of prior concentration of the industry. A variety of local firms had been established to produce the photomasks, testing jigs, chemicals, silicon and special production equipment essential to manufacturing semiconductors. Many of these inputs were not easily available elsewhere in the country. Providing all of these inputs and services in-house would have been either impossible or excessivly costly for small new firms. Even the larger firms benefitted from taking advantage of the lower costs due to the economies of scale in producing inputs or services to so many firms. Finally, infrastructure and transportation networks had been well established in the county, thus ensuring efficient and uninterrupted air service and easy transfer of products to the airport. Supplies of energy and water and provision of sewage facilities were also guaranteed in the county.

The creation of a milieu which was highly conducive to interfirm communication, information transfer and personnel mobility was an equally important form of localization economies. In an industry marked by rapid technological change, pervasive intercompany diffusion of ideas and severe competitive pressures which demanded always staying at the "leading edge" of technology, there were clear benefits to spatial proximity and the clustering of firms. Small firms especially benefitted, given the frequency of product copying, second sourcing, and pirating of information and personnel in the industry. There was also an unusually high degree of interaction between employees of rival firms in Santa Clara County. Many were close personal friends and had gone to school together or worked together in the past, and much information, brainstorming and gossip were exchanged over the telephone or at the local "watering holes". Stanford's education and seminar programs and the activities of newly formed industry associations headquartered in the area further encouraged this interchange.

Santa Clara County companies also found it very easy to attract top scientists and engineers from all over the country to the "Santa Clara scientific community". Once the county had attained the status as the seat of all knowledge and the hotbed of technology for the semiconductor industry, ambitious young scientists in the field invariably wanted to land jobs or start their own firms in the county.

Through social interaction, these young professionals also created a social and cultural milieu in the valley which provided a highly desirable lifestyle for these scientists. The social status and desirability of the area should not be underestimated as a factor in the continued success of the industry in Santa Clara County. Scientists, executies and managers all have stressed the sentiments of this observer,

> "It's a particularly pleasant place to live and work--a beautiful landscape of hills and plains, a bounteous garden of nature where fruit trees and wild flowers bloom even in February. . . . Few places on earth so agreeably

> mix hedonistic delights with the excitement of urbanity. . . . It enjoys mild winters, fog-free summers and a balmy spring and fall. Outdoor sports and recreation are year-round attractions . . . The area boasts 4,000 Ph.D.s . . . There are also at least 12,000 horses, some kept by those Ph.D.s right on their home acreages, which are often within minutes of work. And within an hour's drive are the shops, restaurants, and cultural offerings of San Francisco." (Bylinsky, 1974)

The social status of living among other Ph.D.s and horse owners and the county's recreational opportunities and suburban lifestyle helped to draw the professional engineers and scientists who are so key to semiconductor production.

Thus the force of agglomeration economies ensured continued clustering by the proliferation of new semiconductor firms born in Santa Clara County during the 1960's and early 1970's. In 1968 alone, thirteen new spin-off enterprises originated in the county, and this pace continued through the first half of the 1970's. Outside of the fertile environment which had been created in Santa Clara County, many of these fledgling firms would never have survived.

Accelerated industrial expansion and continued agglomeration thus transformed Santa Clara County into the internationally famed Silicon Valley, the capital of the semiconductor industry and the largest concentration of high technology and electronics enterprises in the world. By 1970, five of the seven largest semiconductor firms in the U.S. had their main facilities in Silicon Valley, and clustered around them was the largest concentration of electronic communications, laser, microwave, computer, advanced instrument and equipment manufacturers in the world.

<u>The regional economic boom</u>. As the local electronics and semiconductor industries grew, so too did the economy of Santa Clara County. The unprecedented speed with which the region's economy boomed reflected the accelerated growth of the semiconductor industry. The continued clustering of electronics production in the valley generated record-breaking rates of regional employment, population and income growth during the 1950s, '60s and early '70s.

Between 1950 and 1975, the population of Santa Clara County increased by over one million people. The pace of population growth in the region far surpassed growth rates for California and for the United States as a whole. Between 1950 and 1960, the population of Santa Clara County grew 121%, while California's population grew 48.5% and the U.S. population grew only 18.5%. Likewise, during the following decade (1960-1970), the county's population grew 66%, while California's 27%, and that of the U.S. only 13.3%

Total employment in the county nearly doubled between 1940 and 1950, and more than doubled again between 1950 and 1960 (See Table 6). In twenty years, over 60,000 jobs were created inthe manufacturing sector alone. Each new manufacturing job generated at least two or three additional jobs. This high multiplier stands in contrast with the estimated 1.2 jobs created by a new manufacturing position in the matured economy of the San Francisco Bay area (Santa Clara County Housing Task Force, 1977). More than 400,000 new jobs were created during these two decades. Between 1960 and 1975, the county's employment grew 156%, three times the national rate of 46% and more than double

TABLE 6.

Average Annual Employment by Industry, Santa Clara County: 1940-1980

	1940		1950		1960		1970		1980	
	No.	%	No.	&	No.	&	No.	&	No.	&
Agriculture	9,400	15.7	16,200	14.7	11,100	4.9	6,641	1.6	3,700	0.6
Construction	4,700	7.8	9,400	8.6	17,800	7.8	22,480	5.5	23,800	3.6
Manufacturing	8,600	14.4	22,100	20.1	70,300	30.8	125,097	30.6	230,000	35.3
Transportation, Communications & Utilities	3,600	6.0	6,100	5.6	9,600	4.2	24,391	5.9	21,000	3.2
Trade	12,600	21.0	22,600	20.6	40,700	17.8	75,579	18.5	123,600	19.0
Fire	2,100	3.5	3,200	2.9	7,900	3.5	20,742	5.1	26,600	4.1
Services	13,600	22.7	18,300	16.7	43,200	18.9	90,389	22.1	142,800	21.9
Government	5,100	8.5	11,700	10.6	26,800	11.8	43,490	10.6	79,800	12.2
TOTAL	59,900	100.0	109,900	100.0	228,000	100.0	409,077	100.0	651,500	100.0

Source: County of Santa Clara Planning Department. "A Study of the Economy of Santa Clara County. POA 1" (1965).

U. S. Bureau of the Census. Census of Population: 1970. California. (Washington, D.C.: U. S. Government Printing Office).

San Jose Mercury. March 2, 1980.

California's 65% increase (Santa Clara County Economic Development-Job Needs Project, 1978). Between 1970 and 1975, the growth rate for manufacturing jobs surpassed such national growth leaders as Houston and Orange County (See Table 7). Thus in the forty year period from 1940 to 1980, total employment in Santa Clara County grew almost 1000%, from 59,900 to 651,500.

This accelerated employment growth was accompanied by a dramatic sectoral shift in the composition of employment, reflecting the shift from an agricultural to a manufacturing based economy. While agriculture and manufacturing each accounted for 15% of the county's employment in 1940, by 1960, 30% of the workforce was employed in manufacturing and only 5% remained in agriculture. During the 1960s, manufacturing employment more than tripled, while agricultural employment declined by about 25%. These trends have continued up to the present. In 1980, only 3,700 people were employed in agriculture, a mere 0.6% of the county's employment, while 230,000 were employed in manufacturing, accounting for an unusually high 35% of total employment. By contrast, manufacturing accounts for only 21% of employment in the U.S. as a whole.

The explosive growth of the region's economy is also reflected in the dramatic increases in its manufacturing value-added and value of shipments. In the five years between 1967 and 1972 alone, value-added in manufacture grew 53% from $1.9 billion to $2.9 billion, making Santa Clara County the third highest ranked metropolitan area in the state of California for manufacturing value-added (after the Los Angeles/Long

TABLE 7.

Manufacturing Employment: Percent Change 1970 - 1977
Santa Clara County, Other Metropolitan Areas, and the U. S.

	1970 - 1975	1975 - 1977
California	-1.6%	6.0%
Santa Clara County	21.6	10.7
Orange County	20.4	10.1
San Diego County	5.9	-0.8
Other Metropolitan Areas		
Atlanta	-4.7	-0.7
Boston	-15.6	6.1
Houston	20.0	7.8
Phoenix	-4.5	5.8
Seattle	9.9	4.9
United States	-8.8	5.6

Source: Santa Clara County Economic Development - Job Needs Project. "Training and Jobs: Ways to Reduce Unemployment in Santa Clara County". (November, 1978).

Beach and the San Francisco/Oakland SMSAs) (Security Pacific National Bank, 1975). By 1977, Silicon Valley ranked 16th in the country in the dollar value of its manufacturing shipments, with an estimated total of $16 billion (Garcia, 1979).

Santa Clara County rapidly became one of the wealthiest counties in the nation. Total personal income in the county grew from $520 million in 1950 to $4,000 million in 1968 (Economic Development Job Needs Project, 1978). In 1969, median family income in the San Jose SMSA (coterminous with Santa Clara County) was already the highest among all of California's SMSAs, and a fully thirty percent above the median family income for the U.S. (See Table 8.) By 1977, per capita personal income in Santa Clara Coutny was $8,632, while it was $7,909 for California and $7,019 for the U.S. as a whole (Security Pacific Bank, 1979).[5]

The rapid expansion and agglomeration of electronics production in Santa Clara County thus created a single industry boomtown. Today, at least one-third of Silicon Valley's workers are employed in the approximately 700 electronics-related companies in the region, while many of the remainder are in occupations which support or service this electronics complex.

TABLE 8.

Median Family Income, 1969 and 1975:
San Jose SMSA, California and the United States

	1969	1975
Santa Clara County	$12,456	$18,500
California	10,732	15,069
United States	9,586	14,095

Source: U. S. Bureau of the Census. Census of Population: 1970. California. (Washington, D.C.: U. S. Government Printing Office).

Stanford Research Institute. "The Mid-Peninsula in the 80's" (Palo Alto, CA: SRI, International, 1980).

Footnotes

1. Before the war, Terman had begun by attempting to convince some of his best students to remain in the West and establish their own firms, rather than seeking employment in the big eastern electronics and electrical companies. He thus encouraged the founding of Hewlett-Packard Co. (in 1959) and Varian Associates (in 1948) in Palo Alto. Today these are two of the largest electronics firms in the county.

2. See the Silicon Valley Semiconductor Industry genealogy which graphically represents the origins and interconnections between the county's semiconductor firms. Published by the Semiconductor Equipment and Materials Institute, (SEMI), Mountainview, California (1979).

3. While the remainder of this section relates the ways in which Santa Clara County was uniquely suited to meet the requirements for successful semiconductor production, it is important to bear in mind that the nature of the spin-off and company formation process by which the industry grew was a result of the particular nature of competition, the ease of entry and the rapid diffusion of technological innovations in the industry which were discussed in the last section.

4. It did not take long for Stanford trained engineers and

industrialists to discover that the defense-related technology that they had been developing was in fact highly amenable to domestic consumer and industrial applications as well.

5. While these measures do show that there is immense wealth in the county, it should be noted that they hide significant disparities and pockets of poverty and unemployment by failing to address the issue of income distribution. Furthermore, the cost of living and the cost of housing in particular, has been considerably above the national average in the county, thus somewhat counteracting these high incomes.

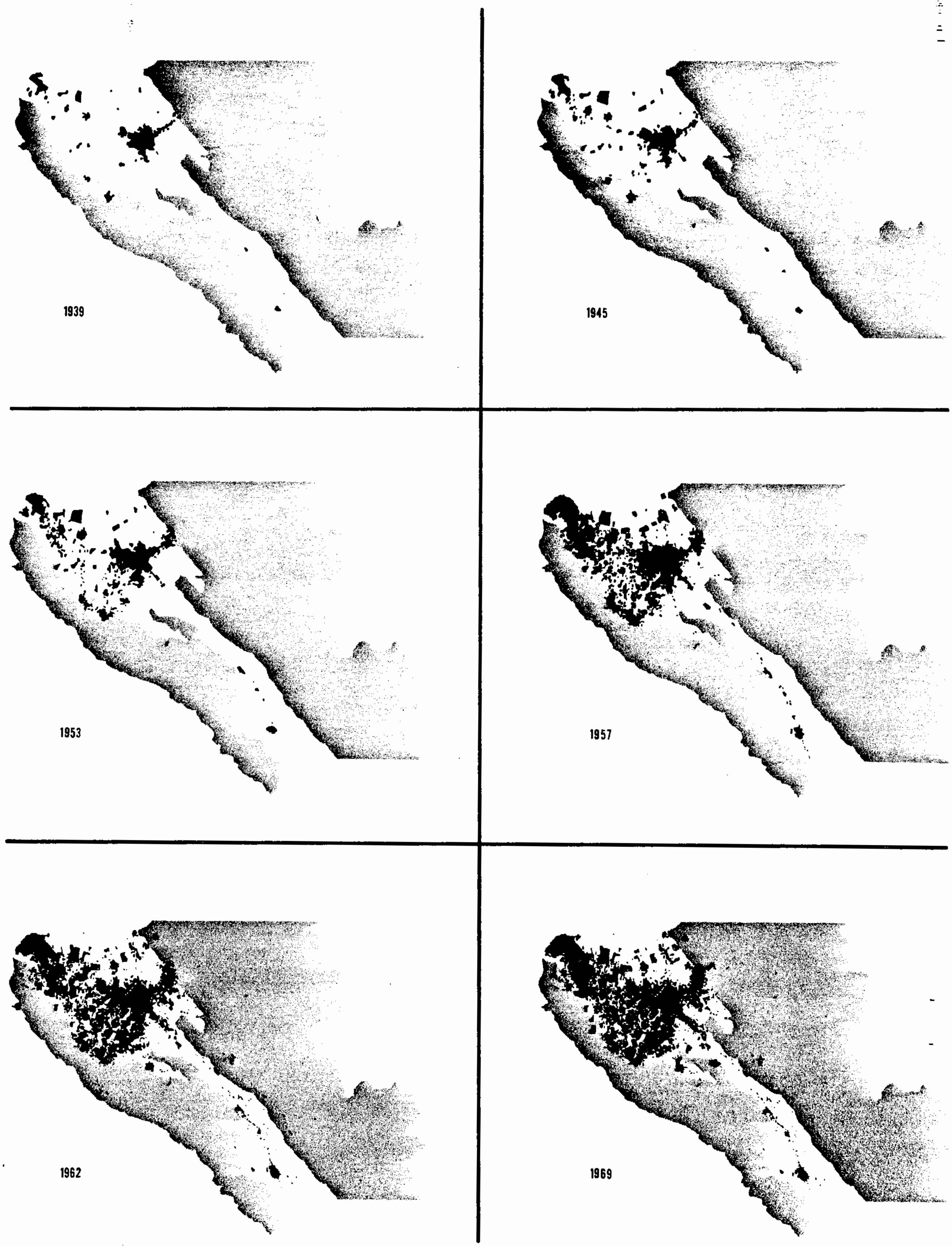
From Orchards to Suburbs: The Logic of Urban Development in Santa Clara County

Historical evolution of land use patterns. The transformation of Santa Clara County's urban landscape is the most striking reflection of the accelerated expansion of electronics production and of the region's economic boom. Within three decades, well over one hundred thousand acres of orchards and farmland were replaced with a sprawling patchwork of industrial parks, housing tracts, shopping centers, strip commercial development and massive freeways. Today, only 12,000 acres of agricultural land remain in cultivation, a mere 4.5% of the valley's total land area (San Jose Mercury, 4/20/80); over 97.5% of the county's population lives in "urbanized" or "urban developed" areas (U.S. Census, 1970). The unprecedented speed with which urbanization spread across the valley is graphically illustrated in Map 2.

The rate of construction in the county has been staggering. 325,000 housing units were built between 1950 and 1975, a full 83% of the total 1975 housing stock of 392,000 units (Rothblatt, 1979; Santa Clara County Industry & Housing Management Task Force, 1979). 37 industrial parks were developed (occupying over 6,500 acres and housing well over 500 firms), and between 1950 and 1965 alone, 85 new shopping centers were built and operating, while over 200 more were either under construction or in planning stages (Santa Clara County Planning Department, INFO 202).

While Silicon Valley appears to have developed as a completely haphazard and unplanned outcome of the county's accelerated economic

HISTORIC PATTERNS OF URBAN DEVELOPMENT, SANTA CLARA COUNTY



boom, closer examination reveals a clear logic underlying the organization of urban space in Santa Clara County. A brief review of the historical development of the county highlights the distinct patterns of land use as they emerged in the county over the post-war decades.

In 1940, San Jose was the largest of nine incorporated jurisdictions in the county. With a population of 68,000, it was the county seat and the center for agricultural processing, packaging and distribution for the region; it boasted a diverse collection of canneries, food machinery industries and supportive businesses and services. The other towns scattered throughout the lush green Santa Clara Valley were, with one exception, small urban pockets of less than 5,000 in population, which acted as service centers for the surrounding agricultural fields. They provided financial, retail, professional and personal services as well as being the market for some of the food produce. Most of the food which was grown on the farms, however, was prepared and processed in the towns for delivery by rail to distant markets.

The one exceptional community in the valley was Palo Alto, a genteel university town of under 20,000 residents, perched in the northern end of the valley about 20 miles away from San Jose. Stanford University, established by railway baron Leland Stanford in 1885, occupied a magnificent 9,000 acre farm in Palo Alto, and provided a focus for the entire northern part of the county. It was from this small enclave that the impetus for the transformation of Santa Clara County emerged.

As the influx of war-related aerospace and electronics enterprises began to locate in Santa Clara County, they clustered their operations in the north around Stanford University. The initial precedent for this was set by the firms which Stanford's Frederick Terman had parented. Hewlett-Packard Co. began operations in a small garage shop in Palo Alto in 1938. In 1942, the Varian brothers pioneered the klystron tube (the foundation of modern radar and microwave communications) in the Stanford laboratories, and subsequently established their firm, Varian Associates, nearby. Terman consciously cultivated a "Community of technical scholars" in Palo Alto. As he described it,

> "Such a community is composed of industries using highly sophisticated technologies, together with a strong university that is sensitive to the creative activities of the surrounding industry. This pattern appears to be the wave of the future." (Bernstein, et al, 1977.)

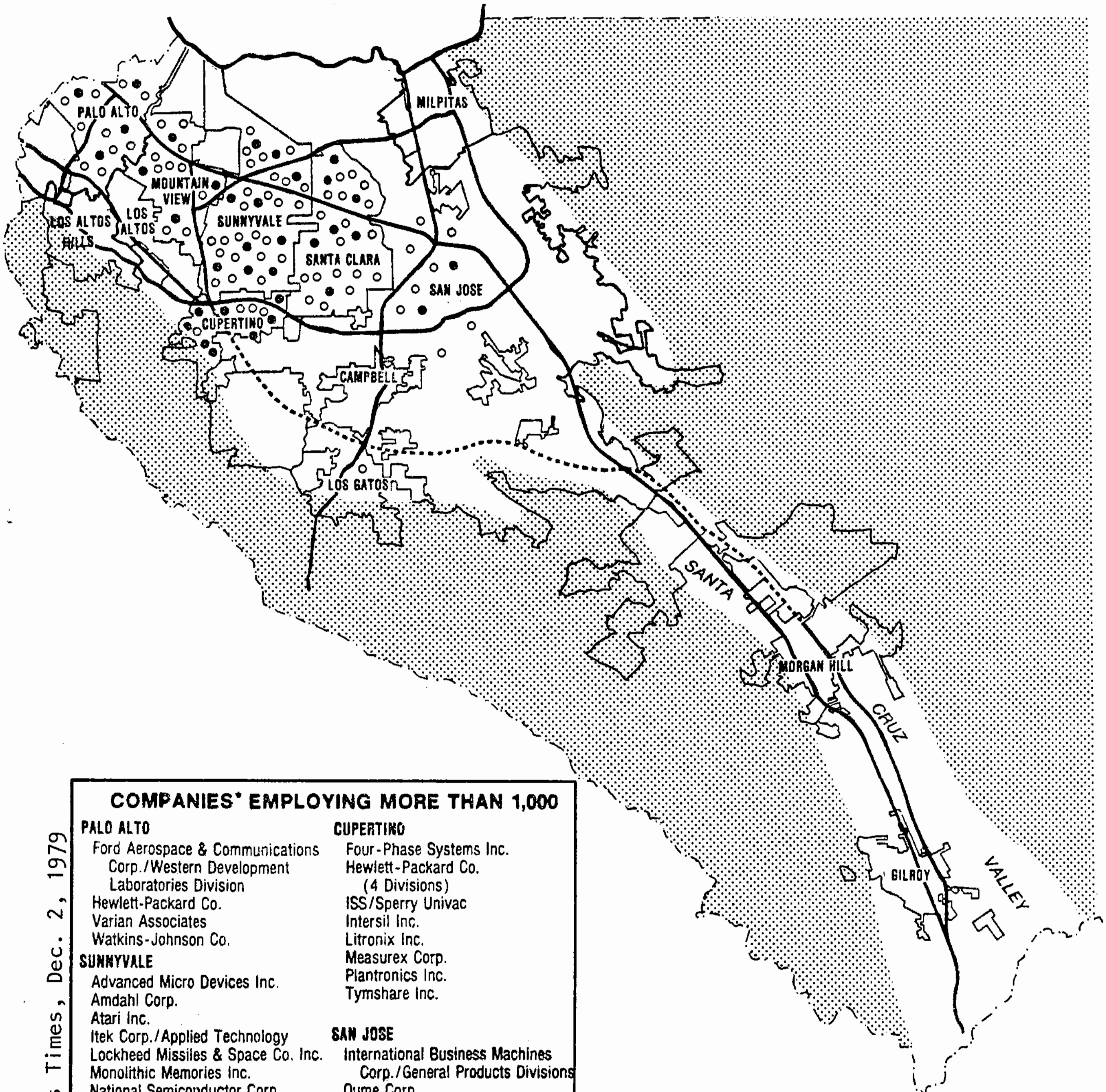
Palo Alto's industrial land rapidly became completely developed and electronics and semiconductor production in the county began to slowly move southward, first to the adjacent towns of Mountain View and Sunnyvale. Eventually it began to fill Santa Clara and Cupertino as well. It did not take long for these cities to realize the benefits of a strong industrial base in terms of local tax revenues. Typically, industry yields a net gain in revenues for a locality, while most single family homes (below a certain assessed valuation), use more services than they yield in taxes. Each of these communities thus actively encouraged industrial expansion by copying the Stanford Industrial Park model and by offering financial, infrastructural and land incentives to new firms.

Stanford's Industrial Park also provided a model for landscaping and set the physical standards for subsequent high technology industry in Santa Clara County. Factories and research buildings were made to resemble low-lying campus buildings and to convey the image of clean, modern and innovative industry. As one observer noted,

> No sooty smokestacks or shabby old factories mar the scenery. The science companies for the most part operate in sleek modern buildings in fifty-one verdant industrial parks, which provide a campus-like setting for research and manufacturing. (Bylinsky, 1974)

This concentration of the electronics industry has resulted in a striking imbalance in industrial development between the north and south parts of the county. In 1970, Palo Alto industry provided one electronics job for every four city residents; in Mountainview the ratio was one to five, in Sunnyvale one to nine, and Santa Clara was one to seven, while in San Jose there was only one electronics job for every fifty city residents (Keller, 1979). Even today, the overwhelming proportion of electronics production remains clustered in the five northern cities (Palo Alto, Mountainview, Sunnyvale, Santa Clara and Cupertino), although recently a few firms have located operations in north San Jose as well. (See Map 3.)

The county soon developed a highly distorted pattern of land use, with a disproportionate concentration of manufacturing employment in the north. Not only are there far more electronics jobs in these cities than in the rest of the county, but they also have a corresponding shortage of housing. As the industry expanded with accelerated speed during the 1960s and 1970s, these cities, in fierce competition for industry, rezoned much of their residential land for industrial use.



COMPANIES* EMPLOYING MORE THAN 1,000

PALO ALTO
- Ford Aerospace & Communications Corp./Western Development Laboratories Division
- Hewlett-Packard Co.
- Varian Associates
- Watkins-Johnson Co.

SUNNYVALE
- Advanced Micro Devices Inc.
- Amdahl Corp.
- Atari Inc.
- Itek Corp./Applied Technology
- Lockheed Missiles & Space Co. Inc.
- Monolithic Memories Inc.
- National Semiconductor Corp.
- Shugart Associates
- Sigentics Corp.
- Verbatim Corp.

MOUNTAIN VIEW
- Acurex Corp.
- Fairchild Camera & Instrument Corp.
- General Telephone & Electronics Corp./Western Division
- Spectra-Physics Inc.

CUPERTINO
- Four-Phase Systems Inc.
- Hewlett-Packard Co. (4 Divisions)
- ISS/Sperry Univac
- Intersil Inc.
- Litronix Inc.
- Measurex Corp.
- Plantronics Inc.
- Tymshare Inc.

SAN JOSE
- International Business Machines Corp./General Products Divisions
- Qume Corp.

SANTA CLARA
- American Microsystems Inc
- Hewlett-Packard Co./Santa Clara Division
- Intel Corp.
- Memorex Corp.
- National Semiconductor Corp..
- Rolm Corp.
- Siliconix Inc.

*Companies are members of American Electronics Assn.

Source: Los Angeles Times, Dec. 2, 1979

○ 200 to 1,000 workers

● over 1,000 workers

MAP 3: LOCATION OF ELECTRONICS EMPLOYMENT IN SILICON VALLEY

Between 1965 and 1975, the total number of housing units that could be accomodated by local zoning plans decreased significantly. As a result, none of the northern cities has provided sufficient housing to accomodate their local workforces.

For example, while 70,000 people were employed in Palo Alto in 1976, only 11,000 of them actually lived in the city. The remaining 59,000 lived elsewhere, mainly in San Jose (Pacific Study Center, 1977). Palo Alto is the most severe case, but the other cities in the north of the county also exhibit this imbalance of job provision relative to housing. In 1975, the five northern cities together accounted for a total of 243,100 jobs, but only 129,000 housing units (Santa Clara County Industry-Housing Management Task Force, 1979). The northern part of the county has thus become known as the "jobs belt" for the entire county, and its cities have prospered with the tax revenues from their strong industrial bases.

The southern part of Santa Clara County in turn developed as the "housing belt" for the county. As early as 1950, the city of San Jose had taken up the role of bedroom community for the county. The initial wartime population increases in the county had stimulated an immediate interest within the San Jose financial community, and in 1950 a new administration came into power in the city with the explicit goal of "making San Jose the Los Angeles of the North". Supported by a pro-growth coalition of landowners, realtors, road-builders, contractors, developers and members of the financial community, this city council was the first in a long succession which explicitly and aggressively promoted the unhampered development and expansion of the city (Belser, 1970). San Jose pursued its own expansion relentlessly through aggressive annexation in order to secure control of all potentially developable turf. Between 1950 and 1975, San Jose grew from a compact agricultural center of 17 square miles to a sprawling suburban city of 147 square miles in area, encompassing about half of the total incorporated area of the county. Table 9 illustrates the rapid growth of San Jose relative to the other cities in the county. The city government granted huge concessions to developers, including the favorable rezoning of lots, generous provision of credit, and the extension of sewers, storm-drains and roads to peripheral areas. In addition, the seemingly boundless flow of federal dollars for construction of the expanding freeways and expressways in the county further speeded and shaped urbanization, as did the provision of Federal Housing Authority (FHA) mortgage financing which made tract developments of low-quality single family homes highly profitable.

San Jose's growth after 1950 was explosive. As the county's population doubled between 1950 and 1960, the population of San Jose tripled. By 1960, the city was the home of a full half of the total population of Santa Clara County, and it has retained that overwhelming plurality up to the present day. Table 10 shows the distribution of the county's population by cities.

Nearby municipalities and unincorporated areas rapidly responded to San Jose's expansionary policies. Between 1952 and 1957 seven incorporations occurred, (it had been 40 years since the last incorporation in the county), and a series of frenzied border wars and annexations

TABLE 9.

Estimated Area of Cities,
Santa Clara County, 1950-1975 (square miles)

	1950	1960	1970	1975
Alviso	9.9	13.7	b	b
Campbell	a	2.9	4.6	4.7
Cupertino	a	4.9	7.7	7.8
Gilroy	1.5	2.2	4.9	5.7
Los Altos	a	5.8	6.1	6.5
Los Altos Hills	a	9.5	9.5	9.5
Los Gatos	1.5	5.8	8.7	8.7
Milpitas	a	7.6	9.3	9.4
Monte Sereno	a	1.4	1.5	1.6
Morgan Hill	2.2	3.6	8.0	9.6
Mountainview	1.1	7.4	11.0	11.1
Palo Alto	6.9	21.6	25.2	25.2
San Jose	17.2	53.0	136.4	147.4
Santa Clara	4.9	11.3	16.6	18.5
Saratoga	a	11.7	11.7	11.7
Sunnyvale	6.1	17.3	22.2	22.9
Total Incorporated	51	180	283	300
Total Unincorporated	1261	1132	1029	1012

Notes: a Not yet incorporated
b City of Alviso consolidated into the City of San Jose 3/12/80.

Source: Santa Clara County Planning Department, INFO No. 556, "Estimated Area of Cities, Santa Clara County. January of Each Year. 1950-1975." (June, 1975).

TABLE 10.

Population of Cities and Unincorporated Areas, Santa Clara County. 1950-1975.

City	1950	1960	1970	1975	1975 Population as Percent of County Total
COUNTY TOTAL	290,500	642,315	1,065,313	1,169,006	100.0%
Alviso	700	1,174	a	a	--
Campbell	b	11,863	23,797	25,108	2.2
Cupertino	b	3,664	17,895	22,023	1.9
Gilroy	4,900	7,348	12,684	15,589	1.3
Los Altos	b	19,696	25,062	26,620	2.3
Los Altos Hills	b	3,412	6,871	6,993	.6
Los Gatos	4,900	9,036	22,613	23,882	2.0
Milpitas	b	6,572	26,561	31,666	2.7
Monte Sereno	b	1,506	2,847	3,111	.3
Morgan Hill	1,600	3,131	5,579	8,882	.8
Mountainview	6,600	30,889	54,132	55,095	4.7
Palo Alto	25,500	52,287	56,040	52,623	4.5
San Jose	95,280	294,196	459,913	551,224	47.2
Santa Clara	11,700	58,880	86,118	82,978	7.1
Saratoga	b	14,861	26,810	29,150	2.5
Sunnyvale	9,800	52,898	95,976	102,154	8.7
Total Unincorporated	129,500	160,882	142,415	132,268	11.3

TABLE 10, continued.

Notes: a Alviso annexed into City of San Jose.
b Not yet incorporated.

Source: County of Santa Clara Planning Department. INPO No. 485. "Total Population and Total Dwelling Units by City, Santa Clara County. April 1, 1950-1970" (May, 1973).

County of Santa Clara Planning Department. "1975 Special Countywide Census" (1978).

were fought between San Jose and surrounding municipalities (see Table 11). These conflicts have left a bitter legacy of mutual mistrust and parochialism among the 15 cities in the county.

Table 12 illustrates the imbalance between the spatial concentrations of employment, population and housing which has emerged in the county. In 1975, the Central and East Valley cities (San Jose, Milpitas and Campbell) accounted for well over half of the county's population and housing units, yet they contained only 41% of the jobs in the county. Meanwhile, the North County cities were the location of 48% of the jobs but less than a third of the county's population and housing units.

Settlement patterns and social residential segregation. As the growth and agglomeration of the electronics industry in Santa Clara County continued, the unbalanced distribution of jobs and population in urban space was reinforced. At the same time, the rapid expansion of electronics production generated a very specific occupational and class structure in Santa Clara County. The dichotomized labor force which characterizes electronics production has been clearly projected onto the urban spatial structure of Silicon Valley. A distinct pattern of social residential segregation has developed within the county, with the fragmentation of the county into fifteen cities allowing for the differential reproduction of the sectors of the labor force in separate communities in the county. The dichotomized workforce of the electronics industry was reproduced in the dual stream of immigrants who flooded into Santa Clara County.

TABLE 11.

Dates of Incorporation for Santa Clara County Municipalities

San Jose	1850
Santa Clara	1852
Gilroy	1870
Los Gatos	1887
Palo Alto	1894
Mountainview	1902
Morgan Hill	1906
Sunnyvale	1919
Campbell	1952
Los Altos	1952
Milpitas	1954
Cupertino	1955
Los Altos Hills	1956
Saratoga	1956
Monte Sereno	1957

Source: Rothblatt, Garr, Sprague, The Suburban Environment and Women (New York: Praeger Publishers, 1979) p. 23, Table 1.4.

TABLE 12.

Jobs-Housing Imbalance: Santa Clara County, 1975

Region of County*	Residents no.	Residents %	Occupied Housing Units no.	Occupied Housing Units %	Employment no.	Employment %
North County	335,100	29.3	129,000	32.9	243,100	48.5
Central and East Valley	655,700	57.3	214,000	54.5	210,300	41.9
Western Foothills	99,700	8.7	32,500	8.3	28,700	5.7
South Valley	24,600	2.1	7,600	1.9	7,100	1.4
Rural Areas	29,400	2.6	9,300	2.4	12,500	2.5
TOTAL	1,144,500	100.0%	392,400	100.0%	501,700	100.0%

*North County Cities: Palo Alto, Mountain View, Sunnyvale, Santa Clara, Cupertino.

Central and East Valley Cities: San Jose, Milpitas, Campbell.

Western Foothill Cities: Los Altos Hills, Los Altos, Saratoga, Monte Sereno, Los Gatos.

South Valley Cities: Morgan Hill, Gilroy.

Rural Areas: Unincorporated areas.

Source: Santa Clara County Industry and Housing Management Task Force. "Living Within Our Limits: A Framework for Action in the 1980's" (November, 1979) p. 3.

On the one hand, the industry's unusually large demand for highly educated scientists and engineers spurred an influx of skilled professionals and technicians from other regions of the U.S. and from other countries (mainly Japan and Korea). While in 1950 only one-fifth of all county residents over 24 years of age had one or more years of college education, two-fifths of all in-migrants between 1955 and 1960 had some college training. During the late 1960's, a full fifty percent of all adult migrants to the area had one or more years of college training (Keller, 1979). Thus the proportion of college educated adults in the county rose significantly to meet the needs of electronics production. By 1970, approximately 40% of the county's population was college educated (Santa Clara County Planning Department, INFO 469).

At the same time, there was a massive in-migration of unskilled, predominantly minority workers in response to the industry's need for unskilled production workers. Foremost among these immigrants were the Mexican-Americans and, to a lesser extent, the Filipino-Americans who had been displaced from California and Southwest agricultural work by mechanization and by rancher employment of lower paid undocumented workers. The remainder were foreign born Mexicans, Filipino immigrants and a smaller number of U.S. blacks and American Indians. This trend in the in-migration process is reflected in the increasing minority composition of the county's population. Hispanics alone accounted for 25% of the total population increase in the county between 1960 and 1970; during that decade their percentage of the total population of Silicon Valley thus grew from 12% to 18%. By 1970, minority groups represented nearly one-fourth of Santa Clara County's population (Keller, 1979). Typically, the women took production jobs in electronics, while many of the men were employed in construction work for the rapidly urbanizing city of San Jose.

In 1970, the electronics workforce in the county consisted of 50.3% professional, technical and managerial workers; 17% clerical and sales workers, and 31% production workers (crafts, operatives, laborers and service workers). The professional, technical and managerial segment was 93% male and only 3% Hispanic, while the production workforce was 70% women and 19% Hispanic workers. A full 35% of the production workforce was minority women (California Employment Development Department,1970). Santa Clara County's electronics industry thus employs a highly segmented labor force, split between a predominantly white, male and highly educated professional class and a predominantly female, minority class of unskilled (or minimally skilled) production wokrers. The economic gap between these two segments of the labor force is large and growing. The average engineering technician in electronics in 1972 earned a salary of $15,000 a year, which was 80% more than the annual wage earned by an average production worker in the industry (Kellery, 1979). By 1979, while a bachelor's degree in electrical engineering commanded a salary of $18,000 to $20,000, and a top design engineer could earn over $50,000, the average wage of a semiconductor production worker was $4.52 an hour, or approximately $9,000 a year (Los Angeles Times, 12/2/79; U.S. Bureau of Labor Statistics, 1979; Business Week, 12/3/79).

The overall occupational structure of the county is similar. In 1970, the occupational breakdown for employed persons in the San Jose SMSA included 33% professional, technical and managerial employees, 25% clerical and sales workers, and 41% craftsmen, operatives, laborers and service workers (U.S. Census of Population, 1970). Job skill requirements for the 1970s mirrored this division. According to a Santa Clara County Job Needs Advisory Report, more than half (54%) of the annual job openings in the county required minimal or no skills (with 25% requiring no high school diploma), while the remaining 46% of job openings required a year or more of secondary education. 30% of the job openings required at least four years of college education or more (Santa Clara County Economic Development-Job Needs Project, 1978).

A pattern of socially differentiated residential communities sprang up during the past few decades precisely in order to accomodate this massive influx of immigrants. They created a highly stratified series of suburbs corresponding to their occupational and income differences. These class and race segregated communities in turn have served to reproduce distinct status differentials among the population.

The cities in Santa Clara County can be divided into four clusters which are differentiated by the occupations, incomes, and education levels of their residents, by the median home values and assessed valuation of the area's property, and by the ethnic composition of their populations. These indicators are broken down by city in Table 13.

Table 13a.

Socio-Economic Indicators,
By City, Santa Clara County

	Assessed Net Valuation Per Capita, 1974-1975 (in 1000s)	Median Family Income, 1969	Median Value of Owner-Occupied Houses, 1970
I. North County Cities			
Palo Alto	$ 7,200	$ 15,036	$ 33,900
Mountain View	4,400	11,830	23,900
Sunnyvale	4,200	13,078	29,200
Santa Clara	4,200	12,135	24,100
Cupertino	5,000	15,122	34,100
II. Central and East Valley Cities			
San Jose	2,900	11,927	25,400
Milpitas	3,000	11,543	23,400
Campbell	3,000	11,865	25,100
III. Western Foothill Cities			
Los Altos Hills	5,600	25,593	50,000+
Los Altos	4,600	18,208	41,600
Saratoga	3,900	19,838	46,400

Table 13a, continued

Monte Sereno	3,200	17,903	44,700
Los Gatos	3,600	13,875	33,000
IV. South Valley Cities & Rural Areas			
Morgan Hill	3,200	10,211	23,200
Gilroy	2,700	10,131	22,200
Unincorporated Areas	3,500	11,598	24,800
COUNTY TOTAL	$ 3,600	$ 12,456	$ 27,300

Sources: Median Income, Occupation, Education and Minority Population from Santa Clara County Planning Office, INFO No. 469 "Socio-Economic Characteristics, Cities, Santa Clara County, April 1, 1970" (November, 1972).

Assessed valuations from Santa Clara County Planning Office, INFO No. 565 "Assessed Valuation by City, Select Years, Santa Clara County, 1959-1976" (January, 1976).

Home values from Santa Clara County Planning Department "Housing Characteristics, Cities, Santa Clara County, 1970".

Table 13b.

Socio-Economic Indicators,
By City, Santa Clara County

	Occupation of Employed Persons, 1970: Prof., Tech., + kind, Managers and Administrators	Occupation of Employed Persons, 1970: Craftsmen and Operatives	Education Levels: Percent Persons of Age 25 or over with 4+ Years of College Education 1970	Minority Population; Percent of Spanish-Americans in Total, 1970
I. North County Cities				
Palo Alto	50.6%	10.3%	41.7%	5.7%
Mountain View	37.2	19.1	23.6	14.0
Sunnyvale	34.6	24.0	19.5	13.3
Santa Clara	25.9	27.8	12.6	18.1
Cupertino	45.8	16.3	29.5	6.4
II. Central and East Valley Cities				
San Jose	29.3	24.9	15.0	21.8
Milpitas	22.1	34.7	7.3	18.6
Campbell	26.7	25.0	13.4	10.5
III. Western Foothill Cities				
Los Altos Hills	63.2	6.3	52.9	n.a.

Table 13b, continued

Los Altos	53.1%	10.2%	38.7%	5.1%
Saratoga	54.0	9.6	37.1	5.3
Monte Sereno	53.4	13.9	34.7	n.a.
Los Gatos	32.8	16.1	26.1	4.9
IV. South Valley Cities and Rural Areas				
Morgan Hill	26.5	22.1	10.9	28.5
Gilroy	21.2	29.9	9.0	46.1
Unincorporated Areas	30.0	23.8	18.0	n.a.
COUNTY AVERAGE	33.1%	22.7%	19.5%	17.5%

Sources: Median Income, Occupation, Education and Minority Population from Santa Clara County Planning Office, INFO No. 469 "Socio-Economic Characteristics, Cities, Santa Clara County, April 1, 1970" (November, 1972).

The county's most affluent professionals and executives reside in the western foothill cities; Los Altos, Los Altos Hills, Saratoga and Monte Sereno are all new cities which sprang up with the development of the electronics industry. Los Altos was incorporated in 1952, the other three in 1956 and 1957. These cities contained about 14% of the county's total population in 1975. Including Palo Alto in this cluster (with its similar professional, high income population), raises the percentage to 20%.

In 1969, the median family income in these foothill cities was at least 50% higher than the county average, with Los Altos Hills leading the county at $25,593. This was more than double the median family income of $11,927 in San Jose. Likewise the median value of owner occupied houses in these foothill cities was above $41,000 in 1970, with the median houses in Los Altos Hills valued at over $50,000. This compared to a county-wide average of $27,300 and only $25,400 in San Jose. As a result, while a town like Los Altos Hills contains no commercial or industrial property, it has the second highest assessed valuation per capital in the county (Palo Alto is first).

Over 50% of the employed residents of the foothill communities were in professional, technical or managerial occupations, and well over 35% of persons over 25 years old had four years or more of college education. Only about 10% of the residents are employed as craftsmen or operatives. Finally, these communities are predominantly Anglo American, with an average of only 5% Hispánic populations. The county average is 17.5%

The northern cities of Palo Alto, Mountain View, Sunnyvale, Santa Clara and Cupertino form the industrial "jobs belt" of the county. They contain about 27% of the county's total population, and the vast majority of electronics production. The concentration of electronics facilities in these cities is reflected in the per capita assessed valuation of property. These cities have the highest valuations in the county, ranging from \$4,200 in Santa Clara and Sunnyvale to \$7,200 in Palo Alto. By contrast, the assessed valuation in San Jose is only \$2,900 per capita. Palo Alto stands out from the other cities in this northern cluster for its unusually high percentage of professionals, its highly educated populace and correspondingly higher median family incomes, all clearly a result of the location of Stanford University in the city.

Taken as a whole, the northern cities are the home of a mixed, and predominantly intermediate occupational and socio-economic strata of the county. The percentage of professionals and technicians and the education and income levels of their populations all fluctuate close to and slightly above the county-wide averages. They also contain percentages of craftsmen and operatives and of Hispanics which are approximately equivalent to the county averages.

There is a clear north-south continuum among the four north county cities of Palo Alto, Mountain View, Sunnyvale and Santa Clara which correspond to the successive southward spreading of the electronics industry. Moving from north to south towards San Jose, the the education levels, percentage of professionals and property values in these cities declines gradually; conversely, the further south the city, the higher the percentage of craftsmen and operatives and of Spanish Americans in a city's population.

Over half of Santa Clara County's total population resides in the three central and east valley cities of San Jose, Milpitas and Campbell. The "bedroom" city of San Jose alone accounted for over 47% of the county's population in 1975. This cluster of cities is thus the home of half a million people, over a quarter of whom are employed as craftsmen and operatives. At the same time that they contain the majority of the county's blue collar production workers, these cities have among the lowest percentage of college educated residents and professional, technical and managerial employees in the county. In 1969, median family income for these cities was consistently below the county average, as were the median home values and assessed property valuations. 21.8% of San Jose's population is Hispanic, the largest concentration of Spanish speaking people in the county.

Finally, the cities of the far south valley, Morgan Hill and Gilroy, and the unincorporated areas are the home of the poorest 13% of the county's population. While the rural, unincorporated areas, the only remaining cultivated agricultural land in the county, are marginally better off than the cities, on the average, the median family income in these two older cities was the lowest in the county, about $10,000 in 1969, as compared with the $12,456 county average. Likewise, house values were well below even those in San Jose and only about 9% to 10% of their population were college educated in 1970. Morgan Hill and Gilroy also have the largest percentages of Spanish Americans out of total population in the county, with 28.5% and 46% Hispanic populations respectively in 1970.

While their low percentages of professionals and technical workers (about 21% to 26% in 1970) are no surprise, their equally low representation in crafts and operatives occupations, (about 22% to 29% in 1970), is explained by the unusually large percentage of laborers, farmers and farm laborers in this part of the county. Only 1% of the county's total population is classified as farmers or farm laborers, while Morgan Hill, Gilroy and the unincorporated areas contained 5.9%, 5.5% and 3.4% respectively. Finally, while the countywide unemployment rate was 5.7% in 1970, it was almost double that in Gilroy, with 10.1% of the population unemployed (SCCPD, INFO 469).

In sum, the residential patterns of the population of Santa Clara County replicate the dichotomized occupational and class structure generated by the dominant electronics industry onto the organization of urban space. The affluent professional-managerial strata of electronics employees are insulated in the western foothill cities, in Palo Alto, and to a lesser extent in the other north county industrial cities with easy access to the electronics complex clustered around Stanford, while the large low income minority production workforce is concentrated in the bedroom city of San Jose and the adjacent cities of Milpitas and Campbell. The county's remaining agricultural workers and poorest, least educated residents are concentrated in the old south valley cities and unincorporated areas.

Residential segregation allows for the reproduction of the differing qualities of labor power for electronics production. Each of the different communities has different institutions, public services and levels of social consumption which are suited to the reproduction needs of the segment of the workforce that resides there.

The differential nature of reproduction in Santa Clara County's class segregated communities is highlighted by the variations in residential densities and the type of housing structures across cities. (See Table 14.) While north county industrial cities are densely settled the western foothill cities average only a single dwelling unit per residential acre. In Los Altos Hills, there was an average of one dwelling unit for every two acres in 1979. By contrast, San Jose and the remaining East and Central valley cities averaged about six dwelling units per acre of residential land. Further, the residents in the western foothill cities are overwhelmingly single family homes. All of the building permits for Monte Sereno and Los Altos Hills and 93.6% of those for Saratoga between 1960 and 1969 were for single unit structures, while in San Jose and the south valley cities, about 35% of the residential construction permits were for multi-unit housing.

The wide variations in assessed property valuations among the county's cities in turn generates vastly different tax bases. The north county and western foothills have strong tax bases and thus provide high quality public services such as parks and schools for their residents without relying on excessively high tax rates, while

TABLE 14.

Density of Residential Development, by City, Santa Clara County

	Average Dwelling Units per Acre of Residential Land (1979)	Type of Dwelling Unit Authorized by Building Permits 1960-69 (Percent Distribution)		
		1 Unit	2-4 Units	5 or more Units
I. NORTH COUNTY				
Palo Alto	20	15.9	8.3	75.8
Mountainview	12	10.7	13.7	75.5
Sunnyvale	10	41.5	20.5	38.0
Santa Clara	18	26.3	20.9	52.8
Cupertino	7.5	50.3	18.8	30.9
II. CENTRAL VALLEY				
San Jose	6	65.1	15.1	19.7
Milpitas	6	81.8	15.7	2.4
Campbell	5	40.4	41.3	18.3
III. WESTERN FOOTHILLS				
Los Altos Hills	0.5	100.0	0	0
Los Altos	3.5	75.4	10.3	14.3
Saratoga	1.5	93.6	0.6	5.8
Monte Sereno	1	100.0	0	0
Los Gatos	1	51.7	13.3	35.0
IV. SOUTH VALLEY				
Morgan Hill	5	61.9	28.1	10.0
Gilroy	7.5	63.3	16.5	20.2
Unincorporated Areas	n.a.	40.7	8.4	50.9

Sources: Santa Clara County Manufacturers' Group. "Vacant Land in Santa Clara County. Implications for Job Growth and Housing in the 1980's" (1980).

Santa Clara County Planning Office. INFO no. 401. "New Dwelling Units Authorized By Building Permits, By Type of Structure. Annually and Cumulative. 1960-1969, Cities and Unincorporated Areas, Santa Clara County" (November, 1970).

the poorer central county cities must set much higher tax rates in order to simply maintain an adequate level of services.

Schools are a key element in differential reproduction of classes, and the income disparities between the county's school districts is dramatic. In 1975-76, for example, Palo Alto Unified School District had well over twice the assessed value per high school student of San Jose's East Side High School District and between three and six times the assessed valuation of San Jose's elementary school districts. The Mountain View-Los Altos High School district has an even higher tax base per student. (See Table 15.)

The county's western foothill cities and Palo Alto are an ideal environment for professional and upper class reproduction. As one industry representative noted, "Our firm remained here because it's an ideal place for millionaires to live." (Interview). The area retains the peaceful, orchard-like character which the whole of the Santa Clara Valley was so famed for during the first half of the century. As a 1970 real estate ad headlined "Country Living" described it, "There's a place where there are still plenty of trees, flowers, fields, orchards, rolling hills . . . your dream and your children have room to grow . . . a beautiful place to live" (San Jose Mercury, 8/16/70). A local newspaper article described the band of residences in the western hills as the most desirable housing in the South Bay area, with large luxury homes set in an attractive rural setting and distinguished by such features as:

> Innovative bathrooms, the vast ones with spa tubs and adjoining private sun decks; tennis and racketball courts; acreage; exercise rooms; quality finishing details; lots of

Table 15.

Tax Base by School District, Santa Clara County

School District	Assessed Valuation per Unit of Second Period, 1975-1976 Elementary	High School
Campbell H.S.		$ 40,931
Cambrian	$ 22,371	
Campbell	30,250	
Luther Burbank	24,380	
Moreland	21,355	
Union	14,544	
East Side H.S., San Jose		40,473
Alum Rock	9,109	
Berryessa	12,487	
Evergreen	14,544	
Franklin McKinley	18,624	
Oak Grove	9,715	
Orchard	15,286	
Fremont H.S.		56,250
Cupertino	22,013	
Montebello	62,372	
Sunnyvale	46,575	
Gilroy	21,617	54,301
Los Gatos H.S.		51,840
Lakeside	49,483	
Loma Prieta	29,432	
Los Gatos	35,050	
Saratoga	31,759	

Table 15, continued.

School District	Elementary	High School
Milpitas Unified	23,386	39,462
Morgan Hill Unified	16,463	56,661
Mountain View - Los Altos H.S.		100,480
Los Altos	52,872	
Mountain View	64,499	
Whisman	37,696	
Palo Alto Unified	56,734	96,010
San Jose Unified	26,262	54,935
Santa Clara Unified	35,950	68,593

Source: Pacific Studies Center (1977) Silicon Valley: Paradise or Paradox? p. 5.

> closets; the three car or better garage; quarters for hired help; building design aimed at effortless entertainment and plenty of floor space are features at the top of the luxurious home market.
>
> Recent sales in the over a half million dollar homes have featured a racquetball court in a windowed basement and a swimming pool designed like a forest grotto complete with waterfall (San Jose Mercury, 5/10/80).

These communities are designed to remain well insulated from the communities to the south and east which house the county's large industrial workforce.

The environment of San Jose features endless stretches of poorly constructed "cracker box" tract homes, strip commercial development, and octupus-like freeways. Many residents are housed in inadequate, crowded and often dangerous housing units. A 1968 study noted that much of San Jose's housing was substandard and had degenerated into areas of "blight" almost immediately. It identified sixteen neighborhoods in San Jose which suffered from critical levels of substandard housing (over 20% substandard housing) and described the corresponding "social pathologies" which characterized these neighborhoods (San Jose City Planning Department, 1968). Furthermore, the agricultural lands lost to development in San Jose were not replaced by other forms of open space. In contrast to the foothill cities, San Jose provides minimal recreational open space for its residents. In 1971, the city of San Jose maintained a ratio of approximately 8.0 acres of open space per 1000 people. (This level represents a 5 yard by 7 yard plot of ground per person . . . and more than half of the city's "open space" consists of school playgrounds.) By comparison, a recent study of the Bay Area recommended 15 acres per 1000 people as a minimum level. The relative inadequacy of San Jose's open space provision is also clear when contrasted with other metropolitan areas. In New York City, the 1971 ratio was 25 acres per 1000 people, in the San Francisco Bay Area, 35 acres per 1000 people, and in Washington D.C., the ratio was 71 acres per 1000 people (Stanford Environmental Law Society, 1971). Thus the problem of the unemployed, poor and minority populations of Santa Clara County have all been concentrated in the central and south valley cities. The political fragmentation of the county has left these concerns and costs in the hands of the city politicans of San Jose, Milpitas, Campbell, Morgan Hill and Gilroy.

Urban Contradictions: Shortages and Smog in Silicon Valley

Introduction. The evolution of the social structure and the land-use patterns generated by expansion of the electronics industry has undermined the profitability of Silicon Valley as a site for electronics production. According to local employers, their operations in Santa Clara County are seriously threatened by three major problems.[1] First and foremost, the unusually high cost of housing in the area is seriously limiting their ability to attract the highly skilled professionals essential to the industry. Secondly, local firms all suffer from a shortage of production-level workers because of the lack of affordable housing and the increasingly long and expensive commutes. Lastly, employers are very concerned with the so-called "anti-business" climate, especially in the wake of the recent moratorium on industrial growth spurred by the county's no-growth movement.[2] Thus the contradictions of the urban spatial structure are most manifest in the breakdowns of housing and transportation provisions and in the social response to the environmental degradation caused by rapid industrialization.

The labor shortages are real. Reams of want-ads in the local newspapers and the frequent radio announcements testify to the stiff competition over the local labor force. A typical Sunday issue of the San Jose Mercury has at least 65 pages of employment want ads. The Stanford Research Institute (SRI) estimates that there are currently a total of 10,000 unfilled jobs in the county (SRI International, 1980). National Semiconductor, for example, which currently employs nearly 9,000 people in the county, has an additional 1,000 job openings in Santa Clara alone. Intel, with approximately 6,000 employees county-wide, could hire an additional 400 now.

Evidence of the costs which each of these problems have imposed on local firms is also manifold. Employers have been forced to resort to a variety of incentives to recruit professionals from outside the area. Most common is the use of "bounties" or bonuses for their own employees if they refer a prospective employee who is eventually hired. Intel, for example, offers "bounties" on a sliding scale of $50 to $200 while Precision Monolithics, Inc. (PMI) offers $300 for a successful referral. Some firms also hire outside "headhunters" for this job (and pay them up to $1,000 per "head"), while other firms have designed special benefit and leave schemes or provided lotteries for vacation trips to lure new employees. Most firms have been forced to continually raise salaries in order to attract engineers to the area.

All employers also report shortages and extremely high turnover among low-skilled production level workers, with 33% being a modest estimate of the average turnover rate. Some have attempted to overcome this problem through paternalism and material rewards to workers. For example, in AMD's American Dream contest, one assembler received a $240,000 bonus, and others received Cadillacs and color televisions (San Jose Mercury, 4/28/80). Others have offered everything from free bus tickets to eye examinations to their new employees. Still other firms have chosen to revise their hourly wage rates upwards as well. AMD, for instance, recently raised their entire wage scale, instituting a minimum starting wage of $4.00 per hour, (previously they paid $3.25 per hour), for unskilled workers. They now have the highest wage scale in the county, with a top hourly wage for experience fabrication workers of $8.00 per hour. Finally, larger firms like Varian and Hewlett-Packard have also invested substantial amounts of money in providing van-pools and carpool arrangements.

Furthermore, the no-growth advocates in the county have succeeded in shifting some of the costs of the housing and transportation problems caused by industrial expansion back onto local firms. In Palo Alto, for example, firms are required to pay "in lieu" fees for all new industrial development in the city to go towards a fund for low and moderate income housing. Sunnyvale recently imposed requirements which will cost Lockheed an estimated $2.6 million in exchange for approval of a one million square foot expansion of their plant. The company will have to contribute funding for such things as traffic signal improvements, road improvements, and the development of additional traffic lanes in the city.

As these economic, social and political costs continue to rise, Santa Clara County becomes less and less desirable as a site for electronics production. The labor shortages and the no-growth movement plaguing Silicon Valley's producers are rooted in the specific class structure and pattern of urban development generated by the electronics industry. The nature of production in electronics has proven contradictory by generating both an urban structure and a socio-political environment which are major obstacles to further growth.

The Housing Crisis. In 1980, the average home price in Santa Clara County passed the $100,000 mark (San Jose Mercury, 4/6/80). With average home prices in the valley almost double those of other western states, local firms find it is nearly impossible to lure experienced engineers from jobs in the sunbelt states or even from the Northeast. The average single family dwelling in the Greater Dallas County (Texas) area cost $64,108 in October, 1979, while during the same month in Santa Clara County the average price was $98,256. Thus semiconductor manufacturers, whose prime out-of-area competitors are in Texas and Arizona, are adversely affected. Unless local firms are able to pay dramatically higher salaries than their competitors, experience professionals who move to the valley must take a considerable cut in their standard of living to afford the housing costs.

During the 1970's housing prices in Santa Clara County began to skyrocket. In 1970, the median priced home in the county cost $23,800. By 1975 it had almost doubled to $45,700. By 1980 it had double once again. Thus over the decade, housing prices in the county increased by an average of 20% a year (Santa Clara County Housing Task Force, 1977). Although home prices have risen significantly in all parts of the country, the price increases in Santa Clara County have vastly outpaced the national average. Between 1970 and 1975, in the nation as a whole, the price of a median priced new home increased 68%, from $23,400 to $39,300; while in Santa Clara County during the same period, the prices increased by 92%. The increases in home prices have surpassed even those of California alone. While home prices in the state as a whole increased 32% from 1976 to 1977 (from $47,000 to $62,000), prices in Santa Clara County rose 40% (from $52,500 to $73,500) (Santa Clara County Housing Task Force, 1977).

The rising cost of materials, land, site improvement, labor and construction account for a sizable portion of these home price increases. The Santa Clara County Housing Task Force (1977) estimated that the most significant components contributing to the increase in home sales price between 1968 and 1976 were material costs (26.1%), profit and marketing expenses (18.3%), raw land prices (13.9%) and improvements for land (13.6%). More recently, the construction costs appear to have declined in importance relative to profits. According to a recent study, the builder's profit contributed to the increase in the cost of housing for comparable houses in the county between 1966 and 1977. Profits were reported to have jumped from 9.1% to 21.6% of the total selling price of completed units (California Builder, April, 1977). The Stanford Research Institute estimates that in 1979, residential real estate profits alone exceeded $30 billion. (That is more than the profits of the 15 largest oil companies during the same year. SRI International, 1980.) This figure includes the large gains made through speculation, which has become a major force contributing to price inflation. According to the Santa Clara County Housing Task Force (1977), at the height of the speculative boom, one out of every three households bought in the county was bought by someone not planning to occupy that house. This has accelerated the rate of price inflation by adding to demand and further restricting supply.

The increase in profit margins testifies to the one unique force at work in Santa Clara County, to the massive imbalance of supply and demand for housing. Housing supply simply has not grown in pace with the county's rapid job growth, and strong demand in a tight market has allowed profits to soar.

In 1977, the county suffered from a shortage of 50,000 housing units. Since then, employment has continued to grow but housing provision has lagged still further behind. From 1977 to 1978, 50,000 new jobs were created in the county, but only 10,020 new housing units were added. In 1979, 90,000 new jobs were created while only 23,000 new housing units came on to the market (Security Pacific Bank, 1979; SRI International, 1980). Thus by 1980, there were about 670,000 jobs in the county and only about 480,000 housing units (San Jose Mercury, 3/14/80). One projection for industrial expansion estimated a countywide increase of between 100,000 and 150,000 additional jobs by 1990, which would push the total number of people working in the county but unable to live there to over 100,000 (Santa Clara County Housing Task Force, 1977).

Meanwhile, the spatial imbalance of jobs and housing in the county is being further exacerbated. The concentration of industrial growth in the northwest cities of Palo Alto, Mountain View, Sunnyvale, Santa Clara and Cupertino has continued, while most new housing construction is occuring further and further from these new jobs. The remaining land zoned for residential uses in the county is concentrated overwhelmingly in east and south San Jose, Gilroy and Morgan Hill.

According to the Santa Clara County Industry Housing Management Task Force, (1980), 60% of all housing and population growth is expected in the city of San Jose alone, particularly those areas to the south of the city center. Furthermore, if existing land use plans are followed and built out according to the designated uses, the Task Force predicts that the number of jobs in the county will double, while housing will increase by only one-third. Such a situation will leave 325,000 people employed in the county without the possibility of housing at any price.

One element in this county-wide shortage of housing capacity is widespread zoning changes from residential to industrial usage undertaken by city governments during the 1960s and early 1970s. This rezoning was motivated by the desire to gain valuable tax bases from industrial development. Data compiled by the County Planning Department shows that the total number of housing units that could be accomodated at buildout by local plans fell from 978,000 in 1965 to 561,000 in 1975, a decrease in capacity of 417,000 housing units. Most of this rezoning occured in the five northern cities (Santa Clara County Housing Task Force, 1977).

The housing shortage is also directly related to the differential nature of reproduction required for the major segments of the electronics workforce. A crucial constraint on the growth of the housing supply is the land-use policies and restrictive planning practices imposed by the cities of the north and northwest foothills to preserve an appropriate environment for their higher income professional residents. Through the mechanisms of local land-use plans, restrictive zoning and social and economic controls, the cities containing the more affluent professional and managerial segments of the county's labor force have protected the rural, isolated nature of their communities by allowing only large single family homes on vast lots of land. This demand for ownership of significant amounts of land for leisure purposes--an attempt to mimic upper-class lifestyles--has dramatically reduced the land available in the county for housing.

Downzoning of land from multi-family to single family housing or from higher to lower density development by local governments are prime examples of this phenomenon. The effects are most evident in the most affluent and predominantly professional foothill cities. In Los Altos Hills there are two acres of residential land for every home, and in Monte Sereno and Los Gatos there is an average of only one home per acre (Santa Clara County Manufacturing Group, 1980). There is strong community concern for protection of the character of the surrounding environment in other parts of the county as well. In 1972, Palo Alto zoned its foothill areas almost exclusively for open space, thus limiting the city's potential residential land and boosting property values (Greenberg, 1974). The northern cities have consistently resisted the construction of high-density and low to moderate income housing. While often acknowledging the need for more housing in the county, the response is always that of the need to protect the local environment--"Not in my neighborhood!" Attempts by local governments to avoid problems of urban congestion through residential growth management and low density zoning have thus drastically reduced the aggregate amount of housing which can be produced in the county. Low density residential dvelopment which preserves the spacious and rural nature of these class segregated suburban communities has thus severely limited the supply of developable land area in the valley, and has created an artificial, socially generated shortage of land available for housing.

The inflation of housing prices is exacerbated by the nature of the electronics workforce. As employment increases, a large percentage of the new jobs created are very high-paying professional and executive jobs requiring employees from outside of the county. Their incomes are five to ten times those of the industry's production workers. Job growth in electronics continually draws more of these well paid workers into the county and given their higher buying power and the shortage of overall supply, these newcomers have bid up housing prices in the county to levels whcih only their incomes can bear. New workers are being drawn into the county for high paying jobs at a rate that is much faster than the supply of housing can accomodate.

Inflationary pressures on home prices originated in the most socially desirable north and northwest foothills near to where most of the electronics jobs are concentrated. In Palo Alto, for example, the price of an average home rose 73.7% between 1970 and 1975 (from $33,900 to $58,900) while in San Jose, the average home price rose only 47% (from $25,400 to $37,400 during the same period (Santa Clara County Housing Task Force, 1977). Eventually, however, as the north county supply of housing reached its limit, demand by the higher income workforce has filtered further and further south in the county. Between

1975 and 1979, home prices rose 154.6% in Palo Alto (from $58,900 to $150,000) and 145% in San Jose (from $37,000 to $92,000) (Electronics, 2/28/80). (See Table 16.) Unable to find housing in the foothills and north county cities, professionals began settling in the most desirable areas of north San Jose. New developments also sprang up further south in the foothills, in Saratoga, Monte Sereno and Los Gatos.

Currently, the price of a "decent, middle class" home in the north county is at least $150,000 (SRI International, 1980). According to a local newspaper,

> The type of home an executive might want, one with three or four bedrooms and several baths, would cost about $400,000 in the Saratoga or Los Gatos areas--favorite home-hunting grounds for up-and-coming electronics executives. (San Francisco Examiner, 11/13/80)

The western foothill areas of Los Altos, Cupertino, Saratoga, Los Gatos and Los Altos Hills are the setting for the most expensive housing in the South Bay area, with a good many homes selling for over $500,000. Some of the hillside estates have price tags of over one million. A recent article in the local newspaper listed nine homes with prices over half a million, and one five bedroom home with a tennis court and swimming pool listed for $1,265,000 (San Jose Mercury, 5/10/80). In these socially desirable, status areas of the county, the price of a house has little to do with the costs of construction. Prices have risen as high as the market will bear. Obtaining a building permit in the area has been compared with having a license to print money, as the profit available to developers is enormous.

TABLE 16.

Median Home Values: Palo Alto, San Jose, Santa Clara County.
Select Years, 1970-1980 and Percentage Increases.

Year	Palo Alto	San Jose	County
1970	$33,900	$25,400	$23,800
1973	56,000	33,000	31,200
1975	58,900	37,400	45,700
1979	150,000	92,000	98,256
1980	n.a.	n.a.	102,000

Percentage Increase in Median Home Values

1970-1975	65%	29.9%	31%
1975-1979	154%	146%	115%

Sources: Santa Clara County Housing Task Force. "Housing: A Call For Action" (1977).

"Silicon Valley Is Filling Up" Electronics (February 28, 1980).

Housing costs are rising much faster than incomes. A growing percentage of middle income families cannot afford to own and maintain a median priced new home in the county, and thus are being forced into the rental market. From 1971 to 1977, median home prices rose from $24,300 to $61,900, or 151.4%, while the median income rose only 42.5%, from $12,358 to $17,610. Estimates indicate that while in 1970, less than 20% of the average family income went towards shelter, by 1979 it was approaching 40%, and even higher for those just entering the housing market (Lefaver, 1980). To purchase a typical single family home in the county today, the prospective owner must earn well over $35,000 a year (Lefaver, 1980). The price of a single family home has thus increased beyond the means of a majority of the county's population.

The housing problem has been exacerbated by a severe shortage of rental units. Since construction of single family homes is so profitable, there is little incentive to build multiple family residences. The return on an investment in multiple family dwellings is low relative to the return on the same investment in single family dwellings. Furthermore, zoning regulations encourage single rather than multiple unit construction. The county's rental stock has thus grown at an even slower rate than the overall housing supply. The number of building permits authorized annually for multiple family units between 1974 and 1977 was never more than half of the total number authorized for single family units. During the entire time period, 26,920 new single family units were authorized, while only 12,629 new multi-family units were authorized (Santa Clara County Housing Task Force, 1977). Between April 1975 and 1979, only 10,000 new rental units came onto the market in Santa Clara County (Los Angeles Time, 12/2/79). Thus in 1980, when the vacancy rate for rental housing hit an all time low of 1.4%, the average cost of a one-bedroom apartment was over $350 per month, and well over $400 per month for two bedrooms (San Jose Mercury, 4/9/80).

In addition to the low construction rate for multi-family units, the recent spate of condominium conversions by apartment owners in the county has further reduced the supply of rental units. Such conversions have yielded substantial profits to the owners, especially given the tight housing market, but have further exacerbated the shortage of affordable housing for the county's low income households.

While the housing crisis is putting a strain on middle income households, it is far more severe for the county's low income population. The average wage earner cannot afford the price of the lowest cost new single family home in the south county. Even renting does not insure adequate affordable housing for many.

Low and even middle income families now find it almost impossible to find affordable shelter, especially near work centers. The least costly houses and apartments are in central and east San Jose and the South County cities, with extremely long commutes to the job areas. Much of the county's low income working population is literally being forced out of the area. With incomes that have failed to rise in pace with the inflation of housing prices, these families are rapidly being displaced--forced to locate further and further away from the job opportunities, and increasingly, out of the county altogether.

According to the director of the Santa Clara County Housing Authority, there are 7,000 to 8,000 people in the county today who are in immediate need of adequate housing. At any one time the housing authority has at least 2,000 homeless families on its files, and it is currently receiving about 150 phone calls a day from people needing help. With the average rent for a one-bedroom apartment between $350 and $375, low income families cannot afford to pay the first and last month's rent plus a deposit which most landlords require. The total initial payment thus amounts to about $800 or $900 at the minimum. Most low income families simply do not have that much money.

The county's homeless people--both new arrivals lured to the area by jobs or longtime residents who have been evicted because they cannot afford the escalating rents--are thus crowded into charity homes or sharing the already crowded apartments or garages of friends. Many are living in their cars (San Jose Mercury, 4/9/80 and 4/21/80).

Silicon Valley's large low income population is thus gradually being forced south into the least desirable housing in the county, and often out of the county altogether. This in turn has exacerbated their financial problems by forcing them to spend a larger proportion of their budget on transportation.

Thus the restricted supply of housing and rapidly inflating prices are increasing the economic polarization within Santa Clara County. Any job growth in electronics requires highly paid engineers from outside of the county. This, in turn, puts further pressure on housing prices and displaces more people. The county's low income population is living in less and less desirable areas further removed from their workplaces at the same time that firms are raising the salaries of their engineers and professionals to compensate for the inflated housing costs.

Transportation. The spatial imbalance of jobs and housing in Santa Clara County has always meant long commutes for some. During the 1970s, however, as the county's population continued to explode and as rising housing costs resulted in the relocation of a growing proportion of the county's workforce further and further from the north county, the problem of transportation reached crisis proportions. According to the personnel manager of Intel, "We're in trouble with our commuting patterns. Eventually the local labor force isn't going to be able to get here because of the crowded highways." (Los Angeles Times, 12/2/79).

By 1975, the high volume of peak hour traffic had created severe congestion on all of the county's major freeways and expressways. An average ten mile commute in the county today takes at least half an hour, while many local workers commute two to three hours daily (Santa Clara County Industry Housing Management Task Force, 1979).

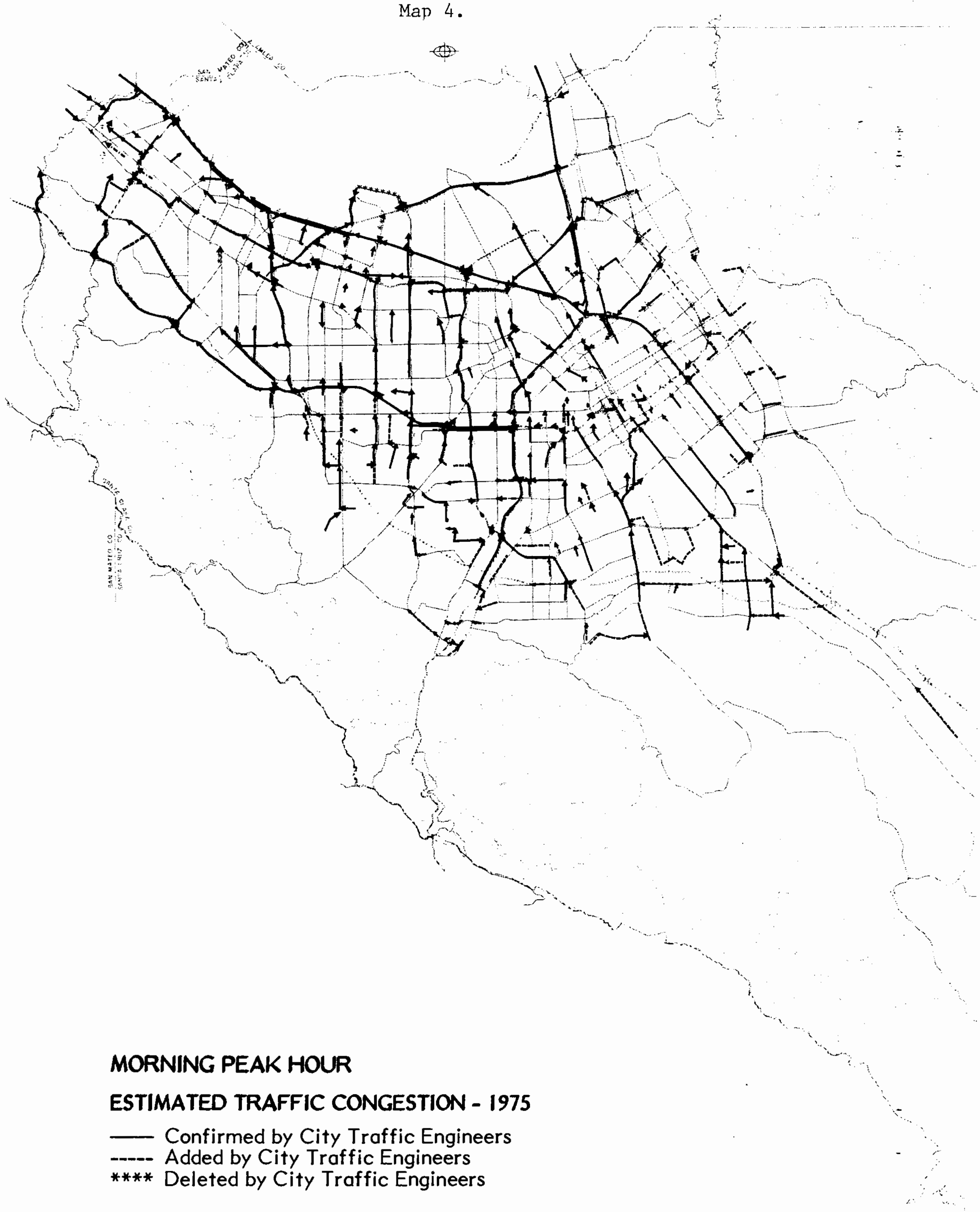
Santa Clara county residents are heavily dependent upon private automobiles for transportation, since there are few viable mass transit alternatives.[3] The trend is towards even further dependence. A recent Transportation/Land Use Study by the Santa Clara County Planning

Department (1979) notes that automobile ownership has been increasing significantly in the county. In fact, Santa Clara County now leads the state's counties in the number of cars per household, with an average of three cars for every five persons. This study also notes that in 1975, transit ridership accounted for only one percent of total county travel, and the Southern Pacific railroad accounted for less than one-sixth of one percent of daily travel. Finally, not only is travel in the county almost exclusively by automobile, but the auto occupancy is extremely low. The study reports that in 1975, during the peak driving hours auto occupancy was 1.18 for the average work trip.

In 1875, over four million automobile trips were taken daily in Santa Clara County. Of these, about 20% or 800,000 were home based work trips. The imbalanced location of housing and jobs in the county has meant that most of these work trips were long, slow and costly. The pattern of traffic congestion highlights the distorted utilization of the roadways resulting from industrial clustering in the northwest cities. Most morning peak hour traffic flows from the southeast to the northwest, from housing to jobs, while the reverse is true for the evening peak hour. The map of morning peak hour Estimated Traffic Congestion--1975 depicts the sections of the major roadways on which commuters were most likely to be forced to stop or slow down during their journey to work.[4]

This pattern is even more striking when these morning peak hour traffic flows are broken down for smaller spatial unis within the county (or Traffic Analysis Districts). As would be expected, the

Map 4.



MORNING PEAK HOUR

ESTIMATED TRAFFIC CONGESTION - 1975

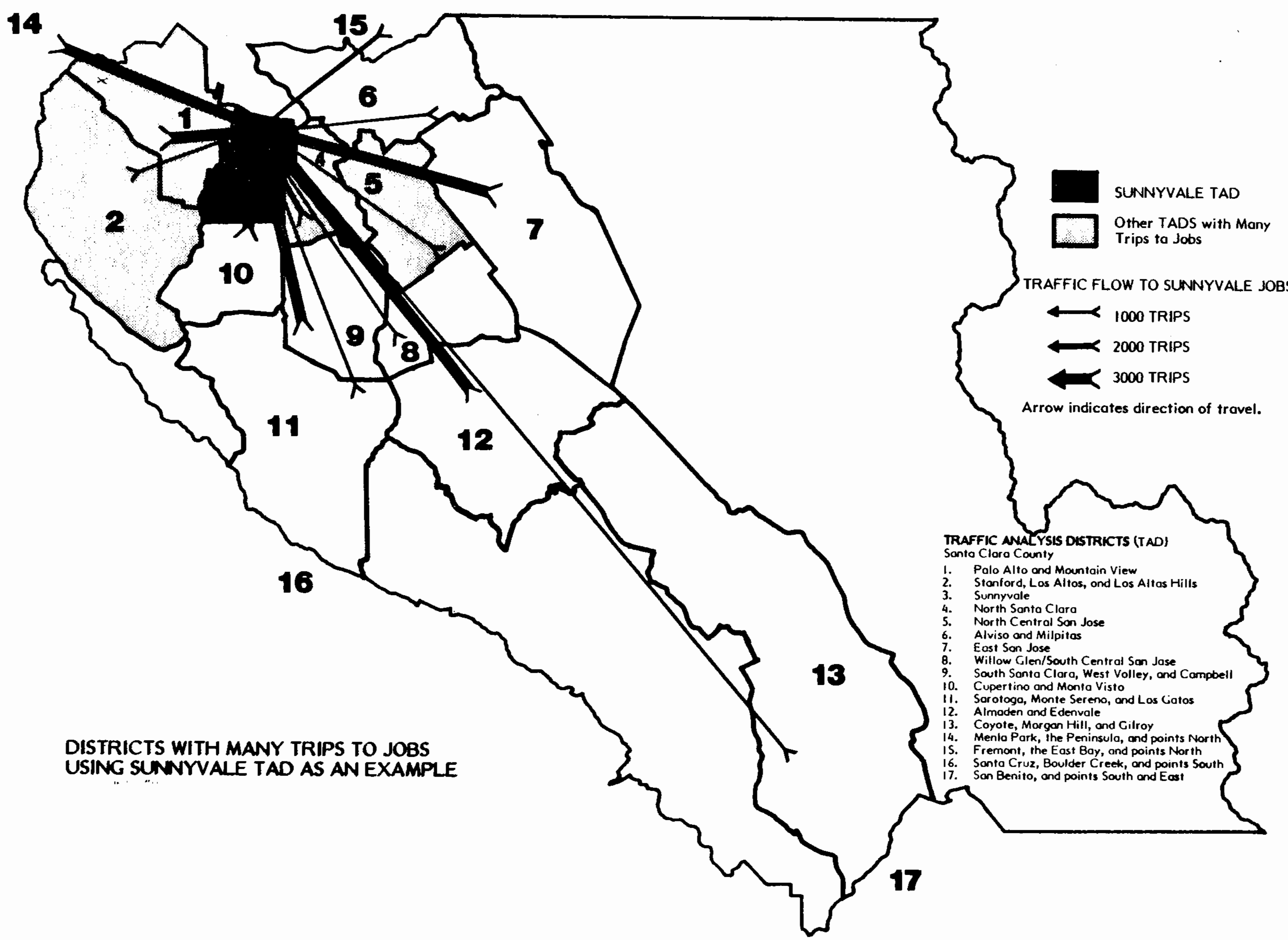
—— Confirmed by City Traffic Engineers
----- Added by City Traffic Engineers
**** Deleted by City Traffic Engineers

SOURCE: SANTA CLARA COUNTY PLANNING DEPARTMENT
JULY 1979

nature of the trips varies greatly between the areas of the county. In the highly industrial job areas of Palo Alto, Mountain View and Sunnyvale, well over forty percent of the morning commute traffic was composed of vehicles entering the area, while in the highly residential areas of east San Jose, Almaden, Edenvale, Saratoga, Monte Sereno and Los Gatos, over fifty percent of their traffic was composed of vehicles leaving the area. The other predominantly industrial job areas of Santa Clara and north central San Jose experienced a.m. peak hour traffic which included a high percentage of vehicles travelling through the area as well as entering it. The centrally located residential areas of Campbell, Cupertino, West Valley, Willow Glen and south central San Jose, Alviso and Milpitas also experienced a high percentage of vehicles travelling through as well as leaving them. Finally, in the self-contained south valley areas of Morgan Hill and Gilroy, traffic was composed primarily of vehicles staying within the area (Santa Clara County Planning Department, 1979). Maps 5a, b and c graphically illustrate the major transportation flows in the various segments of the county. In Map 5a, Sunnyvale is used as an exmple of an industrial area where all traffic flows in to the jobs. Map 5b uses the south central San Jose area to illustrate the areas which are dominated by through trips, and Map 5c depicts the experience of the highly residential areas where most trips originate.

Severe transportation congestion is a direct counterpart to the housing crisis in Silicon Valley. Both derive from the county's distorted patterns of urban development and land use. Both are a product

Map 5a.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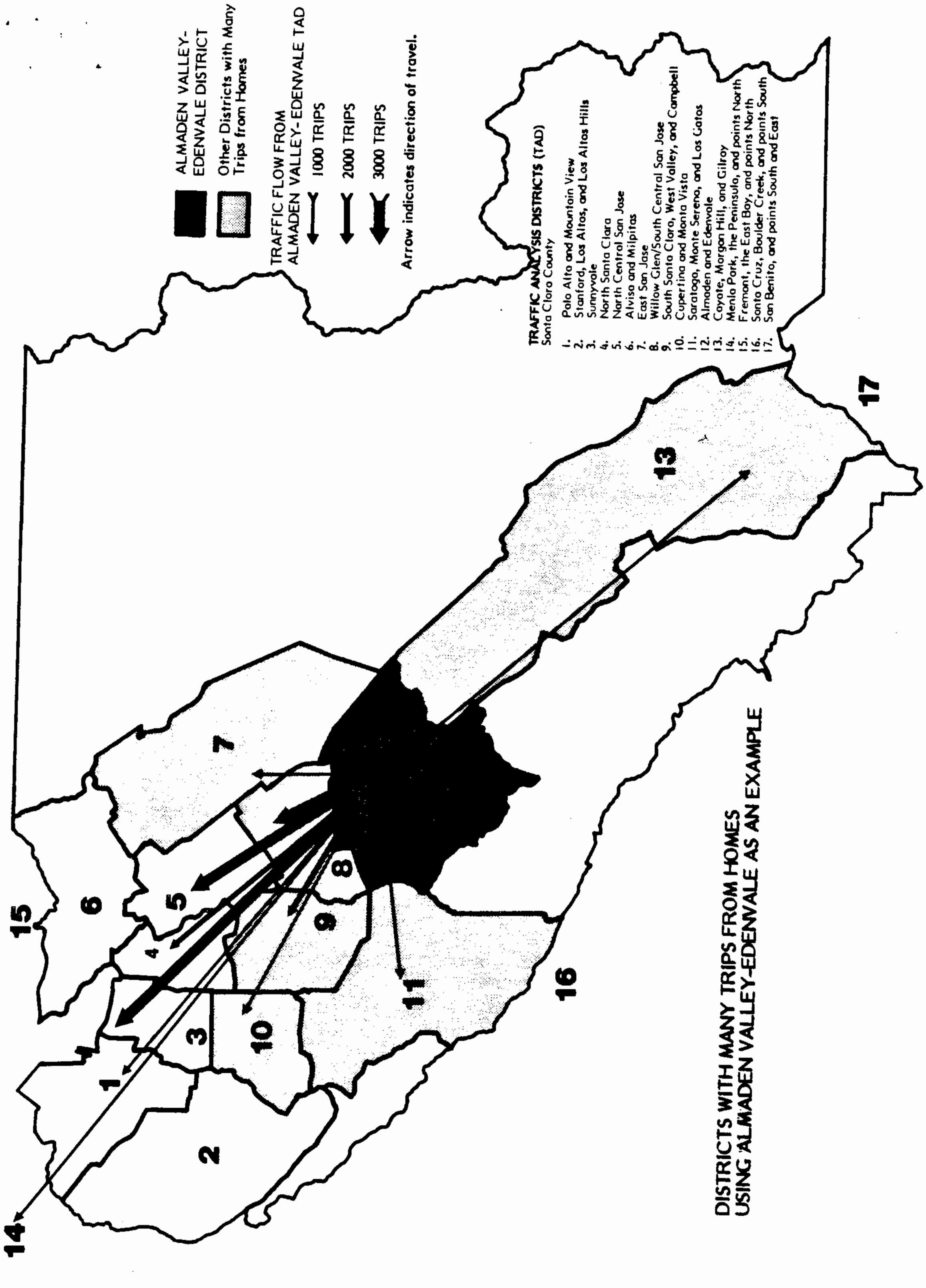
SUNNYVALE TAD
Other TADS with Many Trips to Jobs
TRAFFIC FLOW TO SUNNYVALE JOBS
1000 TRIPS
2000 TRIPS
3000 TRIPS
Arrow indicates direction of travel.
TRAFFIC ANALYSIS DISTRICTS (TAD)
Santa Clara County
1. Palo Alto and Mountain View
2. Stanford, Los Altos, and Los Altos Hills
3. Sunnyvale
4. North Santa Clara
5. North Central San Jose
6. Alviso and Milpitas
7. East San Jose
8. Willow Glen/South Central San Jose
9. South Santa Clara, West Valley, and Campbell
10. Cupertino and Monta Vista
11. Saratoga, Monte Sereno, and Los Gatos
12. Almaden and Edenvale
13. Coyote, Morgan Hill, and Gilroy
14. Menlo Park, the Peninsula, and points North
15. Fremont, the East Bay, and points North
16. Santa Cruz, Boulder Creek, and points South
17. San Benito, and points South and East
DISTRICTS WITH MANY TRIPS TO JOBS
USING SUNNYVALE TAD AS AN EXAMPLE

Map 5b.


ALMADEN VALLEY-EDENVALE DISTRICT
Other Districts with Many Trips from Homes
TRAFFIC FLOW FROM ALMADEN VALLEY-EDENVALE TAD
1000 TRIPS
2000 TRIPS
3000 TRIPS
Arrow indicates direction of travel.
TRAFFIC ANALYSIS DISTRICTS (TAD)
Santa Clara County
1. Palo Alto and Mountain View
2. Stanford, Los Altos, and Los Altos Hills
3. Sunnyvale
4. North Santa Clara
5. North Central San Jose
6. Alviso and Milpitas
7. East San Jose
8. Willow Glen/South Central San Jose
9. South Santa Clara, West Valley, and Campbell
10. Cupertino and Monta Vista
11. Saratoga, Monte Sereno, and Los Gatos
12. Almaden and Edenvale
13. Coyote, Morgan Hill, and Gilroy
14. Menlo Park, the Peninsula, and points North
15. Fremont, the East Bay, and points North
16. Santa Cruz, Boulder Creek, and points South
17. San Benito, and points South and East
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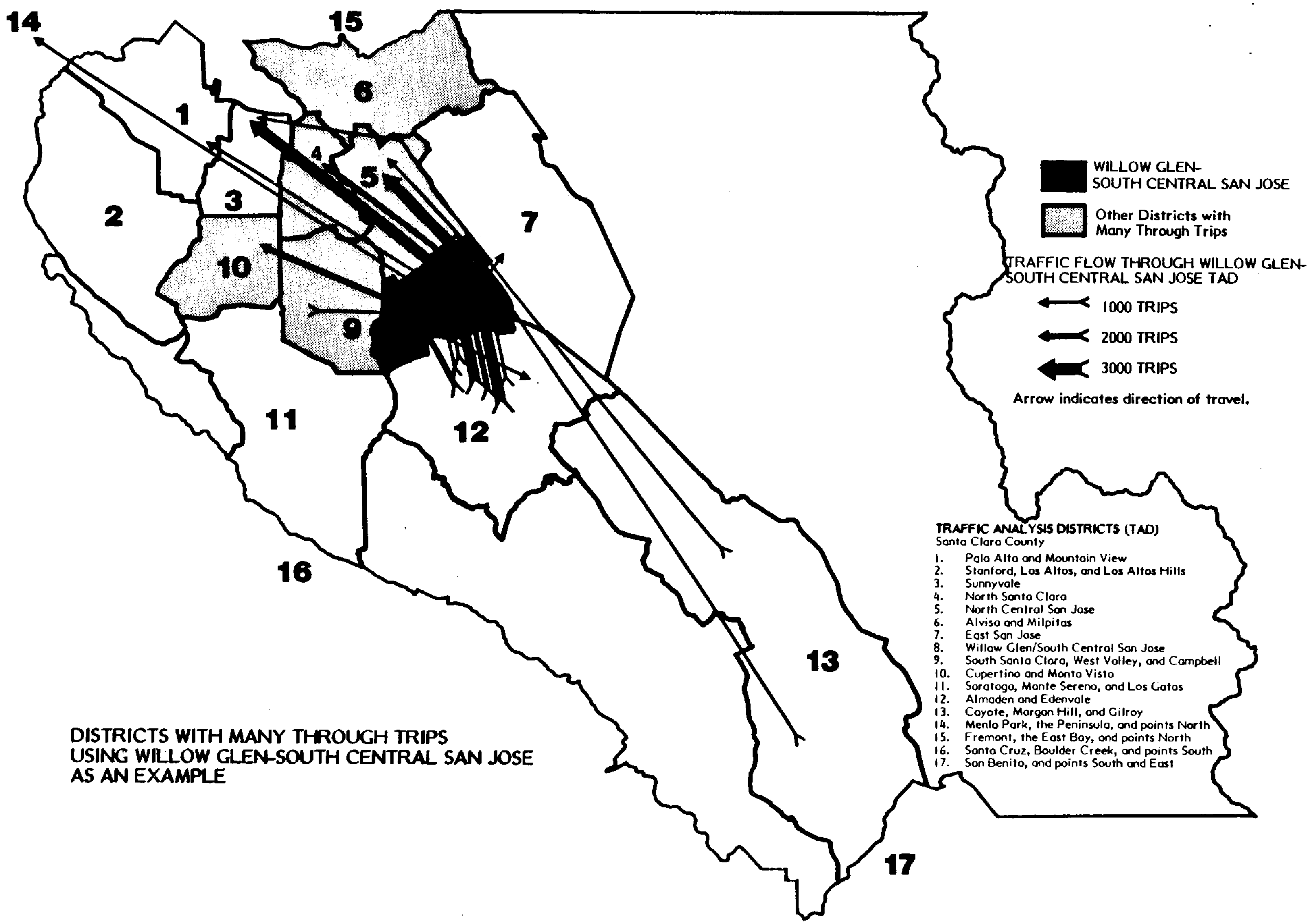
DISTRICTS WITH MANY TRIPS FROM HOMES USING ALMADEN VALLEY-EDENVALE AS AN EXAMPLE

Map 5c.



DISTRICTS WITH MANY THROUGH TRIPS
USING WILLOW GLEN-SOUTH CENTRAL SAN JOSE
AS AN EXAMPLE

of the unusually to-heavy class structure generated by electronics production. Just as the demand by the industry's large and growing professional middle class for spacious rural lots of land has limited the county's supply of developable land for housing, the spreading of this low density and highly land-consumptive form of development from its concentration in the north and northwest county southward into San Jose and the foothills in the southwest has exacerbated the congestion of already crowded highways. The sprawling of single family homes on large lots of land is rapidly consuming vast amounts of land surrounding the north county industrial belt. The large production workforce, which must still get to and from work daily, has in turn been pushed further and further from employment in the north county. The county's already crowded highways must thus accomodate longer commutes by the spatially distant production workforce along with a growing volume of commutes by more centrally located but sprawled-out engineering and managerial employees.

Thus the large low skilled workforce which is essential to electronics production is becoming less and less accessible to employers in Santa Clara County. Congestion and inflated housing and transportation costs are rapidly reducing the number of workers who can afford to live in the area and successfully travel to and from work every day.[5] Frustration with the long and costly commutes may well account for the high turnover rates in production jobs as well as for the overall shortage of less skilled labor.

The quality of life. Along with massive labor shortages, the speed and nature of urban development has severely affected the environment and the quality of life in the county. The Planning Department's 1979 transportation study forecast that by 1990, morning rush hour traffic would have grown 40%, but roadway capacity would increase only 10%.[6] Thus congestion, which is already severe, is predicted to become unbearable by the end of this decade. It is projected that there will be more than 130,000 cars competing to reach destinations in the Northwest part of the county during morning rush hours. That is more than ten times as manyvehicles as can be accomodated during a single hour on all six lanes of the Bayshore freeway. The study concludes that,

> As now planned, the land use patterns and growth rates of Santa Clara County will overwhelm the capacity of the major roadways in the urban area by 1990. The results will be delays and frustrations for the commuters and an overflowing of traffic into neighborhood streets with the associated noise, pollution, accidents, and life-style disruptions that the traffic will bring into the neighborhood. (Santa Clara County Planning Department, 1979)

The veracity of these predictions is already evident. Negative impacts from congestion and overburdened traffic networks are being felt throughout the county. The living environment in the centrally located residential areas (between the job growth and the housing growth areas) is the most severely affected by the massive amounts of through traffic. With jobs continuing to cluster in the northwest and north San Jose, traffic is being squeezed into the neighborhood streets of residential areas. As mentioned previously, these areas suffer from a lack of open space areas as well.

Air pollution is now at hazardous levels in Silicon Valley. The automobile dependence of the county's perpetually growing population is responsible for degradation of the region's air quality. Mobile sources account for 94% of the countywide emissions of carbon monoxide, 58% of the hydrocarbons, and a large percentage of various other pollutants (SCCPD, 1979). According to the Bay Area Air Quality Management District, Santa Clara County accounts for between 28 and 33 percent of Bay Area emissions for various pollutants (SCCPD, 1979). As a result, one or more state or federal air quality standards is violated at least ten percent of the time in the county, while the remainder of the time, pollution levels fluctuate very close to these standards (Industry Housing Management Task Force, 1979).

The no-growth movement. An active and vociferous coalition of local community groups, elected officials, planners and individual residents committed to the institution of public controls over industrial growth also developed in Santa Clara County during the 1970s. The emergence of this no-growth movement from an avowedly pro-growth enviornment is another striking manifestation of the urban contradictions generated by electronics production. The no-growth movement is in fact a social and political expression of the same contradictions evident in the county's spatial development. It too has its roots in the particular class structure of the region.

The rapid expansion of the electronics industry and of its huge labor force concentrated in Santa Clara County has not been accompanied by unionization. In fact, with the exception of a few of the larger established systems firms (such as Westinghouse and Lockheed), the local electronics workforce remains totally unorganized. The lack of labor organization in the county thus far is attributable to a variety of factors, including the youth of the industry, the overwhelming predominance of women and minorities in the production workforce (and the shortcomings of traditional organizing strategies and approaches for this new labor force), the failure of unions to devote sufficient resources and energy to an assertive organizing drive in the area and the active union-busting activities and paternalistic practices of local employers.[7] Perhaps equally as important, however, is the large proportion of the workforce which is professional, well-educated and highly paid, which does not consider itself part of the working class and does not associate its concerns with traditional union goals and activities. Although the rapid growth and agglomeration of the electronics industry has failed to produce a traditional workers' movement thus far, it has instead generated a middle class no-growth movement speaking to the needs and concerns of this professional strate of the workforce.

Public concern with the urban and environmental impacts of growth is another product of the class structure generated by the electronics industry. As previously noted, between 1950 and 1970, when the county's population nearly quadrupled,(to over one million), half of the tremendous influx of migrant labor had at least some college education. This large, highly educated professional strata has provided the consciousness and impetus for the county's no-growth movement, through their membership in a variety of well-informed and organized special interest groups and their active involvement in local politics and issues.

The need for appropriate and differential reproduction of this large, professional middle class is the key to the no-growth movement, just as it underlies the imbalanced patterns of land-use and the corresponding crises of the county's housing and transportation systems. This accounts for its recent emergence. The accelerated urbanization of Silicon Valley had created substandard and dilapidated housing conditions, abysmally low quality schools and public services, and slums for the poor and ethnic minorities of the county from the very beginning. However, the social residential segregation of the residents of the county into class-based communities with fragmented local government jurisdictions effectively insulated the upper income professional and managerial strata from these problems.

By the early seventies, however, the crises of the urban system had begun to seriously affect the everyday lives of the middle class. Twenty-five years of accelerated industrial expansion had taken a serious toll on the environment of Santa Clara County. Transportation congestion had overwhelmed the roads shared by all of the county's residents and spread into the north county residential areas; the effects of hazardous levels of air pollution and deteriorating water quality could not be spatially isolated from the north county, nor could the breakdowns of sewage plants, storm drains and sewers; everyone suffered from the rapid disappearance of open space and the relentless inflation of housing prices. The amenities and qualities of life which had originally made Santa Clara County so desirable and attractive to these professionals were rapidly being destroyed.

As a local developer put it,

> When you flush the toilet and nothing happens, when you back out of your driveway and you're in a traffic jam on your cul-de-sac, when the next guy hou hire has to live in a tent, then you know that the problems of the jobs-housing imbalance have arrived. (San Jose Mercury, 3/3/80)

Improvements in sewers, as well as in roads, parks and other basic public works have not proceeded at a pace adequate to match the pressures for growth resulting from economic expansion. Recent breakdowns indicate that sewage treatment plants and pipelines are nearing the limits of their capacity to absorb wastes from new developments and increasing the likelihood of a major breakdown creating major ecological damage to the Bay. The water quality in the local reservoirs, streams and the San Francisco Bay already has been seriously damaged. While traffic congestion and the brown-orange haze which it created are now part of everyday life in Silicon Valley, the orchards of the north valley have all but disappeared, new neighborhoods are being created which lack adequate parks or open space areas, and more and more of the valley is being covered over with parking lots, industrial parks and shopping centers.

Furthermore, the limits of the valley's safely developable land are being reached. According to the Industry Housing Management Task Force, almost all of the remaining vacant land in the county is unsuited to urban development due either to excessive risks to development posed by steep slopes, earthquakes, landslides, floods, fire or geologic instability or to the location of prime agricultural soils, natural resources preserves and open space areas which should be protected from urban encroachment.

While in the past, the costs and urban displeasures of rapid industrialization were confined primarily to the low-income areas of San Jose and the south county, these negative externalities have spread to affect the remainder of the county. Even living in Palo Alto or Los Altos no longer protects one from these problems, and many engineers and professionals are also being forced to look elsewhere in the county for housing. Thus the growth of a large, educated and environmentally conscious middle class has coincided with the increasing severity and pervasiveness of urban problem and generated the movement to limit growth in Santa Clara County.

No-growth sentiments accumulated force over the course of the decade through growing community awareness of a series of single issue concerns. The Association of Bay Area Governments Environmental Management Plan, the Mass Transit Commission Santa Clara Valley Corridor Evaluation, and the Santa Clara County Housing Task Force Report are major signposts of the growing concern with environmental, transportation and housing problems in the county.

The movement culminated most recently with the strongly worded recommendations of the Santa Clara County Industry and Housing Management Task Force. In a 62 page report entitled, "Living Within Our Limits: A Framework of Action for the 1980's" (published in November, 1979), the task force provided an examination of these problems, and concluded that,

> Our rapid growth of industrial jobs, the main force driving urban growth, has created a strong economy but is now threatening many qualities which made the Santa Clara Valley a desirable place to live and work . . . Santa Clara County is growing faster than we can successfully control . . . Conditions suggest that we are reaching the limits of systems we depend on for comfort, health and generall well-being.

Uncontrolled insutrial job growth is identified by this report as the primary force underlying the county's housing crisis, environmental degradation, transportation congestion and infrastructural bottlenecks. It advocates strict governmental control over the rate, amount, type and location of future industrial development, with an eye to drastically curtailling job growth in the county. "We need to plan for an amount and rate of growth that can be supported by both our constructed facilities, including our transportation network, sewage treatment system, housing supply, and by the desirable natural environment." (Industry Housing Management Task Force, 1979)

The report recommends various measures, including rezoning undeveloped industrial land to residential, limiting employment densities on existing plant sites, requiring the involvement of private industry in the provision of housing and improvement of transportation systems and ending all public financing for development of parks. Other recommendations include the creation of a county-wide metropolitan government to deal with overall issues of land-use planning and area wide urban problems and the implementation of revenue sharing arrangements to redress the disparities in fiscal revenues and service provision between cities.

This document and its recommendations have spurred community involvement and interest. A series of public forums, debates and discussions were sponsored by the county planning department and the individual city councils were all asked to take concrete positions and actions in line with the Task Force recommendations. Observation of these forums and interviews with involved participants makes it clear that the vitality of the no-growth movement in the county can be attributed primarily to the organizational efforts of environmental and conservation groups, fair housing advocates, the League of Women Voters, the American Association of University Wives, other civic associations and some of the local urban planners and politicans. All of these groups consist predominantly of white, well educated middle class women from the north county cities. (Ironically, many are the wives of engineers, managers and executives of the electronics industry.) Notably absent from public participation in this debate have been representatives of organized labor or the large non-unionized electronics workforce, representatives of the ethnic minorities, particularly the Mexican American community (which accounts for approximately twenty percent of the county's population), or even representatives of community groups from the cities of the south county. The movement speaks most directly to the concerns of the professional strata with the quality of life in Santa Clara County, rather than to those of the poor, unemployed or discriminated against minorities.

The predominance of these middle class forces in the north county cities thus accounts for the recent elections of strong no-growth advocates to the city councils of Palo Alto, Mountain View and Sunnyvale. Definitive actions to slow or limit growth have been taken by these cities. The city council of Sunnyvale imposed a four-month moratorium on industrial development during the spring of 1980 to provide time to reassess their policies towards growth. They subsequently devised an innovative set of policies including imposition of fees on all new private industrial development for the improvement of local transportation and infrastructure networks, rezoning of substantial amounts of land from industrial to residential usage, strict regulations concerning the density of industrial development and a variety of proposals for the provision of childcare, car pools and other services for the working population. Palo Alto has also begun to require "in lieu" fees for all new industrial development, the revenues from which go towards subsidizing low and moderate income housing in the city. Mountain View has also imposed regulations concerning the physical appearance and environmental impacts of new industry development.

Such successes have been notably absent in San Jose and the south county cities, however. They are still actively attempting to attract industry to their turf in order to gain the employment and tax benefits.

In fact, the city manager and the Planning Director of San Jose issued a public report sharply criticizing growth control recommendations that seek to limit industrial development in the county. "Controls on job growth may be fine for the north county", the report says, but it "would lock San Jose (and other job poor cities) into a position of permanent housing surplus." The report concludes by reconfirming San Jose's drive to attract new industry (San Jose Mercury, 2/25/80).

The Task Force proposals to severely limit industrial growth and the subsequent actions of these cities pose a clear threat to local industry. In 1978, the Santa Clara County Manufacturing Group, an organization representing fifty-one of the county's largest employers was formed with the stated purpose of enabling Santa Clara County industry to "cooperate in addressing major issues affecting the overall attractiveness of Santa Clara County as a place to live and work". This entry of the business community into the public debate, when for years they had been able to ignore city-level politics with the knowledge that their interests would be promoted, signals their growing concern about the no-growth sentiments in the county.

The Manufacturing Group has actively lobbied to prevent the imposition of future moratoriums on growth or the rezoning of land from industrial to residential, as well as to prevent further regulations on the nature of their growth or sharing of the costs of housing provision. Along with maintaining an active presence at relevant community affairs and in the press, the group publishes a widely publicized survey of vacant land in the county in an attempt to convince the public that there is ample developable land remaining in the county and that the problem of the jobs-housing imbalance is not so severe or irremediable as it might appear. In other words, to support their position that the county's problems can be solved without government interference in the "free market" and especially without limitations on job growth.

Concluding comments. As the urban problems of Silicon Valley intensify, local firms face rapidly escalating production costs, shortages of labor and increasing socio-political threats to the stability of production. These forces are a powerful push factor, propelling the search for more profitable and reliable sites for production.

In April, 1979, the Santa Clara County Manufacturers Group surveyed local companies (the sample represented 55% of the county's total 207,000 manufacturing employees) and found that over two-fifths (44%) of their projected job growth during 1979-81, approximately 49,000 jobs, was planned for areas outside of Santa Clara County. (The majority, 41%, was planned for areas outside of California altogether.) The major reasons cited for the expansion outside of the region included the lack of sufficient workers in all categories (professional, skilled and unskilled labor), and the high cost of housing in Santa Clara County, which makes it hard to attract new employees to the area (Santa Clara County Manufacturers' Group, 1979). This process is self-reinforcing. Today, virtually all of the electronics and semiconductor firms in the county that are large enough to expand their manufacturing operations are doing so in locations outside of Silicon Valley.

This disperson of production is a response to the historically evolved contradictions of the local spatial structure. However, it is only the simultaneous maturing of the industry itself which has allowed firms to undertake this decentralization strategy. While the "push" for the relocation of manufacturing came from the problems of the spatial structure in Silicon Valley, restructuring of the industry has provided the "capability" for it.[8] The following section thus examines the changing structure and dynamics of the semiconductor industry in detail.

Footnotes

1. The information presented here is based on the opinions expressed by industry representatives in the personal interviews which I conducted as well as in some of the community forums I attended during 1980. These results are completely substantiated by those from a similar series of interviews with 28 local manufacturers conducted by the Economic Development-Job Needs Project in Santa Clara County in 1977.

2. There is also considerable concern among semiconductor producers about the possibility of energy shortages and brownouts in the area as a result of rapid and highly energy dependent growth.

3. While bus transit is available to 61% of the County's residential areas, it generally takes twice the auto driving time, and thus is not seen as a viable alternative to the automobile (Santa Clara County Planning Department, 1979).

4. Areas are defined as congested when the flow of traffic is unstable and operating speeds are reduced to high traffic volumes.

5. Santa Clara County Planning Department (1979) estimates the "predicted job ceiling" for the county--the amount of job growth that can be feasibly accomodated by the existing capacity of the transportation system--will be reached by 1990 if current trends continue.

6. The existing density of development around the major freeways means that they cannot be widened without massive displacement of homes and offices. Public opposition to freeway and road expansion projects in Santa Clara County is currently very strong.

7. The representative of National Semiconductor boasted that they have management people and facilities to deal with six foreign languages on their assembly lines: Vietnamese, Cambodian, Philipino, Chinese, Korean and Spanish.

8. Walker and Storper (1979) provide this terminology and quite useful analytical approach to industrial relocation and dispersion as requiring both "push" and "capability" factors.

III. THE ERA OF CONSOLIDATION AND DECENTRALIZATION

Industrial Restructuring

Introduction. A fundamental restructuring of the semiconductor industry began during the seventies and is still underway. While growth continues to be explosive, reflecting the increasing pervasiveness of integrated circuits, the nature of technology, production, owndership, competition, and the entire structure of the industry are rapidly being transformed. Semiconductor firms are changing character from small, intensely competitive, technology dominated ventures to large, mature marketing-oriented corporations. This reorganization of production has freed firms from the need to agglomerate and provided them with the capability to decentralize manufacturing out of Silicon Valley.

Continued growth of the semiconductor industry. The continuing spread of semiconductors' applications into all sectors of production, communication, transportation and services, underlies the industry's phenomenal growth. Sales climbed at a compound rate of 19% annually during the seventies, and exceeded $7 billion in 1979 (*Business Week*, 7/21/80). While the military-aerospace industry and the computer industry provided the largest markets for semiconductors during the 1950s and 1960s, today, rather than serving one or two markets that grow in pace with the GNP, the industry serves a continually diversifying market of proliferating applications. According to industry analysts, the strongest growth era in history is yet to come. Traditional computer, consumer and industrial markets are growing strongly, automotive and telecommunications markets are expanding even faster, and a resurgence of military-aerospace demand has just begun.[1] With the exception of the 1975 recession, demand has outpaced supply consistently during the decade. In fact, the semiconductor industry doubled manufacturing capacity in the two years between 1978 and 1980 alone (Business Week, 7/21/80). While growth may slow down temporarily with the current recession, the industry is now better protected than ever before by the rapid expansion of military, telecommunications and automotive markets. Production for mass markets is becoming far more pervasive, and an enormous volume of integrated circuits is being purchased by a few big customers. The number of companies using more than $100 million worth of semiconductors annually jumped from one to seven between 1976 and 1979, and is expected to reach 17 in 1981 (Business Week, 12/3/79).

Analysts agree that semiconductor manufacturers will be among the fastest growing firms of the 1980's. Predicting that integrated circuits will play a crucial role in solving such problems as inflation, dwindling productivity and the energy shortage, (through, for example, the use of microprocessors, electronic mail, mini-computers, and electronic typewriters in offices and automobile fuel injection systems in cars), they forecast that annual sales will reach $50 billion by 1985 (San Jose Mercury, 2/23/80).

Technological advances. Dramatic advances in the technological complexity of semiconductor devices are fundamentally altering the nature of competition in the industry. Semiconductor technology has become increasingly sophisticated with the advent of MOS (metal-oxide-silicon) technology in the sixties and especially with the current rise of very large scale integration (VSLI). Twenty years of exponential growth in chip density (the number of electronic components on a single chip) have seen the growth from less than 100 components per chip in 1960 for medium scale integration (MSI) to about 10,000 in the mid 1970s for large scale integration (LSI). In 1979, IBM initiated the VLSI generation with a chip capable of storing 65,536 bits of information and containing 70,000 components. (It is called a 64K random access memory, or 64K RAM.) The industry is now on the verge of introducing the VLSI 256K RAM, which will contain over 250,000 components. Thus VLSI is another step in the industry's tradition of continuous miniaturization--a tradition which lowers the expense of computation and tremendously enlarges the variety of uses for which semiconductor electronics are cost effective.

As more and more circuits are squeezed onto a single chip, the enormous complexity of the resulting circuits has far-reaching implications for semiconductor producers. One commentator noted that, "VLSI means more than making tiny circuits tinier; it is making small companies large." (Robinson, 1980). To begin with, the complexity of this newer breed of circuits makes them essentially immune to copying by rival firms. Moreover, the size of R & D expenditures necessary to keep abreast of new technological developments is prohibitive to all but the largest firms. In 1979, for example, Intel devoted 10% of total sales, of $67 million to research and development (Intel Corporation Annual Report, 1979). Small independent firms with sales of $100 to $300 million in sales will find it very difficult to keep up with the advancing technologies in the future.

The cost of designing the current breed of circuits is astronomical. Design costs began to rise with the start of the VLSI era, and have accelerated ever since. The first microprocessor at Intel had 2300 transistors and took four man-years to develop. Today, representatives of Zilog (a Silicon Valley firm and spin-off of Intel) report that their most sophisticated device, which has 20,000 transistors on it, required a full thirty man-years of development effort (Robinson, 1980). Since the design engineers are generally the most sophisticated scientists in a firm--a first-class design engineer currently commands a salary of at least $60,000 a year--development costs have escalated dramatically (Business Week, 12/3/80). Along with the growing complexity of circuits, the labor intensity of the design process helps to explain the skyrocketing design costs. In response, computer-aided design tools and new ways to organize the components of microcircuits are being studied extensively.

Production process. The semiconductor industry is also rapidly becoming one of the most capital intensive industries in the U.S. According to veteran industry analyst Benjamin M. Rosen, president of Rosen Research Associates, Inc., semiconductor manufacturing is seven times more capital intensive than other U.S. industries (San

Francisco Business Journal, 6/16/80). As circuits decrease in size and increase in complexity, the equipment required for fabrication is for fabrication is far more sophisticated and costly. New technologies like VLSI require massive investments to initiate production. At the same time, dramatic increases in expenditures on automated equipment are also being undertaken to reduce the growing labor component in production. As a result, the cost of starting a new, state-of-the-art semiconductor manufacturing plan has skyrocketed to $50 million. In 1965, the cost was only $1 million (Business Week, 7/21/80).

Semiconductor firms are facing enormous new demands for capital. In 1978, capital expenditure accounted for 8 percent of total industry sales. In 1980, it will reach 20 percent. The top seven U.S. semiconductor suppliers alone are expected to spend more than $1 billion on production equipment during the year, an increase of 51% over 1979, which in turn was 63% above that of 1978. Intel, for example, will spend $150 million in 1979. National Semiconductor intends to add at least one new production facility each year through 1985 (Business Week, 7/21/80).

Revolutionary changes are also underway with increasing automation of the wafer fabrication process. In the past, the rapid pace of technological innovation in the industry dictated low levels of automation in manufacturing, as any investment in costly machinery would have tied a firm to a specific technology which was very likely to become obsolete before sufficient returns on the investment could be reaped. Automated equipment has been available, however. For example, IBM, which produces solely for in-house use and thus is able to pace the introduction of innovations, recently began production in a fully automated semiconductor manufacturing laboratory. The production line in IBM's Quick Turn Around Time Laboratory (QTAT) consists of over 100 automated devices all controlled by multiple IBM computer systems (San Jose Mercury, 2/18/80). Industry leader Texas Instruments has also been consistently ahead of other firms in automating production. The early use of robot arms and computerized assembly systems allowed TI to gain market share by driving prices down to levels its competitors could not match (New York Times, 5/13/80).

As semiconductor firms increasingly produce for large volume mass markets, and as the technology becomes more complex, the adoption of automated techniques to increase productivity and reduce costs is becoming far more widespread. Automated equipment is extremely expensive, making it a major factor in the industry's escalating capital expenditures. Yet as some firms automate, others are forced to follow suit to remain competitive.

The escalating costs of production equipment are exemplified by the varying levels of sophistication and cost of photolithography equipment. The traditional method of photolithography used a simple contact printer, which cost about $15,000. More sophisticated and reliable methods have been phased into many laboratories recently, including the projection printer and the direct step-on wafer. These methods, which have much higher yield levels and require less labor, sell for $240,000 and over $600,000 respectively. As circuit feature sizes decrease even further, so that conventional optical systems will not work, the use of x-ray or electron beam lithography will become necessary. Electronic beam lithographers, already in use by some firms, allow the transfer of circuit patterns with far more speed, accuracy and resolution than conventional methods, but they sell for $1.5 to $2 million apiece. Similar cost escalation is occurring in most other types of production equipment.

While semiconductor production was never something done in a garage, the steeply climbing costs of the equipment necessary to stay abreast of the advancing technology is altering the character of companies from small, high technology ventures to big businesses concerned mainly with costs, revenues and profit margins. As one industry representative observed, it is necessary to have a large volume of business--at least $100 million in sales a year--in order to simply pay off the large overhead costs. The rapidly rising amount of capital needed to continue in the VLSI race is thus a dominant concern of today's semiconductor firms.

<u>Entry conditions</u>. The effective barriers to entry into the semiconductor industry have risen dramatically with the increasing complexity of semiconductor devices and manufacturing processes. Between 1965 and 1980, the cost of starting a new semiconductor manufacturing facility increased fifty-fold. Further, technology no longer diffuses with such ease as previously, and since design costs are

climbing even more steeply than the price of new equipment, only the largest firms can afford the R & D to keep abreast of new technological development. Moreover, as production for mass markets enables longer production runs, and increasing automation of the production process, significant economies of scale in both production and in marketing are attainable by the larger, more well-established firms in the industry. This further raises the barriers to potential new entrants in the industry. The proliferation of new start-ups which typified the young industry has come to a half in recent years. While dozens of semiconductor firms sprung up during the 1950s, 1960s, and early 1970s to compete for a share of the growing electronics markets, in recent years the number of new start-ups has dwindled to almost nothing. Over thirty semiconductor companies were started in the 1960s, but only three were founded during the 1970s (San Francisco Business Journal, 6/16/80).

Restructuring of ownership. Driven by these huge new capital needs along with the pressure of growing international competition, semiconductor companies are disappearing as independent entities equally as fast as they sprung up or were spun-off in the past. In an accelerated process of restructuring, the small, independent semiconductor companies of the past are being acquired by larger corporations and conglomerates. In fact, while 36 new semiconductor firms were started up between 1966 and 1979, only seven of them remain independent today (Business Week, 12/3/79).

Despite their speedy growth, semiconductor companies have been extremely poor generators of capital. Competition has kept profits low. At the same time, intensified foreign competition, from Japan in particular, has begun to erode the share of world-wide component markets held by U.S. based producers. (The U.S. currently controls about two-thirds of the world semiconductor market.) The seriousness of the threat posed by Japanese firms to the dominance of U.S. companies in basic semiconductor technology (especially in the battle over VLSI) has been a major spur to the integration of once independent firms. Unable to generate the necessary capital, and in danger of losing their technological edge to competitors here or abroad, firms have been forced to give up their independence in order to gain funds from outside sources.

The wave of acquisitions and investments by large corporations and conglomerates (both foreign and domestic) in the independent American semiconductor companies has accelerated the process of centralization of control over electronics production. This amalgamation and centralization process has been dominated by the backward integration undertaken by the large component customers such as electronics systems and equipment producers. Semiconductor companies are trading their technology to their own end users in return for capital. Independent semiconductor companies are rapidly becoming tied to major computer and electronic equipment companies which use integrated circuits in almost all of their products.

During the late 1970s over twenty such investments and acquisitions were made. In 1979, even the grandfather of Silicon Valley, Fairchild Camera and Instrument Corporation, was acquired by the French conglomerate Schlumberger Ltd., and Mostek Corporation, the leading maker of state-of-the-art random access memory chips, was taken over by the American aerospace giant United Technologies. These two deals together involved outlays of over $750 million! (Business Week, 12/3/79). Table 17 lists the acquisitions of independent semiconductor firms which occurred between 1975 and 1979.

Ownership in the industry is also becoming increasingly international. One industry analyst reports that 12 of 21 recent semiconductor acquisitions have involved foreign companies (Business Week, 12/3/79). As a result of the growing frequency of international investments (mainly by West German and Japanese companies), an estimated 15 percent ofAmerican semiconductor capacity reportedly belongs to foreign corporations (Far Eastern Economic Review, 12/14/79). This has been complemented by a proliferation of international joint-ventures and cross-licensing agreements between U.S. companies and foreign competitors which allows the exchange of technological expertise for access to foreign markets. In fact, this increasing internationalization of ownership undercuts many of the current industry complaints about foreign competition.

In addition to these acquisitions, a growing number of large electronic systems, computer and equipment companies which rely on the use of large quanities of integrated circuits have chosen to

TABLE 17.

Acquisitions of Independent Semiconductor Makers, 1975-1979.

Year	Acquisition	Buyer	Price Paid ($m)
1975	Signetics	U.S. Philips Trust, Netherlands	49
1976	MOS Technology	Commodore International, U.S.	1
1977	Litronix	Siemens, West Germany	16
	20%, Advanced Micro Devices	Siemens, West Germany	27
	Solid State Scientific	VDO, West Germany	5
	24%, Intersil	Northern Telecom, Canada	11
1978	Electronic Arrays	Nippon Electric, Japan	9
	Spectronics	Honeywell, U.S.	3
	Synertek	Honeywell, U.S.	24
	25%, American Microsystems, Inc.	Bosch, West Germany	14
1979	Mostek	United Technologies, U.S.	349
	Microwave Semiconductor	Siemens, West Germany	25
	Fairchild Camera	Schlumberger, France	397
	14%, Unitrode	Schlumberger, France	10

Source: "Can Semiconductors Survive Big Business?" Business Week, December 3, 1979, p. 67.

develop their own "captive" in-house semiconductor operations. Between 1975 and 1979, the number of such captive suppliers in the U.S. grew from 19 to 43. In some instances, such as defense systems manufacturers, the chips they require are so specialized that semiconductor firms refused to design them. For this reason, firms such as Hughes Aircraft, Lockheed, and McConnell Douglas have all developed their own internal fabrication capabilities. On the other hand, AT&T's Western Electric and IBM have been making integrated circuits for internal use for a long time. Most recently, manufacturers of large and minicomputers have begun developing the ability to produce at least some of their components internally. Silicon Valley equipment and instrument producers Varian Associates and Hewlett-Packard Corporation are prime examples of firms which also make their own proprietary chips. As such key customers build their own in-house semiconductor operations, independent suppliers lose more and more of their business.

Further contributing to this overall vertical integration process, is the trend by some semiconductor producers to undertake forward vertical integration themselves through the production of higher value-added products such as subsystems, systems and equipment. This process was initiated with the boom of consumer electronics in the middle seventies. At that time, semiconductor companies which made the chips for calculators, for example, realized that it would be even more profitable to produce the entire instrument. National Semiconductor and Texas Instruments are dominant examples of this trend. They each produce a variety of products based on semiconductor technology, including electronic supermarket registers, calculators, microcomputers, digital watches and computer memory systems, along with a broad range of semiconductor devices.

Thus, restructuring in response to the demands of new and rapidly changing technologies, production processes and the threat of intensified foreign competition has accelerated the process of vertical integration and centralization of control over electronics production. While many large electronics corporations and conglomerateds are buying out independent semiconductor houses, other electronic companies are establishing their own in-house semiconductor fabrication facilities and a few semiconductor firms are also swelling in size and producing electronics end-products themselves.[2]

Dynamics of competition. These pressures are fundamentally altering the nature of competition in the semiconductor industry and promoting the emergence of massive, well-entrenched companies with large volume production capacities and stable market shares. A company can no longer stay ahead in the industry through rapid technological advance and the technological superiority of its products alone. The traditional role of technological innovation in continually altering market shares has thus diminished considerably. While the semiconductor industry will always be distinguished by its technological-basedness, other, more traditional forces are coming to dominate the nature of competition and to determine the success or failure of high-technology firms. Capital formation, labor costs and productivity, and expanding markets are becoming the key concerns of semiconductor producers.

Integrated circuit technology has become so complex and powerful that the challenge to producers now is to devise innovative new applications for the technology and to find profitable outlets for these applications. Semiconductor firms are now devoting R & D resources primarily to product development as a means of expanding the size of their markets, rather than to basic research. It is only through selling vast amounts of chips that firms are able to amortize the large amounts spent on designing new products and to afford the rapidly escalating costs of production equipment. While designing innovative applications for semiconductor devices is indispensable in that it has the potential to create new markets, active marketing efforts are also becoming imperative as a means of gaining market share. The current strategy of large firms like Intel and National Semiconductor is to market a variety of prefabricated, mass produced semiconductor devices on a large scale.

Raising productivity in manufacturing is a central concern of semiconductor companies as they begin to produce for mass markets. With longer, more stable production runs, automation of production is not only economically feasible, but is a competitive necessity. Automated manufacturing and assembly processes guarantee yield rates that are generally higher and certainly more reliable than hand labor. Widespread adoption of auotmated techniques will reduce production costs as it raises productivity.

Along with this development of economies of scale in both production and marketing which favor the larger, well-established firms over smaller firms or new entrants, a transformation is occurring in pricing strategies. The highly competitive price slashing through learning curve price reduction which characterized the young industry is being replaced by a stabilization of chip prices and more traditional pricing strategies. Prices of integrated circuits have in fact begun to rise, rather than to fall recently (Robinson, 1980; Electronics, 6/21/79). This in turn permits greater profit margins for all firms and it will allow innovating firms to reap substantially greater monopoly rents than in the past. Such pricing strategies in turn further increase the competitive advantage of larger firms with wider market shares over smaller and more limited firms.

Industry structure. The semiconductor industry is thus becoming increasingly concentrated. Only the largest most financially stable and well established firms will be able to compete in the future as the nature of competition revolves increasingly around marketing and mass production rather than innovation and technological advance. Already, many smaller independent firms have been forced into mergers or acquisitions, or out of business altogether. While the largest firms are growing rapidly in size, others are losing ground rapidly.

Industry analysts predict that by 1985, no more than ten giant corporations will occupy the majority of the industry's market share with broad product lines and technology and world-wide production centers and sales.[3] In a recent study of the industry, the Wall Street investment firm of Merrill, Lynch, Pierce, Fenner and Smith, Inc., predicted a shakeout and the ultimate emergence of an oligopoly consisting of Advanced Micro Devices, American Microsystems, Inc., Intel, Mostek, Motorola, National Semiconductor, and Texas Instruments (Electronics, 6/21/79). Below these large firms on the pyramid, they predict, there will be a variety of smaller low and high volume specialists making integrated circuits, the former producing for specialty "niches" and custom applications and the latter producing for in-house use.

Employment implications. Employment statistics for the semiconductor industry reveal the most striking trend of the seventies was the continual expansion of employment. Between 1970 and 1977, when total employment in the U.S. grew only 15%, employment in the semiconductor industry grew almost twice as fast. Over this period, employment grew 27.6%, from 88,500 to 112,900 employees. More significant, but less apparent, is the decline in production workers relative to total employment and the reduction of the labor component as a percentage of the total costs of production. Between 1970 and 1977, when the value of shipments more than doubled, the percentage of production workers out of total employment in the industry declined from 68.1% to 55.3%, while the actual number of production workers employed remained fairly stable. The cause of this decline is difficult to pinpoint, as it is attributable to a combination of factors. First,

Table 18a.

Employment in the Semiconductor Industry: 1970-1977.

Year	Total Employment	Production Workers	Production Workers / Total Employment (%)
1970	88,500	60,300	68.1%
1971	74,700	45,500	60.9
1972	97,600	58,400	59.8
1973	120,000	74,700	62.3
1974	133,100	81,600	61.3
1975	96,700	52,400	54.2
1976	102,500	59,700	58.2
1977	112,900	62,400	55.3

Source: U.S. Bureau of the Census. Annual Survey of Manufacturers, 1970 - 1979 and Census of Manufacturers, 1972, 1977. (Washington, D.C.: U.S. Government Printing Office).

Table 18b.

Labor Intensivity of Semiconductor Industry, 1970-1977.

Year	Value of Shipments ($ m)	Cost of Payroll ($ m)	Cost of Payroll / Value of Shipments (%)
1970	$ 1,501.2	$ 663.6	44.2%
1971	1,599.6	658.1	41.1
1972	2,704.8	953.1	34.5
1973	3,647.7	1,201.0	32.9
1974	4,305.1	1,466.6	34.1
1975	3,276.9	1,200.5	36.6
1976	4,473.8	1,371.2	30.6
1977	5,238.2	1,587.5	30.3

Source: U.S. Bureau of the Census. Annual Survey of Manufacturers, 1970 - 1979 and Census of Manufacturers, 1972, 1977. (Washington, D.C.: U.S. Government Printing Office).

it is likely that an increasing amount of unskilled assembly work was shifted to offshore sites during the period, thus reducing the percentage of production workers in the U.S. Second, as the scientific depth of the industry increased, the dependence on highly skilled manpower has increased, thus boosting the percentage of non-production workers required. Third, and perhaps the most significant, the widespread introduction of automated production processes has reduced the number of production workers needed to produce a given level of output.

The declining labor intensivity of semiconductor production as a result of automated processes is also illustrated by the reduction of the cost of payments relative to the total value of shipments. In 1970, payrolls accounted for 44.2% of the total value of shipments. This percentage declined steadily during the 1970s, so that by 1977, the cost of payrolls was only 30.3% of the total value of shipments.

Unfortunately, more recent data is not available to evaluate the effects of the massive increases in capital spending and automation during the last three years of the decade. These will undoubtedly reduce the industry's labor intensity considerably. For example, during the 1970s, capital expenditures fluctuated between 8% and 10% of the total value of shipments, while estimates put capital expenditures for 1980 at 20% of total output (Business Week, 4/21/80). According to the vice chairman and co-founder of Intel Corporation, Robert Noyce, "The case for increased employment in the near term is very tough. New jobs will not be created" as the industry becomes more capital intensive (New York Times, 8/20/80).

The industry's labor force is also becoming more severely dichotomized as a result of these restructuring processes. The increasing sophistication and complexity of technology require a growing proportion of highly skilled professionals for research, development and design, while automation is further reducing the skill levels of the production workforce. While it might be argued that advanced technology and automation will increase employment in the long run because innovation, by enhancing productivity and thus reducing costs will lead to increased semiconductor sales and ultimately more jobs in the industry, it is clear that the jobs to be created are of a qualitatively different nature. Fewer jobs will be available for middle skilled workers like mask makers, draftsmen and fabrication technicians, and there will be a multiplication of low-skilled monotonous and repetitious jobs which pay little and offer no prospects for advancement. One counteracting tendency is the growth of professional, technical, and managerial employment as production expands, and a corresponding development of hierarchies and differentiation among this growing strata of the labor force.

Decentralization of production. For twenty-five years, the semiconductor industry's control and R & D (research, production development and design operations) and its wafer fabrication (advanced manufacturing) facilities remained in close spatial proximity to each other. In many firms, these two phases of production rapidly outgrew a single building or site, yet they still clung together tenaciously in the same region.[4] Only when the contradictions of continued concentration became serious obstacles to local expansion did the spatial decentralization of manufacturing occur. Dispersal of advanced manufacturing did not begin until the late 1970s and is still underway. This delay stands in sharp contrast to the early detachment and export of the assembly phase of production to low wage overseas sites. Internationalization of assembly began in 1960, and was almost completely achieved during that decade. The difference in timing derives from the process of producing semiconductors. Assembly is a truly discrete phase of production and does not change for different products. It is technically simple and routine and requires only minimal assistance from trained engineers. Thus it was easily separable from the rest of production very early.

Wafer fabrication, on the other hand, is a complex and delicate process. The transfer of a new device from the development lab to a fabrication facility is extremely difficult, as what was being done only by highly skilled engineers on a prototype basis must be adapted to factory conditions for volume production by workers who are generally unacquainted with the principles underlying what they are doing. Once this transfer has been accomplished, the delicacy and sophistication of the manufacturing process demands the ongoing presence of engineers and technicians.

As long as firms remained small and an area had proven successful as a site for production, it was much safer to keep manufacturing concentrated in the same geographic area as the company's R & D, and thus within the reach of top engineers and scientists in case of difficulties. Furthermore, continuous technological change and innovation in the industry meant that new products and new fabrication processes were continually being introduced. Physical separation of manufacturing would have been both risky and costly.

By the late seventies, when urban contradictions forced the rupture of these two phases of production, the problems of spatial separation had been eased somewhat by the restructuring of the industry. The rise of mass production has resulted in increasing stabilization of fabrication processes and longer production runs. Thus, while the technological problems of separation have not been eliminated, this stabilization of both product-lines and fabrication processes has reduced the level of risk considerably.

Further, increasing automation and the deskilling of direct production work has facilitated this separation considerably by reducing the need for trained, experience production workers, while the larger size of firms allows them to hire the middle management and technical-professional employees needed for the new production facilities.

Footnotes

1. The military is becoming more and more dependent on new high technology products, especially in the areas such as radar, communications, sensors and command controls. Thus as defense spending grows, so too will the military market for semiconductors. An indication of the resurging government interest in electronic components is the recent Department of Defense funding of a six-year, $200 million program to accelerate development of the next generation of very high speed integrated circuits (VHSIC) for signal processing. This is the largest DOD expenditure on semiconductor research and development since the 1960s (San Francisco Business Journal, 6/16/80).

2. An interesting twist to this overall consolidation process is also emerging as the technology of semiconductors advances. As the miniaturization and increasing capability of individual circuits continues, the boundary between component makers and computer makers will become increasingly blurred. Intel has announced plans to produce entire minicomputers on silicon chips and eventually even to put entire mainframe computers on chips ("micromainframe" chip computers).

3. This trend is leading many industry observers to question whether the creativity and entrepreneurial drive that characterized the semiconductor industry in its early days can be continued into

the era of giant corporations. For example, a recent Business Week cover story was entitled, "Can Semiconductors Survive Big Business?" (Business Week, 12/3/79).

4. This is true not only for Santa Clara County, but also for the industry's other major concentrations: Texas Instruments in Dallas, Texas, and Motorola in Phoenix, Arizona. It is also true for the electronics agglomeration around Route 128 near Boston, Massachusetts.

The Upgrading of Santa Clara County

The new locational hierarchy of production. Silicon Valley's urban contradictions, rooted in the increasing difficulty of accomodating and reproducing both segments of the industry's growing workforce within the same metropolitan area, are being resolved through the geographic separation of production from control and development. Just as with the movement of assembly to offshore sites, this geographic separation of production from control allows firms to take advantage of variations in the types of labor and conditions for production and reproduction in various parts of the country (or the world), exploiting the most appropriate site for each of the different phases of production (Massey, 1978a). Most significantly, it allows the continued concentration in Silicon Valley--which is uniquely suited for high technology R & D and control--by undermining the class basis of the local urban contradictions.

The 1970s were a period of rapid expansion and consolidation for Silicon Valley's leading firms. By the late seventies, the five largest semiconductor producers in Santa Clara County were in the ranks of the industry's top eight producers, along with Texas Instruments and Mostek in Texas, and Motorola in Arizona. The Silicon Valley firms, National Semiconductor, Fairchild, Intel, Advanced Micro Devices, and American Microsystems, Inc., all grew dramatically during the decade. All five had attained sales of over $100 million by 1979, while National, Fairchild and Intel all had surpassed $500 million (see Table 19).

TABLE 19.

Santa Clara County Semiconductor Firms:
Ownership Status, Sales, Employment, Expenditures on Capital and R & D: 1979.

	Firm	Ownership Status	Sales ($000)	Employment	Expenditures: Capital ($000)	Expenditures: R & D ($000)
1.	National Semiconductor	Independent	719,740	35,000	72,000	67,935
2.	Fairchild	Schlumberger: 100%	500,000*	26,000	73,000	n.a.
3.	Intel	Independent	662,996	14,000	96,700	66,700
4.	Advanced Micro Devices	Siemens: 20%	148,276	8,000	50,000	10,886
5.	American Microsystems Inc.	Bosch: 25%	108,553	3,700	10,400	8,800
6.	Litronix	Siemens: 100%	35,000	3,400	n.a.	2,100
7.	Precision Monolithics Inc.	Barnes: 100%	22,700	500	1,405	1,954
8.	Micro Power Systems	Sieko: 50%	20,000*	380	1,000*	n.a.
9.	Addington Labs	Eaton Corporation: 100%	10,000	40	1,000*	n.a.

*Estimated Figures.

Sources: 1979 Annual Reports - National Semiconductor, Schlumberger, Intel, Advanced Micro Devices, American Microsystems Inc.; "Introduction to Litronix: An Affiliate of Siemens"; Interviews.

They all expanded employment dramatically during the decade as well. Intel, for example, employed only 200 people in 1970. By 1979, the firm's total employment had reached 14,000.[1]

The large size of these firms has freed them from the need to agglomerate and allowed them to disperse production, and thus to escape the risks and unusually high costs of producing in Silicon Valley. The five semiconductor giants, along with the county's older electronic equipment and instrumentation corporations, Hewlett-Packard and Varian Associates, and a few other larger electronics and semiconductor producers, have led the way in decentralizing manufacturing facilities out of Santa Clara County. The pattern is to establish new divisions for separate product lines in dispersed locations. Since 1975, the county's largest semiconductor and electronics firms have consistently located all new direct production facilities outside of the region. Most have also established company policies that no future manufacturing expansion will occur in Santa Clara County. The corporate site planners of these firms agree that major industrial expansion in Santa Clara Valley would be unnecessarily risky.

A sizable gap separates the giant firms from the remainder of the county's producers. As Table 19 indicates, the county's smaller semiconductor firms are all partially or completely owned by outside companies; they rarely have sales which exceed $25 million, and of the over thirty other semiconductor companies in the county, only three have more than 1,000 employees (Axelrad, 1979; California Manufacturers' Register, 1979). Smaller producers can barely afford the cost of an entirely new production line ($50 million), let alone the additional expense incurred in establishing a separate facility outside of the region. These firms remain dependent upon the region's agglomeration economies, the "luxury of suppliers" and other unique services available in the Silicon Valley environment. As the representatives of smaller firms consistently noted, there is still no place better for a small high-technology firm to locate than Silicon Valley where the technological expertise, labor force and suppliers are concentrated. This inability to expand outside of the area further disadvantages the smaller firms relative to the large ones. They are forced to bear the higher costs of labor and transportation in the region, and they also face the possibility that the no-growth movement will eliminate the option of expanding production within the county altogether.

Meanwhile, research and development operations and the corporate headquarters of even the largest firms remain concentrated in Santa Clara County. At the same time that they are investing in manufacturing plants outside of the region, Hewlett-Packard, AMD, and Varian Associates are currently constructing massive new international corporate headquarter buildings in the county. National Semiconductor, Fairchild, Intel and AMI already have sizable headquarters there, and have indicated their intentions to remain. HP and Fairchild also have highly sophisticated basic research laboratories in the county, and AMD is currently constructing a new research center in Sunnyvale to develop new process technologies.

This retrenchment and continued clustering of corporate headquarters and of R & D facilities in Santa Clara County reflects the persistence of characteristics which made the area attractive to the industry twenty years ago. Silicon Valley is now known as the world-wide capital of the semiconductor industry. There are clear institutional advantages for the research and development branch of a science-based industry to remain concentrated in this technological watershed, where innovative activities and high technology labor continue to mutually attract each other. The region's agglomeration of top-notch scientists, educational and research institutions and leading high technology companies guarantee ongoing, high level scientific interchange.[2] At the same time, and equally as important, the personal roots which have developed are deep, and Santa Clara County provides the prestige and social milieu which is important to the industry's high-level professionals and executives. The personal preferences of the industry's executives, management and veteran scientists cannot be overstated as a force for the continued clustering of the industry's headquarter and research operations.

During interviews, the county was repeatedly referred to in superlatives which invoked images of a prestigious and stimulating place to live with its proximity to beaches, mountains, San Francisco, airstrips for private airplanes and the companionship of other professionals. As the corporate administrator of National Semiconductor put it, "Our president, top executives and engineers all have home and families here and like it . . . It's a very desirable place for millionaires to live."

A locational hierarchy of production is thus evolving in the semiconductor industry, whereby the highest paid professional and managerial segments of the industry's workforce will remain in the elite enclave of Santa Clara County performing the control and R & D functions, while other regions will become production sites for the manufacture of semiconductors and home of the required concentrations of unskilled and poorly paid workers. Table 20 shows the current spatial distribution of the facilities of the Santa Clara County firms surveyed, divided according to the separate phases of production. It reveals the newly emerging territorial division of labor in the industry. (The precise locations of these facilities are listed in Appendix B.)

Class restructuring. Industrial restructuring is itself a process of class restructuring.[3] In this case it is a means of escaping the urban contradictions of Silicon Valley, contradictions which are rooted in the class structure of electronics production. As the nature of Santa Clara County's function in the industry changes, so too will the class structure and character of the region. This geographic reorganization of production has direct implications for the rate of economic growth, the class structure and the nature of future urban development in Santa Clara County as well as in the regions where new manufacturing operations are being located.

The transformation of Silicon Valley is already underway. The local employment structure is changing dramatically. Over recent

Table 20.

Location of Facilities
of Eleven Santa Clara County Based Firms by
Phase of Production
(Plants Currently in Operation
or under Construction)

Phase of Production:[a]	Control	R & D	Advanced Mfg.[b]	Assembly
Location:				
Santa Clara County	11	11	35	1
Pacific Northwest and Southwest	0	0	34	3
Rest of U.S.	0	0	12[c]	0
Europe and Japan	0	3	15[d]	0
Third World	0	0	0	29[e]

Notes: a This division of the production process is sometimes arbitrary in the case of many older facilities with mixed uses. In particular, all R & D includes prototype production lines and assembly, so therefore includes manufacturing and assembly in the research lab. The guideline for allocation thus is the dominant process occurring in a plant. If the two are of equal importance, e.g. control and R & D are often in the same building, the plant is counted twice; otherwise all plants are counted only once.

b Advanced Mfg. refers to wafer fabrication for semiconductor production. Since two of the firms included are electronics, not solely semiconductor firms (Hewlett-Packard and Varian), the term manufacturing is used.

c This number would be only three if H-P and Varian were not included.

d Facilities established in Europe and Japan are mainly through joint-ventures and co-production agreements, and typically are established in order to gain access to foreign markets.

Table 20, continued

e This number does not include the additional subcontracting in the third world undertaken by many firms, which would boost the number.

Sources: 1979 Annual Reports: Hewlett-Packard Co., Varian Associates, Intel, National Semiconductor, Precision Monolithics Inc., Advanced Micro Devices, American Microsystems Inc., Schlumberger, "An Introduction to Litronix: An Affiliate of Siemens Corporation." Interviews: Addington Laboratories, Micro Power Systems.

years the county's electronics workforce has become increasingly white collar. Santa Clara County's electronics workforce is now 65 percent white-collar, or twice as heavily white-collar as the electronics industry nationwide (Snow, 1980). A slowing down in the growth of manufacturing employment and population in the county, along with the current shortage of office space, also signals the shift from a predominantly manufacturing based economy to increasingly research-oriented and administrative operations (San Jose Mercury, 5/8/80).

As manufacturing jobs dry up and the cost of living in the area skyrockets, the county's low income, minority and aged populations are rapidly being displaced and driven out of the area (SRI International, 1980). As a center for control and R & D, the county will be the home of the industry's highest level professionals and top management. Only these highly paid individuals who already own homes or who can afford housing in the county will remain. Santa Clara County will thus become an expensive, white-collar enclave.

The urban landscape is being upgraded as well. Widespread condominium conversions, urban redevelopment in San Jose and environmental protection programs all are contributing to this process. The active participation of the Santa Clara County Manufacturers' Group in working to solve the county's transportation, housing and environmental problems signals their concern with the declining quality of life in the county as well. Silicon Valley's urban problems, especially transportation congestion and environmental deterioration, threaten the desirability of the area as a home for these professionals and

and executives, and thus as a location for research and control. In fact, it appears that the no-growth movement will end up serving the long run interests of the industry. It is now profitable for the largest companies to separate production from control and research, and it is clearly desirable to retain Santa Clara County as the center for the latter. Thus it is advantageous, and even necessary for these firms to slow the local growth of manufacturing and to devote ample resources to the upgrading of the urban environment in the interest of future growth of a different sort in the area. Meanwhile, expansion of production is continuing at full speed elsewhere in the country.

A final twist to this scenario is that many of the county's smaller firms which are unable to separate and disperse their production facilities will be seriously squeezed if not allowed to expand their own production within the county. The no-growth policies may thus also serve to help eliminate some of the smaller competitors in the industry.

Footnotes

1. Notably, only two of the county's largest firms have managed to remain totally independent, with the remainder either completely or partially owned by other corporations.

2. As in the past, Stanford University is actively promoting this by striving to maintain its position at the leading edge of basic research and technology. For example, the University recently announced plan to build a $16 million research center to investigate and advance the technology of Very Large Scale Integrated Circuits (VLSIs) and their application in government and local industry. Larger local firms are contributing millions of dollars to cover the costs of construction and of the expensive equipment for the Center for Integrated Systems; government research contracts will be the main source of funding for the center. This center and its laboratory will be the largest of their kind in the country. It is expected to train 100 Master's degree and Ph.D. students a year, as well as to promote research into the automation of circuit manufacturing and to provide training programs and conferences to keep scientists up-to-date with industry trends.

   Stanford also promotes cooperative interaction between some of the older, larger companies and the university on basic research

research developments through its Affiliates Program. Local firms contribute financially to Stanford in order to become special "affiliates". This special relationship with the university entitles them to access to special research reports on the latest scientific breakthroughs, along with regular seminars and meetings which promote "high level intellectual stimulation".

3. The inspiration for this approach to industrial restructuring as class restructuring was provided by Massey (1980). Her analysis of the implications of industrial restructuring for class structure through examination of the decentralization of electronics and electrical industries in the U.K. have contributed much to this author's understanding of the processes occurring in Silicon Valley.

Dispersal of Production and New Regional Growth

Industrial location. Semiconductor and electronics manufacturing is being dispersed to locations far from the industry headquarters in California. Investment in new facilities by Silicon Valley's companies has been directed to a variety of sites in the Pacific Northwest and Southwest states of Oregon, Utah, Texas, Colorado, Arizona and Washington. Table 21 lists the specific locations of these newly established facilities. What, if anything, do all of these sites have in common?

The common lore among planners and policy-makers, and the literature on industrial location, concur in their judgment of the electronics industry as a "footloose" industry, which, lacking technological dependence upon proximity of raw materials, markets or spatially located inputs, has the freedom to locate virtually anywhere. (See, for example, Florence, 1972.) While undoubtedly freed from these more traditional constraints on location, a qualitatively different set of constraints governs the location decisions of high-technology companies. The new constraints are social and cultural rather than technological or stricly economic. As the case of the semiconductor industry exemplifies, they are rooted in the nature of production in science-based industries, and in particular, in their dependence upon professionals and skilled manpower for manufacturing as well as for research and development.

The fundamental locational constraint for semiconductor firms derives from the unique social structure of production. Successful operation of a semiconductor manufacturing facility requires that

Table 21.

Location of Advanced Manufacturing Facilities of Santa Clara County Firms: 1980

Firm	Plant Locations
Hewlett-Packard Company[a]	McMinnville, Corvallis, Oregon; Boise, Idaho; Fort Collins, Greely, Loveland, Colorado Springs, Colorado; Everett, Spokane, Vancouver, Washington; Roseville, California; Raleigh, North Carolina.
National Semiconductor	Salt Lake City, Utah; Tucson, Arizona; Vancouver, Washington.
Fairchild Camera & Instrument	South Portland, Maine; Worpingers Falls, Massachusetts, Tulsa, Oklahoma (planned).
Intel Corporation	Aloha, Oregon; Chandler, Arizona; Austin, Texas.
Varian Associates[a]	Salt Lake City, Utah; Florence, Lexington, Kentucky; Grove City, Ohio; Geneva, Illinois; Beverly, Danvers, Lexington, Woburn, Massachusetts.
Advanced Micro Devices	Austin, Texas.
American Microsystems, Inc.	Pocatello, Idaho.
Signetics	Orem, Utah.
Intersil	Ogden, Utah.
Memorex[a]	Plano, Texas.
Zilog	Boise, Idaho.
Spectra Physics[a]	Eugene, Oregon.
Siltec[a]	Salem, Oregon.

Table 21, continued

<u>Notes</u>: a Firm is not a semiconductor firm.

b For semiconductor firms, advanced manufacturing is the same as wafer wabrication. For other firms, the process varies.

<u>Source</u>: Interviews; San Jose Mercury News, Business Section.

at least a quarter of the workforce be professionals or semi-professionals who are versatile in the scientific principles involved in wafer fabrication and who adjust, control and maintain the sophisticated processes. At the same time, the manufacturing process requires a large pool of minimally skilled production workers to perform the repetitious and routinized loading, monitoring, processing and cleaning tasks. Therefore, semiconductor manufacturing cannot simply locate in the lowest wage regions of the country, or of the third world. While unskilled labor for producton is widely available in the form of low-wage female and immigrant labor, the necessary engineers and skilled personnel are few and far between.[1] The need to attract and hold on to skilled technical and management personnel is thus a major consideration for all firms. But the ability to attract and hold on to this strata of workers is not linked to salary alone. Professionals will not live in any location. These high status personnel are the only part of the labor force free to choose their residential location with secure knowledge that jobs will follow (Massey, 1980). Considerations of life style and environment are of great importance to these workers, and thus social-spatial differentiation is a key element in the locational decisions of the industry.

All of the industry's other inputs--the chemicals, gases, silicon, metals and the production equipment--are generally accessible, and easily and inexpensively transported as are the semiconductors themselves. As previously noted, the miniature semiconductors have such a high value relative to their weight that air-freighting them to

Asia for assembly is economical.[2] The only significant technological requirement for manufacturing is well-developed infrastructure, especially airport facilities, for transportation of personnel and goods, along with a reliable and abundant supply of energy. These are available in many locations. It is rather the composition of the labor force required for manufacturing which limits the free mobility of the industry. Manpower is thus the industry's fundamental locational constraint (Castells, 1978).

According to the representatives of the firms interviewed, the foremost consideration in selecting a new site for manufacturing is the ability to attract and retain professional and technical personnel. Of secondary importance is the availability of an abundant direct workforce. On a third level, the general preconditions for production--necessary but not sufficent--are reliable air transportation, an abundant energy supply and "positive" community and local government attitudes.

Corporate site planners unanimously stressed such attributes as "livability for professionals" and an "attractive quality of life" as the prime considerations in selecting a new site for semiconductor manufacturing. As one individual put it, "The key to success in the industry is the ability to attract and hold on to engineers and technicians . . . If you create jobs in an attractive location, people will flock in." There was widespread agreement on what constituted such an attractive and desirable location in the repeated emphasis on such things as a clean, modern environment with a nice landscape, access to urban culture, proximity to a university and an academic community, ample recreational opportunities, affordable housing, and a comfortable place to settle and raise a family.[3] In fact, the descriptions sounded much like an attempt to replicate the prestigious social, cultural, and institutional milieu which is so attractive to young professionals in Santa Clara County. During the interviews, I was continually reminded of the previously cited description of Santa Clara County which noted the "beautiful landscape . . . sleek modern building . . . campus-like setting . . . year-round sports and recreation . . . and the shops and cultural offerings of San Francisco" (Bylinsky, 1974).

Rather than making location decisions based on quantitative economic or technological considerations such as wage levels, transportation costs or the availability of inputs, these individuals make highly qualitative judgments. There is an insistence on the personal intuition involved in site selection and the importance of the visit to the location to get an emotional feel for the environment and its attractions. In other words, it involves a judgment of the social value of a location. A recent Wall Street Journal article described the desirable qualities of Austin, Texas, (where AMD and Intel recently located facilites) as a location in these words:

> A very livable city with a great quality of life . . . Austin is becoming as well known for its high technology and intellectual cachet as for its status as the state capital . . . The academic community around the University of Texas provides a large pool of skilled labor and a relaxed alternative to the breakneck pace of Houston. (Wall Street Journal, 3/14/80).

While the specifics may vary--Austin, Texas, has different attractions than Portland, Oregon, or Salt Lake City, Utah--they all provide attractive and prestigious environments which meet the social and cultural requirements for the reproduction of an educated professional class.

Semiconductor manufacturing facilities are, without exception, being located near sizable universities. Proximity to a university serves a number of purposes, both social and functional. One large Silicon Valley firm surveyed their engineers on locational preference and found unanimous agreement in selection of a "metropolitan area near a large, well-known university" over a "lovely, but not remote rural area". The explanation, repeated by representatives of other firms as well, was that young professionals desire to be near universities in order to continue their education and to upgrade themselves. Many of their employees take university classes to keep up with the changing technology and to obtain advanced degrees. Again, this reflects the demand for institutions which provide reproduction of a very specific kind of labor power.

Universities also affect the character of a community, providing a social and physical environment which is desirable for the professional strata of such high-technology industry. The image of clean, modern industry, of research institutions and of an academic community is an image which is consciously promoted by these high-technology firms. Advanced Micro Devices even calls its new manufacturing branch plants "campuses".

Finally, a large university also guarantees an easily accesible supply of skilled labor for manufacturing operations, so that firms do not need to import all of their technical manpower. It does seem, however, that most top engineers are recruited from elsewhere.

The costs of selecting a site with a less than appropriate social environment are very high. For example, according to Business Week, when Hewlett-Packard tried to establish a division in Corvallis, Oregon, many of their key engineers refused to move there. Despite proximity to Oregon State University, others who did move "found themselves 50 miles short of boredom, and defected soon after arriving in Oregon's rainy Willamette Valley." (Business Week, 3/10/80). That division reportedly lost manufacturing continuity, product development faltered and manufacturing lapses slowed delivery. The division has operated in the red for the past two years.

Surprisingly, location near a large university serves another purpose. It helps to insure the secondary location condition, the availability of an abundant unskilled workforce. While large amounts of less skilled labor are clearly important in production, it is not a primary constraint upon location because the appropriate labor force is generally universally available in the form of female labor. As previously noted, the production workforce for semiconductor production is predominantly female. It tends to be disproportionately minority women; many firms actively seek out these minority women as the most desirable labor pool.[4] According to firm representatives, married women who are earning the household's second income are desirable, as they are the most stable workers.[5] They also report a preference for women with high school degrees and little or no previous industrial experience. In other words, firms look for women who are forced to work by economic necessity and whose inexperience and/or minority status makes them a particularly stable and submissive workforce.[6] Thus, location near a large university was noted as guaranteeing a pool of female labor, i.e., the wives of returning graduate students who need the income. Likewise, location near a government installation (an army or naval base) was mentioned as it insures a constant supply of women who often have little other diversion. The availability of unskilled labor is therefore a major consideration, but not the fundamental constraint on locational decisions, as women everywhere are entering the labor force now at high rates, and as economic conditions insure a continued need for two incomes in many households.

Firms assess the labor pool in a potential location in advance, and reportedly a minimum population of 100,000 to 150,000 is required to guarantee an adequate supply of unskilled labor. As the semiconductor industry remains almost completely unorganized now, firms are also very wary of areas of active unionization. Finally, all firms now have clear policies of dispersing manufacturing activities in order to avoid direct competition for the same labor pool--both skilled and unskilled--along with the other problems of concentration they are now experiencing in Santa Clara County.

The third level of locational criteria are easily met by a multitude of locations. Reliable and direct air transportation is needed for the freighting of goods but more importantly, for the transportation of people. Location within proximity of headquarters allows a firm's "top notch" engineers to fly out on short notice to deal with difficulties in the manufacturing process, as well as allowing easy access for top executives.[7] Thus many firms noted that a three hour plane ride was the furthest east from Santa Clara County they would locate. The semiconductor manufacturing plants so far (with one exception) are located in or to the west of Texas; and the most often cited possibilities for future sites are all in the Pacific northwest or the southwest.[8]

The semiconductor industry is highly energy intensive. It reportedly uses 15 times more power than an average industrial complex uses. With increasing automation, the electricity needs for production are growing dramatically (Science, 5/2/80; AMI interview). As previously noted, energy brownouts can cause severe damage not only to the product but also to the production equipment. Thus the guarantee of an ample and reliable supply of energy is a factor in site location. (The Pacific northwest was often mentioned as desirable for its reliable supply hydroelectric power.)

Finally, "positive" community and local government attitudes were often mentioned in conjunction with a criticism of the no-growth attitudes and policies in Santa Clara County and California in general.[9] This industry is actively being courted by chambers of commerce all across the country, so this condition is generally easily met. It is the kind of industry everyone likes: clean, modern and seemingly unobtrusive, so firms are often able to gain considerable concessions from local governments for locating within their jurisdictions.[10]

New hubs of high technology industry are thus being created throughout the West by the dispersion of semiconductor manufacturing outside of Silicon Valley; and the places they are going are new, middle-sized metropolitan areas which provide the institutions and favorable social, cultural and physical environment which constitute a desirable quality of life for the appropriate reproduction of the industry's professional manpower.

New regional growth. The restructuring of electronics and semiconductor production is generating a new pattern of geographic regionalization in the U.S. Disperse regions of the country are now beginning to boom with the rapid expansion of high-technology production facilities. Arizona is a prime example. Virtually every semiconductor company headquartered in Silicon Valley is actively considering sites in both Phoenix and Tucson, reportedly because of the area's affordable housing, desirable quality of life and lifestyle (recreation, culture, university) along with the cooperative local government attitudes, the large pool of unskilled labor and minorities, and the fact that it is a "right to work" state (Los Angeles Times, 12/2/79). National Semiconductor and IBM have recently established plants in Tucson along with a number of other high-technology electronics and aerospace companies, e.g. Hughes Aircraft, Burr Brown Research Corporation, Gates Learjet Corporation, TEC, Inc., Veeco Instruments, Inc. and the

Jerrold Electronics division of General Instrument Corporation. As a result, between 1970 and 1979, Tucson's manufacturing labor force doubled from 9,000 to 18,000 (Waller, 1980). A similar process is occurring in Phoenix, where Intel and Spectra Physics are among the more recent newcomers. Thus due in part to these new high technology concentrations, Arizona has been the fastest growing state in the nation over the past decade, with its population up 51.4% from 1.68 million to 2.54 million (Los Angeles Times, 12/2/79).

Along with this rapid regional economic growth, the class structure and the organization of local space in these growing areas is also being altered by the ingress of the industry. While the feedback effects of the decentralization of elecrronics manufacturing on the class structure and nature of future growth and urban development in Santa Clara County seem fairly clear, this discussion of the specific effects of the industry on these new regions can only be speculative. These processes are just beginning, and much further research on the subject is necessary.

Two considerations are key. The first is the nature of the decentralization process. While all of these larger multidivisional firms are dispersing manufacturing facilities for individual product line divisions to new locations, the organization of R & D and technological activities has varied. Within such a multi-product, multilocational firm, two strategies are possible. Under a centralized structure, all R & D and work on new products, processes or major improvements are concentrated in one central R & D facility (and almost always located with the headquarters). Aside from minor readjustments, no R & D is performed at the branch plants, only direct production. The class structure generated in the new region under such centralized organization includes a certain percentage of low and middle management and some low ranking engineers and technicians to man the production process, along with a high proportion of less skilled production workers (mainly women) earning low wages. This arrangement comes very close to generating a regional division of labor by class within the industry (given the limitations inherent in the technological-basedness of the manufacturing process). It creates regions which are used solely for direct production and thus completely subject to "external control" (Massey, 1980). This regional division of classes also undermines the basis for the kind of urban contradictions which were experienced in Silicon Valley.

A decentralized organization of corporate R & D, on the other hand, involves dispersing short term, product oriented R & D functions along with direct production. In this way, while the highest level long range research remains concentrated at a central lab, the individual product line divisions are far more self-sufficient, acting as operating units with considerable management decision-making and innovation capabilities. Intel, for example, follows a strategy of moving entire operating divisions rather than just manufacturing facilities. They start by creating two mirror-image organizations at least a year ahead of time, with the idea that one will move and the other will stay (Business Week, 3/10/80). The class structure generated in this instance comes closer to replicating that in Santa Clara County, and is far more contradictory than the centralized strategy, as a whole strata of high level professionals for R & D along with a more extensive management hierarchy are developed in the new region. In this case, the potential exists for the urban contradictions inherent in accomodating both segments of the labor force. While more research is needed, it appears that the larger firms, such as Intel, Hewlett-Packard and Motorola are pursuing this decentralized strategy, while smaller firms such as AMD and AMI have kept R & D centralized.

The second major consideration is the level of regional clustering and the industrial mix in the new regions. While an agglomeration like that in Silicon Valley will never be reproduced by this industry because the entire structure and nature of competition have changed and because firms have learned to scatter, rather than concentrate their operations, some new regional concentrations of high technology industry are emerging. While desiring to avoid the extremes of concentration, firms also clearly want to avoid the risk of being pioneers in an area. Furthermore, the social desirability of an area, which is key to successful location is often generated by the prior presence of a similar class of people, and thus a similar type of high-technology operations. (This includes electronics, semiconductor, aerospaces, and high technology equipment and support industries.) Already new centers of electronics production have appeared in Austin, Texas, (Advanced Micro Devices, IBM, Motorola, and Data General), Salt Lake City, Utah, (National Semiconductor, Varian Associates, Signetics and Intersil), Colorado Springs, Colorado (Hewlett-Packard, Mostek, Digital Equipment, Inmos, Honeywell, and NCR) along with Phoenix and Tucson (Business Week, 3/10/80).[11] This tendency to cluster may well aggravate the stress on the local urban structures. (There are a few exceptions to this pattern of industrial clustering, such as the isolated location of AMI's first manufacturing branch plant in Pocatello, Idaho.)

It is likely that the urban processes and problems which arose in Santa Clara County will thus be reproduced in these new regions. The structure and dynamics of the industry have been completely transformed, so these processes and their specific outcomes will not be the same as those in Santa Clara County. However, it appears that the bifurcated labor force with a high proportion of professional and technical employees which characterizes production in the industry (and other similar high technology industries) is being reproduced in many of these new regions. Since the top management and highest level professionals will remain concentrated in Silicon Valley even if technology is decentralized, it is unlikely that the class structure in the new regions will ever be as severely dichotomized as in Santa Clara County. However, as the technological sophistication of production increases, a larger percentage of highly skilled professionals are required for the manufacturing process. Furthermore, the firms are now much larger and production and employment are growing very rapidly. A few large firms clustered in one area can potentially create equally severe problems as many small firms.

Evidence of the replication of Santa Clara County's spatial form and urban contradictions is provided by the case of Tucson, and Phoenix, Arizona. Along with the previously mentioned economic boom, familiar urban problems are emerging. To begin with, a large percentage of the new jobs are not going to local residents. For example, the new IBM plant established in Tucson in 1979 has 3,000 employees, and more than half of them--those in the top paying white collar and engineering jobs--were imported from outside of the region. Likewise, in Phoenix, 44% of the heads of families of in-migrants are under 35 and have college degrees (Los Angeles Times, 12/2/80). At the same time, observers have noted the widespread practice by these new high technology firms of hiring large numbers of women, especially minority group women, for the low paying unskilled production jobs (Waller, 1980). Thus, a familiar class structure is being produced, and with it, similar urban problems.

Tucson and Phoenix are also currently experiencing dramatic inflation of land and housing values. The housing boom is reportedly resulting from the rapid growth of demand for luxury housing (priced at $300,000 and up) by an influx of management personnel and professionals from places like California. A shortage of housing has developed as well, with the vacancy rate for single family housing now under 1%. Along with the escalating cost of living, the sprawling nature of urban development in both Tucson and Phoenix, has resulted in severe transportation congestion and environmental damage.

One observer has predicted the emergence of "a 'silicon desert' in Arizona, a 'silicon mountain' in Colorado, and a 'silicon prairie' in Texas" following the "Silicon Valley" model (Electronics, 2/28/80). Further research will be able to verify whether similar dynamics to those experienced in Santa Clara County are actually in progress in Arizona, as well as Austin, Colorado Springs and Salt Lake City. The regions are attractive to electronics firms because of the social milieu and quality of life they provide for professionals. However, provision of appropriate conditions for the reproduction of this professional middle class is not sufficient; the remainder of the manufacturing workforce must also live and be reproduced in the same urban area. This is where Silicon Valley's problems were rooted; as the industry grew, it became increasingly difficult to accomodate both segments of the industry's workforce within the same metropolitan area. While the contradictions have been resolved in Santa Clara County through the upgrading of the region's functions and elimination of the need for a production workforce, these problems may be reproduced in the new cities where the industry is locating. The resolution cannot be the same in these cases, as they cannot all eventually become control and research centers. Along with the sprawling urban form and the accompanying congestion, housing shortages and escalating cost of living which already typify these cities, we can also expect the emergence of similar movements to limit and control the adverse effects of industrial development on the local environment.

Footnotes

1. In fact, one of the most repeated complaints made by the industry associations and employers is the shortage of engineers being trained in the U.S. It is most often voiced in conjunction with demands for greater government funding of education.

2. Even in other branches of the electronics industry, such as computers, transportation costs are not a major factor in plant location, as, "A 16 wheel truck can carry $3 million worth of computers . . . and that gives you enormous mobility" (Business Week, 3/10/80).

3. While a low cost of living is often mentioned, it is a distinctly secondary element in the overall calculus which does not subsume the more qualitative factors.

4. Thus, Austin, Texas, was cited as having an especially desirable labor pool because there are many unemployed Chicanas there. The vast numbers of Asian and Mexican immigrants in the southwest undoubtedly helps to explain the concentration of new firm locations in these Sunbelt areas rather than in the northeast.

5. The large scale use of women as the unskilled and semiskilled labor force for electronics manufacturing is clear in the fact

that the worker per household ratio in Santa Clara County is 1.6, the highest in the nation (SRI International, 1980).

6. This reliance on female and minority workers, combined with slavishly paternalistic practices, goes a long way in explaining the difficulties in unionizing electronics workers in Santa Clara County. See Massey (1980) for a related discussion of the use of female labor for electronics production in the U.K.

7. One firm reported an average of 60 trips a month by engineers and executives between their site in Idaho and the home base in Santa Clara County.

8. The one exception is Fairchild, which has two New England wafer fabrication plants. These were acquisitions of old plants from firms going out of business, rather than new construction; however, the success of these plants indicates that the west coast orientation of most Santa Clara firms may well be related to a considerable degree of west coast chauvinism.

9. California was unanimously rejected as a future site, generally due to the high cost of housing, problems of energy supply and "unfavorable" business climate.

10. One firm representative told the story of buying land for a large facility in San Diego and after getting the city permit,

being told that the water and sewer hook-ups would cost $2.5 million. He simply found a site elsewhere, sold the land and proceeded to build on the new site where they got not only free hook-ups, but also tax concessions.

11. The Portland, Oregon/Vancouver, Washington area is also developing as such a cluster, with HP, Computer Automaton, and Intel there already. However after the recent volcanic activity from Mt. St. Helens, National Semiconductor announced that they had stopped construction on their new facility in Vancouver. It is not likely that other firms will choose to locate there in the near future.

IV. CONCLUSION

The transformation of the Santa Clara Valley from a bucolic agricultural community into a sprawling metropolis exemplifies the drastic acceleration in the pace with which regional growth and decline are now occurring in the U.S. In the early 1950s, a few fledgling electronics firms were taking root in the sparsely populated university town of Palo Alto. By 1970, Santa Clara County had become one of the fastest growing and most affluent counties in the nation, as well as the world's densest concentration of high technology industry. By 1975, with a population exceeding 1.2 million, the county was already suffering the consequences of its explosive growth. Skyrocketing housing and land costs, shortages of manpower, seriously congested transportation networks and a no-growth movement now plague the very electronics firms whose rapid expansion so completely transformed the county's landscape. Silicon Valley's high technology companies are now restructuring and dispersing their manufacturing operations to locations outside of the county rather than continuing to grow in the region. Santa Clara County's era as a manufacturing center has ended. The whole cycle--the transition from a rural agricultural economy to a highly urbanized, manufacturing based economy and the ensuing emergence of urban contradictions which are once again transforming the nature of the region's growth--took little more than two decades.

As this thesis demonstrates, Santa Clara County's regional boom was a direct outcome of the evolution of the electronics industry which clustered in the valley; the accelerated pace of economic growth and urbanization reflected the phenomenal speed with which electronics production expanded during the post-war period.

Electronics production also shaped the urban landscape--the specific organization of space--in Santa Clara County. This particular spatial structure subsequently developed to the point of creating political, economic and social limits to the further growth of the industry in the county, and in turn has fed back into production and influenced the course taken by the electronics industry.

Thus the dispersion of electronics and semiconductor production out of Santa Clara County is not because the city is too big, and has too many people and jobs. Nor is it a result of having grown too fast or having grown under the control of greedy developers. The urban problems which are driving industry away from Santa Clara County are not simply those of misplanning, nor are they the outcomes of some general processes of urbanization under capitalism. Rather, they are due to the specific urban structure created by the industry and the social and functional contradictions inherent in it. Along with economic growth, electronics production generated a highly dichotomized class structure in the county, one which was distinguished by a large proportion of professional and highly skilled manpower along with the remaining majority of unskilled and minimally paid production workers. The patterns of land use and urban development in the region evolved so as to accomodate the vastly different lifestyles and nature of reproduction required for these dominant types of labor power. This need for the differential reproduction of the major segments of the dichotomized electronics workforce--and in particular the social and spatial requirements of the affluent professional class--is at the root of Silicon Valley's urban problems. Despite the fact that the local spatial structure developed in response to the needs of electronics production almost exclusively, as the industry expanded it became increasingly difficult to accommodate and reproduce both segments of the industry's workforce within the same metropolitan area. Inflation of housing prices, transportation congestion, labor shortages and the no-growth movement all are manifestations of the limitations, both physical and social, of the local spatial structure for accommodating the industry's workforce. Facilitated by the changing nature of competition and ownership patterns and the expanded scale of production in electronics, the dispersion of manufacturing out of the region is thus a direct response to these urban problems--the industry's means of escaping the contradictions it has produced in the local spatial structure.

This new locational behavior in turn is having direct feedback effects on the nature of growth and urban development in Santa Clara County, as well as on regional growth and the organization of urban space in areas where manufacturing is being located. The most sophisticated research, design, development and control functions remain clustered in Silicon Valley, while the county's manufacturing operations are gradually being phased out. Santa Clara County will thus be upgraded as an elite control and R & D center, and its urban landscape will soon reflect this. Meanwhile, the decentralization of semiconductor production is generating an entirely new pattern of geographic regionalization in the U.S. Whole new regions of the country are now growing as centers for electronics manufacturing, and the patterns or urban development in these areas may replicate elements of the experience of Santa Clara County.

Future research will be able to verify the repetition of similar urban processes in new centers such as Austin, Salt Lake City, and Tucson as a result of their high concentrations of electronics production. Santa Clara County might be viewed as a prototype--the model of the spatial form of the future--generated by such science-based industries in order to accommodate the dichotomized class structure with a large professional component.[1] Along with sprawling urban form and the accompanying congestion, housing shortages and escalating cost of living which already typify these cities, we might expect the emergence of professional middle class movements to limit and control the adverse effects of industrial development on the local environment.

This thesis has illustrated the specific impacts of the electronics industry on the processes of regional growth and urban development in Santa Clara County. The rapid expansion of electronics production in the region generated not only rapid economic growth but also a specific class structure and organization of local space. The latter, as they evolved historically eventually created contradictory effects which altered the industry's locational calculus. This in turn is having feedback effects on the nature of regional growth and urban development in the county, as well as on the regional and urban geography elsewhere in the country.

A comprehensive understanding of regional processes must thus examine the nature of production and the effects and contradictions created by the impact of industrial development on local social and spatial structures, as well as the contradictory effects generated by regional economic growth. Similar analyses of the impact of other industries on the urban and social structures in places where they are located will help to isolate similar impacts and feedback effects generated by production, and will enrich our understanding of industrial behavior and the processes of regional growth and decline.

Some final implications of the process of industrial restructuring described here can also be noted. The geographic separation of production from control and research in semiconductor industry has generated a spatial division of the industry's workforce by class. While internationalization and relocation of the routinized assembly phase of production to the third world effectively isolated the least skilled and lowest paid workers from the remainder of the workforce, this redistribution of manufacturing activity allows the spatial separation of the most highly educated professionals and the top managerial strata from the less elite professionals and technicians, the middle management and the semiskilled production workforce. This regional division of producton by class has allowed industry to escape some of the costs and contradictions of a spatially concentrated class structure. The spin-off of assembly to the third world reduced labor costs dramatically in a period of severe competition and cost cutting; the relocation of manufacturing allows escape from the costs of the urban contradictions the industry has generated in Santa Clara County.

However, as production and employment in the industry continue to expand, successful unionization of the workforce is increasingly likely, especially given the continuation of minimal wages for production level work, the deskilling of the work process, and increasing awareness of the health and safety hazards exposed in the industry.[2] The potential is especially great in the new manufacturing regions where the higher proportions of production workers are concentrated and which are subject to the added element of external control.

As such contradictions arise in urban areas across the country, and create growing obstacles to production, it is unclear what the response of the industry will be. The Silicon Valley response was a one-time resolution. The four major and most salient trends currently underway in the electronics industry do, however, provide a hint as to possible responses by the industry.

First, automation of production is occurring very rapidly in the industry; given the easy availability of the technology, it is a likely response to the problems of worker organization and rising labor costs. Secondly, production is becoming increasingly internationalized. The near future will undoubtedly bring an accelerated expansion of wafer fabrication and advanced manufacturing facilities in offshore sites in Europe and Asia in competition for access to and control over growing foreign markets, as well as in order to overcome competitive disadvantages created by tariffs and the lower labor costs abroad. This process will be facilitated by the increasing internationalization of ownership through joint-ventures and international co-production agreements. Thirdly, the role of the state in promoting the industry's growth is expanding once again. The massive resurgence of defense spending and the current calls by the business community for such "sunrise industries" will provide a huge boost to the industry. Finally, as the amalgamation and monopolization of the semiconductor, computer and other systems producers continues, the emergence of giant and powerful transnational electronics conglomerates will provide the industry with more flexibility and resources with which to respond to these local contradictions.

Future research and organizing efforts must thus increasingly be focused on the international level on the nature of international competition and the internationalization of production.

Footnotes

1. The entire structure of employment in the U.S. is in fact becoming dichotomized in a similar direction, with increasing numbers of white collar professionals and semiprofessionals, at the same time as the deskilling of direct production work occurs. Thus, we are already seeing the evolution of spatial structures similar to that of Santa Clara County in cities all over the country. This also requires further research, and a detailed analysis of specific cities and their social and spatial structures.

2. The electronics industry is extremely hazardous. According to a U.S. OSHA representative, "The electronics industry is misleading. People think of it as wires, soldering and transistors. But when you get to semiconductor production, you're really talking about chemical reactions. It's a chemical industry." (San Jose Mercury, 4/7/80). Toxic chemicals are used for virtually every stage of wafer fabrication; many are hazardous, some are poisonous and a few can cause cancer.

   A highly successful education and organizing drive concerning the industry's potential health and safety hazards is well underway in Santa Clara County. A Santa Clara County semiconductor firm, Signetics, was recently cited by the National Institute for Occupational Health and Safety (NIOSH) as having a "significant occupation-related health hazard". Three women who were fired from their jobs at Signetics after complaining of the health hazards have filed a $25 million class action suit against the firm (San Jose Mercury, 2/21/80). The local Project on Health and Safety in Electronics (PHASE) is well organized; local employers are clearly worried about this health and safety drive.

APPENDIX A.

INTERVIEWS CONDUCTED

		Date of Interview
I.	Industry Representatives	
1.	Addington Laboratories Incorporated Dennis Contois Division Manager	2/20/80
2.	National Semiconductor Gregory Harrisson Corporate Administrator	2/22/80
3.	Varian Associates Thomas Moreno Vice President of Corporate Development	2/22/80
4.	Litronix Douglas Fraser, Andrew Mann and Gary Hile Site Selection Team	2/26/80
5.	Advanced Micro Devices (AMD) Thomas Skornia Vice President Corporate Services	2/27/80
6.	American Microsystems, Inc. (AMI) Ralph Jensen Manager Administrative Services and Facilities	2/27/80
7.	Hewlett-Packard Corporation John Brown Corporate Site Planning	2/29/80
8.	Micro Power Systems John Hall President	2/29/80
9.	Intel Corporation Gerald Diamond Corporate Site Selection	3/5/80
10.	Precision Monolithics Inc. (PMI) Anthony Steimle Vice President of Manufacturing	3/5/80
11.	Fairchild Camera & Instrument Corporation Charles Smith Vice President and General Manager	3/19/80
II.	Local Individuals	
1.	Sunnyvale Planning Department Edward Moore Director of Planning	1/28/80
2.	Mid-Peninsula Citizens for Fair Housing Chris Cooper	1/28/80
3.	Santa Clara County Planning Department Cathy Remson-Lazarus Planner	2/11/80

4.	International Brotherhood of Electrical Workers (IBEW) Vivian Harris Union Organizer	3/4/80
5.	Santa Clara County Manufacturer's Group Peter Giles President	3/7/80
6.	Mid-Peninsula Coalition Housing Fund Janet Owens President	3/19/80
7.	Central Labor Council, Santa Clara County AFL-CIO Mike Nye President	3/24/80
8.	Stanford University, Engineering Department Ferril McGhie Dean	3/24/80
9.	Sierra Club/Peninsula Conservation Center Ellen Christiansen Coordinator	3/24/80

APPENDIX B.

Name of Firm: Existing Facilities[a]	Planned Facilities[b]	Year Established	Product	1979 Sales (000)	1979 Employment
1. HEWLETT-PACKARD COMPANY		1939	Electronic equipment for measurement, analysis and computation. Includes electronic data products, medical electronic equipment, electronic test and measurement equipment and analytic instrumentation.	2,361,000	52,000
*Palo Alto, CA	*Palo Alto, CA				
Cupertino, CA	Everett, WA				
Mountainview, CA	Spokane, WA				
San Jose, CA	Vancouver, WA				
Santa Clara, CA	Roseville, CA				
Sunnyvale, CA	Greeley, CO				
Santa Rosa, CA	Raleigh, NC				
San Diego, CA					
McMinnville, OR					
Corvallis, OR					
Boise, ID					
Fort Collins, CO					
Loveland, CO					
Colorado Springs, CO					
Andover, MA					
Waltham, MA					
Rockaway, NJ					
Avondale, PA					
South Queensferry, SCOTLAND					
Grenoble, FRANCE					
Böblingen, GERMANY					
Waldbronn, GERMANY					
Tokyo, JAPAN					
SINGAPORE					

APPENDIX B.

8.	LITRONIX, continued. Penang, MALAYSIA MAURITIUS				
9.	PRECISION MONOLITHICS, INC., (PMI) *Santa Clara, CA Manila, PHILIPPINES[j]	1969	Linear monolithic integrated circuits, conversion circuits.	$22,700	500
10.	MICRO POWER SYSTEMS *Santa Clara, CA Tijuana, MEXICO Manila, PHILIPPINES	1971	Custom made semiconductor products and technologies.	n.a.	380
11.	ADDINGTON LABORATORIES, INC. *Sunnyvale, CA	1971	Custom made microwave semiconductors for use in aircraft and missiles.	n.a.	40

NOTES: a Listing of existing facilities does not include marketing, sales and service offices. * connotes corporated headquarters building.

b Planned facilities listed are new facilities or expansions underway or definitely planned as of 4/80.

c Hewlett-Packard has a 50-50 joint-venture with a Japanese firm.

APPENDIX B.

1.	HEWLETT-PACKARD COMPANY, continued. Penang, MALAYSIA SOUTH AFRICA					
2.	NATIONAL SEMICONDUCTOR *Santa Clara, CA[d] Salt Lake City, UT SCOTLAND SINGAPORE	Tucson, AZ Vancouver, WA FRANCE[e]	1959	Semiconductor devices and integrated circuits. Also digital systems based on semiconductor technology (e.g. watches, calculators and minicomputers).	$719,740	35,000
3.	FAIRCHILD CAMERA & INSTRUMENT *Mountainview, CA Palo Alto, CA San Jose, CA San Rafael, CA Healsburg, CA South Portland, ME Worpinger Falls, NY ENGLAND HONG KONG SINGAPORE	Tulsa, OK Cebu, PHILIPINES	1957	Semiconductor components and integrated circuits. Also semiconductor test systems and systems based on semiconductor technology. (e.g. automotive systems, televisions, cameras, watches, aircraft, etc.).	n.a.	26,000
4.	INTEL CORPORATION *Sunnyvale, CA	Albuquerque, NM	1968	Semiconductor memories, microprocessors, memory	$662,996	14,000

APPENDIX B.

5.	VARIAN ASSOCIATES, continued Melbourne, AUSTRALIA Georgetown, ONTARIO Hayes, ENGLAND[g] Tokyo, JAPAN[g] Tijuana, MEXICO Tuam, IRELAND TAIWAN Puerto Rico				
6.	ADVANCED MICRO DEVICES (AMD) *Sunnyvale, CA Austin, TX *Sunnyvale, CA Penang, MALAYSIA Manila, PHILIPPINES	1969	Complex digital analog, LSI, monolithic and MOS integrated circuits.	$148,276	8,000
7.	AMERICAN MICROSYSTEMS, INC. (AMI) *Santa Clara, CA Pocatello, ID Pocatello, ID Swindon, ENGLAND Seoul, KOREA	1966	MOS and large scale integrated circuits.	$108,553	3,700
8.	LITRONIX *Cupertino, CA Sunnyvale, CA	1969	Solid state optoelectronic components and related products.	$35,000	3,400

APPENDIX B.

4.	INTEL CORPORATION, continued.			systems and microcomputer systems.		
	San Jose, CA Livermore, CA Mountainview, CA Santa Cruz, CA Aloha, OR Chandler, AZ Austin, TX	Aloha, OR Chandler, AZ				
	MALAYSIA PHILIPPINES BARBADOS	Haifa, ISRAEL				
5.	VARIAN ASSOCIATES		1948	Analytic instruments, vacuum pumps, components and systems. Electron tubes and solid state equivalents. Industrial equipment and medical systems.	$493,000	13,000
	*Palo Alto, CA Santa Clara, CA San Carlos, CA Walnut Creek, CA Florence, KY Lexington, KY Salt Lake City, UT Beverly, MA Danvers, MA Lexington, MA Woburn, MA Grove City, OH Geneva, IL	*Palo Alto, CA[h]				
	Turin, ITALY Bremen, GERMANY					

APPENDIX B.

NOTES: Continued.

d National Semiconductor has 19 buildings on a 55 acre plot of land in Santa Clara

e National Semiconductor has a joint-venture integrated circuit facility with Saint Gobain Pont a Mousson which will be operated by Eurotechniqe.

f Fairchild has a joint-venture with GCE England for a wafer fav facility in England.

g Varian is affiliated with EMI Vanon in Hayes England, and ANELVA Corporation in Tokyo, Japan.

h Varian has complete plans for an International Corporate Headquarters Building in the Stanford Industrial Park, which has been threatened by the county's no-growth movement. They plan to fight hard to build it as planned, and then halt any further construction in the county.

i AMD has complete plans for a 12,000 square feet "Technology Development Center" in Sunnyvale, and for an International Corporate Headquarters Building also in Sunnyvale of 88,000 square feet. Construction is planned for 1980 and 1981 respectively; thereafter no construction in the county will be done.

j Precision Monolithics does not have any facilities offshore. They subcontract all of their assembly to Taiwan, Hong Kong and the Philippines. They do not intend to buy an offshore site in the near future.

SOURCES: Interviews with representatives of all firms.
1979 Annual Reports: Hewlett-Packard, National Semiconductor, Intel, Varian Associates, Fairchild, Advanced Micro Devices, American Microsystems, Inc., Precision Monolithics, Inc., "An Introduction to Litronix: Affiliate of Siemens Company".

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