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THE FATES OF *DE NOVO* AND *DE ALIO* PRODUCERS IN THE AMERICAN AUTOMOBILE INDUSTRY 1885–1981

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Do laterally diversifying firms outlast new startups? Or does organizational inertia give the advantage to startups? We explore these questions here using the experiences of American automobile manufacturers from 1885 through 1981. We advance and test an integrative model that allows the organizational effects of entry mode to vary across the firm's life cycle. We also compare the life chances of laterally diversifying firms by industry of origin, including especially bicycle, carriage and engine manufacturers. Findings show the potentially integrative value of an evolutionary approach to strategy.

A classic theme of the strategic management literature holds that successful business firms possess resources and distinctive competencies that can be leveraged into other markets and industries. Various theories of this kind emphasize different 'leveragable' assets, including capital, technology, specialized skills, organizational structure, and knowledge acquired from experience in similar activities (Teece and Pisano, 1994). Perhaps the most visible current incarnation of this theme revolves around Hamel and Prahalad's (1994) concept of 'core competence.'[1] According to these analysts, 'core competence-based diversification reduces risk and investment and increases the opportunities for transferring learning and best practice across business units' (Hamel and Prahalad, 1994: 293).

Another theme in the strategic management literature draws on work on entrepreneurs and organizations to regale the virtues of new organizations. By this perspective, new organizations often possess advantages because they are assembled to address the needs of the day. Cooper, Willard, and Woo (1986: 252), for instance, note that 'the young firm . . . does not have a stake in the status quo. Employees' security and influence are not tied to traditional ways of competing.' New firms are also often seen as more flexible and adaptable to quickly changing circumstances. By contrast, established organizations exhibit inertia (Hannan and Freeman, 1984; Haveman, 1992). This implies that older organizations will often be slower to act in nonroutinized ways (Henderson, 1993). It also means that when older organizations do act, they will be encumbered by organizational baggage of the past (for a review of the evidence, see Barnett and Carroll, 1995).

Obviously, these two themes potentially stand in direct contradiction with one another. However, researchers have often ignored (or finessed) this apparent contradiction and conducted studies based solely on one or the other theoretical theme, frequently advancing supporting evidence (Dunne, Roberts, and Samuelson, 1988). Because studies typically focus on a single industry, this practice implicitly suggests application of theories by context. That is, as the empirical evidence accumulates, one theme may eventually be seen to apply predominantly to, say, industries with strong

Key words: entry mode; organizational ecology; automobile industry; organizational capabilities

[1] Hamel and Prahalad (1994: 199) define a core competence as 'a bundle of skills and technologies that enables a company to provide a particular benefit to customers.'

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economies of scale while the other may apply to industries with, say, fast-changing technologies. A popular way of categorizing theories in this manner involves looking at the extent of technological change defining new industries (see, for example, Tushman and Anderson, 1986; Rosenbloom and Christensen, 1994).

Another way to reconcile the two themes would be to consider them both within more comprehensive theories of strategy, organization and industry evolution. That is the approach we adopt here. We use the framework of organizational ecology (Hannan and Freeman, 1984) to develop integrative hypotheses about the fates of startup firms and of diversifying firms entering an industry. We build on established ecological models of the organizational life cycle and organizational population evolution (Hannan and Freeman, 1989; Hannan and Carroll, 1992). Several of our hypotheses also synthesize ideas from the two themes into a single general model that is intended to apply across a wide variety of industries.

Our analysis estimates rates of organizational mortality of automobile producers in the U.S.A. In order to allow full integration with theories of organizational evolution, we begin observation at the inception of the industry in 1885. We use data that trace the individual experiences of all known producers from this point until the end of 1981. The study thus covers much of the history of the American automobile industry and includes information on virtually every known producer.

We compare rates across organizational types of entrants. Consistent with the themes of the strategic management literature, we distinguish between new startup entrants and diversifying entrants coming from other industries.[2] Following common practice, we refer to the former as *de novo* entrants or producers, the term coming from Latin and meaning literally 'from anew.' For symmetry, we define and refer to the latter by its Latin companion, *de alio*, a term meaning literally 'from another.'

Of special interest to many theories of strategy and organization are questions about the relative chances of *de alio* entrants from different origin industries. In the case of automobile production, the greatest numbers of *de alio* producers came from bicycle, carriage and engine manufacturing as well as from other motor vehicle production (e.g., motorcycles, trucks) and retail sales of automobiles (thus 'diversifying' through backward integration). Because much resource-based theory suggests that some of these industry backgrounds will endow diversifying firms with special knowledge or assets, we also investigate and compare the fates of these different types of *de alio* automobile producers.

THEORY

Managers usually implement theories of strategy and organization in their firms with clear expectations about implications for performance. Yet, too few of these theories make explicit predictions about *organizational-level* outcomes. And, few have been rigorously scrutinized with organizational-level performance data (Carroll, 1993; Barnett and Carroll, 1995).

Ecological theories show some promise in allowing strategy research to overcome these limitations. These theories of organizations tend to be explicitly about the longevity or survival of the organizational entity itself.[3] Ecological theories base their predictions on observable characteristics of organizations and the nature of their competitive environments. The two most developed models of organizational mortality concern: (1) the relationship between organizational age and the probability of death; and (2) the relationship between the number of organizations in a population (referred to as density) and the probability of death (including especially failure). Each model carries with it a substantial track record in empirical research.

Most studies of *age dependence* in organizational mortality find that the rate of death declines with organizational age (Singh and Lumsden, 1990). Theoretical interpretations of this effect

[2] We do not examine organizational variations in diversification entry, e.g., internal development or acquisition (Yip, 1982).

[3] Ecological theories base these predictions on the form of the organization as well as specific characteristics such as age, size and location in a competitive system (see Singh and Lumsden, 1990). Of course, survival is not the only organizational-level performance variable relevant to strategy theory and research. However, its use does mitigate many of the problems often associated with organizational-level outcome variables (see the discussions of this matter in Carroll, 1993, and Barnett and Carroll, 1995).

usually draw on Stinchcombe's 'liability of newness' arguments, which ascribe the higher earlier failure rates to the learning of new roles, to the interaction difficulties of strangers, and to an undeveloped network of suppliers and buyers. Negative age dependence can also occur as a result of unobserved heterogeneity in organizational mortality rates (see Blossfeld, Hammerle, and Mayer, 1989). This heterogeneity might reflect either stable differences across organizations or time-varying differences in the way organizations develop and change. Despite the presence of great heterogeneity in the world of organizations—much of it unobserved in empirical research—an intriguing recent study finds that organizational mortality rates increase with age[4] (Barron, West, and Hannan, 1994). The claim is that better data on size, in particular updated size information across the life histories of all firms in a population, generates this finding. It can be explained by processes of organizational senescence, which include bureaucratic rigidity and political stultification.

Virtually all studies of *density dependence* in organizational mortality invoke the evolutionary theory of legitimation and competition (Hannan and Carroll, 1992). According to this theory, initial increases in the density of an organizational form elevate its legitimation, thereby leading organizational founding rates to rise and failure rates to fall. At higher levels of density, legitimation reaches a saturation level and competition dominates organizational evolution. Increasing competition generates lower founding rates and higher failure rates. There is also a persisting competitive effect of density at the time of an organization's founding on its failure rate. All told, the theory posits three specific empirical predictions that have been well supported: (1) founding rates display a nonmonotonic inverted U-shape relationship with density; (2) failure rates show a nonmonotonic U-shape relationship with density; and (3) age-dependent schedules of failure rates are higher for organizations founded in high density environments (see Singh and Lumsden, 1990; Hannan and Carroll, 1992).

Unfortunately, neither the research program on age dependence nor the one on density dependence pays sufficient attention to organizational variations in founding events (e.g., the distinction between *de novo* and *de alio* entrants). Yet we believe that these frameworks provide the potential for integrating the two themes about competitive advantage in new industries. Consider, for instance, the organizational life cycle depicted by the age dependence program. The notion that organizational mortality varies with age and that this variation might correspond to organizational characteristics and processes suggests that effects of entry by lateral diversification (i.e., *de alio* status) might do so as well. Likewise, the evolutionary pattern associated with density dependence suggests that the fates of *de alio* entrants might have to do with population dynamics at time of entry—factors usually not considered in studies of this kind.

Organizational life cycle effects

We expect that, consistent with most previous research, both *de novo* and *de alio* entrants will display negative age dependence in mortality. However, we believe that the relative rates of mortality of the two types of firms differ by stages of the organizational life cycle.

De alio entrants usually arrive with an ample stock of resources, including capital and personnel (Mitchell, 1994). The stock is typically sufficient to ensure operation for an extended period, regardless of the success of the entrant's activities (Levinthal, 1991). Moreover, the fact that the *de alio* entry has actually occurred means at least initially the most severe inertial constraints in the origin firm have been overcome (other potentially diversifying firms with greater inertia never make or implement the decision to enter). And, the likelihood that the decision to diversify requires some justification within the origin firm suggests that some planning and resource acquisition actually precede entry.

By contrast, *de novo* firms frequently experience failure because of poor planning, undercapitalization and other resource shortages. Unlike *de alio* entrants, *de novo* firms cannot get technical assistance or subsidies from their origin firm. *De novo* firms also cannot rely on an origin firm's assets for collateral in seeking financing from banks and other third-party lenders (Bruderl, Preisendoerfer, and Ziegler, 1992). These factors should be especially important in the early stages

[4] Other studies suggest that mortality rates may be nonmonotonic, with the rate rising initially and then declining (see Levinthal, 1991; Bruderl and Schuessler, 1990).

of a firm's operation, before its products generate revenues. Consideration of typical situations for both types of entrants leads us to argue:

Hypothesis 1: De alio *entrants will have lower initial death rates than* de novo *entrants.*

Of course, not all *de novo* firms fail to plan or acquire sufficient resources prior to entry. Those which do engage in planning and resource acquisition should show differences in mortality similar to that of *de alio* entrants (Levinthal, 1991). Researching this issue for many organizations over a long historical period is a formidable task. However, for firms engaged in large-scale production activities such as automobile manufacturing, it is often possible to separate the initiation of certain preproduction activities from the onset of production. We have been able to do so for would-be *de novo* automobile producers who did one of the following prior to production: built a prototype; incorporated the concern; or listed themselves as a producer in an industry directory. The time elapsed between these activities and production we define as the preproduction period. In our view, the firms involved in these preproduction activities likely spent more time and effort in planning and resource acquisition than other firms. These efforts likely led to greater resources at the time production began; however, they also likely generated more inertial forces as well. In addition, we think that preproduction periods represent a window of opportunity for early low-risk learning, especially by trial and error (Nelson and Winter, 1982). For these reasons, we hypothesize:

Hypothesis 2: De novo *entrants with observed preproduction periods will have lower initial death rates than other* de novo *entrants.*

What about the risks of mortality as a firm ages? *De novo* firms may possess fewer resources than *de alio* firms but they also contain less organizational and political structure. So when confronted with opportunities and problems, *de novo* firms are capable of moving decisively and redeploying people, machines and capital (Tushman and Anderson, 1986). *De novo* firms not only learn, their flexibility means that the substance of what they learn can be incorporated into their structures (Henderson, 1993; Rosenbloom and Christensen, 1994).

De alio firms also learn. But their greater resources imply that vested interests have more stake in the status quo in these firms (Haveman, 1992). *De alio* firms also must deal with the justifications used in their origin firms at the time of their creation. In many cases, *de alio* firms have interested sponsors and critics in the origin firms, persons sometimes with formal authority over the entrant. Because of such processes, *de alio* firms are more likely to have formally developed plans—documents, understandings and agreements intended as blueprints for future action. So too will *de novo* firms with observed preproduction periods. All these factors serve to increase organizational inertia.

We think that differences between *de novo* and *de alio* firms in flexibility and inertia become overwhelmed by resource differences in the startup period. But as firms age, inertia becomes increasingly important and the ability of *de novo* firms to move faster and to learn faster at later stages implies:

Hypothesis 3: The initial advantages of both de alio *entrants and* de novo *entrants with observed preproduction periods will diminish with organizational age and become liabilities.*

Organizational population effects

How does organizational population structure shape failure rates of *de novo* and *de alio* producers? Fully developed answers to this question should consider the focal population. But for *de alio* entrants, it should also consider the population from which they diversified because conditions there likely affect subsidy levels as well as the ease of return. Given that *de alio* entrants usually come from a variety of organizational populations and industries, the data requirements for testing such theories are daunting. So, we begin this line of inquiry in a more modest vein, by considering the density-dependent theory of legitimation and competition for the two types of entrants. How should it apply? In our view, both *de novo* and *de alio* producers should experience the forces of legitimation and competition. The returns to longevity resulting from the institutionalization of the organizational form characterizing the population should not differ by entry mode. Likewise, both types of producers should experience increased competitive pressure as population density grows.[5]

Hypothesis 4: Mortality rates of both de novo *and* de alio *producers will have a nonmonotonic U-shaped relationship with organizational population density.*

We do recognize that many factors suggest that density effects will be stronger for one entrant type than the other. For instance, possible subsidies to *de alio* producers from origin firms may make them less vulnerable to competitive pressures. Although we regard such comparisons as potentially very interesting, we believe it would be premature to develop hypotheses of this kind without first demonstrating the more fundamental pattern.

What about differences among *de alio* entrants? Much theory in strategic management emphasizes the skills and knowledge held by firms as a result of their successful operation in origin industries or populations. For instance, the expertise Honda developed with combustible engines in the motorcycle industry is often cited as the reason for the company's later success in automobile manufacturing. Hamel and Prahalad (1994: 199) refer to the source of these advantages as a firm's core competence, which they define as 'a bundle of skills and technologies that enables a company to provide a particular benefit to customers.' Examples include: Eastman Kodak's expertise in chemical imaging, Walmart's abilities in logistics and Toyota's efficiency in quality manufacturing.

Such theories assume that the skills and knowledge acquired in one industry are transferable to another and that different origin industries equip firms with systematically varying levels of potential advantage. Indeed, Hamel and Prahalad (1994: 207) actually include 'extendability' in their definition of core competence: 'A core competence is truly core when it forms the basis for entry into new product markets.' It follows tautologically that firms that diversify on the basis of their core competence will be able to outcompete firms diversifying on other bases.

Unfortunately, theories of this kind rarely get more specific in making predictions. Analysts and managers can often identify a diversification based on core competence only in retrospect, after the success of a *de alio* entrant has been demonstrated—when it then becomes possible to abstract a common underlying dimension between the old and new activities. Given the myriad of possible abstract connections among a firm's activities, this means that these theories tend to be unfalsifiable, at least in their general forms.[6] However, within the context of any particular industry, it is possible to develop falsifiable predictions based on detailed analysis of the characteristics of various origin industries and the new industry. We conduct such an analysis for automobile manufacturing and the origins of most of its *de alio* entrants in the next section. This leads to a stronger hypothesis than the general claim of the literature, which we state formally here for reasons of scholarship, even though it only implies that producers from different industry origins will have unequal viability:[7]

Hypothesis 5: De alio *producers from origin industries with relevant specialized transferable skills and knowledge will have lower death rates than those from other industries.*

RESEARCH SETTING: AUTOMOBILE MANUFACTURING IN THE U.S.A.

Organizational theory has drawn heavily on organizational innovations in the American automobile industry for insight. The development of mass production techniques at Ford in the early twentieth century provided the empirical basis for much early work on efficient job design. Later organizational changes in the management structure of General Motors served as part of the inspiration for Chandler's (1962) well-known strategy-structure thesis. General Motors' transformations also played a major role in William-

[5] As Barnett *et al.* (1994) demonstrate, different organizational forms can generate varying degrees of competition (and possibly, legitimation) as well. These ideas imply disaggregating density by organizational form. Although we think it may be interesting to explore such issues for *de novo* and *de alio* firms, we do not explore them here.

[6] For example, Hamel and Prahalad (1994: 230) claim that apparently unrelated product market diversification 'may be closely related in terms of core competencies.'

[7] The weakness of this hypothesis lies in its implied null, namely, that death rates across origin industry will be equal.

son's (1975) transaction cost theories of efficient firm boundaries and of the corporate M-form of organization. In more recent years, numerous organizational scholars have looked closely at Toyota to understand quality and efficiency in manufacturing.

With the organizational spotlight focused on large automobile manufacturing firms, much of the industry has been neglected. Despite an occasional passing reference to the industry's early history (Lawrence and Dyer, 1983), virtually no organizational research has systematically examined this period (for exceptions see Hannan *et al.*, 1995; Carroll *et al.*, 1994). With much current interest steeped in evolutionary concerns, questions about the origins and development of an industry so economically central as automobile manufacturing seem important. A few facts about the early industry make these questions compelling.

For instance, our data collection efforts (described below) yielded systematic information on 2197 producers who entered the American industry at one time or another. The diversity of cars, technologies and organizational forms associated with these efforts was enormous (Carroll and Hannan, 1995). A key question for organizational theory concerns how these many and varied producers evolved into the industry as we know it.

Table 1 shows the distribution of *de novo* and *de alio* entrants over the history of the industry. *De novo* firms outnumber *de alio* firms by a ratio of almost 2 : 1. A little over 20 percent of *de novo* firms engaged in some observable period of preproduction, with the bulk of these lasting a year or less. *De alio* producers came from an assortment of industries, with the greatest numbers from carriage and engine manufacturing; bicycle manufacturers represent a distant third origin industry.

Figure 1 gives a better historical sense of entry patterns. It displays annual counts of entries by *de novo* and *de alio* producers for the years 1885–1981. Obviously, an early period—from about 1897 to 1922—experienced the greatest number of entries of both kinds. However, we find it remarkable that throughout this period *de alio* entries apparently track *de novo* entries closely: peaks and troughs of the two curves shown in Figure 1 correspond to each other within a window of a year or two.

Table 1. Counts of American automobile producers by origin type

Total firms	2197*
De novo firms	1427
Observed in preproduction	312
0–1.0 year in preproduction	220
1.0–2.0 years in preproduction	43
2.0+ years in preproduction	49
De alio firms	722
Age at entry data available	78
Age 0–5.0 years at entry	22
Age 5.0–10.0 years at entry	16
Age 10.0 + years at entry	40
Industry origin data available	577
Bicycle manufacturing	44
Carriage manufacturing	126
Components	11
Dealers	26
Engine manufacturing	111
Other motor vehicles	76
Other industry	183

*The total number of firms exceeds the sum of *de novo* and *de alio* firms because a few cases could not be readily classified.

The contrast with Figure 2 strikes one immediately. This figure shows the annual counts of entries for the three most common types of *de alio* producers: those who came from engine, carriage and bicycle manufacturing. Although all three sources experienced an early wave of entries right before and after 1900, divergence is the rule thereafter. Most notably, entry from carriage manufacturing declines much sooner after 1900 than the other two types. Carriage manufacturers also show a big surge in entries around 1910, when numbers of the other two decline.

Which type of *de alio* entrants possessed potentially advantageous, transferable skills and knowledge? Table 2 represents our attempt to summarize the various relevant attributes of the different major origin industries of *de alio* producers. Culled from historical and other analyses (Rae, 1984; Hounshell, 1984; Flink, 1988), this figure shows that important (but different) technical assets were held by those from bicycle, carriage and engine manufacturing as well as producers of other motor vehicles. Market resources were held by automobile dealers and also by bicycle and carriage manufacturers, who often sold their products directly to the public.

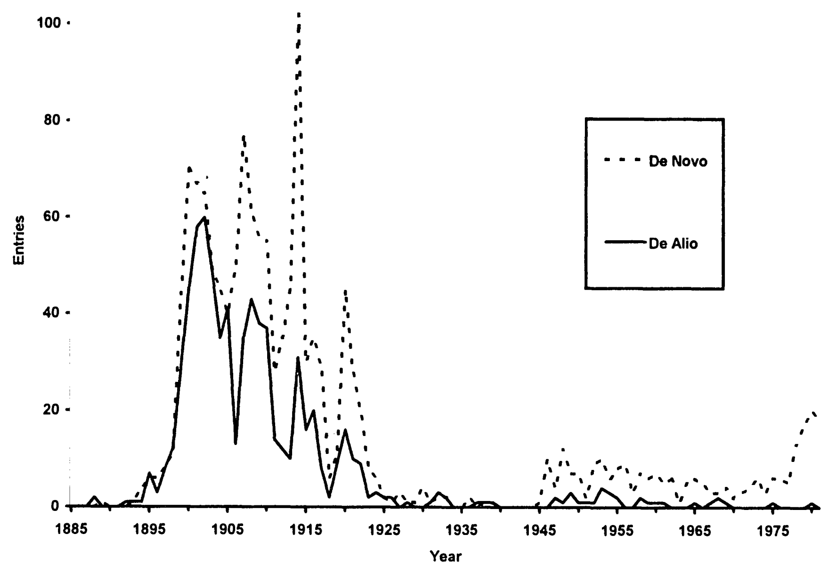

Figure 1. Entries of *de novo* and *de alio* American automobile producers

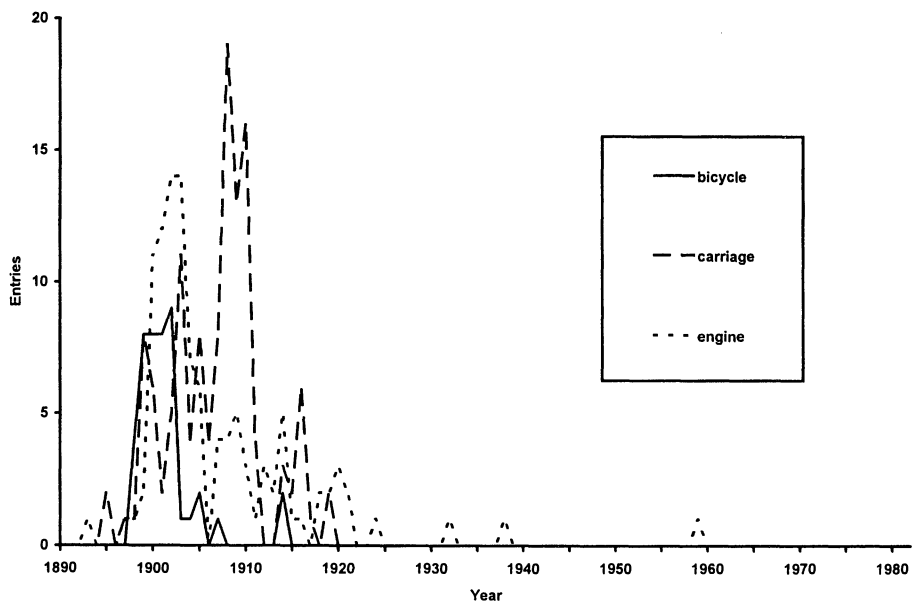

Figure 2. Entries of bicycle, carriage and engine manufacturers into automobile production

Table 2 illustrates a potential problem of many general arguments about diversification advantage, namely, that without clear *a priori* empirical specification they can become irrefutable—for example, Dosi and Teece's (1993: 19) claim that 'the probability of failure for any firm while entering a new market will be proportional to the technological and market distance from its current competencies.' Because firms from each origin industry possess some skills or knowledge that plausibly give them a unique advantage (and conversely some that disadvantage them), and because these characteristics can always be interpreted in terms of 'distance,' any pattern of findings can be explained retrospectively by this type of general argument unless the theory provides

Table 2. Assessment of competencies of *de alio* producers in automobile manufacturing

Bicycle manufacturers
Technical skills in armory and stamping
Assembly knowledge
Limited engine expertise
Consumer market experience
Financial resources
Carriage manufacturers
Technical skills in woodworking
Assembly knowledge
Limited engine expertise
Consumer market experience
Financial resources
Automobile dealers
Familiarity with consumer market (cars)
No technical expertise
Engine manufacturers
Critical new technical part
Competing technologies
Assembly knowledge highly limited
Little consumer market experience
Other motor vehicle manufacturers
Technical knowledge
Assembly knowledge
Little consumer market experience
Components suppliers
Limited technical knowledge

guidance as to how to translate them into more specific *a priori* predictions.[8] Unfortunately, the theories usually do not do this. Dosi and Teece's (1993) technological and market distance, for instance, is specified as a function of 'knowledge-based relatedness,' another concept with no obvious *a priori* empirical meaning and for which it is tempting to draw inferences based on outcomes.[9]

Despite these theoretical difficulties, we think that, when forced to be specific in advance about this context, most analysts would conjecture that the greatest advantages accrued to engine manufacturers.[10] Why? A number of reasons suggest themselves. First, propulsion constituted the defining 'new' piece of the motor car. Most historical accounts of the industry trace its development to technological developments in propulsion technology (Rae, 1984; Flink, 1988). Second, propulsion technology developed fast and unpredictably, with even competing types of engines rapidly changing and improving. By many assessments, the eventual dominance of the gasoline-powered internal combustion engine surprised early industry participants. Third, the engineering expertise needed to understand propulsion technology and engine manufacturing existed in short supply. Fourth, several successful early automobile manufacturers came from engine manufacturing, including Benz and Daimler. All these reasons suggest that application of Hypothesis 5 to this context predicts that automobile producers with prior experience in engine manufacturing will have lower death rates than other *de alio* producers.

RESEARCH DESIGN, DATA AND METHODS

The research design guiding our analysis constitutes what is typically referred to as a population study. Rather than use a sample, we examine data on all automobile producers known to operate in the U.S.A. We investigate the period from 1885 to the end of 1981, the beginning of the industry to the latest date covered by our major sources. By tracing the fates of many individual producers, we can estimate the effects of organizational characteristics and conditions on firm mortality, an important performance variable. Complete coverage over the extended period allows us to investigate clearly how change unfolds over the lives of firms and the history of the industry. It also permits testing of theories without resort to untenable assumptions such as temporal equilibrium or historical efficiency (Carroll and Harrison, 1994).

The long-term population design aids especially in evaluating claims about *de alio* entrants. In a

[8] We think that many current theories which explain organizational change by resort to concepts involving the extent of technological change potentially suffer from this problem. The problem is that the extent of technological change is often best inferred from the outcomes it generates.

[9] See, for example, the study by Teece *et al.* (1994) where distance or relatedness is equated with prevalence of diversification moves.

[10] When posed with the question, seminar participants at business schools usually give this answer as well.

first set of analyses (pertinent to Hypotheses 1 through 4), we examine the life chances of *de alio* producers as contrasted with those of *de novo* producers with and without preproduction stages. In a second set (pertinent to Hypothesis 5), we look exclusively at *de alio* entrants and compare their life chances by origin industry. To our knowledge such an analysis has not been conducted for any industry. Instead, studies of lateral diversification (e.g., Pfeffer and Salancik, 1978; Burt, 1992; Teece *et al.*, 1994) often equate the entry event itself with success, thus assuming hyperrationality (see Barnett and Carroll, 1993). These studies also usually combine observations on firms with many different origin and destination industries without employing controls.

The data we analyze come from our attempt to code information on all producers of automobiles from 1885 to late 1981. The cornerstones of our coding are the three volumes of the *Standard Catalog of American Cars* (Kimes and Clark, 1989; Gunnell, Schrimpf, and Buttolph, 1987; Flammang, 1989). Two important sources of supplementary information are the *New Encyclopedia of Motor Cars* (Georgano, 1982) and the *World Guide to Automobile Manufacturers* (Baldwin *et al.*, 1987). For contemporary periods, we also used Kutner (1979) and *Automotive News* (1993).

Each of the main source books represents the culmination of years of work by groups of historians, journalists, collectors, and others. The *Standard Catalog* builds carefully on previous lists and compilations from a wide variety of sources including industry directories, newspapers, trade journals, city directories and magazines. It contains entries for every car known to have been built in the U.S.A., as well as all incorporated automobile manufacturers and those manufacturers listed in industry directories. The entries contain capsule histories of each car or manufacturing concern, along with detailed technical information when available. The *Standard Catalog* strives to provide comprehensive coverage of the American industry. The supplemental sources provide additional historical and technical information and, on rare occasions, contain some cars not found in the *Standard Catalog*.

Entries in the sources are usually organized by car 'marque' (or 'make'). Our interest in organizations required a time-consuming process of aggregating this information to the firm level.[11] Some firms consist of more than one marque. For example, General Motors currently produces cars under the following separate marques: Buick, Cadillac, Chevrolet, Oldsmobile, Pontiac, and Saturn. In years past it manufactured cars under the following discontinued marques: Cartercar, Elmore, Ewing, LaSalle, Marquette, Milburn, Oakland, Rainier, Scripps-Booth, and Welch. Some marques shifted successfully across firms over time. For instance, Cadillac started out as the product of Cadillac Automobile Company in 1903; the firm changed its name to Cadillac Motor Car Company before it was eventually acquired by General Motors in 1909.

The aggregated firm-level data file contains information on all known producers as well as many unsuccessful attempts at production. We distinguish between them by defining as a producer an automobile manufacturer that reached a level of production sufficient to generate revenue, however small. This definition includes many small producers.

For each producer firm, we determine a beginning date at which operations commence and an ending date at which mortality occurs or observation ends (technically referred to as 'censored' cases). When exact dates appear in the sources, we use those. In many instances, however, the main source gives detailed 'seasonal dates' such as late spring, midsummer, early autumn, etc. We codify these season references and convert them to precise numerical dates within the year. In other instances, we know only the year in which an event ended.

We use procedures to deal with imprecise dates known only to the year and to make dates of differing levels of precision comparable to each other.[12] Basically, our procedures use the midpoint of the period over which an imprecise date creates uncertainty. So, for example, a firm that is known only to start and stop production in 1910 could possibly have a lifetime of anywhere from 1 day to a full year. Our procedures set the lifetime at 0.5 year, the midpoint of the uncertain range.

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[11] This is actually a 'within industry' definition of the firm since we do not consider activities outside of automobile manufacturing.

[12] Imprecise dating creates what is known as time-aggregation bias. Our procedures are consistent with Petersen's (1991) recommendations for dealing with this problem.

To the extent possible given the sources, we code different types of both founding events and mortality events. For present purposes, we ignore much of this information and collapse the different types of events into basic categories representing founding and mortality generally defined. For founding events, we consider all automobile manufacturers who entered production, retaining only the founding distinctions of *de novo* entry, *de novo* entry with prior preproduction and *de alio* entry. For mortality, we follow convention in ecological theory and collapse across all ending events that resulted in the demise of a unique organization, including cessation of production, bankruptcy and acquisition by another firm. Including acquisitions makes the analyses more general but does not affect the findings.[13]

Our analysis revolves around rate or hazard function models of the mortality process. As is conventional, we define the rate of mortality at the organizational level as the probability of mortality in an infinitesimally small interval (see Blossfeld *et al.*, 1989). We estimate regression-like effects of covariates on the rate using the TDA statistical package (Rohwer, 1993).

Preliminary nonparametric analysis of the data showed monotonically declining age dependence in the mortality rate. Among parametric models that allow this feature in parsimonious fashion, we found in early analyses that a good-fitting model for this data is the commonly used Gompertz model.[14] In this model the rate is specified as

$$r(t) = \exp[\beta_0 + \beta_1 X_1(t) + \dots + \beta_k X_k(t)]$$
$$\exp([\gamma_0 + \gamma_1 Z_1(t) + \dots + \gamma_m Z_m(t)]t)$$

where t represents age and $X(t)$ and $Z(t)$ are covariates. A negative coefficient γ_0 indicates negative or declining age dependence in mortality. Covariates can be included in either the age-independent vector (signified by the $X(t)$ variables above) or the age-dependent vector (shown as $Z(t)$ above). Most of our analysis uses a loglinear specification of covariates with inclusion in the age-independent vector. As is conventional, we split spells at least every year in order to update values of the covariates.

The analysis uses the following variables, either constructed from the automobile data files or compiled from other sources.

Density—N(t). This variable measures contemporaneous organizational population density (divided by 100). It indicates the total number of producer organizations in the population in a year. As suggested by prior theory, we also use the square of this variable, divided by 10,000 for ease of reporting. Density variables are lagged 1 year to ensure exogeneity.

Density at Founding—N(0). This variable gives the organizational population density at the time of an organization's founding. This covariate is fixed for each organization. In reporting, we divide its value by 100.

Size. A variable recording the realized production capacity of a firm in terms of numbers of cars. This variable is updated annually and relies on numerous sources, which often differ by firm. For smaller firms, size is often imputed.[15] We report effects of this variable divided by 1000.

Age. Years the firm has spent in automobile production.

De Alio. A dummy variable indicating that the firm is a lateral diversifier, with prior activities in another industry.

Bicycle Producer. For *de alio* firms, a dummy

[13] More specifically, we have reestimated the models reported here excluding acquisitions from the mortality state and the basic findings do not change. Perhaps this robustness results from the fact that only 80 of our ending events are coded as acquisitions.

[14] Our main comparison in the early analysis involved the Gompertz and the Weibull models of the hazard function. We later reestimated some of the models reported below using a piece-wise constant rate specification for age dependence, although we did not let other effects vary across age because of the complexity of such a specification in this context. Estimates from these other models suggest that the findings reported below do not hinge unreasonably on the Gompertz specification.

[15] For firms for which some but not all information on capacity could be found, we interpolated missing years. For firms for which no information could be found, we assumed they were small producers and assigned a random value below the lowest quartile for that period. Sensitivity analysis shows that these procedures do not have great effects on findings.

variable indicating prior activities in bicycle manufacturing.

Carriage Manufacturer. For *de alio* firms, a dummy variable indicating prior activites in carriage manufacturing.

Dealer. For *de alio* firms, a dummy variable indicating prior activities as a dealer for automobiles.

Other motor vehicles. For *de alio* firms, a dummy variable indicating prior activities as a manufacturer of other motor vehicles.

Components. For *de alio* firms, a dummy variable indicating prior activities as a supplier of automobile components.

Other industries. For *de alio* firms, a dummy variable indicating prior activities in an industry other than bicycle manufacturing, carriage manufacturing, car dealer, other motor vehicle manufacturing, or components.

Age(0). For *de alio* firms, the age of the firm in years at time of entry into automobile production.

Preproducer. A dummy variable indicating that a *de novo* firm engaged in observable preproduction activities.[16]

Preproducer Time. For *de novo* firms that engaged in preproduction, a variable measuring the time elapsed while in preproduction. That is, this variable reports duration information for all firms with a score of unity on the Preproducer dummy.

Industry Production. Indicates the total number of cars produced in the U.S.A. in a year. Taken from various annual issues of the Motor Vehicle Manufacturing Association's *World Motor Vehicle Data*. Measured in millions of cars.

GNP. Records annual estimates of gross national product (in hundreds of billions of dollars) at 1958 prices. Coded from *Historical Statistics of the United States* (U.S. Department of Commerce, 1975) and *Statistical Abstract of the United States* (U.S. Department of Commerce, various years).

Periods. Relies on the assessment of Altshuler *et al.* (1984) to define periods of technological/organizational regimes in the world automobile manufacturing industry. Codes a set of three dummy 'effect' variables corresponding to the dates associated with these regimes: *Mass Production*, which takes the value of one from 1902 to 1981; *Product differentiation*, which takes the value of one from 1950 to 1981; and the Japanese Just-In-Time/Total Quality Control (*JIT/TQC*), which takes the value of one from 1968 to 1981.

World War II. A dummy variable which takes the value of one for the years 1942–45, the period when World War II disrupted normal domestic production.

FINDINGS

Table 3 presents estimates of Gompertz mortality models using all the data on autmobile producers. These models provide basic tests of Hypotheses 1 through 4. Each model contains a similar set of baseline variables measuring the effects of organizational size, population density, industry production, economic conditions and time periods. Differences across models have to do with specification of the De Alio and Preproducer variables, included either separately or together and either in the age-dependent vector of the model or not.

The estimated negative effect of organizational age in all the models tells that the overall hazard of mortality declines with age. In specification (3.1), the significant negative coefficient associated with *de alio* status shows clearly that these producers have lower initial mortality rates than *de novo* producers. The same holds true for *de novo* firms with preproduction stages, as inclusion of 'Preproducer' in (3.2) shows. These findings provide strong support for Hypotheses 1 and 2, thereby illuminating the theme that lateral diversifiers possess an advantage.

Models (3.3) through (3.4) represent various specifications designed to test Hypothesis 3, the

[16] These activities consist of: (1) building a car; (2) incorporating as a car manufacturer; or (3) listing the concern in an industry directory. For full discussion, see Carroll *et al.* (1994).

Table 3. Maximum likelihood estimates of Gompertz models of organizational mortality for American automobile producers 1885–1981 (standard errors shown in parentheses)

Equation no.	(3.1)	(3.2)	(3.3)	(3.4)	(3.5)
Constant	−0.266*	−0.239	−0.235	−0.223	−0.217
	(0.123)	(0.124)	(0.125)	(0.124)	(0.125)
$N(t)/100$	−0.709*	−0.680*	−0.681*	−0.686*	−0.688*
	(0.124)	(0.125)	(0.125)	(0.125)	(0.125)
$N(t)^2/10{,}000$	0.085*	0.081*	0.082*	0.083*	0.083*
	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)
$N(0)/100$	0.323*	0.305*	0.305*	0.308*	0.308*
	(0.038)	(0.039)	(0.039)	(0.039)	(0.039)
Size/1000	−0.153*	−0.148*	−0.148*	−0.151*	−0.151*
	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)
Industry Production	0.053	0.054	0.054	0.056	0.056
	(0.040)	(0.040)	(0.040)	(0.040)	(0.040)
GNP	−0.339*	−0.342*	−0.342*	−0.342*	−0.343*
	(0.081)	(0.080)	(0.080)	(0.080)	(0.080)
Periods					
Mass Production	0.449*	0.454*	0.454*	0.457*	0.458*
	(0.119)	(0.119)	(0.119)	(0.119)	(0.119)
Production Differentiation	0.475*	0.450*	0.450*	0.441*	0.442*
	(0.224)	(0.224)	(0.224)	(0.223)	(0.223)
JIT/TQC	−0.340	−0.333	−0.330	−0.331	−0.326
	(0.347)	(0.346)	(0.347)	(0.346)	(0.346)
World War II	−0.620	−0.601	−0.596	−0.552	−0.544
	(0.724)	(0.724)	(0.724)	(0.724)	(0.724)
De Alio	−0.137*	−0.150*	−0.157*	−0.150*	−0.160*
	(0.048)	(0.048)	(0.059)	(0.048)	(0.059)
Preproducer		−0.129*	−0.129*	−0.218*	−0.218*
		(0.058)	(0.058)	(0.072)	(0.072)
Age	−0.090*	−0.088*	−0.090*	−0.097*	−0.099*
	(0.007)	(0.007)	(0.009)	(0.008)	(0.010)
De Alio × Age			0.003		0.004
			(0.013)		(0.013)
Preproducer × Age				0.029*	0.030*
				(0.014)	(0.014)
log L	−3860.6	−3858.0	−3858.0	−3855.8	−3855.8
N	8625	8625	8625	8625	8625

*$p \leq 0.05$

argument that diversification and planning advantages diminish with time because of organizational inertia. These models place the De Alio and Preproducer variables in the age-dependent vector. Estimates support the hypothesis in that both variables show negative effects in the age-independent vector (as before) and positive effects in the age-dependent vector. However, only the Preproducer variable shows a statistically significant age-dependent effect.

Using only the significant estimates shown in Model (3.4), Figure 3 provides a plot of predicted effects for the three basic organizational types of entrants. All three show big declines in mortality rates with age. *De novo* firms without preproduction have the highest initial mortality rate. *De*

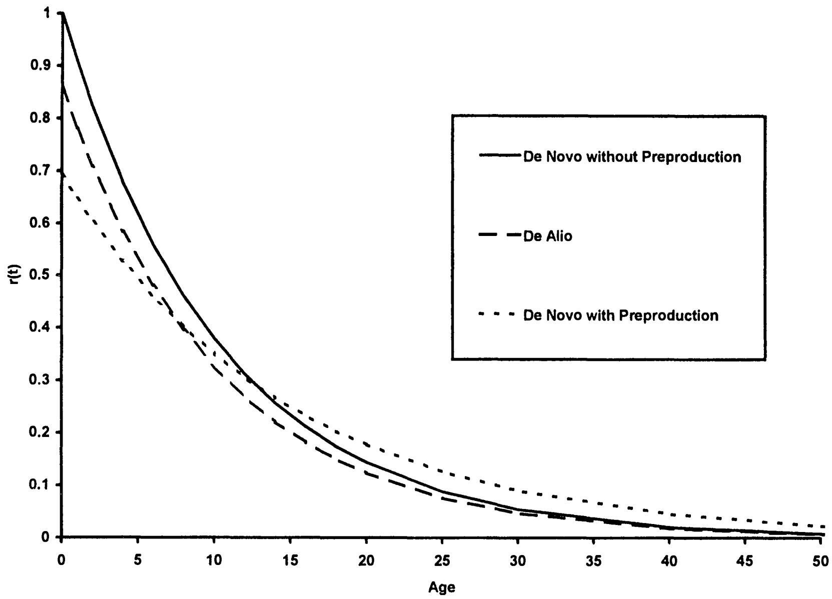

Figure 3. Predicted effects of *de alio* and preproducer status from Equation 3.4

alio firms begin with lower mortality rates and, with age, these rates converge with those of *de novo* firms without preproduction. But they always remain lower. By contrast, *de novo* producers with preproduction show the lowest initial death rate and then show the highest death rate at later ages. Death rates for these firms decline with age at a slower pace than other types. By about age eight, the mortality rate of *de novo* firms with preproduction exceeds that of *de alio* producers; by about age twelve, it exceeds that of *de novo* firms without preproduction. The differential pattern between *de novo* firms with and without preproduction is exactly that predicted by Hypothesis 3.

Hypothesis 4 maintains that mortality rates of both *de novo* and *de alio* producers will exhibit nonmonotonic density dependence. Below we present estimates of models directly testing this argument. For the moment, however, it is worth noting in Table 3 that for the full data set (combining both *de novo* and *de alio* types), effects of density are always in the predicted directions and always statistically significant. So too are estimates of the density delay term. Given previous research, we would hardly expect the model to work separately for the two entrant types if it did not work here for the whole population.

Table 4 presents estimates of models extending those of the previous table. These models build on (3.4) by including in various specifications 'timing' variables relevant to *de alio* status and preproduction. Specifically, Age(0) measures the age of the firm at the time it enters automobile production; it is available for only some *de alio* firms.[17] Preproducer Time indicates the length of time spent in preproduction and it is available for all preproducers. Thus, expanding the models of Table 4 in hierarchical fashion requires entering Age(0) along with the De Alio variable but the Preproducer Time variable can be entered alone since it represents a multiplicative expansion of the Preproducer dummy. As estimation of Models (4.1) and (4.2) shows, age at entry lowers the initial mortality rate for *de alio* firms; its effect does not, however, appear to diminish with time in automobile production. Models (4.3) and (4.4) show that substituting time in preproduction for the preproducer dummy variable improves model fit slightly (note the small decrease in the log of the likelihood function). Moreover, the previous pattern of estimates supporting Hypothesis 3 persists: preproducers not only have lower initial death rates that decline more slowly with age than that of nonprepro-

[17] The Age(0) variable depends on such information being reported in our sources for *de alio* entrants. Among other things, a reported Age(0) variable might be associated with a firm's size, visibility or its wealth.

Table 4. Maximum likelihood estimates of Gompertz models of organizational mortality with timing variables for American automobile producers 1885–1981 (standard errors shown in parentheses)

Equation no.	(4.1)	(4.2)	(4.3)	(4.4)
Constant	–0.232 (0.124)	–0.231 (0.126)	–0.183 (0.125)	–0.185 (0.125)
$N(t)/100$	–0.690* (0.125)	–0.680* (0.125)	–0.703* (0.125)	–0.677* (0.125)
$N(t)^2/10{,}000$	0.083* (0.028)	0.082* (0.028)	0.087* (0.028)	0.083* (0.028)
$N(0)/100$	0.311* (0.039)	0.309* (0.039)	0.285* (0.040)	0.281* (0.041)
Size/1000	–0.152* (0.023)	–0.150* (0.023)	–0.157* (0.024)	–0.148* (0.023)
Industry Production	0.067 (0.040)	0.066 (0.040)	0.063 (0.040)	0.063* (0.040)
GNP	–0.344* (0.080)	–0.343* (0.080)	–0.354* (0.080)	–0.353* (0.080)
Periods				
Mass Production	0.459* (0.118)	0.455* (0.118)	0.465* (0.118)	0.464* (0.118)
Product Differentiation	0.384 (0.223)	0.388 (0.223)	0.393 (0.223)	0.387 (0.222)
JIT/TQC	–0.339 (0.345)	–0.341 (0.345)	–0.288 (0.345)	–0.297 (0.345)
World War II	–0.588 (0.724)	–0.558 (0.724)	–0.560 (0.724)	–0.501 (0.724)
De Alio	–0.103* (0.049)	–0.107 (0.061)	–0.090 (0.049)	–0.096* (0.049)
Age(0)	–0.016* (0.005)	–0.022* (0.007)	–0.014* (0.005)	–0.015* (0.005)
Preproducer	–0.205* (0.072)	–0.202* (0.072)		
Preproducer Time			–0.083* (0.024)	–0.140* (0.031)
Age	–0.097* (0.008)	–0.099* (0.010)	–0.093* (0.008)	–0.094* (0.007)
De Alio × Age		0.002 (0.013)		
Age(0) × Age		0.001 (0.001)		
Preproducer × Age	0.030* (0.014)	0.028* (0.014)	0.025* (0.012)	
Preproducer Time × Age				0.013* (0.003)
Log *L*	–3847.9	–3846.7	–3844.0	–3839.5
N	8625	8625	8625	8625

$^*p \leq 0.05$

ducers, the effects grow the longer a firm stays in preproduction. All in all, the estimates of this table confirm and extend the findings of Table 3 which support Hypotheses 1, 2 and 3.

Table 5 displays estimates of models estimated using only a subset of the data, those cases containing information on *de alio* producers. The purpose is to compare the life chances of *de alio* producers by industry origin, evidence pertinent to Hypothesis 5. Model (5.1) provides the 'global' test. It shows estimates of the baseline model with inclusion of dummy variables (in the age-independent vector) for each of the industry origin categories except engine manufacturing, which is the omitted category. These estimates suggest that the biggest and strongest advantages accrued to carriage and bicycle manufacturers: coefficients associated with these categories are strongly negative and statistically significant relative to engine manufacturing; they are also more negative than other categories. Model (5.2) shows reestimates of the same model but with the industry origin dummies also included in the age-dependent vector. This specification does not look promising. Although the age-independent effects of (5.1) persist, none of the additional terms is significant.

Using the logic of planned contrasts to ensure independence of tests (see Hays, 1973: 588–593), the final two columns in the table report estimates of models designed to highlight comparison of life chances of engine, bicycle and carriage manufacturers. Model (5.3) uses data only from these three origin types of *de alio* producers; all other cases are excluded from the analysis. This model again omits the engine manufacturing category and represents a modified reestimate of (5.1).[18] As before, this evidence suggests strongly that bicycle and carriage manufacturers experienced better fates in autmobile production than did engine manufacturers. These findings do support the milquetoast Hypothesis 5. But they do not support the more specific translation of this hypothesis (about engine manufacturers) we advanced based on our reading of automobile history and the strategy literature.[19]

What about possible differences between the fates of bicycle and carriage manufacturers? Model (5.4) presents an independent test based on data only from these two industry origins; other types are excluded. Here the omitted category represents bicycle manufacturers. Because analysis shows that the difference is not significant when the carriage dummy is included in the age-independent vector, Model (5.4) includes it only in the age-dependent vector.[20] As shown, the effect here is negative and significant. This finding tells us that initial mortality differences between bicycle and carriage manufacturers are minimal. But the estimated model also says that with age, the rate for carriage manufacturers becomes increasingly lower. Figure 4 presents a plot displaying this relationship.

Table 6 presents models estimated separately for *de novo* and *de alio* producers. These estimates speak directly to Hypothesis 4, which holds that both types of entrants will be nonmonotonically density dependent. For each type we report a conventional specification of the density model. The estimates show that the mortality rates of both types of entrants depend nonmonotonically on density. First- and second-order terms of density follow expected directions and are statistically significant for all estimated coefficients except one. So too are the density delay terms.

Comparing estimates across types of producers, we find it interesting that absolute values of the density coefficients are larger in every instance in the *de alio* equations. We view this as a potentially important general finding that to our knowledge has not been reported before. We also note the effects of size are considerably stronger for the *de novo* producers and the effects of age are fairly similar for the two types of producers.

DISCUSSION

We began by noting two potentially contradictory themes about organizations in the strategy literature. On the one hand, a number of theories and analyses extol the virtues of related diversifi-

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[18] Coefficients for two of the period dummies could not be estimated with this reduced data set because of the limited variation.

[19] In another model, not shown here, we also examined directly whether the life chances of *de alio* entrants from engine manufacturing differed from those of *de novo* entrants. The estimated coefficient associated with engine manufacturing is positive in this model but it is not statistically significant.

[20] In terms of the equation shown earlier, this specification includes the carriage dummy as a Z variable but not as an X variable.

Table 5. Maximum likelihood estimates of Gompertz models of organizational mortality for *de alio* automobile producers 1885–1981 (standard errors shown in parentheses)

Equation no.	(5.1)	(5.2)	(5.3)	(5.4)
Constant	0.022 (0.232)	−0.008 (0.242)	1.39* (0.466)	0.907 (0.536)
$N(t)/100$	−1.11* (0.230)	−1.12* (0.230)	−1.68* (0.344)	−1.74* (0.437)
$N(t)^2/10{,}000$	0.154* (0.053)	0.153* (0.053)	0.305* (0.078)	0.349* (0.097)
$N(0)/100$	0.478* (0.072)	0.494* (0.074)	0.496* (0.099)	0.619* (0.138)
Size/1000	−0.080* (0.029)	−0.085* (0.030)	−0.038* (0.017)	−0.787* (0.160)
Industry Production	0.114 (0.083)	0.119 (0.084)	0.373* (0.174)	0.690* (0.191)
GNP	−0.289 (0.149)	−0.291* (0.149)	−1.64* (0.536)	−1.74* (0.661)
Periods				
Mass Production	0.292 (0.217)	0.269 (0.219)	0.538 (0.356)	0.017 (0.491)
Product Differentiation	−0.084 (0.456)	−0.077 (0.456)	3.49* (1.74)	
Bicycle Producer	−0.429* (0.187)	−0.495* (0.226)	−0.551* (0.193)	
Carriage Manufacturer	−0.591* (0.138)	−0.507* (0.172)	−0.617* (0.146)	
Dealer	0.138 (0.220)	0.348 (0.269)		
Other Motor Vehicle	−0.208 (0.164)	−0.154 (0.201)		
Components	−0.230 (0.331)	−0.465 (0.541)		
Other Industries	−0.209 (0.123)	−0.179 (0.148)		
Age(0)	−0.014* (0.005)	−0.014* (0.005)	−0.006 (0.005)	−0.004 (0.005)
Age	−0.091* (0.011)	−0.076* (0.029)	−0.078* (0.017)	0.018 (0.028)
Bicycle Producer × Age		0.008 (0.036)		
Carriage Manufacturer × Age		−0.026 (0.034)		−0.101* (0.027)
Dealer × Age		−0.094 (0.079)		
Other Motor Vehicle × Age		−0.021 (0.045)		
Components × Age		0.123 (0.201)		
Other Industries × Age		−0.013 (0.032)		
log *L*	−1156.1	−1154.4	−538.0	−369.0
N	2690	2690	1427	1053

$^*p \leq 0.05$

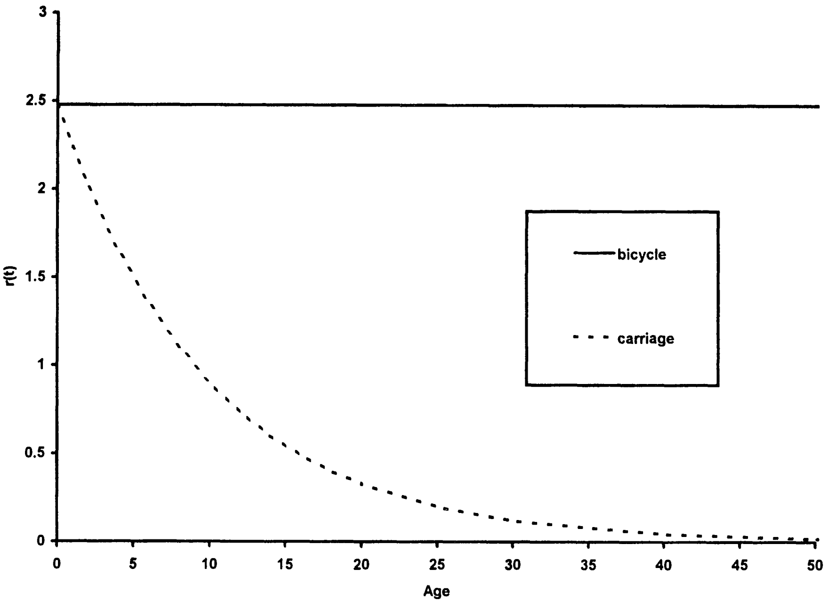

Figure 4. Comparison of bicycle and carriage manufacturers from Equation 5.4

cation, asserting as rationale the expected competitive advantage of skills and expertise obtained in prior industries. On the other hand, some other theories and analyses claim that new organizations carry the advantage. By this view, not only do new organizations get set up specifically for the tasks at hand, they also move more nimbly and learn faster. Older organizations, by contrast, suffer from the obstacles of inertia.

Our proposed synthesis of these seemingly disparate themes does not take the usual tack of trying to bound theories by industries of applicability. Instead, we believe that each theme's insights arise from the operation of processes that affect organizational outcomes at different stages of the life cycle. Early in an organization's life, we think that the skills, knowledge and other assets accumulated in prior periods of planning, organizing and operating in related industries give the organization an advantage over those without such periods. Later in the life of an organization, however, these same factors diminish in importance and likely create inertial drag, at least relative to new organizations.

The synthesized argument implies that *de alio* entrants and *de novo* entrants with preproduction periods will have lower initial mortality rates but that mortality of these firms relative to others will increase with age. In models of declining age dependence, the implication is that *de alio* firms and *de novo* firms with preproduction periods will have rates that decline more slowly with age than those of other *de novo* firms. The empirical findings reported above on the American automobile manufacturing industry generally fit these predicted patterns. Both *de alio* entrants and *de novo* entrants with preproduction periods show lower initial death rates. And both show slower declines in the rate with age than other *de novo* producers, although this effect is not statistically significant for *de alio* producers. We conclude that the insights of each theme are real and that there is merit in exploring further the life cycle synthesis advanced here.

A second major focus of our efforts involved exploring the sources of advantage of various *de alio* entrants relative to each other. Our data here allow us to explore variations in fate as a function of origin industry. Relevant theories do not get very specific in making predictions about the sources of advantage, except to imply that they will vary across origin industries. However, we believe that most analysts would think that in automobile manufacturing those coming from engine manufacturing would possess important skills, knowledge and other resources giving them an advantage.

This turns out not to be the case. By our empirical analysis, the greatest longevity advantages in automobile manufacturing accrued to

Table 6. Maximum likelihood estimates of Gompertz models of organizational mortality for *de novo* and *de alio* producers (standard errors shown in parentheses)

Equation no. Type of founding	(6.1) *De novo*	(6.2) *De alio*
Constant	−0.493* (0.155)	−0.036 (0.217)
$N(t)/100$	−0.492* (0.155)	−1.06* (0.211)
$N(t)^2/10{,}000$	0.047 (0.034)	0.149* (0.047)
$N(0)/100$	0.256* (0.048)	0.428* (0.064)
Size/1000	−0.191* (0.033)	−0.097* (0.033)
Industry production	0.031 (0.047)	0.104 (0.080)
GNP	−0.276* (0.089)	−0.508* (0.200)
Periods		
Mass Production	0.522* (0.147)	0.363 (0.208)
Product Differentiation	0.473 (0.256)	0.522 (0.497)
JIT/TQC	−0.743 (0.391)	1.60* (0.731)
World War II	−0.760 (1.02)	−0.416 (1.04)
Age	−0.087* (0.010)	−0.093* (0.011)
Log *L*	−2425.9	−1422.05
N	5493	3132

$*p \leq 0.05$

bicycle and carriage manufacturers. Both origin industries show significantly lower rates of death than other *de alio* entrants, including especially engine manufacturers.

Why? What sources of advantage did bicycle and carriage manufacturers enjoy? Answers at this point can only be speculative, of course. But several of them leap out from the relevant historical literature. First, bicycle manufacturers played a central role in developing technology relevant to automobiles. As Flink (1988: 5) explains:

> key elements of automotive technology that were first employed in the bicycle industry included steel-tube framing, ball bearings, chain drive, and differential gearing. An innovation of particular note is the pneumatic bicycle tire . . . The bicycle industry also developed techniques of quantity production utilizing special machine tools, sheet metal stamping, and electric resistance welding that would become essential elements in the volume production of motor vehicles.

To a lesser extent, similar technological spillovers came from carriage making. Second, despite the importance of propulsion technology, engines could be purchased from others. And, knowledge about engines disseminated widely: 'no development of importance in automotive technology went unreported in one or another of engineering journals, bicycle periodicals, automobile trade journals, newspapers and popular magazines of the day' (Flink 1988: 13–14). Third, bicycle and carriage manufacturers frequently had experience in marketing and in retail sales and service. It seems less likely that engine manufacturers did. Fourth, both bicycle and carriage manufacturers understood best the enormous problems of assembly entailed in automobile production. In fact, efficient assembly may well be the most difficult organizational problem faced by automobile producers. Historian of technology Hounshell (1984: 190) points to it as the critical factor confronting producers of all kinds around this time. He notes that 'despite the refinement of "old" manufacturing technology and the introduction of new techniques, the bicycle industry merely exposed and did not solve the fundamental problem in the production of complex consumer durables: assembly.'

We think that if engine technology diffused rapidly, then relevant bicycle and carriage technical matters would have also. We also believe that if retail sales experience was critical, then we would have seen *de alio* producers who had been automobile dealers do better. So we conjecture that the gist of Hounshell's analysis holds here, that assembly knowledge and expertise propelled both bicycle and carriage manufacturers into automobile production with an advantage. But that still does not explain why carriage manufacturers show the lowest rate of death of all origin industries, lower than bicycle manufacturers and increasingly lower with age.

Again, speculation must carry the day. We offer three observations. First, and most simply, we note that assembly of carriages more clearly resembled assembly of automobiles than did that of bicycles. In fact, many early cars consisted essentially of carriages with engines and power-train mechanisms—the automobile was initially coined the 'horseless carriage' for good reason. The second observation concerns a possible difference in the labor systems of bicycle and carriage manufacturers. From the few firms for which we have been able to find information on their labor contracts, it appears that inside contracting may have been the usual nature of contracting in bicycle manufacturing while wage and piece rate systems perhaps prevailed in making carriages (Hounshell, 1984; Snyder, 1984; Goldman, 1987). Inside contracting is a system whereby the manufacturer engages in bargaining with independent contractors who operate inside the manufacturer's factory. Typically, inside contracting results in agreements in which the contractor agrees to deliver a finished or assembled set of components for a fixed price, thereby assuming most of the risk. The difference between inside contracting and wage labor is potentially important because automobile manufacturing firms with inside contracting systems never obtained real information on assembly costs (because the contractor would hide it) whereas the others did. Obviously, improvement and learning would be easier to manage with accurate cost data in hand. Third, a perverse exit barrier may have been at work, preventing carriage manufacturers who stumbled from returning to their prior industry as easily as could bicycle builders. Recall that carriage manufacturers rushed into automobile production in large numbers as late as 1910 (see again Figure 2). By then the carriage industry's viability had clearly waned,[21] essentially trapping those who had diversified into automobile production.

These last two observations—about wage systems and about exit barriers—seem buttressed by census data on the distribution of organizational forms in the early bicycle and carriage manufacturing industries (U.S. Bureau of the Census, 1902). Over 50 percent of the bicycle manufacturers operating in 1900 were incorporated companies, about 30 percent were individual operators and less than 20 percent were limited partnerships. By contrast, only 6 percent of carriage manufacturers used the incorporated company form and over 70 percent were individual operators. In our view, the incorporated companies seem more likely to have adopted complex labor arrangements such as inside contracting. Incorporated companies also probably retained their manufacturing bases in the origin industry when they diversified into automobile manufacturing whereas individual operators were more likely to actually switch industries. If so, then individual operators would be more likely to get trapped by exit barriers.

Finally, we note that findings reported here confirm and extend organizational ecology's density-dependent model of legitimation and competition. All estimated specifications of organizational mortality show the expected patterns of, first, nonmonotonic U-shape relationship with contemporaneous density and, second, persisting positive effect of density at founding. Moreover, these patterns hold separately for mortality of *de novo* and *de alio* producers, although the effects are considerably stronger for *de alio* types. We regard this difference as interesting and worthy of future theoretical and empirical effort.

We also find intriguing the effects of age and size observed for *de novo* and *de alio* producers. In similar previous work on medical sector producers, Mitchell (1994) found that size effects did not differ but that the age effect is stronger in *de novo* firms. By contrast, our estimates reveal similar age effects but a much stronger size effect for *de novo* producers. We are not sure why these different results obtain but we suspect that our findings are tied to the density findings.[22] Whatever it is that makes *de novo* producer death rates more size-sensitive likely also plays some role in making these firms less density dependent. For the moment this puzzle remains on our drawing boards.

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[21] It is interesting to note, however, how late many carriage makers came to understand the threat the automobile presented to their industry (see Snyder, 1984).

[22] Mitchell (1994) does not report a specification allowing density effects to vary across entrant types.

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