Networks, Knowledge, and Niches: Competition in the Worldwide Semiconductor Industry, 1984–1991[1]

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The authors develop a conception of an organization-specific niche in a technological network. This niche is defined by two properties: crowding and status. The authors hypothesize that crowding suppresses an organization's life chances and that status enhances life chances, especially for those organizations in uncrowded niches. They operationalize this conception of the niche using patents and patent citations, and they find support for these hypotheses in an examination of technological competition in the worldwide semiconductor industry. In the conclusion, they compare these findings to earlier research and highlight some of the particular advantages of this conception of the niche.

It is well understood that ideas and inventions rarely arise in isolation. Rather, each idea or invention builds upon others and, in turn, often serves as the foundation for new knowledge. Considered from the macro level, the production of knowledge in any reasonably coherent domain evolves as a network or web, with nodes denoting ideas or inventions and crosscutting ties representing the ideational commonalities among these nodes (Latour 1987; Callon 1987). An earlier study (Podolny and Stuart 1995) specified some dynamic properties of an evolving network in a technological domain; it predicted which nodes of the network would become

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central to the advance of knowledge and which would become technological "dead ends."

Less considered—and less understood—are the competitive implications of such weblike structures for the actors collectively involved in their production. Granted, the importance of ideas and innovations for competitive success is acknowledged broadly. Particularly in a knowledge-based society, ideas and inventions are distinctive assets that affect an organization's viability. As a result, organizations invest considerable resources in protecting their inventions through patents and litigation. Much organizational analysis has explored which structures and systems are most conducive to proliferating ideas and transforming them into commercially significant inventions (Stinchcombe 1990; Burgelman 1983; Eisenhardt and Schoonhoven 1990). However, such studies have typically assumed that invention processes take place *within* organizations. Even Schumpeter (1947), who most clearly recognized the importance of invention to economic competition, failed to consider how the intricate interdependencies among organizations underlie the development of ideas that shape the competitive dynamics among organizations. In Schumpeter's model of competitive dynamics, entrepreneurs and monopolists are the bearers of spontaneously generated ideas that lack any discernible foundation in the activities of others.

Once we dispense with the notion that ideas and inventions arise spontaneously from an organization's own investments in research and development, it is clear that an organization's points of contact with this evolving network simultaneously imply mutualistic and competitive relations with other producers of knowledge. But, how does one devise an analytically tractable representation of an actor's points of contact with this evolving network? In this article, we formulate an answer to this question. We develop and test a series of hypotheses relating an organization's technological niche to its growth in the market.

Our focus on the relationships between technological competition and organizational life chances does not mean that we believe that technology is the only important domain of organizational competition. In addition to the technological arena, organizations compete in labor, financial, and product markets, as well as in a variety of other contexts. Not every domain has relevance for the life chances of every organizational population. For example, at least during the 1980s, biotechnology firms competed in the domains of technology, human capital, and financial capital. But, for the most part, they did not compete in product markets, if only because the vast majority of these new ventures lacked marketable products. Clearly, competition in the technological arena matters more for some organizational populations than for others. Our goal here is to conceptualize an organization's position in the technological landscape and to document how this position affects its life chances in one technology-driven industry. In the conclusion, we discuss possible generalizations of our formulation.

Although we believe that an enhanced understanding of organizational life chances and market dynamics provides adequate justification, we see two additional motivations for this inquiry. First, we want to reconcile a focus on technological invention with an open-systems perspective on organizations. In the late 1960s and early 1970s, sociologists devoted considerable attention to the role of technology in shaping organizations and affecting market outcomes (Woodward 1958, 1965; Thompson and Bates 1957; Burns and Stalker 1961; Perrow 1967; Pugh et al. 1969). However, in the middle and late 1970s, a variety of emerging intellectual approaches, such as population ecology, neoinstitutional theory, resource dependence, and transaction cost economics, came to view organizations as "open systems" with structures and internal processes that were determined primarily by environmental factors. Because technology had always been regarded as an internal attribute of the organization, it was difficult to combine a concern with technology and these open systems perspectives that have come to dominate macro-organizational research. Accordingly, "technology studies" is now a much less vital area for organizational inquiry. Regarding a technological area as an evolving network within which organizations are situated makes it possible to reintegrate a focus on organization-environment relations and the study of technology.

Second, we seek to refine sociological theories of the *niche*. The concept of niche plays a central role in the sociological perspective on competition. While perhaps most readily associated with organizational ecology (Hannan and Freeman 1977, 1989; McPherson 1983), the niche concept has also received considerable attention in sociological work on markets from a network perspective (White 1981; Burt 1992; Podolny 1993). The concept of niche provides an orienting lens for sociological work on competition because it exemplifies a fundamental disciplinary premise: the recognition of a duality between actor and position and an expectation that position is the primary determinant of opportunity and constraint.

In our view, this article makes two contributions to niche theory. First, it introduces status as a meaningful dimension of organizational niches, highlighting the relevance of this dimension to organizational life chances. In its original use in organization theory, the (fundamental) niche refers to the region of an externally given resource space in which an organizational form can persist (Hannan and Freeman 1977). Most efforts to specify the niches of organizational forms have used this conception and have specified niches in terms of a mapping of forms to external environments. For instance, earlier research (Freeman and Hannan 1983) defined niches of restaurants using information on the breadth of services they supplied, and Carroll (1985) defined niches of newspapers using information on the degree to which their content emphasized "general interest." McPherson (1983) and collaborators (McPherson, Popielarz, and Drobnič 1992; Popielarz and McPherson 1995) define niches of voluntary associations with reference to the sociodemographic distributions of their members. Baum and Singh (1994) define niches of day care organizations in terms of the age ranges of children that they are licensed to serve. Despite the differences among these efforts, they all seek to define niches using information about externally given resources (possible—or actual, depending on the application—customers, members, clients).

Status, as we conceptualize it, does not refer to a mapping to an external environment. It is an instance of *endogenous population structuring.*[2] Like other forms of endogenous population structuring such as size-localized competition (Hannan and Freeman 1977) and resource partitioning (Carroll 1985), status structuring arises from the dynamics of the interactions of the members of an organizational population.

This article follows Podolny (1993) in arguing that status arises from acts of deference between organizations. It demonstrates that, at least when providers of resources confront considerable uncertainty in choosing organizations as exchange partners, differences in status affect the flow of resources across niches. While our measurement of status relies on information about technological ties among firms, we discuss in the conclusion different operationalizations that might be appropriate in other contexts.

The article's second contribution to niche theory concerns the foregoing observation that organizations compete on multiple dimensions and hence occupy niches in multiple domains. Once the multiplicity of domains is recognized, two questions become especially salient. First, under what conditions does the competition within a particular domain become more relevant to organizational life chances? This article offers at least some hints of an answer. It provides some evidence that, at least during a period of rapid growth in market demand, the competition in the technological domain places greater constraints on organizational growth than does the competition for consumers, once the technology is taken as a given. That is, the characteristics of a firm's technological niche matter more for growth than does the sales growth of the firm's technological competitors. In the conclusion, we use this finding as a basis for speculating about the conditions under which technological competition might be more or less

[2] One clear way to establish the difference between the two ideas is by considering an organizational population with only one member. The niche in the sense of a mapping to external environment is well defined in this case. The status niche is not because no other organization is available to give deference.

relevant to organizational life chances than the competition in other niche domains.

Second, how interdependent are the multiple dimensions of organizational niches? For example, how does a firm's niche in the technological domain affect its niche in product markets? Drawing on the distinction between fundamental niches and realized niches and using our study as an illustration, we argue that an organization's realized niche in one domain helps to define its fundamental niche in other domains. In effect, the outcome of competition within one domain shapes a set of organizational competencies or resources that bound the possibilities for expansion in other domains.

Our article proceeds as follows. First, we define an organization's position or niche in its technological network by distinguishing positions along the dimensions of competitive crowding and status. Competitive crowding refers to the density of organizations with similar technological antecedents. Status refers to the deference that is implicitly shown to an actor when others build on its inventions. We concentrate on the implications of these dimensions for an organization's growth rate. We hypothesize that (1) crowding depresses growth rates and (2) under conditions of high uncertainty, status elevates them. After developing these hypotheses in further detail, we briefly discuss our methodology of using patents and patent citations to represent the technological network. We then provide an empirical test of our hypotheses in an examination of organizational growth in the worldwide semiconductor industry during 1985–91.

POSITIONS IN TECHNOLOGICAL NETWORKS

Figure 1 depicts a hypothetical technological network. The nodes of the network represent inventions, and the ties represent technological commonalities linking inventions to their antecedents. A tie from one invention to another implies that the consequent invention either builds upon or is premised upon the technology of the antecedent. The numbers associated with inventions denote their order of entry into the technological network. Ties flow backward in time because an older invention cannot build upon a younger one. In earlier work employing this basic imagery, Podolny and Stuart (1995) focused on the competition among individual *inventions* for the attention and resources of organizational actors. Consistent with this focus, they defined niches and conducted analyses at the level of the individual invention.

This article considers the competition among the organizational actors themselves (instead of their inventions considered singly). Accordingly, we define niches at the level of the organization. Specifically, if we define a technological tie as a link between an antecedent and consequent inven-

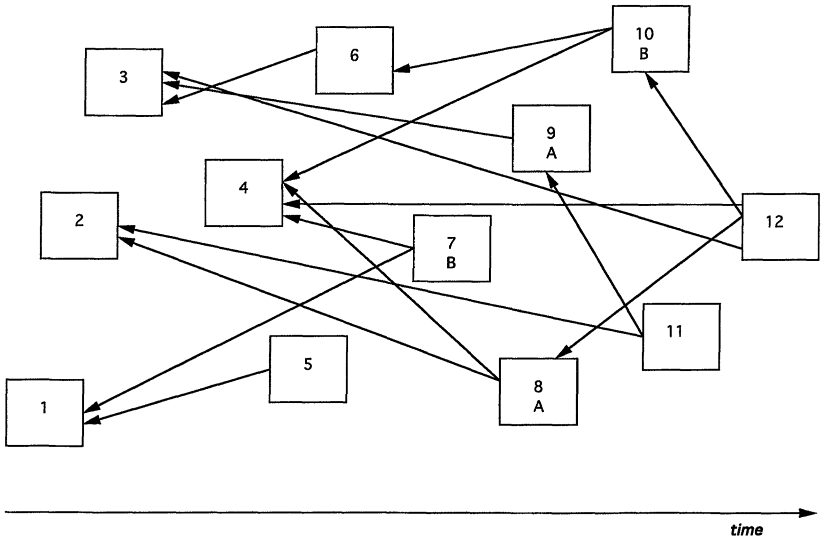

FIG. 1.—Hypothetical technological network

tion, then *an organization's niche is its position in technology space, as defined by the pattern of technological ties involving its inventions.* In other words, an organization's niche in the technological network is manifest in its points of technological contact with the inventions of other organizations.

Figure 1 illustrates the basic idea. It represents the inventions of two organizations, A and B. Organization A has two inventions. Its position is defined by the ties of these to inventions 2, 3, and 4 and by the ties from inventions 11 and 12. Organization B's position is defined by its two inventions' ties to inventions 1, 4, and 6 and its tie from 12.

An organization's position in a technological network constrains its possible strategies in two ways. First, practices and routines built around the underlying technology sharply delimit the extent and direction of organizational change (Nelson and Winter 1982; March 1988; Stuart and Podolny 1996). So too do investments in human and physical capital and alliances (Hannan and Freeman 1984). An organization might gradually adjust its underlying technological competencies through "local search," but significant change in position in the technological network demands fundamental alteration of the organization itself. Second, position depends not just upon the actions of the focal actor but also on the actions of the other organizations involved in the production of the technological network. In other words, position is only weakly under the control of the organization. Durable patterns of relations among organizations tend to lock individual organizations in place. For both these reasons, a high degree of path dependence or inertia characterizes underlying positions in a technological network. Were technological position not characterized by strong inertia, then it would make little sense to consider technological position as a constraint on organizational action. Only when a feature of the organization cannot be changed easily does that feature provide a basis for segmenting an organizational population into distinct niches.[3]

The concepts of niche and niche overlap provide links between this definition of organizational position and competition. We propose a two-dimensional representation of the niche. The first dimension reflects common patterns of ties among organizations' inventions. The second dimension reflects the extent of direct technological linkages between the inventions of a set of organizations. The implications of these dimensions for competition among organizations differ greatly.

COMPETITIVE CROWDING

Niche overlap between two organizations in a technological network can be regarded as a function of the degree of common dependence on prior inventions as foundations for their research activity. Figure 2 presents an example in the form of a Venn diagram. Organization *i*'s activity draws on 50 inventions in the technological network; organization *j*'s activity builds on 100 inventions in this network; 25 inventions serve as antecedents for the innovative activity of both organizations. We define *niche overlap,* denoted by α_{ij}, as the proportion of *i*'s niche simultaneously occupied by *j*. In this example, $\alpha_{ij} = .5$ and $\alpha_{ji} = .25$. Note that overlaps are bounded by zero and one, and they are not necessarily symmetric. This understanding of niche overlap as similarity in patterns of ties has strong parallels in the ecological and network literatures. Hannan and Freeman (1989) define niche overlap as similarity in profiles of dependence on resources. Burt (1992) uses the network idea of structural equivalence in exchange relations to define the competitive intensity between actors. In a work that bridges network and ecological traditions, McPherson (1983) defines niche overlap in terms of a common distribution of members across

[3] For example, in the work of McPherson (1983) and collaborators (McPherson et al. 1992; Popielarz and McPherson 1995) on niche structures of voluntary organizations, homophily bias among individuals creates path dependence in organizational memberships.

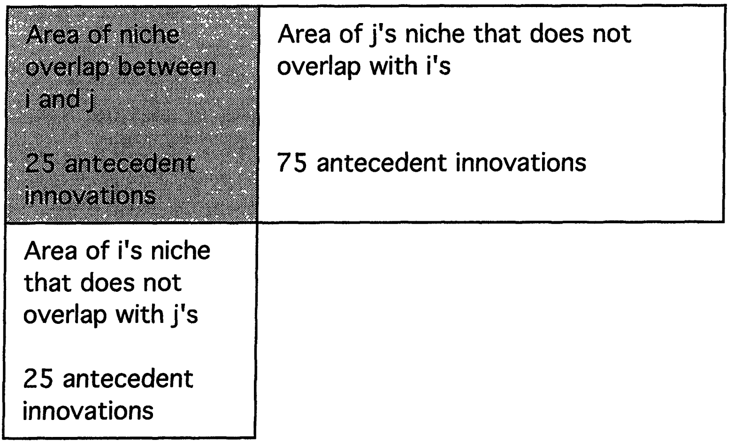

FIG. 2.—Niche overlap of two hypothetical organizations

several sociodemographic characteristics. He argues that the competition between two voluntary organizations for members is directly proportional to the similarity of their memberships on sociodemographic characteristics.

Our central contention follows directly from niche theory: the greater the asymmetric niche overlap (α_{ijt}), the stronger is the competitive effect of organization *j* on organization *i* at time *t*. A like pattern of technological antecedents implies a similarity—or even redundancy—in technological competencies. The greater the overlap in technological competencies, the more that *j*'s pursuit of its market possibilities affects the ability of organization *i* to pursue its opportunities.

Consider a focal organization's relationship with all organizations involved in the collective production of the technological network. Our conception of niche means that an organization's market opportunities are inversely proportional to the extent of its overlaps with all other organizations in the population. We define the *crowding* around an organization's niche as the sum of its niche overlaps:

$$A_{it} = \sum_{j \neq i} \alpha_{ijt}.$$

Thus, considering the implications of technological redundancy for the viability of an organization and abstracting from effects on the demand side, we hypothesize that crowding (high levels of niche overlap) impairs organizational life chances.

HYPOTHESIS 1.—*An organization's life chances decline monotonically with crowding (the sum of niche overlaps).*

STATUS

We regard status as a characterization of an actor's position in a social network. Network researchers distinguish two types of social distance: structural equivalence, which summarizes the similarity of patterns of relations to others, and cohesion, which summarizes the pattern of direct ties between actors (Burt 1987; Borgatti and Everett 1992). We draw a corresponding distinction between niche overlap deriving from a similar dependence on technological antecedents and status deriving from the direct (possibly asymmetric) technological ties between actors.

While common dependence on technological antecedents indicates substitutability and thus a competitive relation between two organizations, the isolated significance of a direct technological relation between two organizations lacks a clear meaning. In taking another organization's invention as a foundation for its own research, an actor establishes itself as a potential alternative to—and thus competitor of—the innovating organization. Direct ties could damage an organization's prospects because the presence of such ties imply more innovative activity that closely resembles that of the focal organization. At the same time, a direct tie (or citation) from one organization to another constitutes an implicit acknowledgment of the importance of the pioneering organization's contribution. Unlike an indirect connection that reveals a common technological antecedent, a direct asymmetric connection suggests a certain *deference* by one organization to the contribution of the other. If the technological community is uncertain about which nodes of the evolving network deserve attention and resources, then the direct deference tie signals that j considers the work of i as worthy of such attention. It shows that j regards the activity already undertaken by i as a better foundation for continued invention than some set of alternatives. By building in an observable way on another organization's innovation, an organization confers a certain legitimacy or status on the innovative activity of the pioneer.

If these conferrals of legitimacy and status get noticed by the relevant actors, then a direct tie from j to i improves i's fortunes. Receiving deference eases the problem of mobilizing resources to build, to sustain, and to expand organizations (Stinchcombe 1965; Podolny 1993). Flows of deference signal controllers of resources that an organization deserves support. One prominent example of a deferential tie that enhanced perceptions of an invention was IBM's entry into the personal computer market. The entry was a signal not just to potential consumers but to software and hardware developers that this invention was one that deserved attention and resource allocation (Anderson 1995).

If direct ties between inventions constitute the dominant form of deference in a technological network, it is reasonable to specify that an organization's status depends on the acts of public deference that it receives from other organizations.

We use two rules for aggregating acts of deference across senders to measure status. In the first, the quantitative significance of an act of deference is proportional to a sender's own status (i.e., the amount of deference that the sender has received):

$$D_{it}^{w} = \sum_{j \neq i} w_{jt} d_{ijt},$$

where d_{ijt} denotes the number of acts of public deference from j to i within an interval of time ending at t, and w_{jt} denotes the weight assigned to acts of deference from a particular j. As we explain in detail below, we choose weights such that w_{jt} is proportional to the status of the sender. We refer to this measure as the *weighted* measure of status.

In forming the second measure of status, we assume that each act of deference has the same significance. That is, the quantitative significance of an act of deference does not depend upon j's status (or other attributes):

$$\mathrm{D}_{it}^{u} = \sum_{j \neq i} d_{ijt}.$$

We refer to this alternative as the *unweighted* measure of status.

Acts of public deference do not necessarily have both status enhancing and competitive implications. However, acts of deference that take the form of *imitation* generally do have. Thus, at least when considered in isolation, a direct tie from one actor to another has an indeterminate effect. However, if the existence of a direct deference tie is considered in conjunction with niche overlap (based on a similar pattern of technological antecedents), its significance becomes more determinate.

If an organization occupies a position having few potential competitors with similar technological antecedents, then it has a more novel technology than an organization in a niche crowded with organizations with similar technical antecedents. Evidence from cultural and market contexts shows that increasing uncertainty about underlying quality makes perceptions of the quality of the actor's endeavors depend on its status (Podolny 1994; Greenfeld 1989). In the context of a technological field, we expect that the more novel—and therefore the more uncertain—the quality of the technology, the more that a direct tie from another organization enhances its *perceived quality.* Conversely, the more common and redundant the organization's technology, the less a direct tie from another organization can positively affect the perceptions of that technology. This reasoning implies that the direct ties affect perceptions of quality most strongly in sparse regions of the technological space.

In contrast, direct ties have the most potent competitive implications in the most crowded portions of the technical space. Suppose many organizations build on the same antecedents as the focal organization *and* draw directly on the inventions of the focal organization. Then the combination of niche overlap (indirect ties through antecedents) and direct ties suggests that the technological network has crowded around the organization's position. In effect, the technological network takes the form of a *clique* structure around the focal organization's niche. On the other hand, suppose many organizations are building directly on an organization's inventions but few organizations are building on its antecedents. This combination suggests not crowding or the existence of a clique structure around the organization's position but an *expansion of the network* from the position of the focal organization. In this case, the organization occupies the position of broker in an untapped technology rather than of redundant member of a clique.[4]

To summarize, we expect that status (direct ties) provides strong signals of quality in sparsely populated regions of the technological space. However, as crowding increases, status matters less to judgments of quality. Thus, status has a positive effect on life chances in uncrowded niches, but the effect declines with crowding. These expectations have two testable implications.

HYPOTHESIS 2.—*The life chances of an organization in an uncrowded niche increase monotonically with its status.*

HYPOTHESIS 3.—*The positive effect of status on an organization's life chances declines with the crowding of its niche.*

Our argument does not imply any predictions about the main effect of status on life chances. Indeed, one cannot specify an average status effect independent of a meaningful assessment of the average crowding or uncertainty in a technological domain. Consider a technological domain with crowded niches and correspondingly low uncertainty. The average status effect in such a domain will likely be negative. Conversely, in a technological domain where the average niche is uncrowded and uncertainty is high, the average effect of status will likely be positive. Rather than specifying

[4] This argument, formulated at the organizational level, directly parallels early discussion (Podolny and Stuart 1995) of competition at the level of the individual invention. According to the central claim of that article, only the combination of direct and indirect ties between a focal invention and another invention implies crowding. Direct ties alone do not constitute evidence of crowding within a focal invention's niche.

an average or main effect for status, hypotheses 2 and 3 specify a contingent effect: status has a positive effect in uncrowded niches, and this positive effect declines with crowding.

This argument closely parallels the theory of density-dependent legitimation and competition (Hannan and Carroll 1992). According to this theory, growth in the number of organizations in a population (density) increases the degree to which the organization form is taken for granted, but there is a ceiling on this process. However, growing density also intensifies competition. At low density, the field is uncrowded and competition is weak. As density grows relative to resources, competition intensifies at an increasing rate. Thus, increases in density in uncrowded niches mainly legitimate the population and thereby increase rates of founding and organizational growth while depressing mortality rates. At high density, further increases have mainly competitive effects, causing rates of founding and growth to diminish and rates of mortality to rise.

To make clear the similarity of the theory of density dependence and the argument presented in this article, consider the basic story of density dependence from the perspective of the pioneers in an organizational population. The pioneers occupy an uncrowded position. As other organizations enter the population (either by foundings or lateral moves from other populations), the degree to which the population is taken for granted is enhanced with little increase in competitive intensity. Thus, the fortunes of the pioneers improve. But, if the inflow continues unabated, the pioneers' fortunes (as well as those of other members of the population) eventually decline as the niche becomes very crowded.

Here we argue that direct ties to an actor in technological space have implications similar to growing density in a limited resource space. In an uncrowded region of technological space, direct ties have a positive effect. But, as the region becomes more crowded, the positive effects of these direct ties decline. Despite the similarity of their theoretical logics, the two formulations produce different empirical implications. Studies of density dependence identify the opposing effects of legitimation and competition from estimates of the effects of complex functions of density. The strategy that shapes our analysis identifies the opposing deference and competitive processes by distinguishing the effects of direct and indirect ties in technology space, as we describe below.

To summarize, niches in the evolving technological network have two dimensions. The first, niche overlap or competitive crowding, corresponds closely to structural equivalence, if overlap means a similar pattern of technological ties. The second, status, corresponds to network centrality. Based on these two views of niche overlap, we have proposed three hypotheses that relate an organization's position in the technological network to its market presence.

A MODEL OF GROWTH AND DECLINE

Our arguments about the effects of status and crowding on life chances potentially apply to a range of measurable outcomes: mortality rates, growth rates, profitability, success in attracting employees or external partners, and so forth. We concentrate on growth rates. We specify a parametric model of organizational growth that builds on prior research and that is potentially consistent with the three hypotheses.

Let S_{it} denote an organization's size during period t. Growth models typically focus on relative sizes at two points in time: $S_{i,t+1}/S_{it}$ and allows growth rates to vary with size. We model the growth of sales using the following specification:

$$\ln\left(\frac{S_{i,t+1}}{S_{it}}\right) \alpha \ \rho S_{it} + \varphi(A_{it}, D_{it}); \quad (1)$$

$$\varphi(\cdot) = \beta_1 A_{it} + \beta_2 D_{it} + \beta_3 A_{it} D_{it}, \quad (2)$$

where A denotes the crowding in organization i's niche and D is a measure of its status.

Hypotheses 1–3 imply that

$$\beta_1 < 0, \ \beta_2 > 0, \ \beta_3 < 0. \quad (3)$$

We test these hypotheses using data on the worldwide semiconductor industry, as we discuss next.

PATENT CITATIONS

To assess positions in an evolving technological network, we must distinguish inventions and the technological connections among them. We rely on patents to identify the inventions, or nodes, in the technological network. Patents are especially useful for this purpose because they are granted only to products, processes, or designs that the experts in the U.S. Patent and Trademark Office consider to be useful and nonobvious, given the current state of the art. In other words, an application will receive a patent only if a knowledgeable, objective third party decides that the work exceeds a minimum threshold of innovation.

As part of the patent application process, an applicant is required by law (1) to cite all of the known, previously patented work that has served as technological building blocks, and (2) to make clear that the work advances beyond these precursors, called the "prior art." Patent examiners must assess the completeness of these prior art citations. If the examiner finds that the inventor has failed to identify a technological precursor that might anticipate the claims of the patent, the examiner may send the application back to the inventor and ask that prior work be cited and that the current proposal be distinguished adequately from this prior work. Because the return of the patent application can delay the application process, applicants have a legal obligation and an economic incentive to cite all of the appropriate prior art. Even if the application is not returned, the examiner may add citations he or she believes are appropriate. Acceptance of a patent application by the Patent Office does not protect the innovator from an infringement case of a competitor with a similar patent. Hence, an inventor has a legal and economic incentive to cite the appropriate art; he or she does not have an incentive to cite strategically the patents of some organizations rather than others to invoke protection from legal disputes.

Several studies have verified that analysis of patents and patent citations provides a useful way to identify inventions (Schmookler 1966) and measure their importance (Trajtenberg 1990). Moreover, the practical utility of the information contained in patents is suggested by the existence of "patent consultants" that sell competitor analyses to client high-technology firms (Eerden and Saelens 1991). Nonetheless, there are still some reasons to be cautious about the use of patents and patent citations to measure positions in an evolving technological network.

One reason for caution is that inventors might not patent certain inventions. They might fear that the public revelation of the invention in the patent application will damage their competitive position more than will the lack of patent protection. A second reason is that industries vary considerably in the extent to which inventions are patented even if they are made public (Scherer 1984).

In our view, the second possibility poses more problems than the first. If key features of an invention are kept secret, then it seems unlikely that the invention could have a significant influence upon the evolution of the technological network. Other organizations cannot build upon inventions that they do not recognize and comprehend. If publicly recognized inventions are not patented, then our methodology of relying on patents and patent citations to define the evolving technological network will incompletely represent the network. We find little reason to believe that even this second problem would bias the results in an analysis of the competitive implications of an organization's technological position. The omission of publicly recognized nodes would simply raise the likelihood of a false null. Even so, these concerns are important considerations in the choice of industry for research on competition and status processes. It was precisely these considerations that motivated us to study the semiconductor industry.

DESIGN, MEASUREMENT, AND ANALYSIS

The Worldwide Semiconductor Industry: 1984–91

The semiconductor industry stands out as a technological domain with a high propensity to patent inventions, at least since the early 1980s. All of the landmark inventions in this industry have associated patents (Wilson, Ashton, and Eagan 1980). During the period covered by our study, semiconductor firms have had strong economic incentives to patent their technologies. Beginning in the mid-1980s, semiconductor firms began to derive significant royalty income from licensing their patented technologies. Moreover, the creation of the court of appeals for the federal circuit in 1982 greatly increased the ability of semiconductor producers to seek damages for patent infringement. To draw on Texas Instruments (TI) as an example, the popular press estimates that TI has earned some $1 billion in royalties from patent infringement lawsuits (Orenstein 1992), and it received $256 million in patent licensing royalties in 1991 alone.

A diverse array of organizational actors participates in the elaboration of semiconductor technology. Among the most important are "merchant" semiconductor producers (firms that sell their semiconductor products on the open market, e.g., Intel and TI), "captive" producers (firms that manufacture more than 75% of their semiconductor products for their own high-technology products, e.g., IBM), national governments or agencies, and universities. Given our focus on growth/decline in market presence, we consider only the merchant producers and the major captive producers. We measure market presence as a firm's annual semiconductor sales. We use data supplied by Dataquest, an international consultancy and market research firm with clients in high-technology industries. Firms included in the Dataquest data account for 90% of worldwide semiconductor sales, and the company claims to collect data for all firms producing more than $10 million in sales (which amounts to approximately .02% of the market in 1992). Data on the internal sales of the major captive producers are reported in *STATUS* (McClean 1984–91), an annual publication of the Integrated Circuits Engineering Corporation. From these two sources, we obtained sales information on 113 firms for 1984–91. These 113 firms include producers in the United States, Asia, and Europe.[5]

[5] Semiconductor sales and patents of subsidiaries were aggregated into the semiconductor sales and patents of parent companies. There were a small number of exits and entries over the period of coverage; so the number of firms in any given year might differ slightly from 113.

We have collected information on all U.S. semiconductor patents granted to these organizations during 1976–91. (Stuart [1995] discusses the procedure for selecting patents to be included in the analysis and lists the primary classes from which the patent data were obtained.) Previous research suggests that the U.S. patent system is the most complete for analyzing international technology. Over 50% of the patents are granted to foreign applicants (Albert et al. 1991). Several information services provide complete patent information over this period. We utilized the Micropatents CD-ROM database. Through 1991, the 113 firms in our study issued 19,507 semiconductor patents and made 62,261 citations.

We included a firm in a given year if it was among the 113 firms listed by Dataquest and if it had at least one patent. In effect, this inclusion rule implies that a firm does not have a technological niche if it has no patents.[6]

Starting with patents issued in 1976 produces some left truncation in the construction of the measures since any technological antecedents before 1976 cannot be cited. Unfortunately, large-scale data collection of patents issued before 1976 is not feasible because these earlier patents are not available in an electronic form. Though this arbitrary lower bound leads us to standardize the measure of direct cites in a manner discussed below, we believe that the effects of this arbitrary lower bound should be small. The product life cycle in the semiconductor industry generally runs about three to five years from introduction to maturity (McClean 1984–91), and our first year of sales data is drawn from 1984. Accordingly, patents issued before 1976 are already at least one and one-half generations old by the start of our analysis of growth in sales.

Competitive Crowding

To determine technological antecedents, one needs to select an appropriate time window for defining an organization's current inventions. It seems unreasonable to assume that an organization's innovative activity in a particular year would be defined only by the patents that were issued in that year or the prior year; yet it seems equally unreasonable to assume that patents received 15 or 25 years earlier would indicate current innovative activity. Because the average product life cycle in this industry is commonly thought to range from three to five years, we use a five-year

[6] Alternatively, one could include even those firm-years where a firm lacked a patent. If one included these firm-years, one would include a dummy variable specifying whether the firm had any patents and then interact this variable with all others in the model. Since the results for firms with patents would remain unchanged under this alternative specification, we simply chose to exclude those with no patents from the analysis.

window. In modeling an organization's growth from year t to $t + 1$, we define an organization's current technology in year t as including all of its patents issued within a five-year window ending in the year t.

We calculate niche overlaps based on the technological antecedents of this five-year window of patents. In other words, α_{ijt} represents the overlap in citations from organization i's patents issued for the five-year window ending in year t and organization j's patents issued over the same years. As noted above, we measure crowding as the sum of the overlaps.

Status

We also employ a five-year window to define status (D_{it}). As noted above, we measure status in two ways. First, we let the deferential significance of a citation be a function of the deference that is shown to the citing firm. Drawing on Bonacich's (1987) measure of status, we compute a weighted measure of status (an aggregate deference vector) as follows:

$$\mathrm{D}_{it}^{w} = \eta \sum_{k=0}^{\infty} \theta^{k} \mathbf{R}_{it}^{k+1}\, 1.$$

The matrix $\mathbf{R}$ has as its elements, r_{ijt}, the counts of the number of citations from organization j to organization i in the five-year window ending in t. We set η, the scaling parameter, so that a score of "1" means that an organization's status is neither high nor low. How much acts of deference from j to i are weighted by j's status is determined by θ. The greater the value of θ, the more that an act of deference from j to i is positively weighted by the amount of deference shown to j. The bounds on values of θ are "0" and the reciprocal of the maximum eigenvalue of $\mathbf{R}$. For the purpose of this analysis, we set θ to equal the reciprocal of the maximum eigenvalue of $\mathbf{R}$.

The unweighted measure of status D_{it}^{u} counts the number of citations to its portfolio of patents divided by the total number of citations made by all organizations during this period to all post-1975 patents.[7] We standardized D_{it}^{u} as a proportion because the left truncation at the start of 1976 causes the "risk set" of citeable patents in the database necessarily to increase over time. That is, a patent issued in 1984 has only eight complete years of patents that it can cite, but a patent issued in 1990 can cite 13 years of patents. Standardizing this measure by the total number of citations made in the preceding five-year window makes the measure com-

[7] We do not include self-citations in the calculation of status scores because a self-citation does not seem to reflect adequately the public deference process that this variable represents.

parable across years. If an organization receives no citations to its patent portfolio during the previous five years, then D^u_{it} equals "0." A theoretical maximum for D^u_{it} is "1," which would signify that all of the citations issued by all organizations in the population during the five years ending in t flow to i.

Additional Covariates

We also included other covariates in the analysis. Patents indicate underlying technical competencies; they also have value as resources that can affect a firm's pursuit of market opportunities. So we control for the number of patents in an organization's current portfolio, again using a five-year window. Also, so that this measure parallels the proportional measure of direct citations, we standardized it by dividing the focal organization's number of patents over the period by the total number of patents issued to all of the organizations in the sample over the same period.

A final covariate of analytical interest concerns a weighted measure of the sales of a firm's technological competitors. We operationalized sales of competitors as follows:

$$C_{it} = \sum_{j \neq i} \alpha_{ijt} S_{jt},$$

where α_{ijt} is the measure of niche overlap discussed above, S_{jt} denotes firm j's sales in year t, and C_{it} represents a weighted average of the sales of a firm's set of technological competitors, with the sales of each competitor weighted proportional to its niche overlap with the focal firm. The more that j falls in i's niche, the more that j's sales are assumed to be targeted toward the same customers. For example, if 50% of the patents that j cites are also cited by i, then we assume that 50% of j's sales are directed toward the same markets as i. This weighting is obviously premised on the assumption that all of a firm's patents contribute equally to its sales. While we recognize the possible inaccuracy of this assumption, we believe that it is the most plausible assumption that can be made in the absence of complete data on the link between patents and sales.

By comparing the effect of total sales of technological competitors to that of crowding, we can evaluate the extent to which growth rates depend more on the technological encroachment or the sales of competitors. If crowding in technology space has a stronger effect on organizational life chances, this suggests that the competition among firms takes place primarily within the technological domain and that growth/decline in sales depends strongly on the position that firms have staked out in the technological domain. Conversely, if the sales of technological competitors have a stronger effect on organizational life chances, then the evidence suggests that the more salient competitive dynamics are those that occur in the product markets after the firm's technological territories have been established.

Estimation

We estimate an elaborated version of the model in equation (1):

$$\ln\left(\frac{S_{i,t+1}}{S_{it}}\right) = (\rho)\ln(S_{it}) + \beta_1 A_{it} + \beta_2 D_{it} + \beta_3 A_{it} \times D_{it} + \mathbf{x}_{it}\boldsymbol{\pi} + \sigma_i + \tau_{t+1} + \epsilon_{i,t+1}. \tag{4}$$

The terms on the right-hand side are defined as follows: σ_i is a firm-specific growth rate, τ_{t+1} is a period-specific effect for calendar time $t + 1$,[8] $\boldsymbol{\pi}$ is a vector of coefficients, $\mathbf{x}$ is a vector of covariates, and $\epsilon_{i,t+1}$ is a random disturbance with normal distribution.[9]

The model includes organization-specific effects: σ_i. Specifying "fixed effects" for each organization has important advantages. First, it removes all between-organization variance from the analysis and thereby controls for any time invariant unobserved heterogeneity among organizations. Thus, the fixed-effect specification constrains the coefficients to be *within-organization* effects. For example, a negative effect for competitive intensity would indicate that an increase in the intensity of competition for a focal organization is associated with reductions in its growth rates. When between-organization variance is not eliminated, one needs to be much more cautious about making within-organization inferences. The apparent effects of changes might reflect enduring differences among organizations rather than changes experienced by the organizations over the analyzed period. A second advantage of organization-specific fixed effects is that it is not necessary to make any assumptions about the distribution of firm-specific effects within the population. Standard random-effects models assume that the firm-specific effects are normally distributed throughout the population; in our dataset, this assumption is violated. In addition to specifying firm-specific fixed effects, we also control for systematic variation across periods by including period-specific effects: dummy variables, τ_{t+1}, for each year except one. We estimate fixed-effects models with OLS.

[8] This specification of period effects controls for temporal autocorrelation.

[9] The literature on organizational growth also draws attention to the importance of organizational age as a covariate in growth models (Barnett 1994; Barron, West, and Hannan 1994). However, organizational age yields no additional information in a model that includes firm-specific growth rates (σ_i) and period-specific effects ($\tau_t + 1$).

TABLE 1

CORRELATIONS AND STANDARD DEVIATIONS BASED ON WITHIN-FIRM VARIATION

Variable	SD	S	P	A	D^w	D^u	C
ln(sales) (S)	.34	1.00	.22	.22	.30	.24	−.07
Patents (P)	.002		1.00	.04	.26	.50	−.03
Crowding (A)	.48			1.00	.13	.10	.04
Weighted status (D^w)	.14				1.00	.84	−.01
Unweighted status (D^u)	.002					1.00	−.03
Sales of technology competitors (C)	4.26						1.00

NOTE.—The text discusses the correlations of weighted status and the relevant interaction terms involving it.

RESULTS

Table 1 presents descriptive information on the variables in the analysis. Since our analysis focuses on only within-firm variance, we report the bivariate within-firm correlations. Table 2 presents the results. We present the results of a set of parallel analyses. We begin with the specification that we think most promising, one that includes main effects of crowding and weighted status and an interaction effect of the two (col. 1). In the second step, we estimate a version of the same model with the interaction term expressed as a product of mean-deviated values of crowding and status (col. 2). Third, we replace weighted status with the unweighted measure (col. 3). Finally, we replace crowding around the technological niche with the measure of sales of technological competitors (col. 4). We present all of these specifications to show that the results are robust across all of the possible alternative specifications. Similarly, it should be clear that the effect of status is not affected by the specification.

The first column in table 2 reports estimates of the main effects for crowding and (weighted) status and the interaction between them. The main effect of crowding is negative and statistically significant. The main effect for status is positive and statistically significant. The interaction effect of crowding and status is also positive and significant. Thus, all three hypotheses find support in these results.

It is important to note one methodological concern. The correlation between status and the interaction effect in the analysis just discussed is extremely high (0.97). We addressed this multicollinearity in a number of ways.

First, following Belsey, Kuh, and Welsch (1980), we calculated a set of collinearity diagnostics to examine the degree to which the estimates might be influenced by collinear relations among the independent variables. Though there are no rigid guidelines for rejecting a null hypothesis

TABLE 2

OLS ESTIMATES OF FIXED-EFFECT GROWTH MODELS FOR SEMICONDUCTOR FIRMS, 1985–91

	1	2	3	4
ln(lagged size)	−.35**	−.35**	−.35**	−.34**
	(.03)	(.03)	(.03)	(.03)
Crowding (A)	−.032*	−.132**	−.036**	
	(.018)	(.043)	(.019)	
Weighted status (D^w)	.69**	.17*		.02
	(.29)	(.09)		(.07)
($A \times D^w$)	−.21**			
	(.09)			
$(A - \bar{A}) \times (D^w - \bar{D}^w)$		−.21**		
		(.09)		
Unweighted status (D^u)			24.65*	
			(12.69)	
($A \times D^u$)			−6.59*	
			(3.58)	
Sales of competitors (C)				−.008
				(.006)
$D^w \times C$				−.0001
				(.0010)
Firm's total patents	−.65	−.65	−1.61	3.17
	(3.79)	(3.80)	(4.35)	(3.46)
1987	.01	.01	.01	.02
	(.03)	(.03)	(.03)	(.03)
1988	.10**	.10**	.10**	.11**
	(.03)	(.03)	(.03)	(.03)
1989	−.01	−.01	−.01	−.02
	(.03)	(.03)	(.03)	(.04)
1990	.05	.05	.06	.08
	(.04)	(.04)	(.04)	(.05)
1991	.08*	.08*	.08*	−.02
	(.04)	(.04)	(.04)	(.05)
R^2 (within-firm variations)	.68	.68	.67	.67

NOTE.—SEs are in parentheses. N = 431.
* $P < .10$.
** $P < .05$.

of no multicollinearity, the diagnostics revealed that the collinearity was well within conventionally accepted levels.[10]

[10] Belsey et al.'s approach first scales **X′X** through singular value decomposition and then computes the eigenvalues and eigenvectors associated with this matrix. A "condition index" for the kth eigenvalue is computed, which equals the square root of the ratio of the largest eigenvalue to the kth one. If the condition index is very large, this

Second, we applied various root transformations to the proportion of direct cites to reduce the correlation between D^w and the interaction term. While we do not report the results here, we found that the results were robust across these alternative specifications.

Third, following one conventional practice for reducing the correlation between a main effect and an interaction term, we mean deviated the variables included in the interaction. This mean deviation reduced the correlation between weighted status and the interaction to 0.30. The results using the interaction term comprising mean-deviated values of A and D^w are reported in the second column. The effects again agree with the hypotheses.[11]

Fourth and finally, we use unweighted status, which equally weights all cites to a focal organization, regardless of the status of the citer. Although we think that this is a less interesting measure of status, it has the advantage that the correlation of the interaction effect ($A \times D^u$) with status is lower than is the case for the weighted measure (0.89 vs. 0.97). The results for the unweighted measure of status appear in the third column. Results in this column agree with the results in the first and second columns. All three hypotheses are confirmed. Given that all alternative specifications yielded the same results, we are reasonably confident that our results are not the by-product of some nonlinearity underlying the relationship between direct citations to the focal organization and sales.

Column 4 replaces competitive crowding defined in terms of technological overlaps (A) with the sales of technological competitors (C). The effect of technological competitors' sales is not statistically significant. The fact that crowding exerts a stronger effect indicates that growth/decline is affected more by the technological encroachment of competitors than by the ability of those same competitors to increase their sales in the market. Given that the market for semiconductors grows throughout the period of our study, this result should not be surprising. Under rapid market

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indicates that there is a principal component of the scaled **X′X** matrix that adds little or no new information to the matrix. While there is no value that is definitively regarded as very large, Belsey et al. (1980, p. 105) state that "moderate to strong relations are associated with condition indices of 30 to 100." In our analysis, the largest condition index is 11.69, considerably below this range.

[11] It might appear that the effect of status drops precipitously in this specification. The main effect of weighted status drops from 0.69 to 0.17 while the estimate of the interaction effect remains unchanged. However, one needs to take account of the effect of the mean in interpreting the magnitude of the status coefficient. In col. 1, the effect of status is $0.69 - .21A$; in col. 2 it is $0.17 - 0.21\ (A - \bar{A})$. The mean of A in the complete data set is 2.53. Thus the effect of status in this alternative formulation is on average equal to $0.17 - 0.21\ (A - 2.53) = 0.70 - 0.21A$, nearly identical to the result in col. 1.

TABLE 3

COMBINED EFFECT OF CROWDING AND WEIGHTED STATUS ON GROWTH RATES

Row	Status	Crowding	Joint Effect	Net Effect of Status
1	low (D^w = .015)	low (A = 2.10)	−.063	
2	high (D^w = .453)	low (A = 2.10)	.180	Row 2 − Row 1 = .243
3	low (D^w = .015)	high (A = 3.02)	−.096	
4	high (D^w = .453)	high (A = .302)	−.071	Row 4 − Row 3 = .025

NOTE.—The "low" and "high" values of status and crowding were chosen to equal the first and third quartiles of the firm-year distributions. The calculations use the parameter estimates from col. 1 of table 2.

expansion, it is less likely that an organization's ability to grow is sharply delimited by the growth of its competitors. Rather, it is determined by its ability to stake technological claims that will give it a share of the expanding market. It seems reasonable to expect that as the market for semiconductors becomes saturated, then the sales of technological competitors might have a stronger effect on growth rates.[12]

Taken together, the results in table 2 indicate that an organization's position on the two dimensions of the niche influence its growth rate. How strong are the effects of status and crowding on growth rates? Given the presence of an interaction effect, it is most straightforward to address this question by comparing the implications of the results for various combinations of status and crowding. We think that it is informative to examine the effects at the first and third quartiles of the distributions of status and crowding. We regard the first-quartile levels as indicating representative "low" values and the third-quartile levels as reflecting representative "high" values. Thus we compare cases that are low on both crowding and status, those that are high on both, and those that are high on one and low on the other. According to our growth model (eq. [4]), the growth rate is a linear combination of the combined effect of status and crowding and the effect of the other covariates (lagged size, period effects, and other covariates). We think of the latter effects as comprising the baseline rate. The joint effect of crowding and status inflates or deflates the baseline rate. So we are interested in the magnitudes of these joint effects.

Table 3 reports the joint effect of status and crowding implied by the estimates in the first column of table 2. Overall we see that increment to

[12] In analyses not reported here, we included the effects for A and C in the same model. When both effects are included, the effect for A is just beyond conventional levels of significance, and the effect of C is not significant.

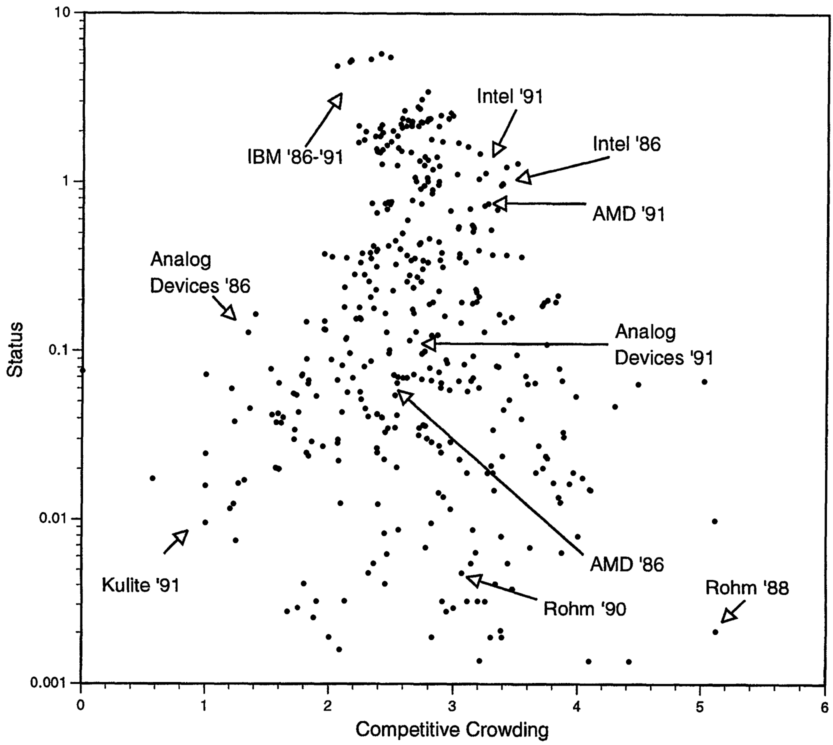

FIG. 3.—Organizational positions in role typology

the growth rate is positive only for the combination of high status and low crowding. The implied growth rate is smallest for the reverse case: low status and high crowding. From the perspective of our argument, the most interesting comparisons are those that compare the effect of status across levels of crowding (the last column of table 3). Consider the multipliers for firms in niches with low crowding (the first two rows of table 3). In this condition, high-status firms have a joint effect that exceeds that of low-status firms by 0.243. Next consider the case of niches with high crowding (the third and fourth rows of table 3). Here the returns to status are lower: 0.025. That is, the returns to status are only a tenth as large as in the less crowded niches.

The distributions of organizations on the two dimensions of the niche suggests an interesting classification of roles in the technological development of the industry. Figure 3 depicts the organizations in our sample along these two dimensions. We plot weighted status on a logarithmic scale so that the distances among the lower status organizations can be detected.[13]

Locations in the figure correspond with particular types of roles. Organization located toward the upper-left corner can be considered brokers of new technologies. They build upon technological antecedents that have been unexploited by their competitors, and they provide a distinctive foundation for the innovative activities of other organizations. Analog Devices occupied such a position in 1986. In direct contrast, organizations situated near the bottom right corner of the space are engaging in innovative activity in congested regions of the technological space and are not contributing to the innovative activities of others. Rohm occupied such a role in 1990. Organizations positioned toward the upper right quadrant are leaders in well-established technologies. Intel occupied this role for nearly the entire period of the study. Finally, organizations in the lower left quadrant are, in effect, isolates, developers of technologies that are not endorsed by other organizations. Kulite Semiconductor Products in 1991 is one example of an organization in this region of the role typology.

While some firms, such as Intel and IBM, occupied a relatively consistent role throughout the entire period of our study, others shifted. The role of Advanced Micro Devices (AMD) changed rather dramatically over the period. In 1986 AMD occupied an intermediate role; it had moderate status and was exposed to moderate crowding. But, by 1991, it had moved close to Intel as a leader in a well-established technology.

DISCUSSION

At a broad level, this article shows that location along the two dimensions of the niche affects organizational growth. The results indicate that status matters for growth of semiconductor firms and that status matters more in more crowded niches. We think that the routinization of technology in this industry makes the existence of any status effects—much less effects as strong as those reported here—noteworthy. The diffusion and commercialization of semiconductor technology dates back to the 1950s, and it seems reasonable to suspect that the average amount of uncertainty associated with the development of technology should decline over time. Newly emerging areas, such as biotechnology, should have the greatest average uncertainty. If our arguments are correct, then status effects

[13] Because it is not possible to plot a zero point on a log axis, we replace all zero values for status with a value of 0.00001 for the purpose of plotting. In the analysis, however, the values remain zero. This figure excludes three outlying points in the lower right-hand corner that lie between six and seven in competitive intensity and fall at zero on the status dimension.

ought to be most readily discerned in such contexts. Therefore, at least for the purpose of detecting status effects, the semiconductor industry would appear to represent a compelling test case.

In this section, we draw some connections between our study and related research. The finding that competitive intensity impedes organizational growth links with the two previous studies. First, it relates to McPherson et al.'s (1992) study of network ties and change in niche positions of voluntary organizations. Niche overlap defined as similarity in patterns of ties has implications not only for voluntary organizations but also for market-based organizations. Second, it demonstrates important parallels between the technological competition observed among inventions and the competition among the organizations that generate those innovations. In their more microlevel examination of technological change in the evolving network of the semiconductor industry, Podolny and Stuart (1995) found that pairs of patents compete for attention to the degree that they share ties to other patents. The findings in this article about competitive crowding raise this relationship to the level of competition among organizations.

The finding that status (direct citations) affects growth rates at low levels of competitive crowding and that the effect declines with crowding represents an extension of recent research in other kinds of market settings. This research has shown that uncertainty increases the dependence of status on network position. A comparative study (Podolny 1994) of the highly certain investment-grade market and the uncertain noninvestment-grade debt markets ("junk" markets) finds evidence that status affects perceptions of quality more strongly in the latter. Here we find that direct citations have a greater positive effect on sales growth in the less crowded niches. Because the less crowded niches are likely to have the greatest uncertainty about competing technological possibilities, this finding reinforces and broadens the claim that uncertainty increases the contingency of perceptions of quality on status. More generally, the positive effect of status on growth rates demonstrates the importance of incorporating this second dimension into the conception of the niche. Whereas the property of crowding or redundancy has been central to various conceptions of the niche, the property of status or public deference has not.

In introducing the model, we discussed parallels between this article's approach and the strategy of analyzing opposing processes of legitimation and competition by estimating complex models of the effects of organizational density. Our finding that the effect of status on growth rates depends upon crowding provides indirect support for the general idea that underlies the theory of density dependence.

In our view, this article has important implications for prior work that has identified organizational niches by the pattern of exchange relations that organizations develop in the market. DiMaggio (1986) exhorted organizational analysts to define niches in terms of observed patterns of exchange relations, without reference to the significance and durability of the relations.

We doubt that it makes sense to use all kinds of exchange relations to define niches. Consider the subject of our study. Merchant semiconductor manufacturers make many kinds of transactions with potentially many different partners in the course of bringing their products to the market. Do all of these exchange relations provide information about fundamental niches? We think not. We have defined organizational growth in terms of sales. Almost necessarily, therefore, growth and changes in the growth rate imply changes in the distribution of exchange relations.

It is perhaps useful to follow earlier research (Hannan and Freeman 1989) in insisting that theoretical progress in understanding niches requires maintaining the distinction between fundamental and realized niches. The pattern of technological knowledge helps to define a *fundamental* niche in the sense that the contours of such a niche are analytically separable from the competitive interactions among members of the population. In contrast, we think that reliance on many other kinds of exchange relations in markets to define niches allows specification of only *realized* niches. This is because the observed exchange relations reflect the operation of competitive interactions among organizations seeking to undertake exchanges. In the worst case, this method of defining niches confounds the causes and the consequences of competition.

Moreover, many kinds of market exchange have a transitory character. When the exchanges are not durable, there is no reason to think that niches identified solely on the basis of exchange relations at some point in time would constrain the actions of the organization.

The observation that the outcome of competition in one domain (e.g., technology) defines the fundamental niche for expansion in other domains (e.g., sales in product markets) opens up a number of possibilities for future research. The first direction is obviously to identify the linkages that exist across different domains. For example, just as competition in the technological domain helps to define the fundamental niche in the product markets for semiconductor devices, so we suspect that the competition among organizations in the labor market for scientists and engineers helps to define fundamental niches that shape the contours of technological competition.

A second direction for future research on organizational niches is to identify the conditions that determine the importance of competition in the various domains for organizational life chances. We suspect that the relevance of a domain varies with the evolution of the industry. For example, in the earliest stages of industry evolution, the competition for financial capital is an important determinant of organizational life chances. However, as an industry matures, we suspect that the ability to obtain financial capital does not strongly discriminate between firms in an industry, and it is therefore much less important to an understanding of the relative success of firms.

In sketching future directions for research, it is perhaps necessary to comment briefly on the generalizability of our approach. For this purpose, it is important to distinguish between the concrete details—employing patents to operationalize niche—and the general strategy of using asymmetric ties to an evolving network of core competencies to define niches and competition. On the one hand, we can imagine that patents could be used in other industries, for example biotechnology. In areas like automobile manufacturing, the use of patents would be less appropriate; it would have no value in the service sector. As we noted earlier, there is considerable interindustry variance in the propensity of organizations to patent inventions, and the researcher needs to be sensitive to these distinctions. For automobile manufacturing, it might be more useful to identify technological inventions as modifications of designs for engines and other components and to identify deference with the imitation of those modifications. The basic two-dimensional imagery of the niche thus does not depend on the use of patents.

Indeed we suspect that this two-dimensional conception of the niche might be applied outside of the technological domain. The sociology of science is an obvious area for potential application. Using journal citations instead of patent citations, one could define a scientist's (or research program's) niche in terms of crowding and status. One could then investigate the significance of a scientist's niche for a variety of career outcomes. Other less obvious choices include the use of legal citations to define the competitive positions of law firms and the use of document flows to define the niches of departments within bureaucracies. In such cases, we expect that direct flows to the relevant organization unit measure status, but similar patterns of flows to others indicate intense local competition. However, less important than the particular areas of application is the fact that this two-dimensional concept of the niche offers a framework for a systematic comparison of the importance of crowding dynamics and status to the life chances of actors across levels and contexts. By freeing the conception of niche position from an identification solely with exchange relations, it opens up the possibility for a general sociological theory of competition that emphasizes the duality of actor and position across a variety of domains.

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