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High Technology Industry and Territorial Development: The Rise of the Orange County Complex, 1955-1984

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Abstract

The paper deals with the growth and development of the Orange County high technology industrial complex. At the outset, a simple empirical overview of the rise of manufacturing in the County is provided. It is then shown how population grew in the County as a function of industrial development. The spatial and social characteristics of this population are described. The structure of the local labor force is also discussed in detail. The argument then moves to a demonstration of how the dynamics of vertical and horizontal disintegration of productive functions have created a peculiar kind of industrial geography in Orange County. These dynamics are examined statistically. It is shown that they involve a transfer of work from larger, more-bureaucratized and more-unionized plants to smaller less-bureaucratized and less-unionized plants. The internal locational logic of the complex is examined. The discussion is rounded out with an overview of the problems of social and territorial reproduction in Orange County.

Introduction

In this paper, I seek to describe and analyze the growth and internal differentiation of Orange County, California, as a high technology industrial complex. The paper falls naturally into two distinct halves. In the first half, I show in detailed empirical terms how the complex grew over the period stretching from about the mid-1950s to the mid-1980s. In the second half, I attempt to reconstruct these events in analytical terms via an investigation of the logic of industrial organization and territorial development. In all, I describe how the complex has made its historical and geographical appearance, how it ramifies with a local territorial process, and how it has evolved into one of the most dynamic growth centers within the American economy today.

The rise of the Orange County high technology industrial complex coincides with a time of considerable turmoil in the U.S. economy as a whole. The period from the mid-1950s to the mid-1980s was marked by deeply-rooted shifts in the geographical pattern of production and population involving (especially in the later part of the period) massive movements of capital and labor from the Frostbelt to the Sunbelt. These movements are often alluded to in the literature as outcomes of a nation-wide restructuring process brought on by changes in industrial technology and global economic conditions (cf. Bluestone and Harrison (1982), Massey and Meegan (1982)). In the Frostbelt, restructuring has left a legacy of derelict industrial capacity, high rates of unemployment, and fiscal demise. In the Sunbelt, by contrast, it has helped to bring about a major economic renaissance and the development of new concentrated points of industrialization at such locations as Silicon Valley, the Dallas-Fort Worth area, Research Triangle Park, Orange County, and so on (cf. Premus (1982)). Many of these latter locations have become foci of growth for a wide variety of high technology industries. Further, as welfare-statist, Keynesian capitalism has started in the 1980s to give way to the new regime of accumulation and social regulation (cf. Aglietta (1979), Lipietz (1984)) based on resurgent economic competition, supply-side policy initiatives and massive federal arms expenditures so these Sunbelt centers are growing with added strength. They have come increasingly to represent a new industrial heartlande in the American economic landscape.

These various developments pose major challenges to geographic theory. At every level of analysis - macro-social processes, the detailed organizational dynamics of the production system, location theory - our existing stock of knowledge is simply unequal to the tasks ahead. I do not claim in what follows to be able to improve much upon this state of affairs, but I do hope to be able to adumbrate at least some preliminary points of departure for a renewed theoretical attack upon the developmental problems of the modern space-economy. I now start on this task with a simple empirical description of the changes that have occurred in Orange County between about 1955 and 1984;

and as the argument develops, I then move into a somewhat more ambitious project of analysis and interpretation based on a developing theory of industrial organization and location (cf. Scott (1983a)).

An Overview of the Orange County High Technology Complex

Orange County is situated in Southern California between Los Angeles County to the north and San Diego County to the south (Figure 1). At the present time, it is made up of some 26 incorporated municipalities, mainly in the more developed northern half of the County, together with a series of unincorporated communities and County lands.

The industrial base: Some definitions. Orange County began to emerge as a definite locus of industrial production some time in the mid-1950s, and over the succeeding years its extraordinarily powerful engines of growth have driven it forward to become one of the most important and highly developed production centers in the American industrial system today (see, for example Table 1 and Figure 2). By far the greater proportion of the County's industrial activity is composed of high technology enterprises producing aerospace and electronics outputs under federal defense and space contracts. Around this basic core innumerable specialized input suppliers have converged.

For the purposes of this analysis, manufacturing industry in Orange County is divided into (a) a high technology sector, and (b) all other manufacturing. The high technology sector is further broken down into two subsectors designated a core and a penumbra. The core is defined in terms of four two-digit standard industrial categories, namely SIC 35 (machinery except electric), SIC 36 (electric and electronic equipment), SIC 37 (transportation equipment), and SIC 38 (instruments and related products). In Orange County these industries commonly make use of technically-sophisticated manufacturing processes and each has high proportions of engineers, scientists and technicians in its labor force. Note that SIC 35 in the county is largely made up of the three-digit sector SIC 357 (office and computing machines). The penumbra is defined as an aggregation of three two-digit industries as follows, SIC 28 (chemicals and allied products), SIC 30 (rubber and miscellaneous plastics products), and SIC 34 (fabricated metals products). The penumbra consists of industries that are apparently somewhat less technically-sophisticated than the core sectors, but they are closely identified with the core because they provide it with many critical inputs and they are tied to it by strong locational affinities.

Without any doubt a more refined definition of the core and the penumbra could be achieved by juggling three- and four-digit standard industrial categories. However, it is impossible to construct meaningful data runs on the basis of a more stringent definition, since published data sources have a strong tendency to suppress information for three- and four-digit categories at the local level. Nor do problems of definition end here, for several changes have occurred over the years in the standard industrial classification so that we need to exercise care in any analysis of time series data. In particular, after 1972, forms of production that were previously classified under SIC 19 (ordnance) were re-assigned to a variety of other categories. In this process SIC 376 (guided missiles, space vehicles and parts) was created as a subsector within SIC 37 (transportation equipment). This means that pre-1972 and post-1972 data runs for SIC 37, (one of the central industries of the core complex) are severely inconsistent with one another.

The pattern of growth. With all of these provisos in mind, we may reexamine the data given in Table 1 and Figure 2. These data describe the growth of manufacturing in Orange County over the last three decades. They show that in the early 1950s manufacturing employment in the County was negligible; that growth accelerated rapidly in the 1960s and 1970s; and that by 1981 manufacturing enterprise had increased to the point where it was employing as many as 225,394 workers. Of these latter workers, 56% were employed in the core high technology sector and 18% were employed in the penumbra.

From the very earliest days of the development of the complex, SIC 366 (communications equipment) has been the major employer and the central pole of economic activity. The fortunes of SIC 366 in Orange County have always been directly tied in to the course of federal defense and space spending and employment in the sector has consistently gone up and down as military and NASA appropriations have expanded and contracted (see Figure 3). In 1959, the sector employed 18.2% of the County manufacturing workers, and it did so in just 4 large plants. By 1970, employment had increased to the point where it now accounted for fully 23.6% of all manufacturing workers, again in predominantly large plants. However, federal defense and space spending (in real terms) was starting to dry up by the late 1960s and early 1970s, and the industry then entered a long period of crisis and decline. By 1981 employment in the sector had fallen both absolutely and relatively to a level such that it now represented only 11.5% of the County's manufacturing labor force. Average plant size, too, had fallen sharply by 1981. Even so, the sector has remained to the present day the County's chief employer and as defense spending has accelerated again in the early 1980s, so the industry has begun noticeably to recover from its long period of crisis.

Thus, and despite its many vicissitudes, the communications equipment sector (along with the aircraft and guided missiles sectors with which it is closely allied) has been one of the central conduits of growth in the Orange County industrial complex. Innumerable electronics, computer, and instruments industries have congregated around it in their turn. These latter industries now constitute important poles of economic activity in their own right, and they are, in particular, very much linked in via upstream procurements to the penumbral industries of the complex. Into this vortex of economic activity a large and variegated labor force has been drawn. Concomitantly, population has grown apace, and an insistent process of urbanization has been set in motion. In short, Orange County has developed into a major growth center with a rapidly expanding train of secondary and tertiary effects. We may now inject more substantive detail into these propositions by attempting to identify and describe the stages of economic growth through which the County has evolved.

The Stages of Orange County's Growth

The origins of the complex, 1955-1960. In the mid-1950s, Orange County was in essence a quiet backwater given over to agricultural pursuits with some modest industrial production geared largely to local resources and needs. The population was small, and residential activity was mainly confined to a few communities in the northern half of the County and along the coast. Some suburban tract development was beginning to make itself evident, however, as the Los Angeles built-up area expanded southwards. In fact, the geographical position of Orange County between Los Angeles and San Diego, together with its abundance of open space, cheap land, and excellent transport connections made it a prime recipient of the overspill growth of the Los Angeles metropolis in the post-War years. The uncluttered landscape of the County together with its abundant recreational facilities and varied natural environments offered ideal living conditions for its rising middle class population, and its conservative political inclinations (then as now) made it an attractive place for business.

The mid-1950s was a time when the aerospace and electronics industries in the United States generally were starting to boom under the stimulus of military procurements and the beginnings of space program contracting. Los Angeles was already a major center of these kinds of industries (cf. Arnold et al. (1960), Steiner (1961)), and local firms grew rapidly as the markets for aerospace and electronics outputs expanded. Concomitantly, many new branch plants were created at this time. These plants were invariably large in size, and they became prime candidates for locational decentralization as a means of escaping from the high land costs and congestion of Los Angeles. In this way, significant numbers of branch plants shifted to the suburban fringes of Los Angeles, and most especially to Orange County. Figure 4 captures the geographical expression of these developments just at a time (1960) when the County was beginning to consolidate its early growth as a focus of high technology industry.[1]

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[1] The data on which Figure 4 are based contain some inherent biases. The same biases also affect Figures 5 and 6. This problem is described in the Appendix to this paper.

A large proportion of the plants that located in Orange County in the second half of the 1950s were thus controlled from outside of the local area. Most of them were large vertically-integrated systems houses (as opposed to products houses making relatively standardized equipment) using large numbers of scientific and technical personnel in the development of custom-designed special-purpose products. Most of the more important of these systems houses (e.g., Babcock Radio Engineering, Hallamore Electronics, Hughes Ground Systems, Interstate Engineering) were classified under SIC 366, as mentioned earlier. Each employed several hundreds of workers in the assembly of highly specialized systems for ground support, space navigation, weapons guidance, aerial and submarine navigation, and so on. These houses formed the backbone of the industrial development of the County and as they put increasingly deeper roots into the local area, so the County's industrial apparatus began palpably to evolve into an organized inter-dependent system.

The intermediate growth period, 1960-1975. Some time in the 1960s, then, Orange County manufacturers began to draw together into a *complex* in the true sense, i.e., a congeries of inter-linked industries sharing among themselves a common pool of labor and various infrastructural services. The number and variety of industrial establishments was increasing greatly at this time, and the whole complex was starting to give evidence of marked structural stratification. Above all, it now had taken on a dual aspect consisting of (a) a set of corporate branch plants representing the basic driving force of the complex, and (b) a set of small-scale entrepreneurial firms tied in to the massive purchasing power of the former group.

Total employment in the high technology sector (core plus penumbra) increased from 24,838 in 1959 to 77,161 in 1970 - an average rate of growth of 19.2% per annum, (see Table 1). Employment in SIC 366 was, of course, dominant, but other high technology sectors were now rapidly beginning to expand. The growth of SIC 367 (electronic components and accessories) was especially strong in the 1960s, and SIC 357 (office and computing machines) was just coming out of its infancy. The high technology penumbra was also now developing rapidly on the basis of its production of major inputs and subcontract services in chemicals, rubber and plastics, and fabricated metals) for the core.

By the early 1970s, the high technology complex had become as tightly organized in geographical space as it apparently was in economic space. The precise locational structure of the core complex in 1972 is depicted in Figure 5. The level of spatial infilling revealed by Figure 5 is rather remarkable compared to the situation for 1960 as shown in Figure 4. The whole northern tier of the County is now covered with high technology manufacturing establishments. Notice that two separate subsystems of industrial activity can be discerned. In the north, around Anaheim and Fullerton there is a loose network of high technology plants. In the south, in and around Irvine, a dense major cluster of manufacturers has come into existence most especially on the industrial park land owned and operated by the Irvine Company. We may take note, in passing, that Figure 5 reveals the propensity of industrial establishments to avoid the central area of the County in Santa Ana with its relatively dense development of residential land use and its high property values.

The Recent Development of the Complex, 1975-1984. From 1970 to 1981 total employment in the core and its penumbra grew from 77,161 to 167,102, which represents an average growth rate of 10.6% per annum (see Table 1). SIC 366 is still the major industrial employer in the County in the late 1970s and early 1980s, though its relative weight is now much less than it was in the 1960s. Otherwise, remarkable growth is evident in all the high technology sectors over the 1970s. Nowhere is this growth more apparent than in the case of SIC 357 (office and computing machines) where employment increased at an annual rate of 56.6% from 1970 to 1981. Strong growth is also observable in SIC 38 (instruments and related products), much of it accounted for by the three-digit subsectors SIC 382 (measuring and controlling devices) and SIC 384 (medical instruments and supplies). In 1981, too, there were 7 large establishments in SIC 376 (guided missiles, space vehicles and parts), employing an estimated total of 7500 workers. In spite of the limited number of establishments in this sector, it has been an extremely important element of the whole complex, and, through its many upstream linkages, one of the central motors of the County's growth.

The geographical outlines of the core high technology complex in 1984 are shown in Figure 6. The continuing intensification of industrial land use by comparison with the situation in 1972 is very obvious. The loose subsystem of plants around Anaheim and Fullerton remains a strong element of the overall industrial pattern of the County. In addition, the subsystem in and around Irvine has developed into an extraordinarily dense and tightly-knit assemblage of manufacturers. This latter subsystem is now the dominant focus of the County's proliferating electronic components, computer, and instruments industries.

Outside of the spatial confines defined by Figure 6 there is even today little industrial land use in the County. What development there is consists only of a few scattered plants straggling southwards along the San Diego Freeway. The major lineaments of the high technology complex today conform quite closely to the main locational pattern laid down in the early 1960s. A reconsideration of Figures 4, 5, and 6 reconfirms this view of things. Surprisingly, perhaps, development did not so much proceed by a gradual southward extension of the complex as it did by a process of infilling with respect to a spatial frame of reference that was set in place virtually from the beginning. We shall see at a later stage in this paper that this state of affairs can in part be understood as an outcome of the lively internal locational logic of the complex as a whole.

The Population of Orange County

The relentless expansion of Orange County's industrial base over the years has brought in its wake a massive influx of population and a considerable enlargement of the local labor pool. The total population of the County increased from 703,925 in 1960 to 1,420,386 in 1970 and to 1,932,709 in 1980. These data are testimony to the rapid pace of urbanization in the county over the last few decades. In 1963, the County passed from merely suburban to metropolitan status when it was designated as a standard metropolitan statistical area under the appellation Anaheim-Santa Ana-Garden Grove.

Figure 7 shows the overall pattern of population density in the County in 1980. Population is clearly predominantly concentrated in the northern half of the County where a typical negative exponential relationship between density and distance from the local core seems to be developing. Even in the more urbanized portions of the county, however, population is consistently rather extensively spread out, and this helps to create a pervasive sense of the geographical amorphousness of the entire place. Today, population densities are still not much higher than 6 or 7 persons per acre over the greater part of the county, and only in the central area of Santa Ana (together with a small outlier in Anaheim) do they begin to rise even to the quite moderate level of 20 persons per acre and above.

Of all the persons residing in the County in 1980, 50.4% were actively employed, and of these, 72.1% worked in Orange

County itself. Furthermore, just as the production system has attracted a large working population into the county, so also has it helped (via the division of labor) to create different socio-economic groups with contrasting residential characteristics. Two distinctive segments of the working population are especially in evidence both numerically and geographically, i.e. (a) managerial and technical cadres, and (b) blue-collar manual workers. Members of the former segment seek above all to live in the prime communities scattered along the coast, such as Seal Beach, Huntington Beach, Newport Beach, and places further south. Members of the latter segment tend to occupy scattered neighborhoods at inland locations where house prices are more affordable.

Increasing numbers of blue-collar manual workers in the County consist of new immigrants to the U.S., most especially Hispanics and, more recently, Asians (or, to conform more strictly to the census designation, Asians and Pacific Islanders). In 1980, Hispanics comprised 14.8% of the total population of the County and Asians 4.5%. As the local industrial system comes more and more to rely on low-paid unskilled and semiskilled workers, these percentages will surely increase. Figure 8 depicts the distribution of the Hispanic population of the county for 1980; and Figure 9 shows the distribution of Asians. It should be noted that Figures 7, 8, and 9 are constructed according to varying density scales so that direct visual comparisons between them are somewhat hazardous.

What is interesting about the patterns of Hispanic and Asian settlement revealed in Figures 8 and 9 is not just that they evince, as might be expected, a strong proclivity to ethnic segregation, but also (and more surprisingly in this apparently formless community) a marked centripetal tendency. As in more established metropolitan areas, the ethnic residents of Orange County gravitate towards the core of the whole urban system. This tendency is no doubt comprehensible in view of the pressures on such residents to maximize their overall access to employment opportunities; and in Orange County is is reinforced by the presence of many small manufacturing plants (whose preferred labor force consists of ethnic workers) close to the geographical center of the County.

It is of some interest to note that only 1.2% of the total population of Orange County is made up of Blacks. This seems to follow from the circumstance that Blacks are not especially sought after as employees, even by low-wage firms in Orange County. The reason for this may well reside in the fact that Blacks, despite their overwhelmingly marginal social position, have a legitimate legal and historical presence in American society. They therefore have at least latent potentialities of pressing employers for recognition of rights that many immigrant workers either cannot conceive of or feel unable to demand. Accordingly, Blacks have not participated in the burgeoning labor market opportunities of the County; nor does it seem likely (so long as immigrant labor is available) that they will do so on a large scale in the foreseeable future.

The Labor Force

Occupational structure. Table 2 provides data on the resident labor force of Orange County by selected occupations for the year 1980. These data cover non-manufacturing as well as manufacturing sectors. However, the selected occupations given in the Table are thought to be especially representative of the employment structure of local manufacturers. For the purposes of comparison, occupational data for the whole of the United States are also given.

A scrutiny of Table 2 reveals that the Orange County labor force is highly variegated yet is also top heavy with managerial and technical workers. This latter observation is underpinned by data from the Annual Survey of Manufactures which show that in Orange County manufacturing industry the ratio of non-production (white-collar) workers to production (blue-collar) workers is on average 6.1:10.0, whereas in U.S. manufacturing as a whole the ratio falls to 3.5:10.0. On this criterion, Orange County is true to form as a center of high technology industrial production. At the same time, however, blue-collar employment in the County has tended to grow rapidly in both absolute and relative terms over the last couple of decades. The trend is captured in Figure 10 which shows production workers as a percentage of all workers in manufacturing for the period 1963-1978. Observe the contrast between Orange County and the United States highlighted by this Figure. In Orange County the proportion of production workers in manufacturing employment has been increasing over the years, whereas in the U.S. generally the proportion has regularly declined.

As I shall argue below, this idiosyncratic trend in Orange County is to some significant degree the result of the susceptibility of local manufacturing plants to vertical disintegration of their productive functions. This has involved the systematic transfer of work from large plants to small plants, which signifies, in turn, a transfer of work from (a) plants with relatively highly unionized workers to plant with very low rates of worker unionization (see Table 3), and (b) plants with overgrown bureaucracies to plants with proportionately smaller managements. The net outcome of this latter trend has evidently been rapid increases in the proportion of blue-collar workers in the manufacturing labor force. Remark in passing that large plants in Orange County seek to compensate for their high levels of unionization by employing much greater proportions of female workers than do small plants (see Table 4).

The production of skills. With the growth and internal differentiation of the Orange County complex has come a widening of the division of labor and the creation of a labor force in the very image of the complex itself. There has accumulated in the County an immense and polyvalent pool of labor with its various skills and attributes finely honed in the work-place and socially reproduced and sustained in the community at large.

One of the hallmarks of a mature industrial complex is the development in adjacent areas of institutions of higher education offering courses and curricula suited to the needs of the local production system. In this way, moreover, a certain socialization of the tasks (and costs) of specialized worker training is secured. In Orange County there is a wide variety of such institutions, the most notable of all being the University of California at Irvine which now offers advanced educational and research programs in many fields directly related to the high technology complex. Among these fields we may mention electrical engineering, medical technology, and bioscience, the latter being a response to the very recent local development of a significant industry producing medical and biotechnical products.

It should be added at once, however, that whereas the University of California at Irvine opened its doors in 1965, it has only lately begun in earnest to link its various programs to the needs of the local industrial apparatus (cf. Applegate (1984)). This remark runs counter to the notion that high technology industry is drawn in the first instance to locations that are rich in appropriate educational resources (cf. Oakey (1981), Premus (1982), Saxenian (1983)). In Orange County, the opposite is the case. Here, it is evidently the prior existence of high technology industry that has brought about the internal transformation of the university. Now that the university is indeed beginning to respond to local demands for specialized manpower, it is likely to become an important element in the overall social and territorial reproduction of the high technology complex. But equally, this importance is subjacent to and contained within (not prior to) the historical logic of the complex as a whole.

We must now turn to the central problem of how this complex is structured in terms of its inner logic of development.

Vertical Disintegration and Polarization

Orange County is a major growth center in the classical sense of the term. It is constituted by a core of dynamic propulsive (high technology) industries around which a penumbra of dependent input suppliers has grown up. At the same time, the development of this system has been underpinned by the proliferation of a contingent labor force and associated urbanization phenomena. As the system has evolved, many new forms of production have made their appearance, and many new firms have moved into the County in a sort of "import substitution" process. In these ways, the organizational complexity of the whole system has tended to increase greatly with time.

Vertical disintegration. One particular aspect of these processes of growth and development is of critical importance. This concerns the evolutionary dynamic of the complex via the division of labor and the vertical disintegration of labor processes. With one or two exceptions, (Sallez (1971), Sallez and Schlegel (1963)), this issue has rarely ever been effectively dealt with in general discussions of the expansion of growth centers. Yet vertical disintegration is notably relevant to any understanding of such expansion precisely because it helps so clearly to pinpoint many of the detailed mechanisms whereby producers become organically intertwined with one another in functioning, growing, and spatially-convergent complexes of manufacturing activity.

I have written at length elsewhere on these problems (Scott (1982a, 1983b, 1984)), and so I shall provide only a brief theoretical overview of them in the present context. To fix ideas, we may start out with an arbitrary example. Suppose we have two kinds of labor processes, labelled a and b, where the output from a is a direct input to b. The outputs of these two labor processes are designated x_a and x_b respectively. When the two labor processes are vertically disintegrated and run as separate enterprises we write their individual average cost functions as $F_a(x_a)$ and $F_b(x_b)$ respectively. Disintegration involves, in addition, a unit transactions cost incurred by the need to find appropriate outputs at a and then shift them to b. We write this unit transactions cost as $T(x_a, x_b)$. Conversely, the two labor processes may be vertically integrated into a single unit of production, in which case we write their average joint cost function as $J(x_a, x_b)$. This joint cost function incorporates within itself whatever internal economies and diseconomies of scope may be created by integrating the two processes. If, after all average cost functions have been appropriately minimized we find that

$$F_a(x_a) + F_b(x_b) + T(x_a, x_b) < J(x_a, x_b)$$

then vertical disintegration of the two labor processes is obviously likely to come about (just as the contrary case will induce integration of a and b). Evidently, vertical disintegration will encourage a proliferation of transactional interrelations between production units, and this will in and of itself tend to provoke some geographical concentration of activity and proto-complex formation. By the same token, concentration will tend (via reductions in the cost function $T(x_a, x_b)$) to give rise to yet more vertical disintegration. By contrast, if vertical integration of labor processes takes place, transactional relations will be internalized, and this is one of the preconditions of the dissolution of localized industrial complexes. In the case of Orange County, disintegration seems so far to have been the overwhelmingly dominant trend.

In the early phases of the industrialization of Orange County in the 1950s producers (as we shall see) were relatively self-sufficient. The large branch plants that moved from Los Angeles into the County at this time were typically vertically integrated and minimally interlinked. They were, for the most part, involved in the production of technologically contrived outputs (above all sophisticated communications systems for military and space purposes) whose assembly posed innumerable scientific, engineering, and managerial problems. New technical problems had to be resolved, specialized equipment and production processes designed, and theoretical knowledge translated into workable and commercially-viable practices. An informed guess, reinforced by recent interviews with local managers, is that there were very significant internal economies of scope for these kinds of branch plants at this time. These economies accrued from the advantages of keeping critical and often rapidly changing labor processes in-house and under the supervision of a single experienced team of managers and technicians. We may surmise, however, that many heavy costs were also incurred by this manner of proceeding, most especially the costs of maintaining a large internal bureaucracy and of massing together hundreds if not thousands of (unionized) production workers. Thus, it seems likely that once it became technically and commercially feasible to farm out certain elements of the production process and to lower make/buy ratios, firms welcomed this opportunity as a means of raising profitability levels.

Again on the basis of the informal interviews mentioned above, it would appear that vertical disintegration became more and more of a practical possibility as industrial technologies and procedures were stabilized so that progressive disarticulation of certain labor processes became economically feasible. These changes evidently involved two broad classes of events: either (a) routinization of production processes to the point where reliance on the services of outside input suppliers was no longer especially problematical, and/or (b) the breaking apart of production processes in the sense that changes in procedures at one stage in the manufacturing system no longer had implications for procedures at other stages. At the same time, small and vertically-disintegrated producers often have special advantages that under the right conditions (e.g. spatial concentration) make them attractive as subcontract partners. Small plants are often endowed with the ability to carry out very specialized functions; they are usually able to use their limited production capacities quite flexibly, whereas large plants are tied to more cumbersome units of fixed capital; and small plants can invariably batten down heavily on labor costs (cf. Friedman (1977)). It was apparently for such reasons as these that the large integrated high technology plants in Orange County began rapidly in the 1960s and 1970s to experience vertical disintegration of their labor processes.

Spatial polarization. As I have already suggested, vertical disintegration is associated with increasing levels of externalization of the transactional structure of production. Disintegration, then, results in producers becoming more functionally tied together within a network of interplant linkages. We may ask, to what degree does this functional association translate into a pattern of geographical association? We can answer this question with the aid of some simple insights into linkage costs.

At the outset, note that interlinkage activities always result in some pressure on producers to gravitate locationally towards their own center of gravity. However, this process does not invariably work itself out in a spatially uniform way. The inducements on producers to locate near to one another will be strong where linkages incur high unit transport costs and where the expenses of face-to-face intermediation of inputs and outputs are great. Such is most especially the case where linkages are small in magnitude (so that transactional economies of scale cannot be obtained) and irregular in their spatio-temporal structure (so that linkage partnerships have to be continually rebuilt). Conversely, where linkages are large in scale and regularized in time and space, unit costs will tend to fall and linkage partners will be under less pressure to locate close to one another (cf. Scott (1983a)).

Thus, depending on linkage characteristics (which in their turn depend on the characteristics of production processes) we would expect to find varying spatial responses to the functional interrelationships between industries. And, indeed, in the case of the large aerospace and electronics producers in Orange County we may distinguish at least two main geographical tiers of disintegrated transactional activity. On the one hand many producers are tied in to a far-flung national and even international network of linkages and subcontract relations involving flows of the order of millions of dollars in monetary value, (cf. Karaska (1967)). On the other hand, however, they are also clearly linked in to a purely local system of detailed procurements and subcontract services. In the same way, Rees (1978) has shown for the case of the Dallas-Fort Worth growth region that as much as 32% of all backward linkages are directed to the local area. In the case of Orange County, such local backward linkages concern not just other aerospace and electronics producers, but also throngs of relatively small-scale specialized firms in such detailed sectors as printed circuit fabrication, plastics molding, ferrous and nonferrous metal foundries, milling and lathing, sheet metal work, contract drilling services, instruments manufacture, research and development, business services of all kinds, and so on. The general importance of these kinds of linkages in high technology growth centers has recently been re-emphasized by Oakey (1984).

As markets for final outputs grow so the whole production system expands and so (via expansions of the division of labor) the process of vertical disintegration continues. Indeed, specialized disintegrated producers in their turn break up into yet more specialized fragments of economic activity (cf. Stigler (1951)). In this way, the whole complex becomes more and more finely differentiated in its internal configuration and more tightly organized in geographical space. Moreover, as we shall see, this tendency to spatial polarization of the complex is reinforced by local labor market dynamics and contingent urbanization phenomena. With the unfolding of these intricately-structured processes, ever more potent "agglomeration economies" are created so that costs of production tend to fall and profitability tends to rise everywhere on the terrain of the complex. This then attracts in further productive investments leading to new growth impulses and the creation of new locational details within the complex.

The complex as a system of production processes. To conclude this section of the paper, we may remark that the view of industrial organization and location outlined above allows us to reconsider something of the theoretical status of the firm and the production process. In general terms, we often think of the production process as a collection of productive activities contained within and bounded by the individual firm, i.e. as a system of internalized transactions presided over by a managerial apparatus. As Coase (1937) has shown, however, the production process also involves the interpenetration of these purely internalized transactional systems with an externalized transactional system made up of all the different linkages between production units. Individual producers are, to be sure, divided from one another in terms of ownership, authority, and financial decision-making, but they are also wholly dependent on one another in terms of the social division of labor. In an industrial complex like that of Orange County all the internal and external facets of the system are coordinated with one another through a single organizational structure. Each unit of production contributes its particular stock of knowledge, skills, and fixed capital to the functioning of the whole complex, and each in turn continually readjusts its internal operation as the complex changes form. No single unit, however, can survive in isolation from the others, which is the same as saying that none can unilaterally create the conditions of its own economic existence. This means that we can only understand the production system of Orange County by seizing it in its totality; and this signifies in turn that we must examine not just the decision-making and behavioral activity of the individual firm, but also the systemic laws of motion of the complex as a whole.

Plant Size and the Employment Relation

In the next three main sections of the paper I attempt to deepen and extend these remarks on industrial organization, vertical disintegration, and the development of the complex. We begin with a discussion of the interconnections between vertical disintegration on the one side and plant size and the employment relation on the other side.

The problem in general. I have alluded above to the process of vertical disintegration in Orange County as involving the transfer of work from large often unionized plants with extended managements to small non-unionized plants with more restricted managerial inputs. If this pattern of reorganization is pervasive we would expect it to be visible in two measurable indices of industrial activity, namely, (a) average plant size (which is expected to decline) and (b) the average proportion of blue-collar workers in the labor force (which is expected to increase). These expectations will be reinforced where (as in the case of defense contractors in Orange County) actual or potential vagaries exist in final markets so that large plants will be tempted to disintegrate as a strategic measure to avoid the backward transmission of uncertainty through their internal vertical structure (cf. Carlton (1979)).

We may add for future reference that if <u>horizontal</u> (as well as vertical) disintegration is occurring then these expectations are likely to be yet further intensified. Average plant size, in particular, will rapidly decline with horizontal disintegration (i.e. as small plants "spin off" from more established enterprises). As Saxenian (1983) and others have shown, horizontal disintegration is a typical mechanism of development in the early and competitive stages of the formation of new high technology industries, and in Orange County it has recently been especially noticeable in the cases of the computer and medical technology industries.

<u>Plant size</u>. The proposition that vertical disintegration in Orange County has been associated with decreasing average plant size does not mean that some plants might not increase in size subsequent to disintegration. On the contrary, we know from the work of Stigler (1951) that there is at least a theoretical possibility that some plants may increase in size after disintegration. What <u>is</u> signified by the proposition is that vertical disintegration will lead to either (a) given quantities of work being carried out by more and more individual enterprises, or (b) given increments of growth engendering a correspondingly deeper social division of labor. In either case, decreasing plant size will consist only of an <u>average</u> trend.

Consider now Figure 11, which graphs out variations in average plant size in Orange County from the early 1950s to the early 1980s. The Figure shows data for both manufacturing as a whole and for the core high technology sector. Two distinct phases of development are distinguishable. From the early 1950s to the mid-1960s there is a phase of increasing average plant size corresponding to the steady decentralization of large capital-intensive and vertically-integrated branch plants from Los Angeles. Then there is a phase from the mid-1960s and continuing irregularly down to the present day of dramatically <u>decreasing</u> average plant size. The hypothesis is that this second phase of development represents a period of organizational change in the complex with much fragmentation of productive functions. By the mid-1960s the main industrial base of the County had been securely set in place, and it was now poised on the threshold of further advancement via internally-structured processes of the division of labor, the establishment of specialized vertically-disintegrated plants, and industrial innovation. Accordingly, over the 1960s and 1970s, the complex absorbed increasing numbers of small specialized producers serving the central polar industries. The net effect of this incursion of ever-widening circles of small plants was an expansion of the externalized transactional structure of the complex, and a steadily diminishing average plant size. I shall elaborate further on these points below.

The employment relation. Vertical disintegration in Orange County has also evidently involved a reassignment of work from plants with high labor costs to plants with low labor costs. Two main points need to be made. First, large plants in Orange County are demonstrably more unionized than small plants (see Table 3). Second, large plants in Orange County also seem to require proportionately more bureaucratic labor than small plants for they face proportionately greater tasks of internal coordination of production activities. Hence the shift of work from large to small units of production is at once a way of replacing unionized by non-unionized labor and of shedding white collar workers in favor or blue collar workers. These changes are intensified by the circumstance that non-unionized blue collar workers in Orange County are increasingly composed of low-wage Latino and Asian immigrants, many of them undocumented. All this is achieved by the externalization of transactional structures so that what was once accomplished by an internal hierarchy of control is now secured by market and quasi-market relations between plants. We might say, then, that in super-addition to all of its other functions, vertical disintegration is a way of substituting markets for hierarchies (cf. Williamson (1975)).

If the above arguments are correct, we would expect to observe, among other things, both tangible decreases in union membership and tangible increases in the ratio of blue collar to white collar workers in Orange County manufacturing industry over the last couple of decades. Let us deal with these two points in turn. First, as Table 5 indicates, union membership among Orange County manufacturing workers has indeed decreased dramatically (in both relative and absolute terms) since the mid to late 1960s. Orange County now has the lowest rate of worker unionization of any county in the state of California. We must exercise considerable caution, however, in attributing the trends revealed in Table 5 uniquely to local vertical disintegration, for they are also part of an overall nation-wide tendency to lower levels of unionization. Unfortunately, the available data do not allow us effectively to decide what part of declining union membership in Orange County may be due specifically to vertical disintegration, and what part may be simply a reflection of the national trend. Second, if we turn now back to Figure 10, we may note that the proportional representation of blue collar workers in the manufacturing labor force has increased steadily since the late 1960s, as expected. This finding is all the more emphatically underlined by the fact that what has been happening in Orange County in this regard runs absolutely counter to the trend for the United States as a whole. At the same time, a third important point can be adduced on the basis of these remarks. It seems reasonable to infer that the observed changes in the employment relation in Orange County have been at least in part responses to labor cost pressures, and we should no doubt therefore also expect to detect some slowing down of wage increases as vertical disintegration has proceeded. In fact, average remuneration levels (in constant dollars) have actually <u>declined</u> in

Orange County manufacturing establishments since the late 1960s, (Figure 12). This is the case, moreover, no matter whether we measure the trend in terms of average payroll costs per employee or in terms of the average wages of production workers. Thus, while the complex has grown at a rapid rate, it has nevertheless managed to head off any sort of upward wages spiral over the last decade or so. This is, to say the least, remarkable in view of both the upward trend in wages in the U.S. as a whole as well as the persistent labor shortages that seem to have plagued Orange County employers over the years.

Statistical Analysis of Organizational Change

The previous paragraphs have discussed in very general terms a number of symptoms and corollaries of vertical disintegration within the Orange County high technology complex. Can we now relate average plant size and changes in the composition of the labor force more directly to the process of vertical disintegration? In this section, I shall present some regression analyses that help to pin these relationships down in a very much more explicit manner.

A measure of vertical disintegration. It has been widely suggested in the literature that an effective statistical measure of vertical disintegration in manufacturing can be constructed as the ratio of total materials costs to total shipments, or, equivalently, but inversely, the ratio of value added to shipments, where shipments are equated with materials costs plus value added, (cf. Adelman (1955), Laffer (1969), Levy (1984), Tucker and Wilder (1977)). The reasoning behind this suggestion is that the shorter the vertical span of activity within any unit of production, the lower the value added, and thus the higher the ratio of materials costs to shipments. In this exercise I shall use the ratio of materials costs to shipments as a direct measure of vertical disintegration. Call this ratio CS_{it} for sector i at time t.

Of course, the ratio variable CS_{it} is an extremely crude measure of vertical disintegration, and it has been widely subjected to criticism in the literature (e.g. Eckard (1979), Maddigan (1981)). Among its several deficiencies, the index is subject to variation as a result of changes in prices, profit rates, wages, and technologies; and it also tends to correlate with short-run economic swings that have nothing at all to do with the process of vertical disintegration as such. Notwithstanding the various possible objections to the index CS_{it}, it turns out to be a moderately useful instrument of analysis. Furthermore, relative to the data that I shall be using in what follows the index picks up vertical disintegration at the level of the plant (as opposed to the level of the firm) and since interest is focused here on the individual units of locational activity, rather than on the firm as such, this is a very positive advantage. Figure 13 shows numerical values of the index for (a) all manufacturing, (b) the core high technology complex, and (c) the core plus penumbra in Orange County between 1964 and

1978. In all three cases, the trend of the index is broadly upwards signifying that vertical disintegration has tended in general to increase with time.

A regression analysis. I shall now seek to correlate CS_{it} with both average size of plant (ASP_{it}) and the proportion of blue collar-workers (BCW_{it}) in sector i at time t. Keep in mind that ASP_{it} and BCW_{it} have no directly causal impacts on CS_{it}. If we find any significant correlations between these variables they can at best be associative, and they are of interest here largely as diagnostic indicators of more deeply-rooted processes that themselves cannot be directly measured for want of data.

Data for the regression analysis were taken from the Census of Manufactures, the Annual Survey of Manufactures, and County Business Patterns; and from these sources it was possible to put together a set of statistical runs (though with many missing observations) for a number of two- and three-digit SIC categories in the high technology sector for the years 1964 to 1978. In all, usable data sets were constructed for the following individual categories: SICs 28, 30, 34, 35, 36, 366, 367, 37, and 38. Additional data sets were constructed for three aggregate sectors, namely, the core high technology complex, the core plus penumbra, and manufacturing industry generally.

The main results for the regressions are laid out in Table 6; they are encouraging though by no means dramatic. For six out of the twelve sectors subjected to analysis the regression statistics were found to be totally without significance, and these sectors are accordingly not shown in Table 6. The remaining sectors enumerated in Table 6 all have at least one significant regression parameter or else have regression equations that are statistically significant overall; these sectors are SICs 30, 366, 37, the core high technology complex, the core plus penumbra, and manufacturing as a whole. Recall, however, that the official definition of SIC 37 was radically revised after 1972 and so the results for this category must be treated with some circumspection. Values of R^2 given in Table 6 are all quite respectable, and the computed Durbin-Watson statistics reveal no serious cases of temporal autocorrelation.

Given the qualifications noted above, the regression results of Table 6 seem to be in reasonable accord with theoretical expectations. The index CS_{it} is largely an inverse function of ASP_{it}, and it is largely positively related to BCW_{it}. However, the results for SIC 366 are a major exception to these generalizations. It is somewhat disappointing to note that so few of the individual regression coefficients displayed in Table 6 are significant, but this seems to be the result both of severely limited degrees of freedom and of a certain tendency to collinearity among the independent variables. In fact, if we compute individual simple regressions of CS_{it} with ASP_{it} and BCW_{it} in turn, we find that many more individual regression coefficients turn out to be significant (while retaining their appropriate signs).

It is apparent that the best regression results are obtained for highly aggregated sectors, and this is no doubt a reasonable finding for we are indeed dealing here with <u>average</u> tendencies that are not always necessarily apparent in every narrowly-defined individual sector. There is a potentially negative aspect to this finding however. If the observed correlations are simply an effect of statistical aggregation rather than a reflection of real economic processes, then they will, of course, be spurious. A further problem is posed by the circumstance that the data under investigation in this exercise do not allow us to distinguish forms of vertical disintegration that give rise to purely local linkages from forms that give rise to non-local linkages. In sum, we really cannot take these regressions as being anything very much more than a rather partial and inadequate symptomatic probing of the internal logic of the complex. In and of themselves, the regressions do not point to strong conclusions. But they are broadly consistent with the overall body of evidence that is under investigation here and, taking all of this evidence collectively, we may invest some degree of reasoned faith in its testimony. We now turn to a more direct description of the disintegration process.

Three Case Studies of Industrial Organization and Location

In this section of the paper I examine three different industries that are important elements of the complex and that exemplify with special clarity the issues discussed above. In each case, I also briefly indicate how industrial organization and location relate to one another. The three industries are (a) injection-molded plastics, (b) printed circuit boards, and (c) surgical and medical instruments. The first two cases exemplify very clearly the phenomenon of vertical disintegration and spatial clustering. The third case is a dramatic recent example of local industrial development by means of spin-off and the horizontal disintegration of functions.

Injection-molded plastics. Injection-molded plastics are a crucial input to Orange County aerospace and electronics producers. Some of these producers maintain an in-house "captive" (i.e. vertically-integrated) molding facility, but they are relatively few in number. For the most part, injection-molded plastics are manufactured in vertically-disintegrated plants in response to the demands and specifications of the buyer (cf. Angel (1984)). Thus, as the complex has grown so also has this symbiotic industry multiplied.

Figure 14 outlines the recent spatial distribution of injection-molded plastics plants in Orange County. Observe the tendency for plants to gravitate towards the main foci of production. Here, they can cut back to the maximum on spatially-determinate transactions costs just as they can, in effect, pool the many specialized demands of individual customers thereby helping to even out the flow of work (cf. Scott (1983a)). Occasionally, injection-molded plastics plants are vertically-integrated with a mold-making shop, especially in cases where molds are changed frequently and the shop can be run close to full capacity. However, it was found by Angel (1984) that 58% of a sample of injection-molded plastics producers in the greater Los Angeles region subcontract out the mold-making function. Figure 14 shows specialized vertically-disintegrated mold-makers in Orange County, and, once more, the proclivity of such plants to congregate close to their main markets is strongly evident.

Printed circuit boards. Printed circuit boards constitute an essential input to the electronics industry. As in the case of injection-molded plastics facilities, many circuit board shops are captive to major manufacturers, though most form vertically-disintegrated and independent units. Like injection-molded plastics plants, printed circuit board manufacturers are prone to cluster close to their major customers (Figure 15). In an earlier study of the printed circuits industry (Scott (1983b)) I showed that small plants are more susceptible to such clustering than large plants, for their external linkage costs are generally more high per dollar's worth of output. This is equivalent to the proposition that the smaller the plant the narrower its spatial circle of customers (cf. Scott (1983b)).

Printed circuit board manufacturers in their turn subcontract out much work. Such specialized tasks as drilling, multilayer laminating, solder fusing, metal-plating, and the like, are frequently put out to specialized shops, particularly where the work involved calls for the use of expensive fixed capital equipment such as numerically-controlled drilling machines or laminating presses. In Figure 15 the locational pattern of drilling shops serving the printed circuits industry is superimposed on the map of circuit board manufacturers. These drilling shops are small in size and on average they employ no more than four or five workers each. They are clearly located in close proximity to the geographical center of the whole complex. Of the 24 drilling shops located in the Greater Los Angeles area in 1982, no fewer than 19 (i.e. 79%) were concentrated in Orange County.

Surgical and medical instruments. In 1984, there were some 75 plants in Orange County classified under the 4-digit SIC category 3841 (surgical and medical instruments). This industry has only very recently made its appearance as an important element of the industrial fabric of Orange County; indeed, it is a more recent development even than the burgeoning computer industry. All the indications are that it will continue to grow strongly in the future. The industry has evidently been attracted in to the area by reason of the County's sophisticated modern industrial base with its many and varied support services and its highly trained technical labor-force. Much of the development of the industry has apparently occurred by a process of horizontal disintegration (spin-off) and specialization. One of the more recent offshoots of the industry has been a group of plants producing cardiopulmonary equipment in the Irvine area. In fact, the industry as a whole is overwhelmingly concentrated in and around Irvine (Figure 16) and there is currently a major effort under way to build connections between the industry and the nearby medical school at the University of California, Irvine.

In addition to surgical and medical instruments there is much local production capacity in such related fields as dental equipment, optical products, hospital supplies, pharmaceuticals, and most recently of all in biotechnology, the latter fuelled by local venture capital. This constitutes an elaborate foundation on which a major sub-complex of medical industries seems to be rising. As this sub-complex grows it will undoubtedly evolve, like the rest of the high technology complex, through a series of evolutionary stages marked by much further horizontal and vertical disintegration of functions.

The Spatial Structure of the Complex

Towards an analysis. On the basis of the three case studies described above it would seem that there is a powerful positive interrelationship in Orange County between the fragmentation of labor processes and the locational clustering of units of production. More generally, there appears to be an intricate logic that runs from the organization to the location of industry and back again. This logic is intermediated above all by the external transactional structure of the production system and it helps to push units of production into various forms of locational association with one another. Additionally, producers also presumably try to find locations that ensure their accessibility to an adequate supply of labor without their having to offer premium wages (cf. Scott (1981)). This latter locational impulse combines with the former to give rise to subtle spatial patterns of industrial development. Let us enquire a little more closely into these relationships.

It was shown above that small plants have an especially strong tendency to cluster together compared to large plants, for they frequently face much more costly unit transactions costs. Simultaneously, interlinked clusters of small plants are quite likely to be extremely labor intensive, with joint employment levels rising to many tens of thousands of workers. These clusters are therefore also under much inducement to gravitate (as collective bodies of producers) towards the spatial center of their main areas of labor supply and in this way to reduce upward pressure on (spatially-determinate) wage rates. By contrast, the linkage costs of large plants are often relatively low in unit terms by reason of the economies scale that come with enlarged transactional activity. Thus, the linkage structures of large plants are usually less geographically restrictive than those of small plants, and large plants are accordingly more able to select from a wider set of locations. The fact that large plants tend to use up great quantities of space means that they are also subject to some pressure to shift to peripheral locations where land prices are comparatively low.

All of these remarks are, of course, quite speculative, and the question of the operative locational tendencies within major industrial complexes remains very much a matter for future research. Even so, the discussion above suggests at once that any large industrial complex will almost certainly exhibit distinctive patterns of internal locational differentiation. These patterns will be likely at a minimum to consist of (a) a spatially-dominant network of small plants in selected central areas of the complex, overlain by (b) a more dispersed distribution of large plants, the latter becoming dominant in peripheral zones. We can scrutinize these propositions further on the basis of the data underlying Figures 4, 5, and 6. If we find that the propositions are at odds with the data then we shall have to reassess many of the finer points adduced earlier about the growth and development of the Orange County complex. The reader is reminded that these data are biased in the sense that small plants are underrepresented throughout (see Appendix). However, this underrepresentation is thought not likely to introduce distortions into the present investigation unless - as seems doubtful - it also entails some systematic spatial bias. The test proceeds in two main stages.

Concentration versus dispersal. To begin with, we subject the data to a simple quadrat analysis. Orange County is gridded into 271 quadrats, each of them 7 1/2 square kilometers in area. Industrial plants in the core high technology complex are then divided into three main size categories, i.e. small (1-100 employees), medium (100-500 employees) and large 500+ employees). For each of the years 1960, 1972, and 1984 we compute the average number of plants (μ_k) per quadrat in the k^{th} size category (see Table 7). We now calculate the theoretical probability, under assumptions of complete locational randomness, that any given quadrat will have at least one plant in the k^{th} size category. This probability is defined by a Poisson process. If $p_k(0) = e^{-\mu_k}$ is the probability that any given quadrat has <u>no</u> plants of size k, then $1 - p_k(0) = 1 - e^{-\mu_k}$ is the probability that the same quadrat has <u>at least one</u> plant of size k. From this latter expression we may calculate the expected number of quadrats with at least one plant of size k. This expectation is equal to $271(1-p_k(0)) = 271(1- e^{-\mu_k})$. We now compare this expectation against the observed number of quadrats with one or more plants of size k. The comparison is carried out in column g of Table 7 where the observed number of such quadrats is expressed as a ratio of the expected. Remark that by means of this latter operation we abstract away from differences in the number of plants in each size category. Clearly, as shown in Table 7, the smaller the employment size class, the more concentrated is the corresponding locational pattern of plants; and the larger the employment size class, the closer to random is the locational pattern of plants. It may further be noted that degrees of locational concentration tend to increase over time, and this may perhaps be interpreted as an additional sign of the increasing vertical disintegration of the complex.

Annular structure of the complex. We may ask if there are not yet further levels of spatial structure in the locational pattern of the Orange County core high technology complex. To be sure, it is possible to discern a certain amount of spatial segregation according to sector, but this is not the important issue at the present moment. More pertinent for immediate purposes is the circumstance that after suitable statistical manipulation, we can find a definite annular gradation in plant size. This effect is observable in relation to the system of concentric rings displayed in Figure 17. The origin of this system coincides with the center of gravity of the whole northern half of the County in Santa Ana. Computation of average plant size for each ring for each of the years 1960, 1972, and 1984 yields the data presented in Table 8. For the year 1960, the overall pattern is rather shapeless, as indeed it ought to be given that this was a time when the complex had not yet really begun to form itself into an organized system. By 1972 there is a definite tendency to increasing average plant size from the center outwards. And by 1984, the tendency is very fully confirmed, though note that in the far periphery of the whole system average plant size drops rapidly away again. This latter phenomenon may well be due to the existence of specialized market and locational niches beyond the geographical confines of the complex proper. Finally, note that the two subsystems of plants in the Anaheim-Fullerton area and in and around the Irvine area are also internally structured according to a very finely-grained annular pattern of increasing average plant size from their centers outwards, though I have made no effort to report upon this latter issue in greater detail.

Conclusion

The development of Orange County has involved the historical convergence of three major lines of force. First, the central axis of the County's growth has always resided in the production system with its strong organizational dynamics as discussed above. Second, this system has steadily drawn into its orbit a large and variegated labor force containing within itself many different skills and attributes necessary to the efficient functioning of the industrial base. Third, there then came into existence a whole series of urbanization phenomena (infrastructure, transport networks, housing facilities, educational establishments, etc.) which ensured the successful social and territorial reproduction of the entire assemblage of phenomena (cf. Scott (1980)). These intertwined events have come to represent a vigorous process of industrialization and urbanization in Orange County today. The more the complex has expanded, the more it has produced, by its own internal momentum, a wider pool of agglomeration economies, and thus the wider still it has expanded.

In fact, the effective putting together in Orange County of an entire industrial complex in which capitalistic forms of production can proceed at an accelerated pace has now turned the

County into one of the foremost industrial regions of the United States. In this sense alone the County is at the other end of the spectrum from the old declining industrial regions of the Frostbelt. Yet both kinds of region have been made within a similar overarching set of capitalist social and property relations. They are testimony to the extraordinary unevenness and disparity that characterize all forms of capitalist development. They are also potent testimony to the genius of capitalism for constructing and deconstructing the social and geographical conditions of its own existence as each new regime of accumulation and social regulation comes and goes. Within the context of the broad capital-labor relation, the cycle of territorial development, reproduction, and transformation proceeds endlessly; it assumes different forms and different modulations at different times and in different places, but its basic underlying logic remains unchanged: production for accumulation. In Orange County, local history is, as it were, being replayed anew. Significantly, it is being replayed in an area where communal historical experience (of the capital-labor relation) has been hitherto almost totally inexistent.

In all of the above I have tried to show how a high technology industrial complex and some of its associated social appendages grew up on the _tabula rasa_ of Orange County. I have sought to achieve this goal both by empirical description and by theoretical investigation. To be sure, the research reported upon here is extremely provisional and almost all of the basic analytical problems to which it makes allusion remain unresolved. Orange County and other places like it obviously pose many puzzling questions to social theorists. We need at this stage very much more research into the processes governing the origins and trajectory of such places. In particular, we really know surprisingly little about their fundamental mechanisms of growth and internal spatial differentiation. Once we have gone beyond the self-evident observation that the Orange County high technology complex owes its initial forward drive and momentum to federal defense and space contracting, we are left with surprisingly little by way of further analytical windows on the County's growth. Three questions seem to be of particular pertinence in this regard. First, to what degree are such phenomena as the Orange County complex structured both functionally and spatially by processes of industrial fragmentation? Second, to what degree are their internal order and logic determined by a system of local labor market processes? And third, to what degree is their development sustained by the kinds of urban environments that ramify throughout their territorial extent? In spite of encounters with these questions in all of the above, they remain very much open to further probing. Their eventual resolution will no doubt depend to a large extent both on the persistence of economic geographers in exploring the detailed empirical conditions underlying the emergence of new growth centers in the Sunbelt and elsewhere, and on the degree to which theoreticians can put together generalized analyses of the essential central mechanisms of production, work, and territorial development in late capitalist society.

Orange County is a foretaste of a novel and still only dimly apprehended pattern of industrial development and urban growth. It is part of a new landscape of capitalism within a newly emerging regime of accumulation and social regulation. Concomitantly, we stand in urgent need of a refashioned theoretical human geography that is equal to the tasks of dealing with these issues, and conscious of their central political meaning.

Appendix

A basic source of data for the research reported upon above is the _California Manufacturers Register_ published by the California Manufacturers Association. This publication allows manufacturing firms in the state of California to insert (free of charge) an entry indicating their main officers, address, products, SIC code, and number of employees. Lists of all plants in Orange County belonging to SICs 35, 36, 37, and 38 were compiled from the information given in the _Register_ for the years 1960, 1972, and 1984. On the basis of these lists, Figures 4, 5 and 6 were then drawn up. For the year 1984, an experiment was carried out on the data culled from the _Register_. A frequency distribution of the size of plants in the four SIC categories was constructed, where size is defined by number of employees. A similar frequency distribution for the same SIC categories in Orange County was then developed on the basis of data given in _County Business Patterns_. It is important to observe that _County Business Patterns_ provides a complete enumeration of all manufacturing plants on a county-wide basis. The two frequency distributions thus obtained are shown together for comparative purposes in Figure 18. It is obvious that the data from the _California Manufacturers Register_ are seriously biased in that they systematically underrepresent small plants with 20 or fewer employees. Prudence is therefore called for in interpreting any analytical results based on these data.

References

M.A. Adelman (1955) "Concept and statistical measurement of vertical integration", pp. 281-330 in National Bureau of Economic Research, Business Concentration and Price Policy, Princeton: Princeton University Press.

M. Aglietta (1979) A Theory of Capitalist Regulation: The U.S. Experience, London: New Left Books.

D. Angel (1984) The Organization and Location of the Los Angeles Plastic Injection Molding Industry, unpublished M.A. thesis, Department of Geography, University of California - Los Angeles.

J.W. Applegate (1984) "Orange County sets its sights on becoming the southern Silicon Valley", Los Angeles Times, Business Section, June 10th 1984, pp. 1 and 7.

K. Arnold, R.G. Spiegelman, N.T. Houston, O.F. Poland, and C.A. Trexel (1960) The California Economy, 1947-1980, Menlo Park, California: Stanford Research Institute.

B. Bluestone and B. Harrison (1982) The Deindustrialization of America, New York: Basic Books.

J. Buchner, J. Curley, J. Everly, and J. Perez (1981) A Survey of Orange County Manufacturing Employers, Orange, California: Economic Dvelopment Corporation of Orange County.

D.W. Carlton (1979) "Vertical integration in competitive markets under uncertainty", Journal of Industrial Economics, 27, 189-209.

R.H. Coase (1937) "The nature of the firm", Economica, 4, 386-405.

E.W. Eckard (1979) "A note on the empirical measurement of vertical integration", Journal of Industrial Economics, 28, 105-107.

A.L. Friedman (1977) Industry and Labour, London: Macmillan.

G.J. Karaska (1967) "The spatial impacts of defense-space procurement: an analysis of subcontracting patterns in the United States", Papers of the Peace Research Society (International), 8, 109-122.

A. Laffer (1969) "Vertical integration by corporations, 1929-1965", Review of Economics and Statistics, 51, 91-93.

D. Levy (1984) "Testing Stigler's interpretation of 'the division of labor is limited by the extent of the market'", Journal of Industrial Economics, 32, 377-389.

A. Lipietz (1984) Accumulation, Crises et Sorties de Crise: Quelques Réflexions Méthodologiques autour de la Notion de Régulation, Paris: Centre d'Etudes Prospectives d'Economie Mathématique Appliquées à la Planification (CEPREMAP), Report Number 8409.

R.J. Maddigan (1981) "The measurement of vertical integration", Review of Economics and Statistics, 63, 328-335.

D.B. Massey and R. Meegan (1982) The Anatomy of Job Loss, London: Methuen.

R. Oakey (1981) High Technology Industry and Industrial Location, Hampshire: Gower House.

R. Oakey (1984) High Technology Small Firms: Regional Development in Britain and the United States, New York: St. Martin's Press.

R. Premus (1982) Location of High Technology Firms and Regional Economic Development, a staff study prepared for the use of the Subcommittee on Monetary and Fiscal Policy of the Joint Economic Committee, Congress of the United States, Washington, DC: U.S. Government Printing Office.

J. Rees (1978) "Manufacturing change, internal control and government spending in a growth region of the USA", pp. 155-174 in F.E.I. Hamilton (ed.) Industrial Change, London: Longman.

A. Sallez (1972) Polarisation et Sous-Traitance, Paris: Eyrolles.

A. Sallez and J. Schlegel (1963) La Sous-Traitance dans L'Industrie, Paris: Durod.

A. Saxenian (1983) "The urban contradictions of Silicon Valley: Regional growth and the restructuring of the semiconductor industry", International Journal of Urban and Regional Research, 7, 237-262.

A.J. Scott (1980) The Urban Land Nexus and the State, London: Pion.

A.J. Scott (1981) "The spatial structure of metropolitan labor markets and the theory of intra-urban plant location", Urban Geography, 2, 1-30.

A.J. Scott (1983a) "Industrial organization and the logic of intra-metropolitan location I: Theoretical considerations", Economic Geography, 59, 233-250.

A.J. Scott (1983b) "Industrial organization and the logic of intra-metropolitan location II: A case study of the printed circuits industry in the Greater Los Angeles Region", Economic Geography, 59, 343-367.

A.J. Scott (1984) "Industrial organization and the logic of intra-metropolitan location III: A case study of the women's dress industry in the Greater Los Angeles Region", Economic Geography, 60, 3-27.

G.A. Steiner (1961) National Defense and Southern California 1961-1970, Los Angeles: Southern California Associates of the Committee for Economic Development.

G.J. Stigler (1951) "The division of labor is limited by the extent of the market", Journal of Political Economy, 59, 185-193.

I.B. Tucker and R.P. Wilder (1977) "Trends in vertical integration in the U.S. manufacturing sector", Journal of Industrial Economics, 26, 81-94.

O.E. Williamson (1975) Markets and Hierarchies: Analysis and Antitrust Implications, New York: The Free Press.

"Animated Film Workers"
Scott (1984) Society + Space, 2, No 3.
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Innovation Diffusion
A New Perspective
Larry A Brown
Methuen Inc.

Table 1

Manufacturing Employees and Establishments
In Selected Industrial Sectors, Orange County[a]

Standard Industrial Category	1959 Employees	1959 Establishments	1970 Employees	1970 Establishments	1981 Employees	1981 Establishments
28 Chemicals and allied products	1160	34	3531	78	8057	128
283 Drugs	n.a.	2	n.a.	9	4719	26
30 Rubber and miscellaneous plastics products	1948	31	5288	108	13208	322
307 Miscellaneous plastics products	n.a.	21	3464	89	9532	288
34 Fabricated metal products	3727	93	8472	203	19964	493
35 Machinery except electrical	2412	119	9230	397	37388	973
357 Office and competing machines	n.a.	3	2498	28	18062	102
36 Electric and electronic equipment	10376	37	38725	197	55194	444
366 Communication equipment	7059	4	27995	30	25961	78
367 Electronic components and accessories	251	8	4696	67	19894	206
37 Transportation equipment	2477	70	6470	119	18627	206
372 Aircraft and parts	1164	19	3002	25	6836	49
376 Guided missiles, space vehicles, parts	-	-	-	-	7500*	7
38 Instruments and related products	2738	22	5445	65	14664	214
382 Measuring and controlling devices	n.a.	3	778	11	4422	62
384 Medical instruments and supplies	0	0	n.a.	25	5899	69
All other manufacturing	13835	410	41328	760	58292	1794
Total manufacturing	38673	816	118489	1927	225394	4574

*Estimate

[a]This Table uses the terminology of the current Standard Industrial Classification Manual (1972).

Source: U.S. Department of Commerce, Bureau of the Census, County Business Patterns.

Table 2

Employed Persons, 16 Years and Over in Selected Occupations,
Orange County and the United States, 1980

	Orange County Total	Orange County %	United States Total (000)	United States %
All occupations	974,845	100.0	104,450	100.0
Managerial and professional specialty occupations	281,642	28.9	22,654	21.7
Executive, administrative and managerial occupations	148,720	15.3	10,379	9.9
Engineers and natural scientists	39,295	4.0	1,715	1.6
Technical, sales, and administrative support occupations	324,891	33.3	30,884	29.6
Technologists and technicians	25,645	2.6	2,074	2.0
Secretaries, stenographers, typists	44,179	4.5	4,827	4.6
Precision production, craft, and repair occupations	117,878	12.1	13,555	13.0
Mechanics and repairers	29,462	3.0	3,983	3.8
Precision production occupations	47,252	4.8	4,444	4.3
Operators, fabricators and laborers	131,207	13.5	19,988	19.1
Machine operators and tenders	38,232	3.9	6,544	6.3
Fabricators, assemblers, etc.	31,961	3.3	2,632	2.5
Handlers, equipment cleaners, helpers and laborers	32,951	3.4	5,086	4.9

Source: U.S. Department of Commerce, Bureau of the Census, Census of Population and Housing, 1980.

Table 3

Union and Non-union Labor in Orange County Manufacturing as a Function of Plant Size

Plant Size (Employees)	Percent Union Labor	Percent Non-union Labor	Number of Plants Surveyed
1-10	1.5	98.5	70
11-25	2.3	97.6	46
26-50	4.5	95.5	44
51-100	16.6	83.3	18
101-250	19.3	80.7	32
251-500	23.5	76.5	20
500+	20.0	80.0	17
Total	8.5	91.5	247

Source: Buchner *et al.* (1981, page 17)

Table 4

Male/Female Employment in Orange County Manufacturing
as a Function of Plant Size

Plant Size (Employees)	Percent Male	Percent Female	Number of Plants Surveyed
1-10	79.2	20.7	70
11-25	74.1	25.9	46
26-50	69.4	30.5	44
51-100	59.5	40.4	18
101-250	64.3	36.6	32
251-500	54.3	45.6	20
500+	64.2	35.7	17
Total	63.1	36.9	247

Source: Buchner et al. (1981, page 13)

Table 5

Union Members in Manufacturing Industry, Orange County 1964-1981

Year	Union Members in Manufacturing: Total	Union Members in Manufacturing: As % of Manufacturing Employment
1965	27,300	28.9
1966	31,800	31.5
1967	34,000	29.4
1968	35,000	26.9
1969	34,900	27.6
1970	32,300	27.3
1971	30,100	27.4
1973	31,100	22.2
1975	29,400	19.5
1977	22,400	12.6
1979	22,600	10.5
1981	27,200	12.1

Sources of data (a) State of California, Department of Industrial Relations, Division of Labor Statistics and Research *Union Labor in California* (published biennially after 1971) (b) U.S. Department of Commerce, Bureau of the Census, *County Business Patterns*.

Table 6

Regression Results for Analysis of Vertical Disintegration

Regression	Constant Term	Regression Coefficient[a] ASP_{it}	BCW_{it}	R^2	F-Ratio	Degrees of Freedom	Durbin-Watson Statistic
30. Rubber and miscellaneous plastics products	-0.234	-0.823 (0.606)	0.972* (0.387)	0.533	6.03*	2/11	1.266
366. Communications equipment	0.327	0.046* (0.017)	-0.159 (0.262)	0.541	4.72*	2/8	2.277
37. Transportation equipment	0.478	-1.485* (0.354)	0.061 (0.060)	0.725	14.25*	2/11	1.351
Core high technology sector (SICs 35, 36, 37, 38)	0.281	-0.362 (0.232)	0.176 (0.173)	0.382	4.01*	2/11	1.290
Core plus penumbra (SICs 28, 30, 34, 35, 36, 37, 38)	0.273	-0.520 (0.292)	0.221 (0.172)	0.474	4.95*	2/11	1.321
All manufacturing	0.296	-0.735 (0.428)	0.297 (0.169)	0.711	14.78*	2/12	1.018

[a]Numbers in parentheses represent standard errors of regression coefficients; the asterisk indicates significance at the 95% level or better.

Table 7

Quadrat Analysis of Plants in the Core High Technology Complex
(SICs 35, 36, 37, 38)

a. Employment size class	b. Number of plants in size class	c. Average plants per quadrat (μ_k)	d. $1-e^{-\mu_k}$	e. $271(1-e^{-\mu_k})$	f. Observed number of quadrats with at least one plant	g. f as % of e
1960						
1-100	18	0.066	0.064	17.42	14	80.37
100-500	7	0.026	0.025	6.91	6	86.83
500+	4	0.015	0.015	3.97	4	100.76
1972						
1-100	96	0.354	0.298	80.83	54	66.80
100-500	29	0.107	0.101	27.37	21	76.73
500+	16	0.059	0.057	15.54	15	96.53
1984						
1-100	199	0.734	0.520	140.92	96	68.12
100-500	62	0.255	0.225	60.98	43	70.51
500+	29	0.107	0.101	27.37	22	80.38

Table 8

Annular Structure of the High Technology Core Complex

Ring	Distance band(km_s)	1960 Number of plants	1960 Average size of plant	1972 Number of plants	1972 Average size of plant	1984 Number of plants	1984 Average size of plant
1	0-3	1	90	2	78	2	35
2	3-6	3	128	24	76	48	118
3	6-9	1	375	51	186	110	232
4	9-12	11	220	15	233	42	270
5	12-15	10	180	32	817	63	415
6	15-18	7	3507	9	731	14	1094
7	18+	3	10	13	644	24	80

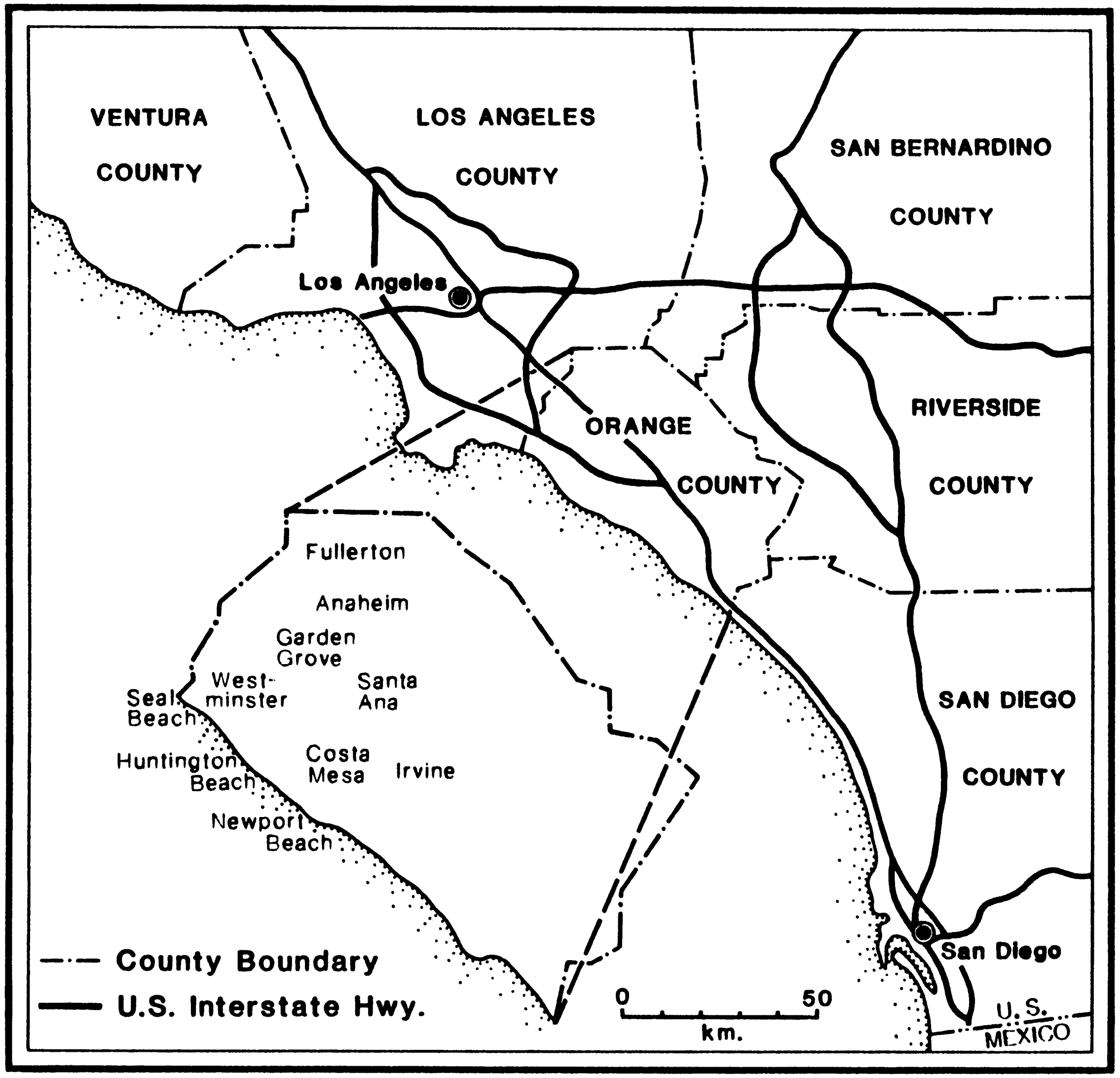

FIG. 1 Orange County in the context of Southern California

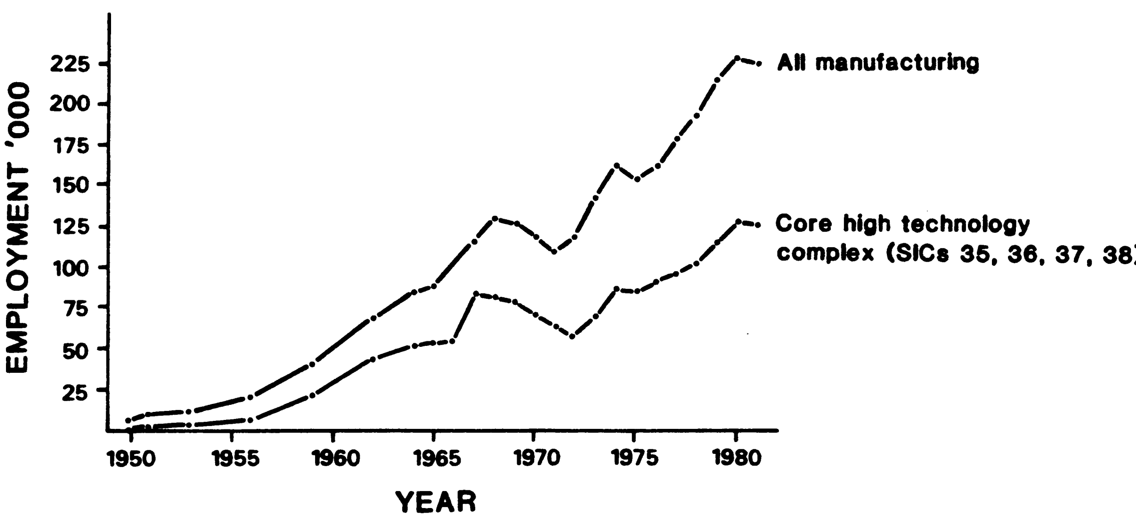

Figure 2

Manufacturing employment in Orange County, 1950-1981. Source of data: U.S. Department of Commerce, Bureau of the Census, County Business Patterns.

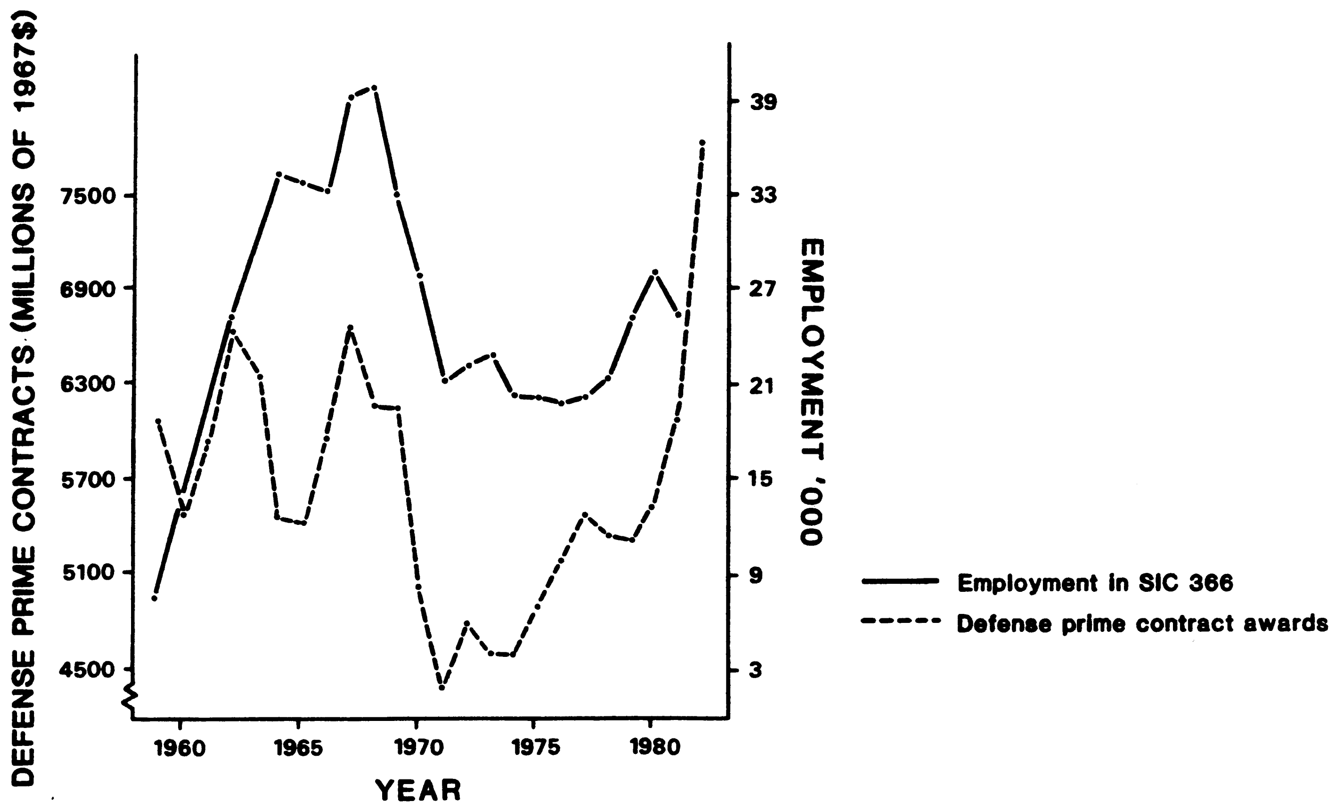

Figure 3

Total employment in SIC 366 (Communications Equipment) in Orange County compared with defense prime contract awards in the State of California. Sources of data (a) U.S. Department of Commerce, Bureau of the Census. <u>County Business Patterns</u>. (b) Department of Defense <u>Prime Contract Awards by State</u>.

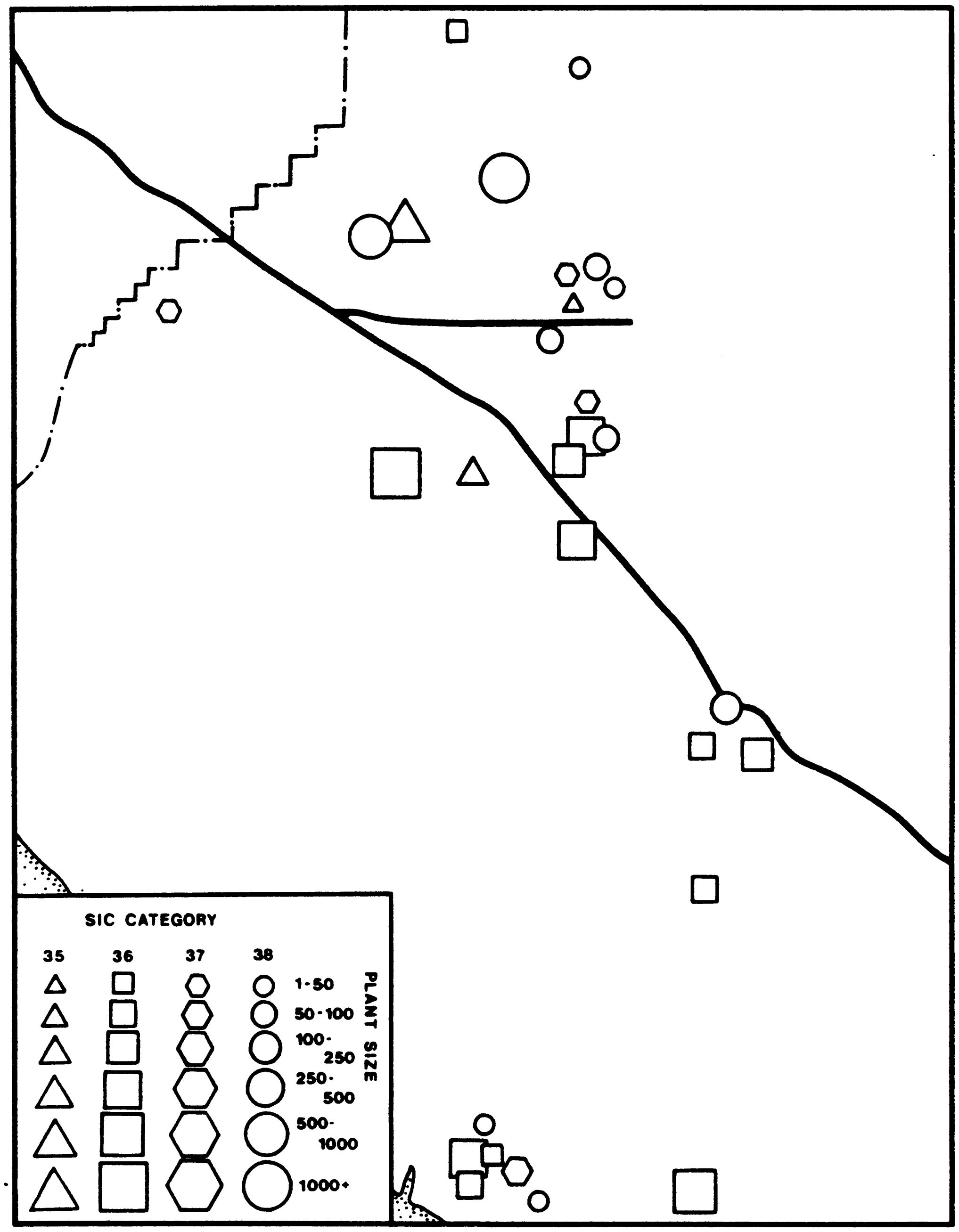

FIG. 4

Orange County core high technology industry and freeway system, 1960. Source of data: California Manufacturers' Association, <u>California Manufacturers Register</u>, 1960.

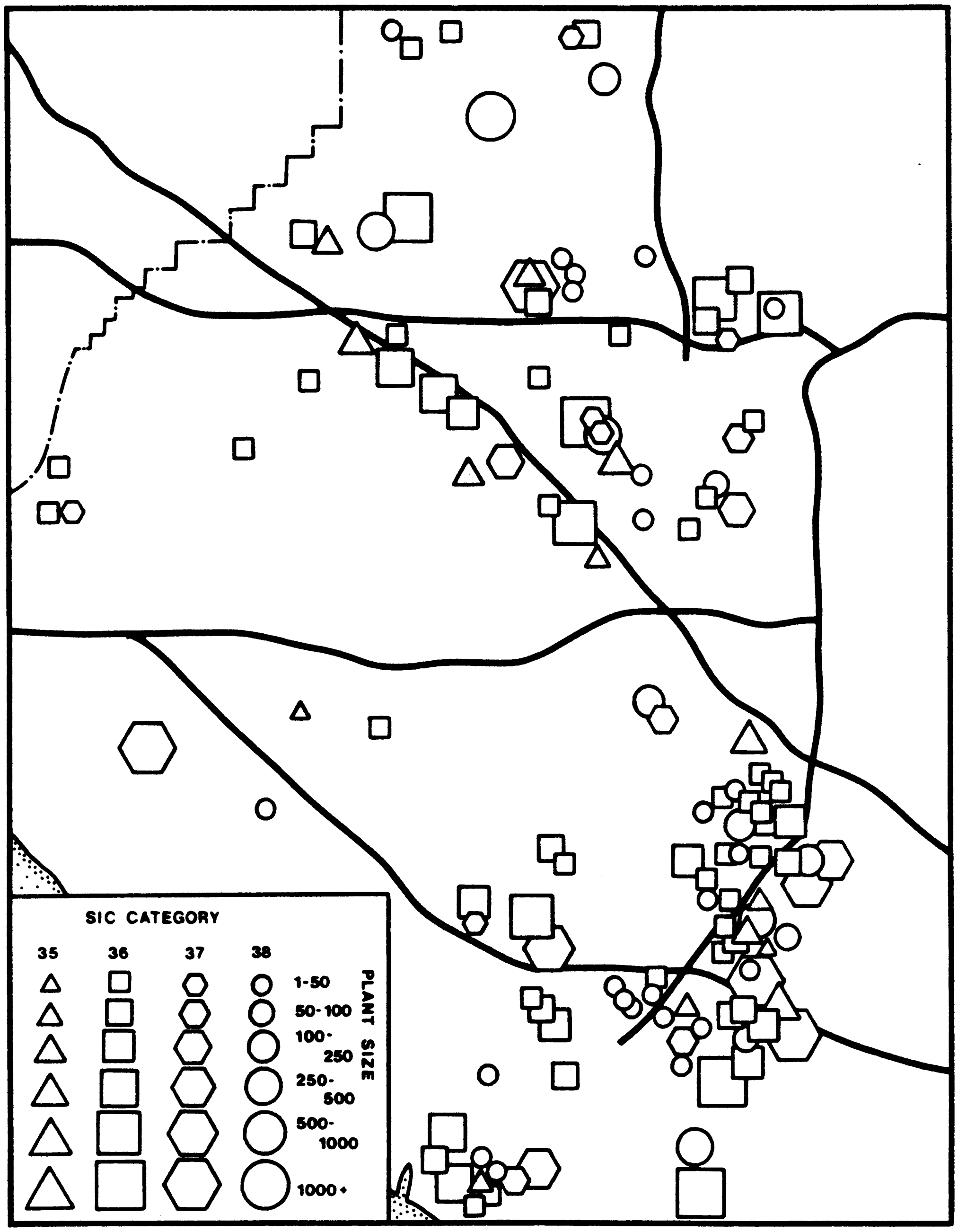

FIG 5

Orange County core high technology industry and freeway system, 1972.

Source of data: California Manufacturers' Association, *California Manufacturers Register*, 1972.

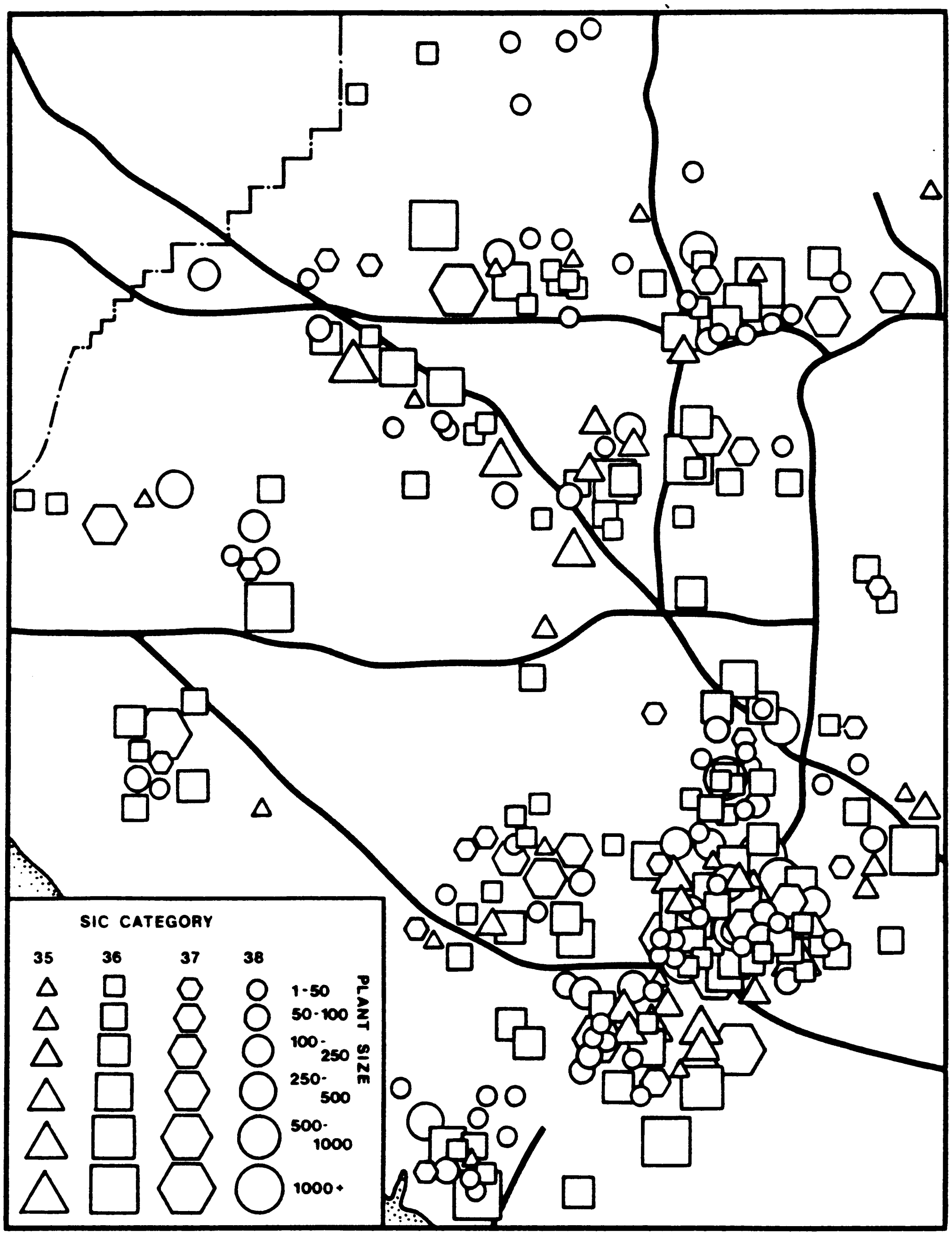

FIG 6

Orange County core high technology industry and freeway system, 1984. Source of data: California Manufacturers' Association, <u>California Manufacturers Register</u>, 1984.

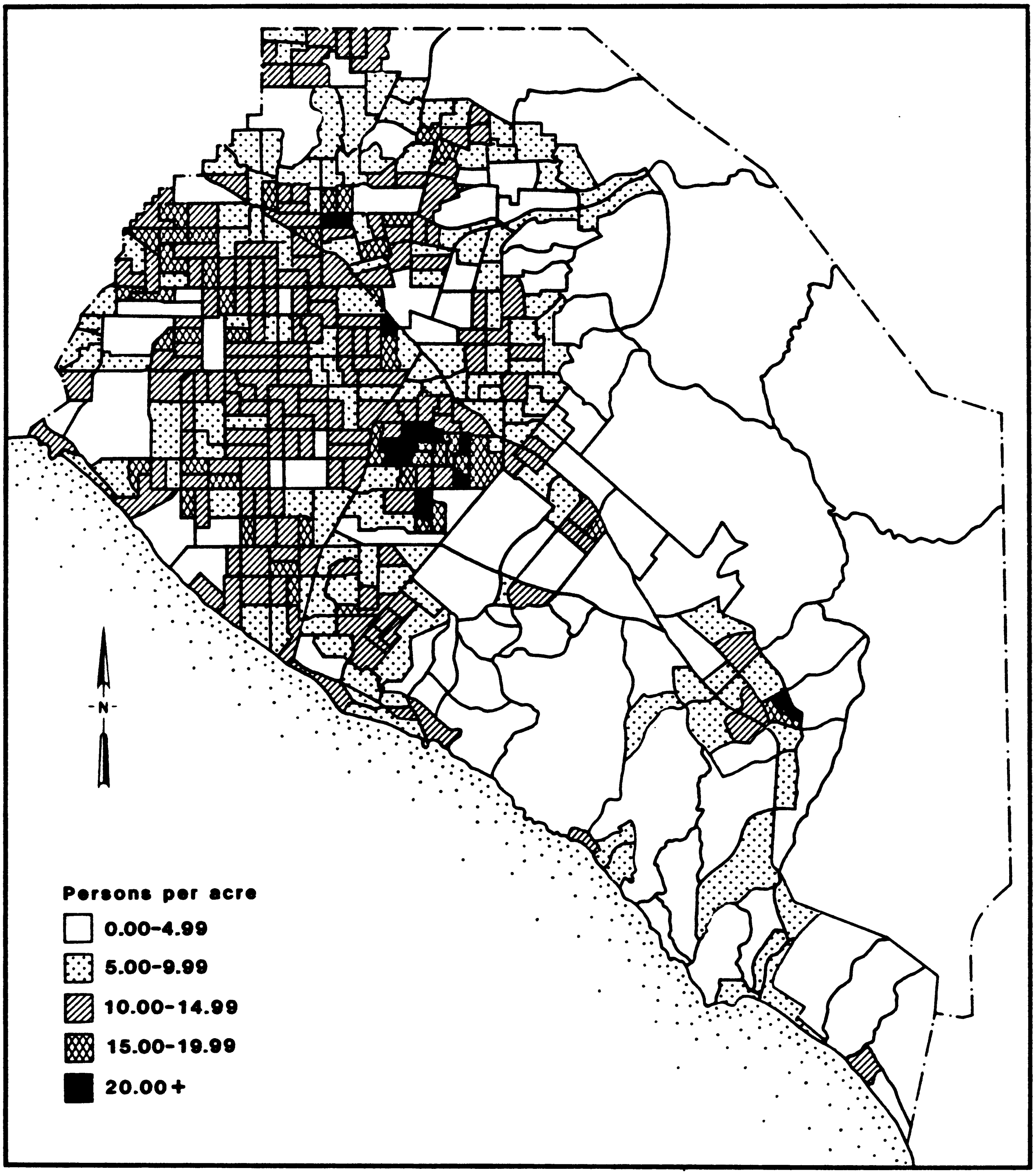

Figure 7

Orange County: Total persons per acre by census tracts, 1980.
Source of data: U.S. Department of Commerce, Bureau of the Census, Census of Population and Housing, 1980.

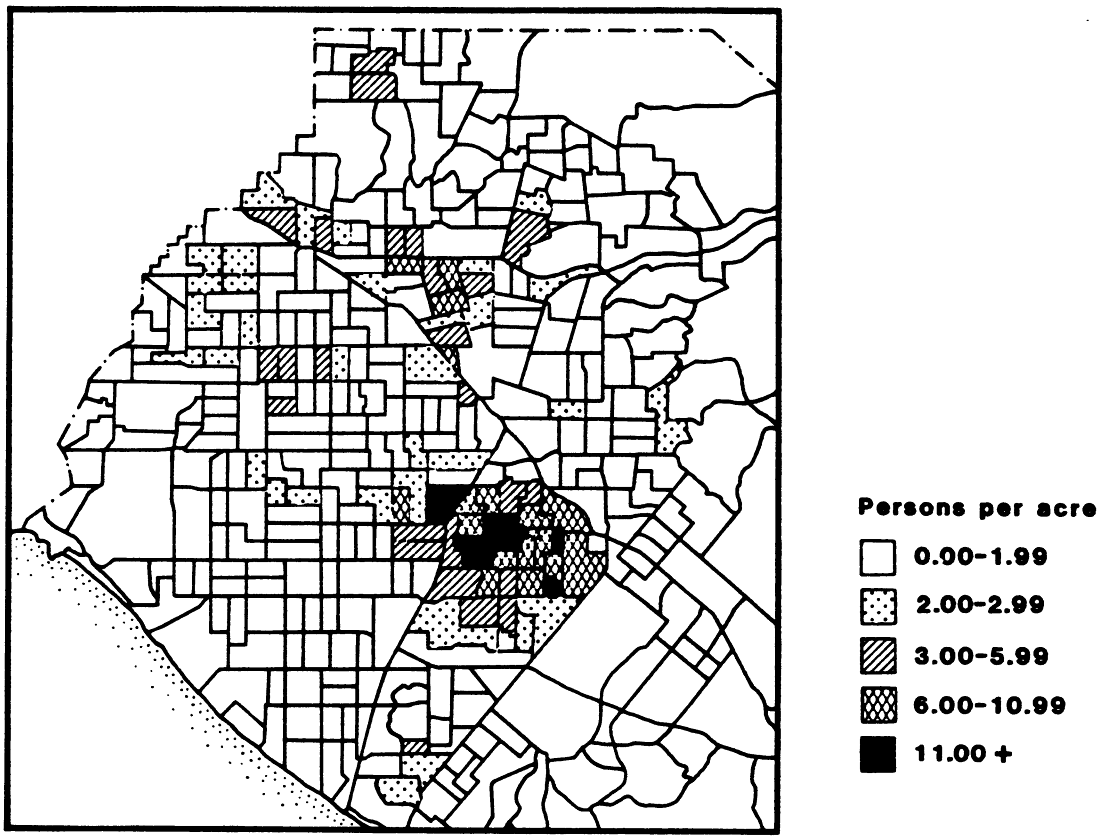

Figure 8

Orange County: Persons of Spanish/Hispanic Origin per acre by census tracts, 1980. Source of data: U.S. Department of Commerce, Bureau of the Census, Census of Population and Housing, 1980.

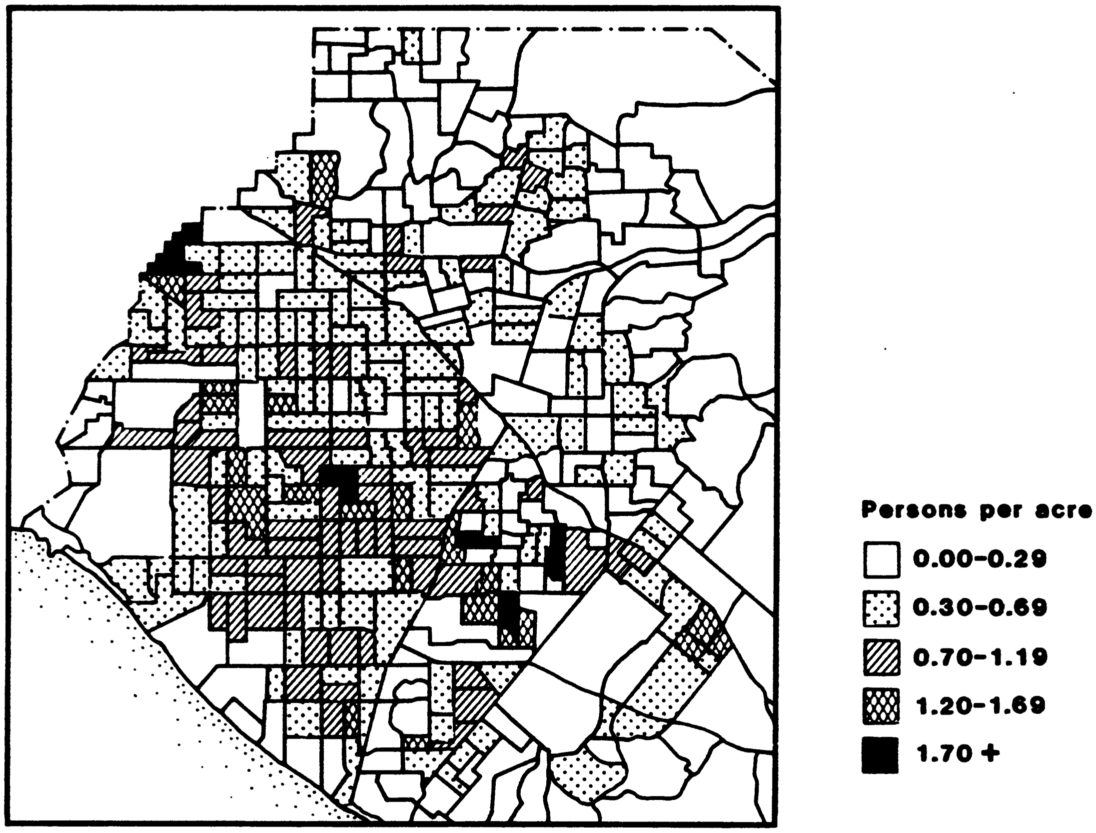

Figure 4.

Orange County: Asians and Pacific Islanders per acre by census tracts, 1980. Source of data: U.S. Department of Commerce, Bureau of the Census, <u>Census of Population and Housing</u> 1980.

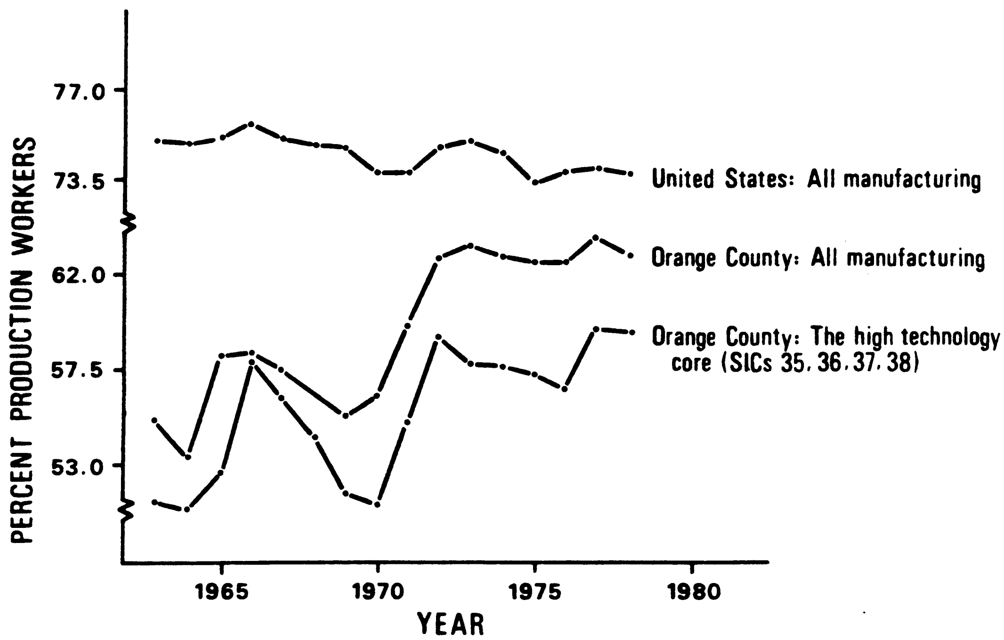

Figure 10

Production workers as a percent of all workers in manufacturing, Orange County and United States. Source of data: U.S. Department of Commerce, Bureau of the Census, Census of Manufactures and Annual Survey of Manufactures.

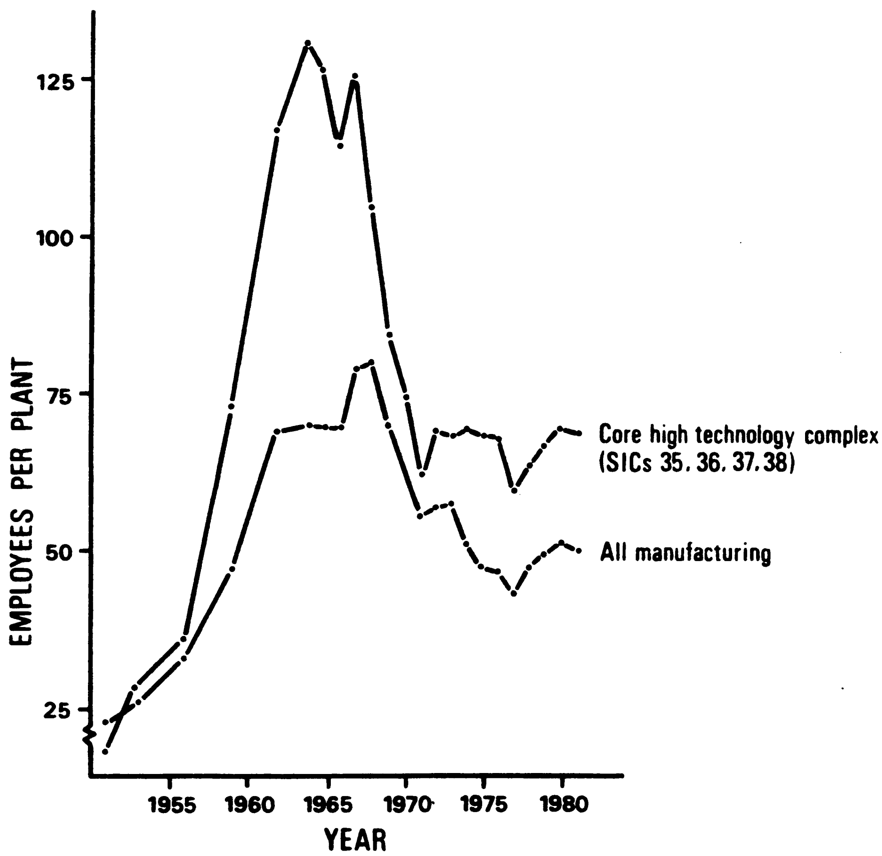

Figure 11

Average number of employees per plant, Orange County; source of data: U.S. Department of Commerce, Bureau of the Census, County Business Patterns.

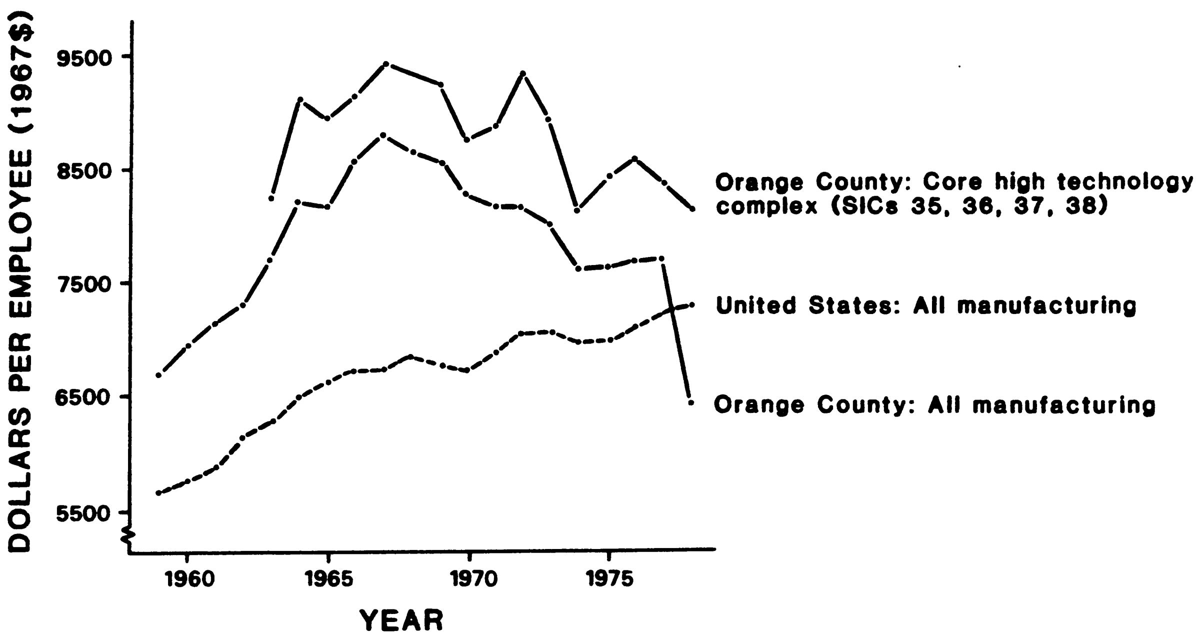

Figure 12
Orange County and United States manufacturing payroll per employee in constant 1967 dollars; source of data: U.S. Department of Commerce, Bureau of the Census, *Census of Manufactures* and *Annual Survey of Manufactures*.

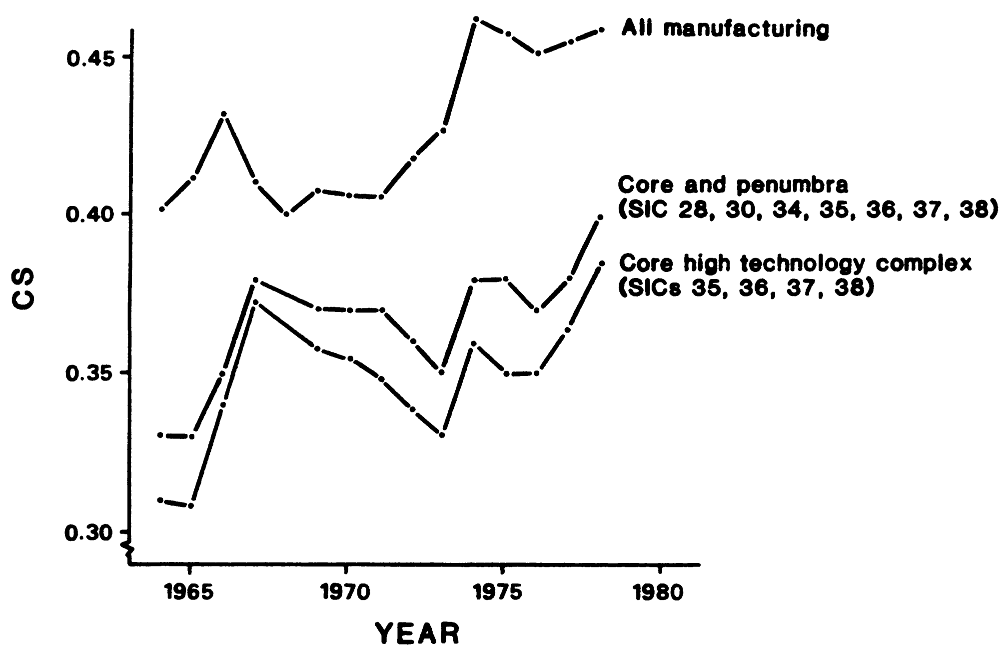

Figure 13

The index of vertical disintegration (cost of materials ÷ value of shipments) for Orange County industries.

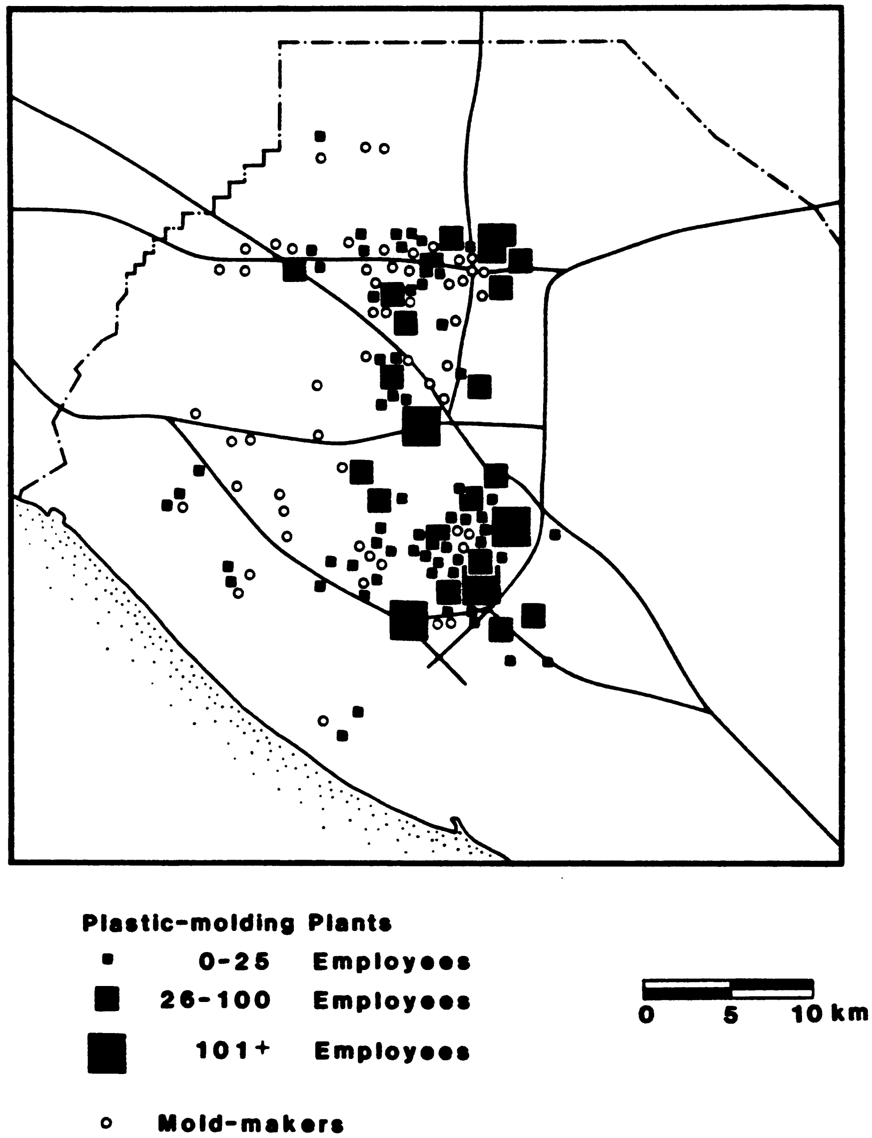

FIG 14. Plastic injection molding plants and mold makers in Orange County. Redrawn from Angel (1984).

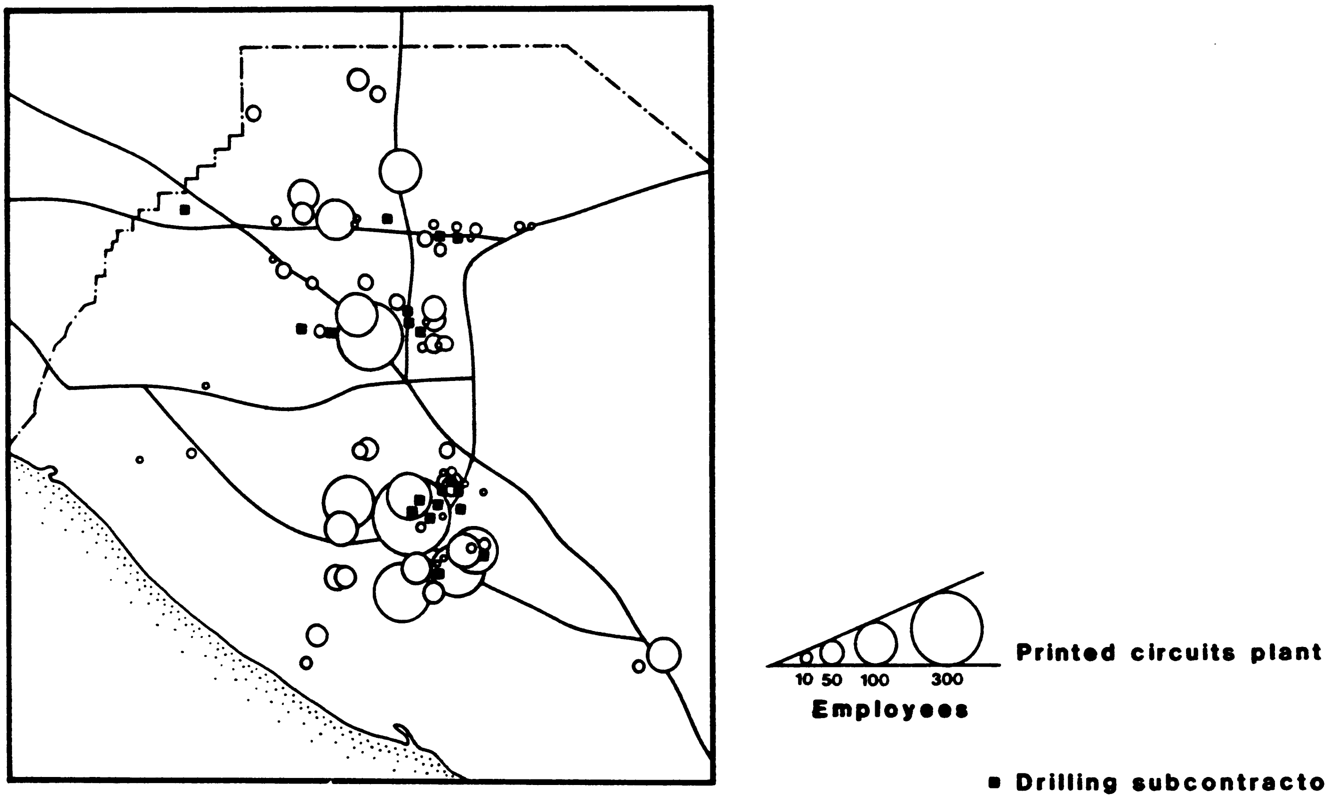

Fig. 15
Printed circuits plants and drilling subcontractors in Orange County.

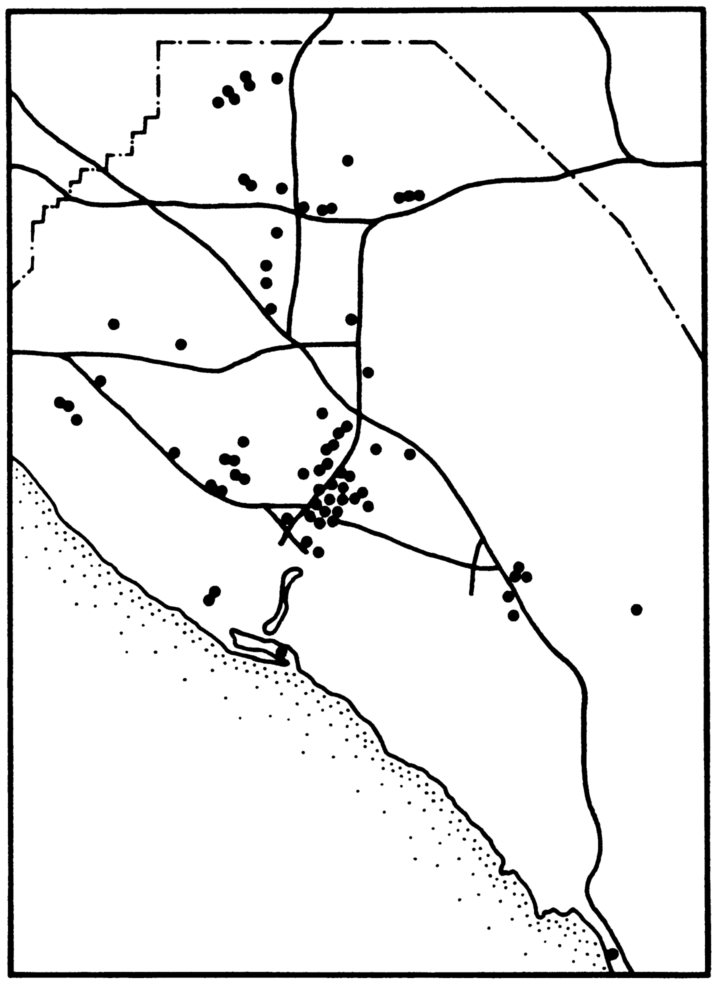

FIG 15

Orange County: Manufacturers of surgical and medical instruments. Source of data: Contacts Influential *Commerce and Industry Directory, North Orange County Firms 1983-1984* and *South Orange County Firms 1983-1984*.

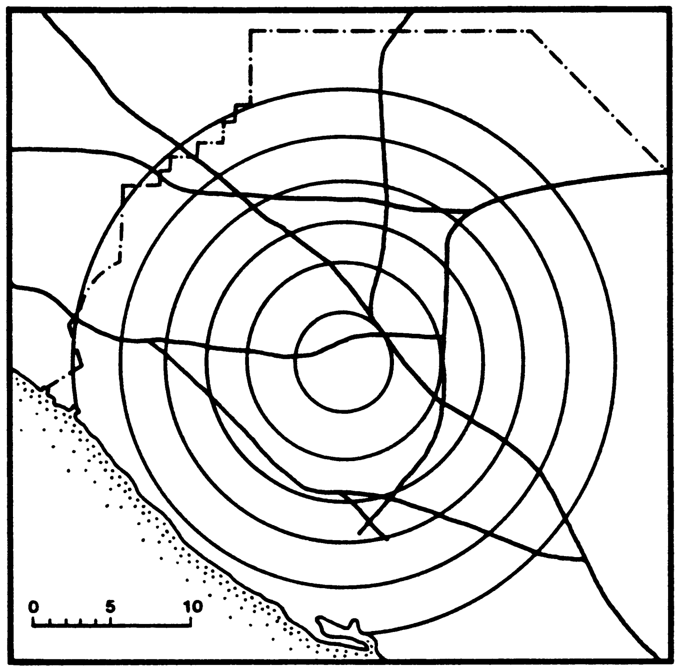

FIG 17

Basic annular structure of the industrial geography of Orange County; rings drawn at 3 km. intervals.

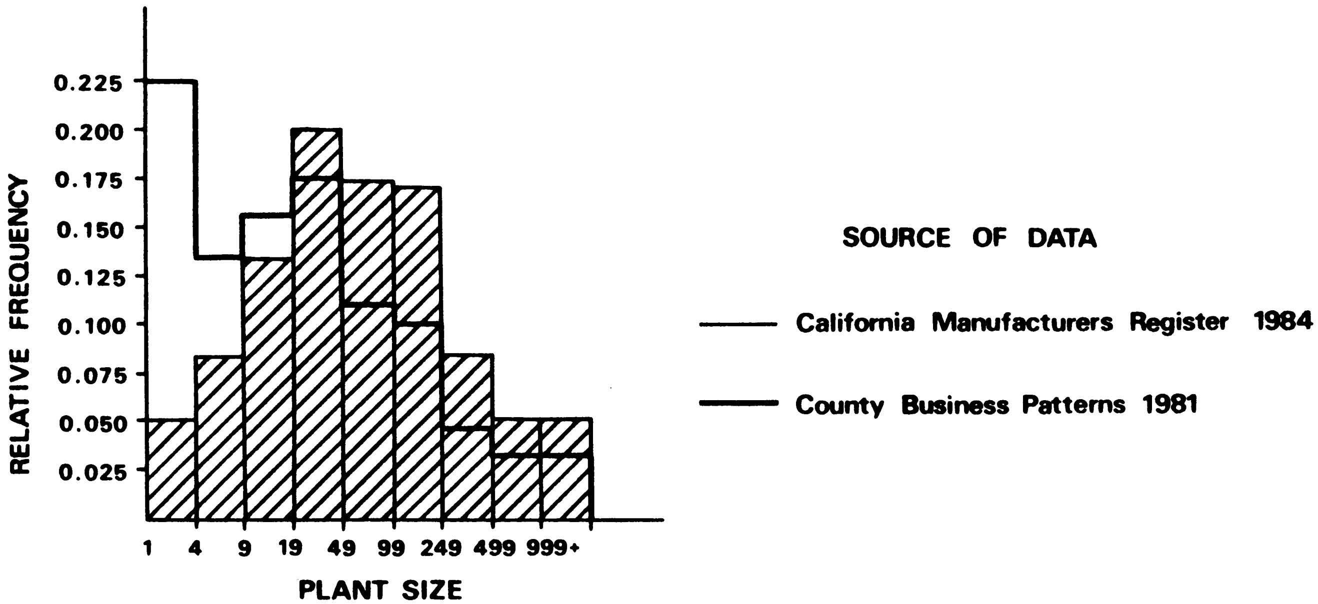

Figure 18

Frequency distributions of plant sizes in the core high technology complex (SICs 35, 36, 37 and 38) based on two contrasting data sources.