The Evolution of Organizational Niches: U.S. Automobile Manufacturers, 1885–1981

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Although the niche figures prominently in contemporary theories of organization, analysts often fail to tie micro processes within the niche to long-term changes in the broader environment. In this paper, we advance arguments about the relationship between an organization's niche and evolution in the structure of its organizational population over time. We focus on the technological niche and processes of positioning and crowding among firms in the niche space, relating them to the level of concentration among all firms in the market. Building on previous empirical studies in organizational ecology, we study the evolution of concentration in the American automobile industry from 1885 to 1981 and estimate models of the hazard of exit of individual producers from the market. The findings show that niche and concentration interact in complex ways, yielding a more unified depiction of organizational evolution than typically described or reported.•

Many analysts' accounts of the U.S. automobile industry's development, including conjectured reasons for particular firms succeeding and failing, can be readily interpreted from the perspective of the organizational niche. For instance, General Motors' historical success against Ford is hailed by many as the consequence of its early wide-ranging multiproduct market position—a broad niche, in ecological terms. In more recent years, the Japanese manufacturers showed that they could build a sizeable presence after entering the market with small low-cost cars, a part of the market in which major American producers were not very competitive. According to a niche interpretation, one would say that the Japanese firms benefited from initial niche positions with little overlap from existing firms, allowing them to gain strength before attempting more direct competition.

In the background of such niche-based processes, the competitive dynamics of the automobile industry have been driven by both cost and innovation, each of which is tied to scale. The scale of automobile production has increased steadily over the last century, and the race to remain competitively large often constitutes a main reason why automobile firms behave as they do. For instance, insider accounts of the recent round of mergers among large automakers, such as Chrysler and Daimler, point to the increasing scale of the global industry as the critical motivation (Vlasic and Stertz, 2000). As a result of this scale orientation, the automobile industry is characterized generally by a long-term evolutionary pattern of increasing concentration.

Industry consolidation and a trend toward market oligopoly have also marked the evolutionary paths of numerous other industries. Examples from various sectors of the U.S. economy include the wine and beer industries, the airline industry, the petroleum production industry, the motion-picture distribution industry, the microcomputer industry, and the steel industry, to name a few. Concentration propels the formation of a strong and visible market structure whose effects inevitably reverberate through all levels of the social system, influencing the behavior of both economic and non-economic actors. For instance, industrial organization economists have

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shown that a broad spectrum of a firm's activities and processes are directly affected by the rising industrial concentration: incentives to innovate, mechanisms for price setting, the expectation for investment returns and stability, budgeting for advertising expenses, and the distribution of wages all seem to hinge on the rising market power of a few dominant producers and the relationships evolving among them. Yet few economists have focused on analyzing the social dimension of market structure. By Scherer's (1970: 210) account, "the economist is forced, without denying their importance, to view variations in industry conduct and performance due to differences in social structure as an unexplained residual or 'noise'." At one level, our goal here is to demonstrate that this "unexplained" component of the contextual constraints and opportunities faced by organizations operating in concentrating industries contains important and systematic processes of organizational evolution that analysts can ill afford to ignore.

In many industries in which scale provides an advantage, the gradual rise to dominance of a few large competitors is accompanied by a horizontal expansion of their market positions or niches. This is the case with the Daimler-Chrysler merger in the auto industry, the WarnerBros.-Lorimar merger in the motion-picture distribution industry, the LTV-Republic merger in the steel industry, and the American-TWA merger in the airline industry. Accordingly, it seems important that analyses of organizational evolution in concentrating industries deal with questions of niche and scale simultaneously and how they interrelate. The answer is far from obvious and might be complex. Theories of aging (Hannan et al., 1998a), density (Hannan et al., 1998b), niche width (Dobrev, Kim, and Hannan, 2001), scale competition (Dobrev and Carroll, 2000), and resource partitioning (Carroll, 1985; Boone, Broecheler, and Carroll, 2000) all seem to be involved. Consequently, our efforts here represent an attempt to integrate insights from the relevant theories into a unified empirical model of organizational evolution. To do so, we set forth a variety of hypotheses about how niche and scale interrelate to produce variations in organizational mortality, focusing on how niche processes change as the industry consolidates.

In contemporary organizational theory, the ecological perspective contains the most developed notions about the niche. Hannan and Freeman (1977) gave the concept fresh legs when they linked it to models of organizational change and environmental selection. Their vision of the niche was broad, defined to include "all those combinations of [environmental] resource levels at which the population can survive and reproduce itself" (Hannan and Freeman, 1977: 947). Hannan and Freeman (1989) made clear that the niche was an n-dimensional resource space, including social, economic, and political dimensions. They also distinguished between fundamental and realized niches, the latter representing the constrained n-dimensional resource space found when competitors are present.

The revitalized niche concept seeded numerous and varied analyses of how organizational environments affect the viability of particular types of organizations (e.g., Carroll, 1988;

Singh, 1990; Baum and Singh, 1994; Dobrev, 1999, 2001). It also germinated several niche models about specific environmental factors, such as the age and size of the potential membership base (McPherson, 1983; McPherson, Popielarz, and Drobnìc, 1992) and the variability of consumer demand (Freeman and Hannan, 1983). An especially productive current line of work uses the locations of organizations relative to each other along one or a few dimensions of resource space to assess competitive intensity (e.g., Barnett and Carroll, 1987; Baum and Mezias, 1993; Podolny, Stuart, and Hannan, 1996; Baum and Haveman, 1997). As Stinchcombe (1990: 136) noted, "socially organized market segments carry different information," and organizational structures reflect these differences.

Yet despite this progress, niche theory could still be pushed further. As Carroll and Hannan (2000) noted, contrary to much early thinking, organizational ecology's most developed theories and models tend to be about organizational population dynamics rather than broader environmental conditions. This is true for niche theory as well, where concerns of niche width, position, and crowding often take precedence over broader factors, including population structure. Although this "micro" orientation is justified by the strong empirical findings to date, it seems to rely on an incomplete conception of the niche, one grounded in the realized niche. Other broader environmental factors are not ignored entirely, but they are not given much theoretical attention, usually getting relegated to the status of control variables.

By contrast, our efforts here reflect an attempt to tie long-term changes in the broader environment in a meaningful theoretical way to the micro processes within the niche. Akin to recent investigations by Barron (1999) and Hannan (1997), we consider the overall structure of the population as an aspect of environment. We develop arguments about the relationship between an organization's technological niche and changes in the structure of its organizational population over time. We analyze processes of positioning and crowding among firms in the niche space and, at the environmental level, relate these processes to the level of concentration in the population, following in a tradition that includes Pfeffer and Salancik (1978).

We chose to study U.S. automobile producers because this population's historical development, like that of a number of other industries, is characterized by a long-term trend of consolidation. Our choice of industry context is motivated in large part by an additional consideration, namely, cumulativity in social science. Previous studies of the U.S. automobile manufacturing population have examined basic ecological problems such as age, size, and density dependence (Hannan et al., 1998a, 1998b; Hannan, 1998; Carroll and Hannan, 2000). We extend this analysis here by developing a unified model of organizational mortality. The unified model incorporates more fully processes related to niche and scale—niche width, niche position, niche overlap, and scale competition. Our specifications integrate findings from the earlier studies of this population (examining age dependence, density dependence, population aging, and scale competition) with ideas developed here on how technological niche width, niche position, and niche overlap interact in organizational evolution as concentration increases. We seek to transfer the isolated progress achieved within the various fragments to a unified specification and to obtain better-fitting models—and thus more satisfying explanations—by integrating processes.[1]

THE ORGANIZATIONAL NICHE IN AN EVOLUTIONARY CONTEXT

In considering the niche of an organization, we attend to the width, position, and overlap with others with respect to technology. The niche width of an organization refers to its variance in resource utilization (Hannan and Freeman, 1977). So, organizations pursuing strategies based on operations across a wide range of environmental resources possess a wide or broad niche and would be classified as generalists. Specialist organizations pursue strategies based on operations across a tight band of resources, so their niches are narrow. A firm's position or location in the niche can be described by the midpoint of this range. Its niche overlap is the degree to which other firms also occupy the firm's niche range. Niche-overlap density is the number of other firms whose niches fall within at least some part of the range. We analyze an organization's niche in a technological space (Podolny, Stuart, and Hannan, 1996; Dobrev, Kim, and Hannan, 2001).

In examining evolution, we track changes in market concentration to consider corresponding changes in social and organizational structure and their effects. We regard the consolidation level of a population as part of the broader environment because, unlike niche-based variables, it is relatively immutable with respect to short-term firm movements and strategic actions. This general theoretical strategy follows a tradition in organization theory dating back at least to Pfeffer and Salancik (1978), who related concentration levels to market uncertainty. It is analytically convenient here because the dominant long-term trend characterizing the American automobile market is increasing concentration.[2]

Only fifteen years after its inception, the industry witnessed the operation of more than 300 automakers; already, concentration had dropped by two-thirds from its initial maximum, a corollary of the very small number of entrants in the first decade of the industry's history. The competitive process that ensued in the following decades led to significant consolidation, and by the eve of World War II, more than nine out of ten producers operating at the beginning of the century had either failed or exited the industry. The dominance of the Big Three was solidified in the postwar years, and despite the entry of some highly specialized firms in the late 1970s that accounted for a modest upturn in density, concentration in the industry remains high. This strong consolidation occurred because during the formative years of the population, broad niche width (generalism) and position in the resource-rich market center conferred competitive advantages to firms (Chandler, 1962; Dobrev, Kim, and Hannan, 2001). Such firms succeeded in dominating the market center, eliminated smaller generalists that fell victim to scale-based selection, and

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It is commonplace in organizational theory to claim to be integrative of various theoretical perspectives. In one sense, our efforts are no different than most—we strive to show how various processes mix together empirically when operating simultaneously. In another sense, we think that our effort is distinctive. The integration that we seek occurs within a single coherent theoretical perspective and attempts to reconcile conflicting elements. We also find that many integration efforts do not build cumulatively on prior model specifications as exactly as we do here (using, in particular, models in Hannan et al., 1998b, and Dobrev and Carroll, 2000).

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Though organizational ecologists have used industry age to capture processes related to evolving market and social structure over time (Hannan, 1997; Dobrev, Kim, and Hannan, 2001), industry concentration seems to be a more appropriate covariate because we develop propositions that link organizational properties and evolving industry structure. While evolution is not a static process and, by definition, must unfold over time, the opposite is not true: time can pass but the industry may not consolidate. The processes we examine and theorize about occur because the market concentrates and partitions, not simply because time passes. If one were to test our theory in an industry that did not consolidate, or in which concentration declined as a result of deregulation, and do so by measuring industry age rather than concentration, the findings would surely be at odds with our predictions.

drove concentration high. This drive to dominance by large generalists left bleak chances for success for other generalist firms seeking to position themselves in the center (Dobrev and Carroll, 2000).

We build theoretical arguments against this backdrop. While we recognize and model the forces underlying consolidation, we do not (for reasons of space and parsimony) specify them here as formal hypotheses. Instead, we focus on developing evolutionary arguments, those related to niche processes that are transformed with population evolution. Our point of departure is resource-partitioning theory (Carroll, 1985), which we use to predict how concentration might alter the mortality consequences of a firm's niche width. Then, based on an understanding of what goes on in a partitioning population, we develop novel theoretical arguments about how niche position and niche overlap change as well with consolidation. We also consider the vexing issue of niche dimensionality.

Niche Width and the Evolution of Concentration

When environments change in uncertain ways, generalist organizations typically display lower mortality rates than specialists (Freeman and Hannan, 1983). Dobrev, Kim, and Hannan (2001) found that this is the case for automobile manufacturers in Europe, and we expect a similar main effect of niche width in the U.S. But resource-partitioning theory suggests a firm's niche width does not imply the same life chances when the market evolves and concentrates. The original insight of the theory comes from comparing the environmental resource space available for specialists as overall market concentration rises. Almost all important variation in market concentration derives from generalist crowding and consolidation. So, the comparison can be made by measuring the total area outside combined generalist targets under different stages of generalist competition. As the competitive struggle for scale among generalists marches forward, the size and target breadth of the survivors increase, but the combined resources held by all generalist organizations declines somewhat (Carroll, 1985; Péli and Nooteboom, 1999). This implies that there is more space available for specialists (total market space minus the combined space of generalists) when concentration is higher (fewer and larger generalists). As this space increases, the viability of specialist organizations also increases, on average. The basic empirical implication is an interaction effect between niche width and concentration on mortality whereby specialist organizations experience improved life chances. In other words, the main niche-width effect of Dobrev, Kim, and Hannan (2001) is reversed in concentrated markets:

Hypothesis 1 (H1): As market concentration shifts from low to high, the effect of niche width on an organization's hazard of mortality shifts from negative to positive.

Resource-partitioning theory assumes a multidimensional environmental resource space. Each dimension consists of states or a smooth gradient of states, and organizations experience the combination simultaneously.[3] That is, every

3 The assumptions here differ considerably from those of the original theory of niche width, in which Hannan and Freeman (1977, 1989) assumed that organizations face only one environmental state at a point in time and that the alternation of states over time imposes contradictory demands on the organization. Here the various states of the environment may impose complementary demands.

firm at every point in time is located within a particular region of multidimensional environmental space. Within each dimension, resources are assumed to be unevenly distributed; the joint distribution displays a unimodal peak representing what is called "the market center" (Boone, Carroll, and van Witteloostuijn, 2002). This means that some environmental areas are more bountiful or lucrative than others, potentially providing scale advantages to those organizations located there. The advantages may be overwhelming. So, in analyzing organizations in these contexts, it is imperative to attend to position or location within the environmental space, as well as to niche width. For example, specialists have great freedom in choice of location; they can locate in the market center or toward either end of the market. Generalists face more constraint in choice of location because a wide niche covers much of the market; yet they can still choose whether to locate the midpoint of their range near the center of the market or toward one of the peripheries. Because of their broader product scope, generalists are also more likely to possess technological niches that spread over the market center. A position in this resource-rich sector of the market provides generalists with the potential to reap scale advantages, to grow and expand further, which in turn makes them more likely than other firms to be centrally located. So, the choices of technological scope and market position are inextricably related to scale, and they are mutually reinforcing. Some of the benefits of being a generalist go hand in hand with scale advantages that may arise partly from location in the part of the market where the peaks in the dimensions of environmental resources intersect. An organization's hazard of mortality is therefore likely to increase as a function of the distance in its position away from the market center. This prediction is consistent with resource-partitioning theory, in which generalists occupying the market center are expected to outcompete those operating in less appealing market segments.

The emergence of a center in a market with many producers means that consumer preferences have become concentrated on a relatively narrow range, and this crowding in the center is likely to affect the various kinds of organizations present. The concentration of consumers at a center means that producers who gain leadership in the center can grow very large, usually exploiting economies of scale. The center's attractiveness also intensifies competition among firms situated there, at least initially, as many producers seek to match their products with consumer preferences. So, while we expect that crowding will increase the mortality rates of organizations located in the center, we also expect that some firms will locate away from this intensely competitive region. Such effects should be especially pronounced for specialists located in the center, whose assets are fully exposed to the intense competition. In contrast, generalists whose niches span the center can potentially offset some of the deleterious effects of crowding in the center with success in less competitive regions covered by their wide niches. But for both specialists and generalists, we expect that as the resource-partitioning process unfolds, and concentration rises, the heightened competition in the center will threaten survival to an extent that overrides the positional advantages of location in this most lucrative part of the market. So, we expect another interaction effect:

Hypothesis 2 (H2): As market concentration shifts from low to high, the effect of position away from the market center on an organization's hazard of mortality shifts from positive to negative.

Niche Dimensionality and the Evolution of Concentration

A difficulty of applying any niche theory to organizations is the inherent multidimensionality of the niche. According to Hannan and Freeman (1977: 947), the "(realized) niche of a population is defined as that area in constraint space (the space whose dimensions are levels of resources, etc.) in which the population outcompetes all other local populations. The niche consists, then, of all those combinations of resource levels at which the population can survive and reproduce itself." There seems to be little debate about this conception. Given this multidimensionality, any rule for measuring niche width based on observable characteristics might be incomplete. This seems more likely when niche-width assessments use only a single dimension, as we did in this study. Of course, one would always prefer to have a fuller set of relevant niche-width measures, but data collection constraints are typically severe for historical populations and perhaps even for contemporaneous ones (e.g., Freeman and Hannan, 1983). And no matter how full the eventual set of niche-width variables deployed, the possibility of incompleteness remains.

We try to deal with this problem conceptually, by taking scale into account. We recognize that the problematic cases only occur when various dimensions of niche width reorder organizations relative to each other in terms of breadth. When niche-width measures correspond across dimensions, incompleteness presents no real problem—any measure is almost as good as another, including those unobserved. Nonetheless, a single unobserved dimension that reclassifies a firm from, say, a specialist into a generalist causes concern. For example, a firm can be a specialist in terms of a single dimension, say, product scope, and offer only a single product. Yet in terms of other, potentially unobserved dimensions, such as marketing outlets and use of advertising media, or distribution channels, it can be a pronounced generalist. Anheuser-Busch's dominance of the American beer market with light lagers is one such example: its technologically narrow product base appeals to a range of socioeconomic and demographic distributions of consumers, including those constituting the bulk of the market. If a summary classification is required when measuring both sets of characteristics, and constructing a combined classification is not possible, then Anheuser-Busch is best classified as a generalist. In our view, the environmental resources on which organizations depend should possess causal primacy over technological or other strategic choices made by organizations in positioning themselves to secure those resources. This reasoning follows directly from Hannan and Freeman's (1977, 1989) conception of the niche and conforms with a long line of ecological theory dating to Park (1936), McKenzie (1926), and Hawley (1950).

In cases such as Anheuser-Busch, the main clue to the important hidden niche dimension lies in its very large scale. Although true specialists could grow very large, in order to do so, environmental resources must be unevenly distributed in a way that precludes the kind of scale-based competition among generalists discussed by Carroll and Swaminathan (2000) and Dobrev and Carroll (2000). This implies that the shape of the joint resource distribution will be polymodal (Dobrev, 2000). If, instead, the resource distribution is unimodal, then very large size usually implies generalism on some important environmental dimension. Although this might seem highly problematic for research that does not observe the dimension, it is not likely to be so, because generalist competition tends to be primarily scale-based. As long as these very large firms are treated appropriately in the analysis as scale-based competitors, there should be little fallout from an incomplete dimensionalization of their niches.

The situation for very small organizations is quite different. There is little chance that a very small organization will be treated as a scale-based competitor in any analysis, raising the question of what to do if it appears as a generalist on observable niche-width characteristics. For example, on a recent trip to Italy, we encountered a small shop that advertised "everything for everybody" *("tutto per tutti")*, an avowedly generalist claim for a retailer. Casual inspection of goods in the store gave the impression that the store offered a wide variety of products for a diverse clientele. If that was all there was to know, then we would have no choice but to live with this classification. But given the very small size of the store, we could not help but think that on some important underlying dimension of resource space, the store is a specialist, perhaps an extreme specialist. Otherwise, as a generalist, it would have been devoured by the intense scale competition it would face. In this case, the store's location inside the central Milan train station is undoubtedly important, as are its longer-than-usual hours of operation.

In many contexts, it may not be possible to infer the operative dimension at work for such chameleon-like small "generalists." Moreover, there may be a number of such unobserved dimensions operating in an organizational population, making direct assessment for all cases infeasible. For this reason, it may make sense to regard very small size as reflecting specialism on one or more unobserved dimensions of specialism. So researchers choosing how to measure specialism may face an inherent conceptual trade-off: either to measure "pure" specialism along a single dimension or to rely on small size as a way of identifying both "pure" and "mixed" (displaying at once generalist and specialist characteristics along different dimensions) specialist organizations. If this approach is appropriate, then the behavior of very small organizations should be similar to highly specialized ones during resource-partitioning: their specialist side should put them in a favorable position in concentrated markets (per H1). At the same time, the generalist traits of mixed specialists may potentially expose them to nonscale competition from large generalists, like the competition for geographic location mom-and-pop stores experienced during Wal-Mart's early expansion in the rural American southwest. Empirically, this means that predictions about the absolute fitness of very small firms in concentrating markets are less appropriate than for "pure" specialists. Instead, the noninvolvement of very small firms in scale competition imparts a survival advantage only in relation to larger generalist firms competing for the market center, yielding another expected interaction effect:

Hypothesis 3 (H3): As market concentration shifts from low to high, the hazard of mortality for a very small organization becomes lower than that of its larger counterparts in the organizational population.

High industry concentration often signals the partitioning of the market space into two distinct segments, market center and periphery, and this has implications for observed niche width. While competitive intensity in the center subsides once surviving generalists settle into their new and expanded territories, specialist entry into the periphery reignites competition. The intensity of this competition may resemble that typical of the formative years of the population. With the evolution of market concentration, this process is replicated in each developing market segment in which specialists seek to advance. The effects of niche width and overlap density for small organizations in concentrated markets, then, should be the same as for early entrants competing for the center during the formative years of the industry. In other words, resource-partitioning processes may be cyclical (Carroll, Dobrev, and Swaminathan, 2003). If resources in the peripheral niches eventually increase because of early specialists' success at legitimating the niche products, then resource competition will ensue in those niches. Just like early competition for resources in the market center, resource competition in the periphery is better fought by firms with broad niches. So while the niche-width effect on mortality will change from negative to positive in the market center, when high concentration in the center leads to peripheral exploration, a broad niche will continue to be advantageous to competitive processes unfolding on the periphery.

Consequently, as the industry concentrates, the reversal of the main niche-width effect is unlikely to affect very small producers, because very small size in a scale-dominated industry, as we argued in H3 above, invariably signifies specialism on at least one unobserved environmental dimension. For very small firms, broad niche width does not imply scale, and therefore need not incite a retaliatory response from dominant generalists, but simply survival protection compared with a company whose only product risks rejection by the market. By the logic of these arguments, substantiated by the historical examples, we expect that the niche-width effect that occurs in unconcentrated markets will also hold for small firms when overall industry concentration is high. Empirically, this implies a three-way interaction effect:

Hypothesis 4 (H4): As market concentration shifts from low to high, the effect of niche width on a very small organization's hazard of mortality shifts from positive to negative.

Niche Overlap and Evolution of Concentration

Although numerous studies suggest that niche overlap corresponds to competitive crowding, others show mutualistic effects (see Barnett and Carroll, 1987; Hannan et al., 1995). The level of market concentration likely matters for the effect of niche-overlap density, and considering it might help to sort out such different findings. As industry structure develops over time, identities and positions become defined and solidified (DiMaggio and Powell, 1983), and the patterns of organizational interaction also gradually become embedded in the evolving industry structure (Hannan, 1997). In concentrated contexts, increases in niche-overlap density might reflect syndicate and alliance formation among new partners, rather than crowding by potential competitors.

There are three plausible reasons why firms might bond with similar others. First, as sociological research on alliance formation suggests, well-established firms with high reputations typically scrutinize potential partners and generally avoid low- or no-status firms for fear of damaging their own reputations (Han, 1994; Podolny, 1994; Stuart, 2000). Accordingly, the clustering of potential partners will likely occur among firms ordered in proximity to one another on the status dimension. In a concentrated market, alliance formation may occur mostly among large dominant generalists that have established dominant positions in a consolidated industry.

Second, in addition to protecting their reputations, dominant firms in a market with a resource-rich center may be prompted to collaborate rather than compete with one another in order to preserve and reinforce the barriers defining the central area. As the resource-partitioning model posits, growth in the peripheral niches of the market is often an outcome of the flattening of the distribution along relevant consumer preferences (Carroll and Hannan, 1995). This process follows from specialists' success in redefining consumer tastes in their favor and thus threatens the positional advantage of generalists. In response, dominant firms may unite against the challenge of smaller competitors and use their economic and social power to uphold the collective advantages of position in the market center.

Third, dominant firms in a concentrated market also likely compete in more than one technological arena. By definition, generalists pursue something of a hedging strategy with respect to the environment. Accordingly, those that have won the late-stage battle for the market center position may be more differentiated from one another than those smaller generalists who competed against each other in the earlier pre-resource-partitioning stage. This speculation rests on the assumption that along with the niche-width expansion experienced by surviving generalists comes an increased variability in the ways they can prioritize among the various internal initiatives that stem from the different segments of their broad niches.

As generalists become more different from one another, interorganizational complementarities likely increase, thereby yielding more opportunities for alliance formation (Nohria and Garcia-Pont, 1991). Recent examples include the joint effort of the Big Three U.S. automobile firms to battle unfavorable industry regulations on emissions standards, the recent marketing slant in the largest macro-breweries ad campaigns collectively countering the micro-brewery movement's claim of superior quality, and Microsoft's investment in Apple, justified by the expectation of greater software sales even at the cost of keeping a formidable competitor in the operating systems market. This reasoning is informed by research on multimarket overlap showing that market differentiation increases growth rates (Haveman and Nonnemaker, 2000) and improves survival chances (Baum and Korn, 1996) in concentrated industries. We extend this argument here by proposing that within a single concentrated industry, relations of mutualism develop among the dominant incumbents. The market rationale for this behavior has been studied exhaustively by economists who point out that there is a strong disincentive for any competitor to engage in a competitive behavior targeted at other incumbents, like starting a price war, in a market in which other competitors have sufficient market power to retaliate swiftly by adopting the same or another equally pointed tactic.

But there is also a social rationale for the evolving partnerships among firms in consolidated markets, given that social ties are likely to develop among the corporate executives of dominant firms. The high visibility and scrutiny to which such high-level managers are exposed makes them identifiable not just with their firms but with the industry as a whole. At that level, they share concerns about public perceptions and accountability, as well as industrywide developments related to regulatory changes, globalization, consumer attitudes, and the like. Moreover, their positions at the helm of powerful organizations place them in similar and highly selective and exclusive circles of the social elite. Additionally, career progression in a concentrated industry implies limited choice of interorganizational transfers, so ties to former coworkers easily translate into ties with current competitors. In short, shared concerns and personal ties may subdue the dynamic of direct competition in concentrated and partitioned markets. Metaphorically, once the pie has been cut, it is in everyone's interest to protect it. Overall, then, we expect the deleterious effect of niche-overlap density on survival chances in a fragmented market to be countered by the beneficial effect of firms' common position in a well-defined, established, structured region of the market, namely, the market center in a concentrated industry.

Hypothesis 5 (H5): As market concentration shifts from low to high, the effect of niche-overlap density on an organization's hazard of mortality shifts from positive to negative.

The process differs for specialists exploring and redefining the peripheral niches of the market. Industry concentration consolidates the market center and subjects the scale competitors operating within its boundaries to various institutional and regulatory pressures. But the edges of the resource space witness the entry of specialized producers who bet their chances on the distinct appeal of their products, which allows them to avoid competition. If this strategy fails, then the competitive intensity to which they become subjected is essentially resource-based and increases with the number of direct competitors. Under such conditions, the effect of niche-overlap density is the same as for early entrants competing for the center during the formative years of the industry.

Conceptualizing this argument as a testable proposition directs attention to the previously discussed alternative means of measuring specialism: along a single technological dimension or by considering small size as a proxy to identify all (including mixed) specialists on multiple dimensions. It seems unreasonable to expect that the competitive process among specialists will be based solely on technology or product range. The small scale of production on which specialists typically rely precludes them from competing across a broad geographic domain. In fact, small-scale organizations often serve customers in different geographic regions, so overlap in technology need not inevitably fuel competition. For example, Climber Motor Corp. of Little Rock, Arkansas, did not compete with Commonwealth Motors Co. of Juliet, Illinois, even though both companies specialized in producing mostly economy-type cars in the early 1920s: both companies lacked the resources and the supplier and distributor networks necessary to offer their products in each other's market. By contrast, Commonwealth, ancestor of the Checker taxi, did compete in its market with Stutz Motor Co., which operated a short distance away in Indianapolis, Indiana. So, in arguing that the reversal of the overlap-density effect (H5) does not apply to specialist organizations, we again use very small size to reflect specialism, so as to capture the essence of our argument in a way that the technology/product-based measure of specialism does not. Accordingly, we predict:

Hypothesis 6 (H6): As market concentration shifts from low to high, the effect of niche-overlap density on a very small organization's hazard of mortality shifts from negative to positive.

Summary: Evolution of Concentration

Our analysis develops arguments about the ecology of an organizational niche in an evolutionary context. At a general level, we take basic theoretical predictions about niches and qualify them by stage of evolution. In a nutshell, we theorize that the effects of niche width, niche position, relative scale, and niche overlap change as the industry consolidates. Table 1 summarizes the general logic of the hypotheses, which develop an evolutionary account of niche processes based on market concentration. During the formative years of an industry when concentration is low, niche width and position in the resource-rich market center should confer competitive advantage. Firms that choose to use their profits from scale to expand the firm's scope rather than to build a cost advantage succeed in dominating the market center by eliminating smaller generalists and driving concentration high. This drive to dominance by large established generalists spells doom for newcomer generalist firms (H1) seeking to advance to the copious center (H2). Instead, consolidation triggers exploration of the periphery, where small specialist firms have a better chance of surviving on previously uncontested terrain (H1 and H3). Although small specialists do not compete on

Table 1

Summary of Hypotheses: Evolutionary Processes Triggered by the Shift from Low to High Industry Concentration

Organizational feature	Change in effect on mortality with rising concentration	Hypothesis
Niche width	Negative → positive	H1
Distance from market center	Positive → negative	H2
Small size	Positive but weaker than for larger firms	H3
Niche width x Small size	Positive → negative	H4
Niche-overlap density	Positive → negative	H5
Niche-overlap density x Small size	Negative → positive	H6

scale, they still benefit from variation in product offerings, which eliminates dependence on a single product (H4). The initially deleterious effect of overlap in the niche should transform into an advantage as market leaders realize the need to cooperate in a mature industry, where identities and structures are solidified (H5). As rising concentration solidifies the market center, the door opens for specialists to pursue positional advantages by differentiation. But if differentiation is not sustainable, small firms too will engage in competition for resources. In that case, the relative resource scarcity in the periphery will amplify the deleterious effect of niche crowding for specialists (H6). Empirically, the rising market concentration should lead to a reversal in the main effects of niche width, market position, and overlap density (H1, H2, and H5). But for small specialists, the effect of niche width turns negative and that of overlap density turns positive because the rising overall industry concentration presents these firms with an opportunity to operate in the unconcentrated market periphery (H4 and H6).

METHODS

We report here analyses of data on all American automobile producers ever known to operate from 1885 to 1981.[4] These data derive from a larger collection effort that coded histories of automobile manufacturers worldwide, using reports of automobile historians and collectors (Hannan et al., 1995; Carroll and Hannan, 1995). The most comprehensive information comes from a multivolume encyclopedic source book that provides thorough authoritative coverage: the *Standard Catalogue of American Cars* (Gunnell, Schrimpf, and Buttolph, 1987; Flamang, 1989; Kimes and Clark, 1996; Kowalke, 1997). Supplementary information for recent periods can also be found in Kutner (1974) and *Automotive News* (1993).

The major sources organize their reports around "marques," or product models, not firms. For instance, although Kimes and Clark's (1996) volume does not contain an entry for General Motors, it does contain entries for Chevrolet, Cadillac, Buick, Oldsmobile, Pontiac, and other marques produced at various times by General Motors. To create records for firms, our unit of analysis, we aggregated entries for all of a firm's various marques across time. The records contain information about spells of automobile production by firms but not about their complete lifetimes, which sometimes involved operation in another industry before and/or after a spell of automobile production. In some cases, the sources do tell

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Our dataset does not include Japanese manufacturers because the first international automaker to start production in the U.S. was Honda, which opened its Marysville, Ohio, plant in 1982, a year after our data window closes. Most of the cars manufactured in Japan and sold in the U.S. prior to 1981 were marketed under the brands of American producers. This was the case with Isuzu, which began manufacturing the Opel for General Motors in 1976, and Mitsubishi, which started producing the Dodge Colt for Chrysler in 1971.

about the creation and destruction of the firms. Insofar as the sources permit, we reconstructed the organizational histories of the firms in these industries. The collection effort revealed an abundance of firms. We found data on 2,197 American automakers, many of them small, short-lived, and obscure firms that introduced highly novel automobile designs and production schemes.

Mortality Events

Organizational life histories end in a variety of ways. For American automobile firms, the most important events associated with the ending of an observed life history involve one of the following: (1) disbanding of the firm; (2) exit to another industry; or (3) merger or acquisition by another firm. Disbanding means that the firm failed as a collective actor. In automobile manufacturing, exit to another industry also suggests a lack of success. The other ending events are harder to interpret. Although merger and acquisition both result in the loss of at least one independent collective actor, firms merge and acquire for diverse reasons. Sometimes a firm flounders, and its owners seek to recover some fraction of their investment by selling the firm. In other cases, a thriving firm's competencies command great value from potential acquirers or merger partners. Because of the ambiguous meaning of mergers and acquisitions, we based our analysis on disbanding and exit to another industry.

The sources do not report exactly what happened to most firms when they dropped from the set of producers, especially when spells of automobile production were short and when the scale of production was tiny. Apparently, automobile historians rarely could reconstruct the details about an exit unless a firm had become reasonably well established. Knowledge that a certain firm disbanded, was acquired, or left the industry usually means that it persisted in the industry long enough that its exit event received notice in the press. Our reading of the historical materials for the U.S. industry indicates that most exits of unknown type were either disbandings or exits to other industries, so we treated these two events alike: the outcome event of interest in this analysis is *disbanding/exit to another industry*, defined to include events of unknown type. Firms known to have ended by other events (merger, acquisition, etc.) were treated as (noninformatively) censored on the right at the times of these events, per standard practice in event-history analysis.

Organizational tenure. We followed convention in modeling a firm's *tenure* (u) in a particular organizational population rather than its organizational age (of course, industry tenure equals organizational age for de novo firms). When dates of entry and exit are exact or nearly exact, tenure in automobile production can be calculated straightforwardly, but archival sources vary in their precision in dating events. Sometimes the sources give the exact date; other times, they give only the month/year, season/year, or only the year. To make analysis tractable, we converted all of the information about timing to decimal years. Year-only dates were coded as occurring at the midpoint of the year. In this case, our coding rules assign the starting time to the middle of the first year and the ending time to the midpoint of the next year, giving a completed tenure of one year, which is the expected tenure under the assumption of a uniform distribution. These rules, which are consistent with Petersen's (1991) recommendations for dealing with the problem of time aggregation, generalize to handle all the cases we encountered.

Some firms' records indicated that they conducted other activities prior to entering the automobile market. Because these de alio firms likely entered with greater resource bases than de novo firms, we included a dummy variable to indicate prior existence (*prior existence*). Carroll et al. (1996) showed that this variable is associated initially with lower mortality risks.

We specified the effects of *organizational density* (*N*) nonmonotonically, consistent with established theory and findings in organization ecology (Carroll and Hannan, 2000), to include a linear and second-order term of annual counts of the number of producer organizations. We also included a fixed covariate for each firm measuring density at the time of its founding (*density at entry*). Following Hannan (1997), we interacted the effects of the contemporaneous density variables with a set of variables measuring the age of the population (*industry age*). This specification allows the effects of density to vary as a function of population age.

We measured *organizational size* as scale of operations, specifically, the firm's annual production of automobiles. We analyzed the main effects of size on firm mortality by using the natural logarithm of this value, *Ln(Size)*. Following previous analyses of automobile populations (Hannan et al., 1998a, 1998b), we also measured the relative size of a firm as the ratio of each firm's size to the size of the largest firm in the national population at the time (*relative size*). The use of this variable coupled with the absolute size measure allowed us to parse out the absolute size effects. Negative (absolute) size dependence occurs because large firms have a greater capacity to produce new knowledge (through greater R&D expenditures), to extract value through efficiencies and complementarities stemming from an elaborate division of labor, and to benefit from economies of learning, managerial skills, etc. These are advantages that large firms would enjoy even if no small firms existed in the industry. By contrast, relative size only relates to advantages like scale and position derived by large firms vis-à-vis their smaller competitors. Further, while the absolute-size effect captures the advantages of large organizations, small organizations have higher failure rates not only because they lack these advantages but also because their thin resource supplies imply narrow margins of error and thus make them extremely vulnerable to market uncertainty (Levinthal, 1991). To capture this compounded absolute-small-size disadvantage, we used a dummy variable for size less than or equal to an annual production of 50 cars (*size* $\leq$ *50*).

Market concentration. Variations in the industry size distribution that may give rise to the emergence of structure and market partitioning are captured by our measure of market concentration. We relied on the frequently used concentration-ratio measure, defined as the ratio of the annual production of the four largest firms to the total industry output for that year (*C4*). For our analysis, this measure has an advantage over other concentration measures because it captures well the process of consolidation in the market center, where only a few firms are able to dominate, which has been the case in the U.S. automobile industry. The measure implies that as the combined market share of the top four industry firms increases, concentration increases proportionately. It also implies that if the market in any given year consists of four or fewer producers, concentration will equal one, even if production is evenly divided among them. This is not a concern in our analysis, however, because we used two other size-based measures to account for positional and scale differences among individual firms: relative size and scale competition (described below).

Organizational ecologists have pointed to a pattern of density evolution that holds across a wide range of industries, including the U.S. automobile industry: the number of organizations initially grows slowly until the form acquires taken-for-grantedness, causing density after that point to increase steeply (Hannan and Carroll, 1992; Carroll and Hannan, 2000). As the carrying capacity of the population is reached and competition sets in, the number of firms decreases, reflecting the consolidation of the market. The subsequent entry of specialists leads to a modest resurgence of density in scale-dominated industries. One important implication of this density pattern for interpreting variation in concentration is that the slow increase in the number of firms in the early years of the industry confines our measure of concentration to equal 1 until at least five firms are present on the market. Because our thesis rests on the argument that rising concentration solidifies industry structure, and because high market concentration in the very early years of the industry clearly does not signify this theorized process, we estimated models in which we controlled for the effect of high concentration during that initial period.

Scale competition. Scale economies exert their force in organizational evolution because of the worsened consequences likely experienced by small firms with relatively higher costs in competition with larger firms. The competitive pressure varies depending on where a firm sits in the size distribution relative to its competitors. This pressure can be modeled by examining the size structure of the competitive environment faced by each scale competitor at any point in time (Carroll and Swaminathan, 2000; Dobrev and Carroll, 2000). Examining the exact position of each scale competitor in relation to its peers reveals not only the extent of its economic advantage related to lower cost but also indicates political and institutional advantages derived from special treatment from policymakers and regulators. The selection mechanism proposed by the scale-competition model has been shown to operate consistently among firms in industries as diverse as macrobrewers (Carroll and Swaminathan, 2000) and automobile producers in Europe and the U.S. (Dobrev and Carroll, 2000). Although the logic of the theory easily generalizes to all markets and industries in which incumbents compete on scale, heterogeneity in the nature of competitors (i.e., the simultaneous existence of both scale and non-scale producers) requires an analysis of the industry-specific scale threshold and cost structure to identify those firms engaged in scale competition, which is not a straightforward task. Ideally, one would use data on both supply (e.g., production capacity, level of utilization, cost structure) and demand (e.g., existing and prospective customer base per model, per company, per year) market characteristics to classify firms. In a situation likely to be common among researchers, we did not have such detailed data, so we developed an alternative.

We used a size threshold to identify the subset of scale competitors, following Dobrev and Carroll (2000), who demonstrated that, in fact, U.S. autofirms with annual production of less than or equal to 50 cars conform to a different schedule of mortality and respond differently to industry consolidation.[5] We also used this cutoff point to identify the subset of large firms likely to experience scale-based selection. For these firms, we used the scale competition variable developed by Carroll and Swaminathan (2000) and Dobrev and Carroll (2000) and measured the aggregate distance of all larger firms from the focal firm. To calculate it, we first found each firm's position at each point in time on a downward sloping curve represented by the inverse quadratic root of the size variable S, after adjusting for minimum size.[6] The calculation is given by $(S_{it} - S_{min})^{-1/4}$; the curve generated by this equation resembles the general long-run average cost curve posited by economic theory for economies of scale. After locating firms' positions on the curve, we then computed the aggregate distance of each firm i from its larger competitors by summing the differences in scores as:

$$\text{Scale competition} = D_{it} = \sum_{S_{jt} > S_{it}} (S_{it} - S_{min})^{-1/4} - (S_{jt} - S_{min})^{-1/4}.$$

As the formula indicates, the greater the number of larger competitors a firm faces, the greater the competitive pressure it confronts, all other things being equal. The contribution of each larger firm to its competitive pressure depends on the firm's exact location. When the focal firm is small, then a unit size difference creates more pressure than when it is large. Put another way, the same difference in scale between two firms generates more competitive pressure for the smaller firm when its absolute size is small than when its absolute size is large.

Niche profile variables. Following Dobrev, Kim, and Hannan (2001), we defined technological niche width (*NW*) as the range of engine capacity in terms of horsepower across all models produced by each firm at any given point in time (a realized niche). By this view, producers define themselves by choosing an array of products. Specialists offer products with a small range of variation on the dimension; generalists display a broad range. For example, the specialist Bartholomew Co. of Peoria, Illinois, in 1919 offered a single model (the Glide, with engine horsepower of 45), and the more generalist South Bend, Indiana-based Studebaker Corp. in 1953

5
In our view, these are conservative cutoff points that do not exclude many small firms perhaps not subject to strong scale pressure. More generally, although the pool of scale competitors identified in any industry characterized by scale competition should conform to the same dynamics predicted by our model of scale-based selection, the cutoff point used to identify scale competitors should be industry specific and derived from the particular production system, minimum efficient scale, and other industry-specific idiosyncrasies. Nevertheless, we performed sensitivity analyses to assure the robustness of our results based on a cutoff of less than or equal to 50 production units. We estimated two additional models. In the first one, we counted all firms in calculating the scale-selection measure. In this case, the estimated aggregate distance coefficient displayed a significant negative effect; this is in line with our theory, which suggests that very small firms (included in this operationalization of the variable) actually benefit from intensified rivalry among scale competitors. In the second model, we raised the size cutoff point from 50 to 500, thus wrongfully excluding many firms from the pool of scale competitors. Not surprisingly, the estimated coefficient for the aggregate distance measure was weaker and not significant, because many firms that were both subject to and exerted scale-selection pressure on their peers were not counted in the model.

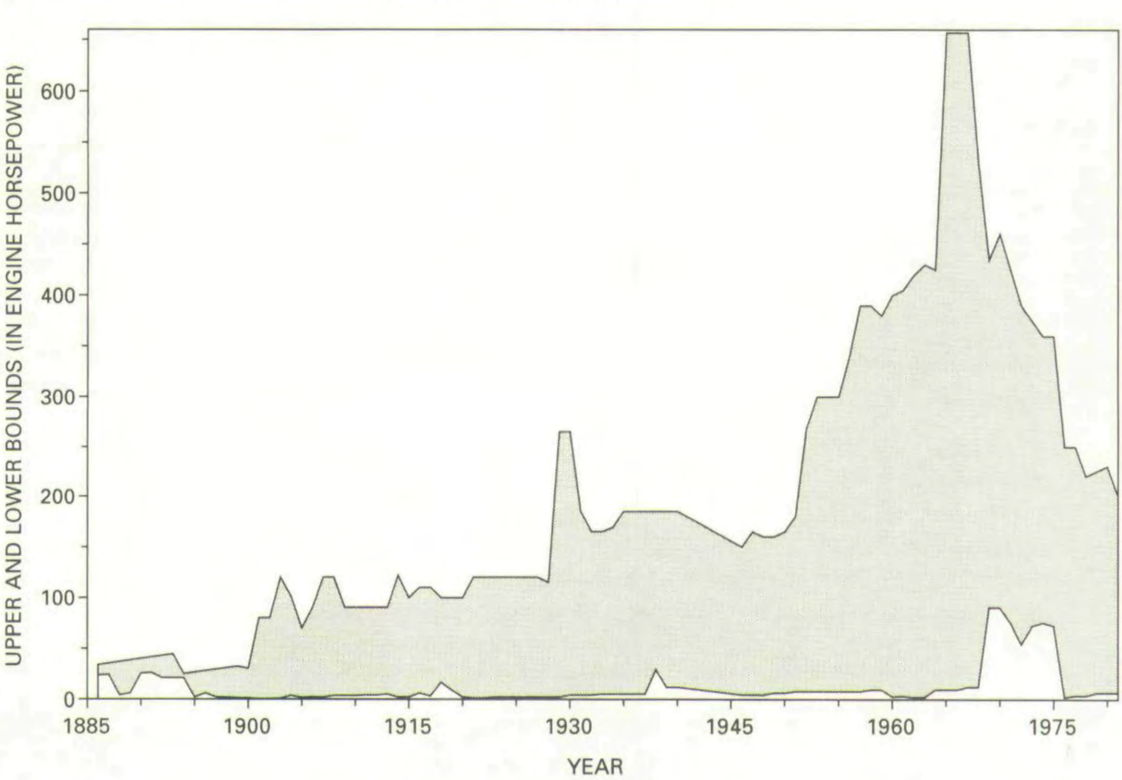
6
Using sensitivity analysis, we determined which functional specification of the aggregate distance variable resulted in the best model fit. We experimented with two other specifications, representing the downward sloping curve as $(S_{it} - S_{min})^{-1/2}$ and as $(S_{it} - S_{min})^{-1/6}$. The fit of either of these alternative specifications was inferior to a model using the inverse quadratic specification, which we ultimately selected.

made cars with engines ranging from 147 to 270 horsepower. Measurement of niche width in this way implies that a firm is capable of producing engines (and bears the costs of production) for all values within its range, whether it actually does or not. Combining the technological niches of all existing firms in any given year produces a picture of the market boundaries in technological space at any point in time. The evolution of the technological space in which U.S. auto manufacturers operated between 1885 and 1981 is presented in figure 1.

Niche overlap density (*NO*) is the count of firms whose niches overlap with the niche of the focal firm. Although there are different ways to compute niche overlap, we chose to use a density measure because it is a better fit with our hypotheses. A more complex alternative would have been to weigh the overlaps based on the portion of the niche that overlaps with that of competitors (Baum and Singh, 1994).

The market center covers the range of the niches of the four largest firms in the industry. This measure of the market center follows the logic of the concentration measure described above. If the four largest firms in the industry provide a telling example of the level of concentration, then the range of their niches should provide an adequate description of the most resource-abundant segment in the market, where the dominant players position themselves. We used the midpoint of a firm's technological product range to indicate its niche position in the market. The midpoint might be used to mark position (or location) whenever niche width on a focal dimen-

Figure 1. Technological bounds of the U.S. automobile market, 1885–1981.



sion can be represented as a continuous variable and the distribution of a firm's capabilities across the range of the niche is symmetrical. Distance away from the market center is the difference between the midpoint of the focal firm's niche and the midpoint of the market center. We estimated the effects of the distances of firms both "above" the market center (*position: DAMC*), meaning a niche width that contains a larger engine capacity than the center, and "below" the market center (*position: DBMC*).

Measuring organizational niches along a single dimension—technological scope, in our case—has its limitations. If our measures of niche width and overlap density capture only market position and competitive dynamics in technological space, then they would be less than ideal for testing the theoretical propositions stated in the previous section. But defining organizational niches along a technology dimension has compensating advantages. Most important, it provides us with a means of making meaningful comparisons of firms that have existed in disparate historical periods, allowing us to analyze the evolution of the industry from its origins. It makes it possible to draw as complete a picture as possible (given the paucity of information for many of the entries in our dataset) of the overall market niches of the automobile firms whose fates we analyze. We think that technological niches in this industry are informative about market position because, upon examination, the choice of engine capacity made by automobile producers over the years reveals not only the ranges of their technological offerings but also these firms' strategies in product marketing and competitive pricing, customer segment targeting, supply-chain management, and innovation. Some examples, drawn from the historical materials we used, illustrate these points. Indicative of the tight coupling between engine capacity and product design was the new Cadillac model General Motors (GM) introduced in 1934; it extended GM's technological niche further. The 16-cylinder, 185-horsepower engine came packed in a luxurious body style in which "the wheelbase was stretched to a mammoth 154 inches making the Cadillac America's lengthiest production car. . . . The bodies were elegant and included the striking and provocatively named Madame X" (Kimes and Clark, 1996: 200). Evidently, GM not only built a more powerful engine to propel a fashionably styled car but also used it as an occasion to spice up its marketing effort. Pricing strategies, too, have always been closely tied to the variation in engine capacity. For example, between 1902 and 1910, Knox, based in Springfield, Massachusetts, transitioned from selling a 5-horsepower runabout (affectionately called "Old Porcupine") in the $1,000 price range to offering a 60-horsepower limousine priced for as much as $6,400.

The technological niche also reflects a firm's competitive market strategy. For example, at a time when other companies were aspiring to prove the universal nature of their product by competing in road races and hill climbs, Detroit Electric "was always careful to insist that its product was not a touring car. . . . It was an urban vehicle, one for women drivers especially" (Kimes and Clark, 1996: 444). This narrow-niche manufacturer appealed to a then-small customer segment by relying on what we would categorically describe as a specialist strategy. Variations in technological product offerings also relate well to intangible strategic resources such as reputational benefits. Industry historians continue to debate if Packard's move into the lower end of the market resulted "in a loss of prestige to the Packard luxury car image from which the company never recovered" (Kimes and Clark, 1996: 1106). Our reading of the data sources also suggests that in many cases the adoption of a new technology had profound repercussions not only for the overall image of the company but for its internal scope and design, shifting firm boundaries both vertically and horizontally: "In 1911 Sterns became a *distinctive car of another kind* when the firm acquired the first American license to the Knight engine" (Kimes and Clark, 1996: 1388). This event not only had a profound impact on the company's range of models with varying engine capacity but also necessitated a subsequent acquisition of a factory specifically dedicated to the production of the Knight engine.

Socioeconomic environmental factors. We also controlled for socioeconomic environmental conditions. The estimates reported below are from specifications that include effects of economic depression (*depression year dummies*), the level of the gross domestic product (*GDP*) adjusted for inflation (taken from Maddison, 1991), and dummy period effects representing industry regimes (*mass production, product differentiation, JIT/TQC*) as defined by Womack, Jones, and Roos (1990). We excluded the years of the Second World War from the analysis because the production of motor vehicles for private use was minimized for the duration of the war in the U.S. This specification of socioeconomic environmental factors parallels those of Hannan et al. (1998a, 1998b) and allows for precise model comparisons.

Model Specification and Estimation

We represented variation in organizational tenure (u) as a stochastic piecewise-exponential function where the breakpoints for the pieces are denoted as $0 \leq \tau_1 \leq \tau_2 \leq \ldots \leq \tau_P$. Assuming that $\tau_{P+1} = \infty$, there are P periods: $I_p = \{u \mid \tau_p \leq u \leq \tau_{p+1}\}$, p = 1, ..., P. After examining life tables and exploring estimates of a variety of choices for the breakpoints, we decided to break the duration scale (in years) at 0.5, 1.0, 3.0, and 7.0. With this choice, the first segment (0,0.5] includes dated events that occur within the first six months in the industry and cases that enter and exit at unknown times within the same year, as discussed above. The second segment (0.5,1] includes dated events that occur within the second six months and cases that enter at an unknown time in one year and exit at an unknown time in the next year. The third and fourth segments are defined similarly. The final segment begins at seven years and is open on the right.

We built cumulatively on previous findings to estimate a unified model of organizational evolution. These findings include specifications of tenure dependence, size dependence, and density dependence (Carroll et al., 1996; Hannan et al., 1998a, 1998b) and scale competition (Dobrev and Carroll, 2000). Given the complexity of the ideas in the hypotheses and the models, we do not dwell on estimates of each of these effects but simply report them. Their inclusion, however, is central to our claims of building a unified model.

In modeling organizational mortality in the U.S. and other automobile industries, Hannan et al. (1998a) explored a nonproportional rate model for combining size and tenure effects. In simple terms, the nonproportionality facet of the model allows the effects of size and tenure to interact in complex ways by yielding different coefficients for size effects at various tenure segments. Hannan et al.'s (1998a) estimates showed that the assumption of proportionality of the effects of size does not fit well the histories of populations of automobile manufacturers in major countries of Europe and in the U.S. That is, allowing nonproportional effects statistically improves model fit, even after taking into account changes in the degrees of freedom. We used the specification here when it improved fit. To be more precise, we specify that the disbanding/exit rate μ_i is a function of tenure in the industry (u), industry age (t), a vector of variables ($\mathbf{s}'_{iu}$) pertaining to size (absolute and relative size, aggregate distance from larger competitors, and dummy for very small size), a vector of other measured covariates ($\mathbf{x}'_t$) including GNP, depression year, and density at founding, a function of contemporaneous density and density squared, as well as the interactions of these density effects and industry age, denoted by $\varphi(N_t,t)$. The functions for assessing the arguments made in the hypotheses relate to niche width (NW), market position (POS), niche overlap density (NO), and concentration (C4), denoted by $\psi(NW_{iu},NO_{iu}, POS_{iu},C4_t)$. The general class of models we estimate has the form:

$$\mu_i(u,t) = \exp(m_P)\exp(\mathbf{s}'_{iu}\boldsymbol{\alpha}_P + \mathbf{x}'_t\boldsymbol{\pi}) \cdot \varphi(N_t,t) \cdot \psi(NW_{iu},NO_{iu},POS_{iu}, C4_t),\ u \in I_P$$

Here m_P denotes a set of tenure-specific effects; the log-linear link imposes the constraint that the baseline hazards be non-negative. The (tenure) period subscript on the vector of size coefficients indicates that we allowed some of these effects to vary by tenure. This general specification sets the hazard of disbanding/exiting to be a nonproportional function of tenure and these covariates. In basic tests of the hypotheses, we estimated models with this general form with the method of maximum likelihood as implemented in TDA 5.7 (Rohwer, 1994; Blossfeld and Rohwer, 1995).

Specifying empirical tests for each of the hypotheses required that we model interaction effects between industry concentration and each of the organizational variables pertinent to the specific hypothesis. In each case, interpreting the effect requires combining the effect of the main term with the effect of the interaction term. For example, to confirm H1, we need to show that the niche-width effect becomes positive when concentration rises; the relevant effect consists of the baseline niche-width effect and the interaction effect between niche width and industry concentration.

FINDINGS

Table 2 presents the basic descriptive statistics of the variables in the event-history file, and the sequence of models in tables 3 and 4 build on each other to yield tests of the hypotheses. The estimates from a baseline specification appear in the first column of table 3 (model 1), which replicates all but one of the main findings of Hannan et al. (1998a, 1998b). The effect of tenure on the rate is U-shaped, decreasing the hazard during the first seven years but reversing direction from that point on. In addition to the beneficial effect of relative size, the nonproportional effect of absolute size suggests that its negative effect on the hazard increases with industry tenure. Meanwhile, the deleterious effect of very small size seems to wear off after the firm's seventh year in the industry. Industry concentration shows a positive but only marginally significant baseline effect on the rate. The estimates of the main effects of density and its interactions with industry age all agree with the predictions of density dependence; all density coefficients except one are highly significant. The positive and statistically significant effect of density at entry on the hazard supports the density delay argument.

Model 1 departs from the models of Hannan et al. (1998a, 1998b) in that it includes the concentration variable. We put it in all our specifications because of the central role it plays in the hypotheses. Inclusion of this variable in the baseline model 1 weakens the negative effect of the very-small-size dummy in the late-tenure period (after seventh year), which was statistically significant in the earlier studies. Per H3, this variable may have lost its statistical power because model 1 is not fully specified: the very-small-size dummy must be interacted with concentration in order to show its effect once a main effect of concentration is included. So, to understand the action in the variables in this specification before moving to the more specific niche-based variables, we begin hypothesis testing by turning to this size-based measure of specialism first and the predictions of H3.

Model 2 shows the estimates of the baseline model with the added interaction of small size and concentration. For consis-

Table 2

Descriptive Statistics for Variables in Life-History Spell File

Variable	Min.	Max.	Mean	S.D.
Density (N)	1.00	345.00	204.90	109.55
Density at entry	1.00	345.00	224.87	106.44
Ln (Size + .1)	–2.30	15.48	3.12	3.48
Relative size (x 10^{-3})	0.00	5284.50	35.55	284.97
Size ≤ 50 (dummy)	0.00	1.00	0.68	0.47
Prior existence (dummy)	0.00	1.00	0.57	0.50
GNP	42.40	977.10	200.10	221.07
Niche width (NW)	0.01	552.01	12.93	32.09
Niche-overlap density (NO)	0.00	362.00	86.12	82.75
Position: distance above market center (DAMC)	0.00	206.50	3.95	9.89
Position: distance below market center (DBMC)	0.00	364.25	16.95	33.02
Change in relative position	0.00	275.02	5.18	11.79
Industry concentration (C4)	0.31	1.00	0.65	0.21
Scale competition x (Size > 50)	0.00	59.92	1.06	3.43

Table 3

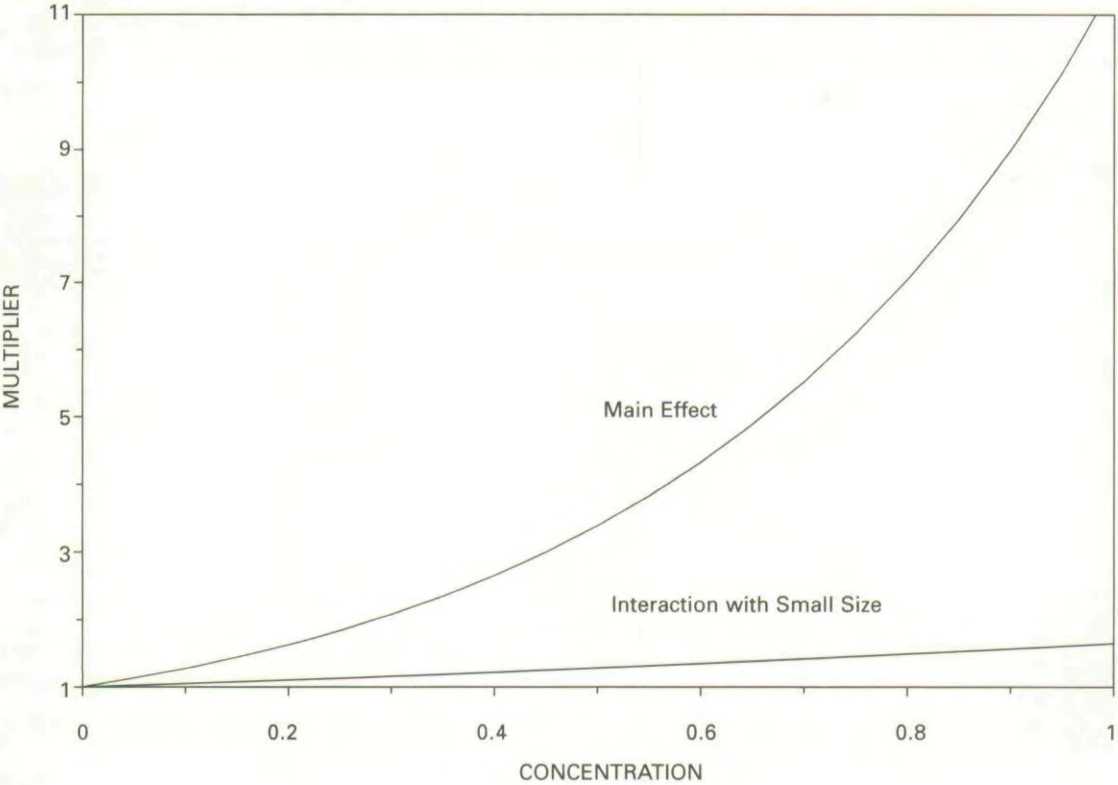
Effects of Population Density, Size (and Size-related Variables) on the Disbanding/Exit Hazard of U.S. Automobile Manufacturers, 1885–1981*

Variable	Model 1	Model 2
Industry tenure and prior experience		
Tenure in the industry		
$u < 0.5$	–1.17 (–3.11)	–2.64 (–5.22)
$0.5 \leq u < 1$	–1.27 (–3.36)	–2.74 (–5.42)
$1 \leq u < 3$	–1.77 (–4.69)	–3.24 (–6.40)
$3 \leq u < 7$	–2.00 (–5.26)	–3.46 (–6.83)
$u \geq 7$	–1.52 (–3.09)	–3.24 (–5.28)
Prior existence	–0.11 (–2.38)	–0.11 (–2.39)
Socioeconomic industrial environment		
Mass production	0.79 (4.69)	0.77 (4.62)
Production differentiation	0.38 (1.70)	0.41 (1.82)
JIT / TQC	–0.06 (–0.16)	–0.09 (–0.27)
Depression year	–0.20 (–3.00)	–0.22 (–3.17)
GNP	–0.001(–1.20)	–0.001(–1.35)
Density and population aging		
Density at entry	0.002 (4.34)	0.002 (3.60)
N	–0.01 (–1.95)	–0.01 (–1.56)
N^2 ($\times 10^{-4}$)	0.49 (2.15)	0.39 (1.71)
N x Ind. age ($\times 10^{-3}$)	0.43 (1.53)	0.34 (1.21)
N^2 x Ind. age ($\times 10^{-5}$)	–0.40 (–2.57)	–0.33 (–2.14)
N x Ind. age^2 ($\times 10^{-4}$)	–0.12 (–2.74)	–0.10 (–2.43)
N^2 x Ind. age^2 ($\times 10^{-6}$)	0.09 (3.10)	0.08 (2.72)
Organizational size-based measures		
Ln (Size)		
$u < 7$	–0.14 (–5.22)	–0.12 (–4.25)
$u \geq 7$	–0.19 (–3.53)	–0.15 (–2.68)
Size $\leq$ 50		
$u < 7$	0.66 (3.85)	2.22 (5.57)
$u \geq 7$	–0.11 (–0.35)	1.70 (3.35)
Relative size ($\times 10^{-3}$)	–0.02 (–2.23)	–0.03 (–2.45)
Industry concentration (C4)	0.66 (1.71)	2.44 (4.13)
Evolutionary processes:		
Scale competition x Size > 50		0.03 (3.03)
C4 x Size $\leq$ 50		–1.94 (–3.94)
Number of spells/events	8892 / 2051	8892 / 2051
Number of parameters	24	26
LR Test	–	23.2 (vs. model 1)
Log-likelihood	–3680.6	–3669.0

* T-statistics are in parentheses; u denotes tenure in the industry.

tency with Dobrev and Carroll (2000), we also included the interaction of the scale competition term and a dummy for the firms to which it applies. The predicted effects of interest, concentration by very small size, are plotted in figure 2. The estimated main effect implies that high concentration increases the rate more than ten times for relatively large firms, but only by about half for very small firms. As expected, small size does not completely eliminate the detrimental effect brought about by consolidation but, as the diverging lines in the figure illustrate, it provides a buffer against this effect that increases as concentration rises. Small size performs the function of a shield against scale competition, which significantly decreases the survival chances of large (but not the largest) firms. Also, the addition of the interaction term between concentration and small size in model 2 streamlines the main effect of concentration, which in this

Figure 2. Concentration effect (by size) on the failure rate of U.S. auto manufacturers, 1885–1981.



model becomes stronger and statistically significant. So, in accord with predictions of resource partitioning, scale-based selection, and size-localized competition theories, we find that while concentration increases the hazard, this effect is mitigated by very small size.

Technological Niche Width and Position

Table 4 shows the results of a complete model specification including the relevant niche-width and overlap-density-related variables.[7] The interaction effects between the niche-width variables and industry concentration in model 3 show that, as predicted by H1 and H2, the directions of the main effects reverse. When interacted with industry concentration, the effect of niche width changes from negative to positive, and the effects of position distance from the market center change from positive to negative. All coefficients are significant, except for position in the high end of the market center. The niche-width and the low-end-position (DBMC) effects are presented graphically in figures 3 and 4, respectively. For niche width, concentration not only stifles the main effect but altogether transforms broad niche into a liability for survival. According to the results and figure 4, as the market concentrates, position in the low periphery (i.e., away from the market center) proves beneficial to the extent that it confers survival advantage to firms located there relative to market-center competitors. But we did not find, as implied by H2, that there is an absolute gain associated with peripheral position under high concentration: the hazard does not become a decreasing function of distance from the market

7
Because concentration in the beginning of the industry was high but did not represent the processes we are investigating here, we needed to estimate if this partial concentration effect was affecting the robustness of our results. We did so by adding an interaction term between industry concentration and a pre-1905 dummy to the model in table 4. Including this additional parameter did not affect the rest of the estimates: its effect was statistically insignificant, and model fit did not improve. Consequently, we conclude that our model is not misspecified as a result of the U-shaped pattern of concentration.

Table 4

Main and Integrative Effects of Niche Width, Market Position, and Overlap Density on the Disbanding/Exit Hazard of U.S. Automobile Manufacturers, 1885–1981*

Variable	Model 3		Hypothesis tested
Organizational size-based measures			
Ln (Size)			
u < 7	–0.11	(–4.03)	
u ≥ 7	–0.14	(–2.45)	
Size ≤ 50			
u < 7	1.58	(3.19)	
u ≥ 7	1.03	(1.74)	
Relative size (x 10^{-3})	–0.03	(–2.45)	
Industry concentration (C4)	1.32	(1.80)	
Evolutionary processes:			
Scale competition x Size > 50	0.03	(3.35)	
C4 x Size ≤ 50	–1.15	(–1.89)	H3
Technological niche width and position			
Niche width (NW)	–0.04	(–3.82)	
Position:			
Distance above market center (DAMC)	0.01	(0.80)	
Distance below market center (DBMC)	0.04	(4.23)	
Change in relative position	–0.001	(–0.27)	
Evolutionary processes:			
C4 x NW	0.05	(4.59)	H1
C4 x Position: DAMC	–0.01	(–0.80)	H2
C4 x Position: DBMC	–0.04	(–3.75)	H2
C4 x NW x Size ≤ 50	–0.004	(–0.76)	H4
Overlap density			
Niche-overlap density (NO)	0.003	(1.83)	
Evolutionary processes:			
C4 x NO	–0.004	(–2.03)	H5
C4 x NO x Size ≤ 50	0.004	(1.71)	H6
Number of spells/events	8892 / 2051		
Number of parameters	37		
LR Test	48.6 (vs. model 2)		
Log-likelihood	–3644.7		

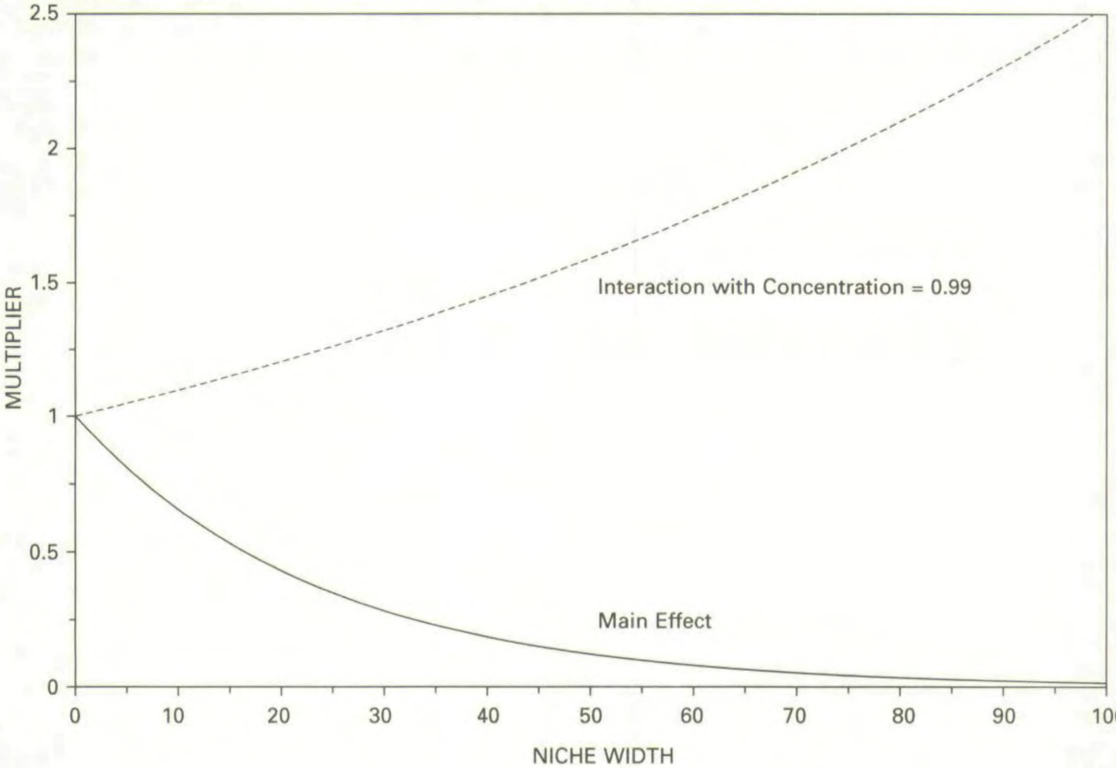
* T-statistics are in parentheses; u denotes tenure in the industry; model 3 includes all covariates from model 2.

center, because the combined (main and integrative) effect is still positive. But the difference in the effect when concentration is low and high is profound by any means, as figure 4 makes obvious.

The historical record also contains many examples consistent with the findings on H1 and H2. For example, Wayne Works, Inc., Martin Wasp Corp., Napoleon Motors Co., and many other producers made successful inroads in the market in the 1920s as concentration neared its peak. Enthused by their early success, these producers expanded their product lines with new offerings that covered the market center. But these moves brought them into direct competition with the established and much larger industry leaders, and the subsequent scale competition spelled doom for the upstarts.

Focusing on size differences among specialists, we conjectured in H4 that as the market becomes concentrated and the periphery expands, a narrow niche constitutes a disadvantage for small firms. This conjecture is supported by the historical record. For example, a peripheral niche that

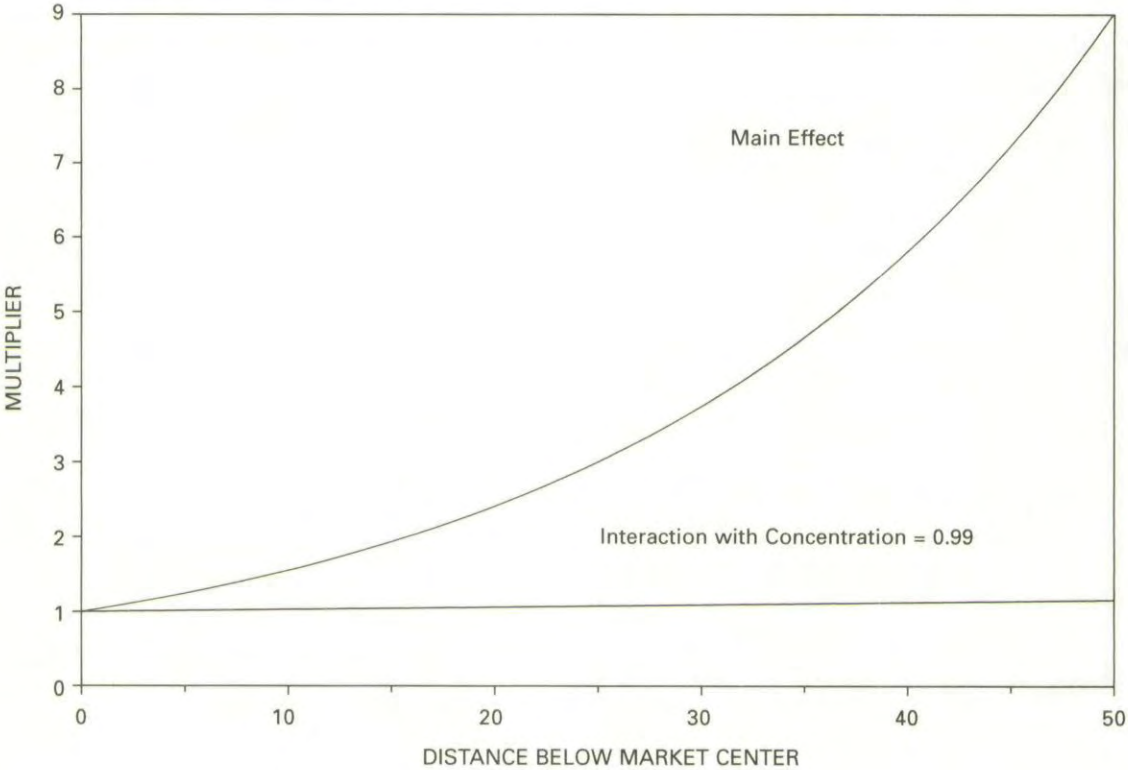
Figure 3. Niche-width effect on the failure rate of U.S. auto manufacturers, 1885–1981.



emerged in the 1950s and 1960s in the highly consolidated U.S. auto industry developed around the revival of early industry experiments with automobiles powered by an electric battery. Among the firms that entered this segment, the longest surviving one was the Boulevard Motor Works, a firm that "offered several different models, each . . . [with] different power depending on the number of electric motors used" (Kowalke, 1997: 824). The ironically dubbed "American BMW" remained in existence for 16 years, far outlasting other electric car producers. Another example, at the high end of the specialized market periphery, comes from the strategic position occupied by Shelby-Amer, Inc. This Southern California company produced a number of different model sports cars with engine horse power ranging from 250 to 450 (i.e., it had a wide niche width). The success of the company is well documented: it manufactured "one of the best performing and best selling American specialty cars ever produced" (Kowalke, 1997: 860). Despite these examples, the empirical test of H4 is insufficient to reject the null hypothesis: although, consistent with our expectation, the effect of niche width interacted with industry concentration and very small size is negative, it is not significant.

The effects for overlap density show that consolidation turns the positive main effect around. As concentration rises, the overall combined overlap density effect becomes negative, not just the interaction effect. The estimated coefficients, graphically presented in figure 5, support H5, namely, that structured markets in which resources have been divided promote mutual dependence and cooperation among incum-

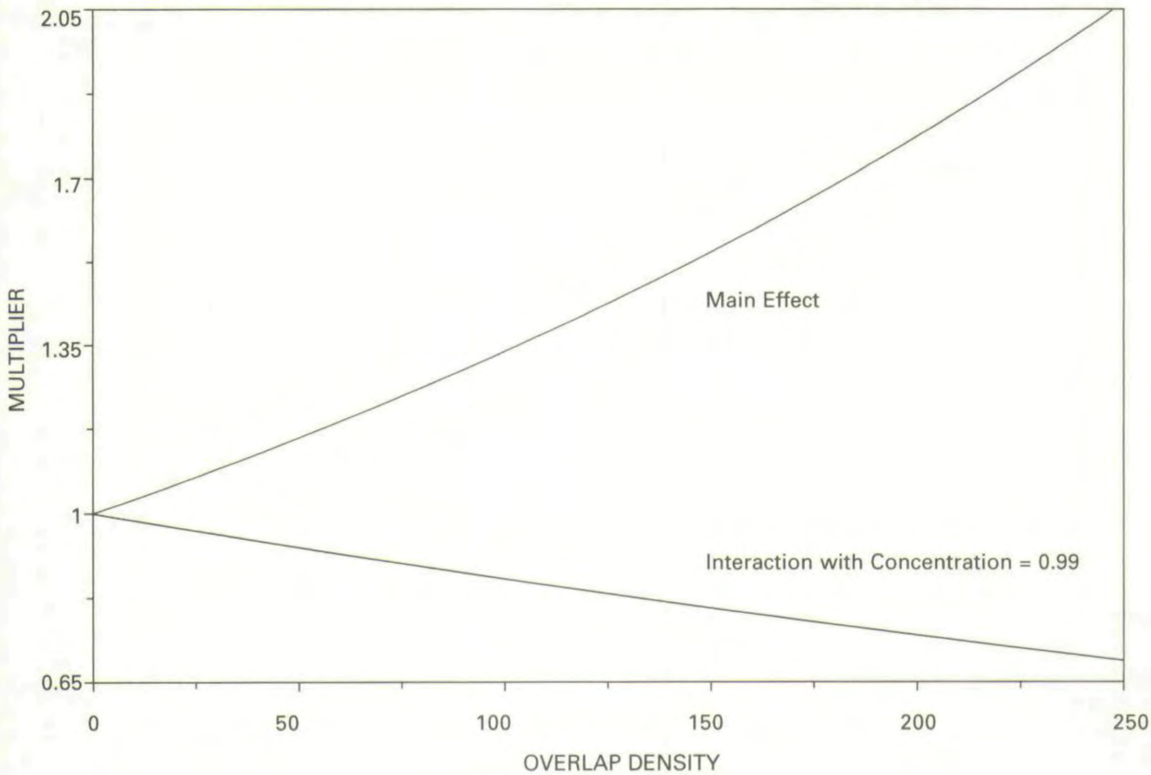
Figure 4. Effect of position (DBMC) on the failure rate of U.S. auto manufacturers, 1885–1981.



bents. Nevertheless, to test the robustness of our findings about overlap density and concentration, we experimented with an alternative hypothesis: that the reversal of the overlap effect from positive to negative reflects the increasing dimensionality of organizational niches and that industry concentration simply fits in as a proxy for this process. Separating the two processes (dimensionalization and cooperation) is important because, while we fully concur that the two processes unfold simultaneously, and this is part of our argument, we also think it unlikely that mutualism will occur when the market is unsettled and resource competition is intense. We tested for this alternative explanation by including an additional interaction of overlap density and industry age. Although its effect was negative and significant, it did not eliminate the significant negative effect of overlap density and concentration. We conclude that our finding does support H5.

Finally, for H6, we reasoned that as the market concentrates, the center will become consolidated and structured, while resource-based competition will take place in the periphery. So, for small specialists in quickly appreciating market niches that invite the entry of competitors, overlap density would signify a threat more than an opportunity for cooperation. As anticipated, the three-way interaction between overlap density, industry concentration, and very small size is positive, but only marginally significant at the .10 level. We cannot conclusively state that the effect of overlap density in concentrated markets is different for very small producers than it is for all other firms.

Figure 5. Overlap-density effect on the failure rate of U.S. auto manufacturers, 1885–1981.



DISCUSSION

Many organizational analysts see the dominance of the American automobile market by the Big Three as inevitable given their technological, organizational, and political choices, but an ecological perspective highlights the uncertain and quasi-random nature of industrial evolution. This view accords with that of industry historians such as Rae (1984: 64), who observed about the 1920s, "When the boom period began, Durant Motors, Studebaker, Hudson-Essex, Maxwell and Willys-Overland could all conceivably have been competitors of General Motors and Ford." To date, ecological research on the automobile industry has focused on modeling basic evolutionary processes involving organizational age, entry mode, size, and density (e.g., Carroll and Hannan, 1995; Carroll et al., 1996; Kim, Dobrev, and Solari, 2001). One set of studies demonstrated that organizational populations of automobile producers undergo the expected density-dependent processes of legitimation and competition (Hannan and Carroll, 1992). These studies also showed that the geographic scale of the legitimation process operates more broadly than competition, transcending regional and national boundaries, while competition tends to be more localized (Hannan et al., 1995; Bigelow et al., 1997). Empirical research on national automobile populations has also spawned a theory of population inertia and a corresponding specification of the density model that interacts the basic processes with population age (Hannan, 1997).

In another set of studies, organizational size figures prominently. Studying several national automobile populations, Hannan et al. (1998a) showed that the effects of organizational size and mortality may emanate from both absolute and relative firm size. Moreover, the effects of size on firm mortality appear to be nonmonotonic and nonproportional with respect to a firm's tenure in the industry, suggesting an interaction between size (growth) and processes linked to organizational aging, the so-called liabilities of newness, adolescence, obsolescence, and senescence. The apparent complexity of size effects presents a theoretical challenge. In addressing the issue, Dobrev and Carroll (2000) used a model of scale-based selection to explain mortality among automobile producers. The model assesses the competitive intensity a firm confronts in the marketplace; it takes into account the firm's position in the size distribution and its distance relative to competitors. Empirical estimates based on the model suggest strongly that relative scale drives selection among large automobile producers with positive feedback, a result consistent with many other accounts.

A more recent set of studies has begun to investigate questions about automobile firms' product market positions and the segmentation of producer populations. These efforts were motivated in large part by the changing technology and historically defined patterns of competitive segmentation that have characterized the automobile industry (Womack, Jones, and Roos, 1990). In the ecological perspective, motivation also derives from an empirical finding in Hannan et al.'s (1998a) study of age and size that suggests the operation of resource-partitioning (segmentation) processes in the American industry. The finding is that very small firms show enhanced life chances at later ages, despite generally negative consequences of both small size and old age.

Dobrev, Kim, and Hannan's (2001) study directly examined questions about positioning and segmentation of firms in the European automobile industries, using conceptualizations of the technological niche exactly like ours. In analyzing producer mortality, Dobrev, Kim, and Hannan (2001) found that broad niche width lowers rates of death but that niche overlap heightens the risk of mortality to an extent that more than offsets the broad niche advantage. Their study also shows that mortality chances rise when a producer firm substantially changes its niche width or its position.

Taken together, the findings from this stream of ecological research demonstrate the operation of several different fundamental processes in populations of automobile producers. But the question of integration remains: How well do the various theoretical fragments fit together? What type of integrative theory is needed? At its most general level, our goal here was to incorporate relevant theoretical ideas and models from organizational ecology and to integrate them into a comprehensive evolutionary analysis of the U.S. automobile industry. In doing so, we developed theory about how niche-based processes operate and change as the industry evolves toward increasing concentration. This approach directs attention to the broader evolutionary environment without undermining recent advances in understanding competition and crowding in the local environment.

The empirical findings show the value of reconciling various theories about the niche in evolutionary relief. Consistent with much previous research, our findings extend this work by considering how niche processes change as a market concentrates. The empirical analysis suggests three new twists on established ecological reasoning. First, we found that both niche width and position in the favorable market center lower organizational mortality rates. Yet we also found that the effects of niche width and position depend on the overall consolidation of the industry, reversing themselves in cases of high concentration. Second, we found that scale competition is intense among most automobile producers but that the smallest producers benefit from a highly concentrated market. Third, we found that crowding within a firm's specific technological niche elevates mortality, yet when concentration is high, crowding seems beneficial. Overall, these findings suggest to us that organizational theories of the niche would benefit by attending to evolutionary changes in the broad environment as well as to details of competition and location within the local environment.

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