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TOWARDS AN ECOLOGICAL UNDERSTANDING OF FIRM FOUNDING AND GROWTH IN EMERGENT POPULATIONS

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ABSTRACT

Organizational ecology is a fast growing domain in organization theory. During the past few years, the theory has evolved from a collection of rather unrelated concepts towards an integrated model of failure and founding, which has been tested with advanced empirical techniques. Despite this increasing convergence within the ecological boundaries, little integration occurs with other intellectual streams which can either be considered as complementary to the density dependence model or as a challenge to the basic assumptions of this model. This paper presents both a review of the theoretical and empirical methods developed during the past five years and an assessment of future research opportunities: can institutional theory, strategic management and industrial economics enrich and stretch the boundaries of the ecological model?

INTRODUCTION

Population ecology represents a collection of theoretical concepts such as resource partitioning, niche theory, density dependence, most of which were introduced in Hannan and Freeman's seminal paper on the population ecology of organizations (1977). Especially the density dependence model, which states that the competing processes of legitimation and competition create a curvilinear relationship between organizational foundings and dissolutions, received much empirical attention in the early and mid-eighties.

This emerging stream of research resulted in a first review by Carroll (1984), who placed the population ecology in general and density dependence in particular in a broader theoretical perspective. Elaborating on the three levels of analysis, which were initially described by Hannan and Freeman (1977 : 933-934) -- the organization, the population and the community --, he stressed the need to introduce variables at each of these levels in further empirical research. Since then, the growing body of empirical research which combined these levels of analysis was classified under the term organizational ecology.

In 1990, a second review on organizational ecology was co-authored by Singh and Lumsden. In this work, they comprehensively classified the empirical research into studies of foundings, disbandings and organizational change. In addition, they analyzed which of the theoretical concepts (such as resource partitioning, density dependence, liability of smallness, liability of newness...) were most frequently tested in those studies. Consistent with the historic evolution of the field, they found that the density dependence model was the most well-researched model, especially in studies of organizational mortality. Unfortunately, this very same model turned out to be also the most controversial concept of population ecology (Delacroix and Rao, 1994). As a response, it was suggested that future research should on the one hand further explore the density variable at different levels of analysis (such as the community versus the population) ; while on the other hand much more research was needed to explore the other theoretical concepts, especially in studies of founding and organizational change.

Both the increased availability of detailed data and the presence of these theoretical concepts, waiting to be tested, has stimulated an exponential number of empirical efforts in this field. In addition, the increasing visibility of this research stream attracted scholars from other fields both inside (e.g. institutionalism, neo-institutionalism) and outside sociology (e.g. strategic management) to jump on the ecological bandwagon. In turn, this snowball effect has recently stimulated scholars in organization ecology to combine some of their concepts with established theories in industrial economics, technology management and organization theory.

But not only did organizational ecology converge with other domains at the theoretical end of the spectrum. An increasing number of researchers borrowed and introduced empirical models and techniques from other domains. For instance, whereas empirical studies of the density dependence model without exception used a form of event history model to analyze the impact of density on organizational mortality, more recent efforts applied fixed and random effects models -- traditionally econometric tools -- to study models of organizational change and growth. This mushrooming of efforts has significantly blurred both the theoretic and empirical research boundaries of organizational ecology.

As a result, during the nineties, major theoretical and empirical advances have significantly contributed to the theory. Consistent with the two previous reviews, this paper not only aims to describe comprehensively the major developments made in the theory, especially during the nineties, but it also tries to evaluate and classify these efforts in different distinct categories and to formulate directions for future research. In addition and in contrast to the two previous reviews, however, which solely concentrate on the theoretical part of the field, this review also describes and critically evaluates the developments in empirical methods and techniques which have become more prominent during the last years. To this end, the paper is organized in two main parts: the first part focuses on the development of theoretical concepts and the convergence of these concepts with theoretical ideas from industrial economics, strategic management, instutionalist theory and technology management. The second part focuses as well on the empirical techniques which have been developed to test the main hypothesis and their integration with econometric regression methods as on the empirical operationalization of the theoretical concepts proposed in the first part.

PART I: THEORETICAL CONCEPTS AND MODELS

I.1. THE BASIC DENSITY-DEPENDENCE MODEL

In their seminal paper on population ecology, Hannan and Freeman (1977) have introduced a novel model to study the impact of density, i.e. the number of organizations in a population, on mortality and founding rates. Underlying is the Lotka-Volterra Model of population growth, which assumes a linear relationship between mortality rate and population size. In the early stages of a population or an industry (or, more in general, a new domain, Gray, 1985), growth in numbers 'legitimates' this kind of population, thereby increasing the founding rate of new organizations and decreasing their mortality rate. However, as density continues to increase, competition overwhelms legitimation and decreases founding rates while increasing dissolution rates. In addition to the time-varying density, almost all initial models also include a measure of 'density at the time of founding'. This population ecology argument dates back to Stinchcombe (1965), who has argued that the 'features acquired by founding are carried by organizations throughout their life cycles'. Organizations that enter an industry or are founded under 'high density'-conditions cannot build up sufficient slack resources and remain very vulnerable to changes in the environment.

Concluding, we can state that the baseline 'population ecology' model makes four claims (Hannan and Carroll, 1992 ; Miner, 1993, p. 356-357):

> Density at time of founding permanently increases mortality rates (and decreases founding rates).
>
> Contemporaneous density has a curvilinear effect on founding rates, increasing them at low levels, but decreasing them at high levels and an equally nonmonotonic relationship with failure rates, initially decreasing them but eventually increasing them.

----INSERT FIGURE 1 ABOUT HERE----

Part A in figure 1 represents this baseline density dependence model. Part A, B and C include the further extensions of the model which will be discussed later on in this paper. An excellent review of the studies that focus on the density dependence hypothesis can be found in Singh and Lumsden (1990:174-175) and more recently in Delacroix and Rao (1994: 256-257). Table 1 is an updated summary of Singh and Lumsden's review of density dependence.

----INSERT TABLE 1 ABOUT HERE----

I.2. DENSITY DEPENDENCE REVISITED

Despite its increasing popularity, the density dependence model has received major criticism both on a theoretical (Zucker, 1991 ; Barnett and Amburgey, 1990) and an empirical basis (Petersen and Koput, 1991). Zucker (1991) argued that population ecology misuses the concept of *legitimacy* to attach an ex post explanation to the empirical finding of curvilinearity (between density and rate of founding/mortality). However, there is no theoretical basis to explain this concept of legitimacy, nor have population ecologists operationalized the concept in measurable variables. Next, the density variable, which is a mere count of numbers, represents a very naive view on the concept of *competition* (Barnett and Amburgey, 1990). Indeed, density suggests that each organization, regardless of size, influences competition in a similar way. This result is not only counter-intuitive. Also does economic theory suggest that larger organizations have a different impact on competition than smaller ones.

On the empirical side, Petersen and Koput (1991) have shown (through a large number of simulations) how unobserved heterogeneity can account for the decreasing part of the mortality-rate curve. Unobserved heterogeneity stands for the specification bias, which results from omitting one or more variables from the data set that are known or believed to be correlated with the dependent variable.

These critiques have inspired scholars of the density dependence model to extend the model in many creative ways. Especially, the problem of unobserved heterogeneity has received much attention. Interestingly, dealing with this problem has led to the convergence of the density dependence model with other theoretical concepts such as liability of small- and newness and resource partitioning. Studies have linked the theoretical rationale behind these concepts with indicators of unobserved heterogeneity, both at the level of the firm and the subpopulation. In contrast, population ecology itself seemed to be much less able to address the theoretical questions related to the concepts of competition and legitimation. But the mechanism behind competition has been a major focus of interest in industrial economics (Tirole, 1988) and legitimacy has received most attention in institutional theories of organization (Zucker, 1987 ; Gray, 1985).

In the next two paragraphs we will discuss how population ecologists have dealt with the issues of unobserved heterogeneity through the introduction of variables at the firm and niche level (see part C and D of figure 1). In the third and fourth paragraph of this section, we will analyze the convergence of population ecology with economic and institutional theory.

I.2.1. Unobserved Heterogeneity at the Firm Level: Introducing the Concepts Liability of Newness and Liability of Smallness in Density Dependence Models.

Liability of Newness versus Liability of Senescence

The 'age' of an organization has been used as one of the first variables to capture unobserved differences between firms. The theoretical explanation goes back to Stinchcombe's (1965) observations that new organizations have higher failure rates than older ones, which is known as the 'liability of newness'. Hannan and Freeman (1984) have subsequently made the same observation, which they explained by an evolutionary argument: They argued that in modern societies organizations with high levels of 'reliability' and 'accountability' are favored by selection processes. Singh and Lumsden summarized (1990:168):

> 'Reliability and accountability of organizational forms require that the organizational structure be highly reproducible. Due both to processes of internal learning, coordination, and socialization within the organization and to external legitimation and development of webs of exchange, the reproducibility of organization structure increases with age. Because greater reproducibility of structure also leads to greater inertia, however, organizations become increasingly inert with age. And since selection processes favor organizations with inert structures, organizational mortality rates decrease with age -- the liability of newness....'

Most of the early studies that included age as an explanatory variable have found a significant negative (monotonic or in some particular cases non-monotonic or inverted-U shaped) relation between age and mortality (which supports the liability of newness hypothesis). Regardless of the direction of this relationship, the fact that age has a significant relationship with mortality suggests that the variable might count for part of the unobserved heterogeneity. In a reply to Petersen and Koput (1991), Hannan, Barron and Carroll (1991:411) reported:

> 'when age is controlled, only three of ten replications have a significant negative effect of density. This result leads us to question Petersen and Koput's assertions that the unobserved heterogeneity explanation is conservative and that spurious density dependence will generally be true in the presence of negative age effects at the organizational level.'

Still, despite this reply and the subsequent use of age as a control variable in many new density dependence studies, both the use of age as an operationalization of the liability of newness concept and as a solution to the unobserved heterogeneity problem remains controversial at least. First, age is used as a proxy for a number of processes which may but also may not be correlated with it. For instance the speed of development of organizational routines is likely to differ between organizations due to structural and cultural factors. Hence, the variation of these processes for organizations of the same age cohort might be so large that age turns out to be a very poor construct. On the other hand, other unobserved variables (e.g. size, financial resources) might be better correlated with the age variable than those which belong to the liability of newness hypothesis strictu sensu.

Second, the 'birth' of an organization is not an idiosyncratic instance, such as the birth of a biological species. In general, two different dates of origin can be defined: Following the economic tradition, one can define the age of an organization or business unit as the number of years that organization or business unit has spent in this particular industry or population. In this case, the focal organization might be a newly founded start-up, or a newly founded business unit of a parent which already exists in another population or industry. Second, age can be defined as the number of years elapsed since the founding of the ultimate parent, regardless of the population or industry in which this parent was founded. In the first case, the liability of newness refers to the industry-specific routines which have been created, while in the second case the organization-specific routines are the central factor of interest. Although there are examples of density-dependence studies which use one of both operationalizations of age (see Table 2), as far as we know, no study has compared them.

More recent studies have challenged the liability of newness hypothesis by including size as a control variable (Barron, West and Hannan, 1994; Carroll and Swaminathan, 1992). Although most studies that control for size report a positive relationship between age and mortality, in a number of cases, this positive effect was not or only marginally significant (Carroll and Swaminathan, 1992).

Barron, West and Hannan (1994) have called this positive effect the 'liability of senescence' which means that older organizations have organizational routines that do not fit anymore in the current environment and that henceforth form an overhead cost which makes the organizations more vulnerable towards acquisition. In earlier work, Carroll (1983) had already tried to explain a similar finding by introducing the 'liability of obsolescence' concept. Basically, he states that (p. 313):

> 'organizational age will coincide roughly with the amount of environmental change experienced by an organization. If this tendency holds on average and core structures are "imprinted in youth", then older cohorts of organizations have lower fitness in the current environment. If this image of organizational development is right, then mortality rates increase with age.'

As a conclusion, we can state that the liability of newness or the liability of senescence may count for some of the unobserved heterogeneity. However, organizational size seems to be a better variable. Although recent research seems to favor the liability of senescence hypothesis, the positive relationship between age and mortality rates is sometimes based on a marginal significance (see Table 2).

----INSERT TABLE 2 ABOUT HERE----

Liability of Smallness

As suggested in the previous paragraph, size might be a better variable to capture unobserved heterogeneity. The relationship between size and mortality is known as the liability of smallness hypothesis. The theoretic rationale behind this hypothesis dates back to Hannan and Freeman's original paper on population ecology (1977), in which they state that 'the appropriate time scale for a selection process increases with the size of the organizations under consideration'. Population ecologists have given two main reasons for this liability of smallness phenomenon. A first explanation is given in Singh and Lumsden's review (1990:176):

> '....the level of structural inertia increases with size....since selection processes in modern societies are such that they favor organizations with greater structural inertia (i.e. inert organizations have lower mortality rates) larger organizations must have lower mortality rates...'

Barron et al (1994:388) analyze the liability of smallness hypothesis from a slightly different point of view...

> '...large organizations can retrench by reducing their scale of operations over long periods of poor performance before they are forced to disband. Small organizations have little room to contract, and they fail quickly once fortunes decline ...'

Other explanations focus on the fact that large organizations have more 'slack resources' on which they can rely during periods of environmental change (Haveman, 1993). Slack resources facilitate experimentation with new strategies and products and facilitate entrance in new markets because it buffers organizations from downside risks.

Most of the early empirical studies support the 'liability of smallness hypothesis' (i.e. negative monotonic effect of size on mortality rates), which has become conventional wisdom in organizational theory. The liability of smallness hypothesis was also consistent a long tradition of empirical economic studies on the size distribution of firms. This stream of research, which was initiated by Simon and Bonini's seminal article (Simon and Bonini, 1958), had traditionally found that in most industries the distribution is lognormal. Although most economists relied on Gibrat's law of proportionate growth to explain this kind of distribution, the lognormal distribution is also the result if the liability of smallness hypothesis receives support. For example, small organizations might face consistently more problems than large organizations, which increases their mortality rates.

The availability of larger and better data sets, however, has resulted in a number of studies which suggested that the correct relationship between size and mortality is a non-monotonic one, which means that neither Gibrat's law nor the liability of newness hypothesis receive unrestricted support (Evans, 1987; Hall, 1987; Wholey, Christianson and Sanchez, 1992). Other studies on the other hand still find a monotonic relationship between size and mortality (Barron, West and Hannan, 1994).

Resource partitioning theory, which is another subject of interest in organizational ecology, gives a theoretic rationale for such a non-monotonic relationship. Resource partitioning suggests that mortality rates will be highest for organizations in the center of the size distribution, while lower for those organizations that are more located towards the tails of the distribution. The rationale behind this is quite simple: small and large organizations use different resources and therefore do not compete with each other. Organizations of medium size, however, are stuck in the middle and compete both with the small (and often specialized) organizations and the large (and often generalist) organizations for the same resources. Therefore one should aspect higher mortality rates in this cohort of organizations (Wholey, Christianson and Sanchez, 1992). Amburgey, Dacin and Kelly (1994) have called this kind a *disruptive* selection, which results in a bimodal size distribution.

Neo-classic economic theory, in contrast, seems to adhere a U-shaped relationship between size and mortality. Economists, in general, state that there exists an 'optimal efficient size' at which unit costs of production are minimized. Failure rates should be lowest at this 'optimum' point while increasing when an organization moves towards one of the tails (e.g. when it enters the zone of inefficiency).

Amburgey, Dacin and Kelly (1994) suggested in a recent study that the relation between size and mortality is even more complex than a simple U- or inverted U-shaped relationship. In fact, the diverse hypotheses suggested by the resource partitioning and the liability of smallness concept should not be seen as substitutes, they rather complement each other. Therefore, they hypothesized that the relationship between size and mortality even takes a cubic form. Their hypothesis was confirmed in a study on Credit Unions between 1981-1989 (see Table 3).

----INSERT TABLE 3 ABOUT HERE----

Based on the discussion in the previous two paragraphs, we might conclude that the introduction of age and size as explanatory variables in the density dependence model, indeed reduces unobserved heterogeneity but at the same time the relation between age, size and mortality seems to be much more complex than initially thought. However, introducing age and size in the density dependence model has had much more profound consequences for organizational ecology as an intellectual stream than simply addressing the question of unobserved heterogeneity. First, it has blended a set of independent theoretical concepts into one coherent model. Second, the level of analysis has thereby changed from the population to the organization (or to be more correct, the organization-spell[1]). This change in the level of analysis opens the door to integrate organizational ecology with other streams of research which have traditionally put greater emphasis on the organizational level of analysis. Moreover, mixed support for both the liability of smallness and newness/senescence hypotheses suggest that a more detailed analysis is necessary (for instance making a distinction between acquisition/merger, bankruptcy and voluntary liquidation as different instances of disbanding, introducing other variables related to the history of the organization or the population). We will return to this integration of organizational ecology with other theories in the next paragraphs.

Of course, unobserved heterogeneity does not necessarily (under certain circumstances can not even) be solved at the micro-level of the single organization. Longitudinal data at this level of analysis are difficult to obtain and are sometimes completely absent (e.g. when entry rates of start-up firms rather than mortality rates are

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[1]namely each time period that an organization is observed.

the focal point of interest). Therefore, organizational ecologists have started to disaggregate the density variable towards the mezzo-level of analysis, that of the subpopulation or niche. It is assumed that organizations in these niches form a homogenous set of competitors. In the next paragraph, we will discuss the various dimensions along which these niches have been constructed.

I.2.2. DISAGGREGATING THE DENSITY VARIABLE: INTRODUCING THE NICHE AS A MEZZO-LEVEL OF ANALYSIS

In organizational ecology, the aggregate 'density' variable models competition as a function of the organizational resource requirements. Hence, organizations with equal resource requirements are perfect competitors. The more similar the resources required by a set of different organizations, the more intense the competition is within this set of organizations.

The aggregate density variable does not necessarily capture the effects of 'heterogeneity' in resources which may alter the competition between firms. In other words, within one industry, there may exist subpopulations of organizations that draw on different sets of resources to compete within the aggregated population or market. Disaggregating the density variable towards the niche level, may correct for unobserved heterogeneity problems, both in studies of mortality *and* founding. Of course, these 'niches' directly result from the theoretical shortcoming in organizational ecology to define the boundaries of 'homogenous' populations. Indeed, it is very difficult to make a theoretical distinction between communities and populations on the one hand and populations and niches on the other hand.

It should also be noted here that the niche concept shows some similarities to the strategic group concept as elaborated in the strategic management literature (see McGee and Thomas, 1986 for a review). Both concepts categorize organizations into competitive groups. Niches differ from strategic groups in the instruments or dimensions used to make this categorization. Whereas strategic group researchers use a combination of more or less abstract variables such as age, employees, assets, etc., organizational ecologists typically select one dimension which seems to be a relevant source of heterogeneity in a particular population. Most studies have concentrated on one or more of the following three dimensions: location, size and market (although there exist isolated examples of other dimensions such as price, composition of the board, etc.).

First, organizational ecologists have used the spatial dimension to identify niches. Lacking real theoretical indications, Carroll and Wade (1991) and Swaminathan and Wiedenmayer (1991) experimented with a geographic disaggregation of the 'national' density variable into state/region and cities (see also Table 4). Their studies found only mixed support for this disaggregation. In a technically appealing effort, Baum and Mezias (1992) calculated the average distance of each hotel in the Manhattan hotel industry from all other hotels in Manhattan. In doing so, they further refined the spatial dimension towards the level of the organization. Their study was interesting in a sense that it found positive support for the hypothesis that location matters indeed with respect to mortality rates. But it is not clear at all whether bringing the variable to the organizational level of analysis really adds so much value. Finally, in a very recent study, Lomi (1995) has explicitly linked the geographic disaggregation of the density variable with the problem of unobserved heterogeneity (in studies of founding). Also he has found strong support for this disaggregation.

Despite these empirical efforts, geographic disaggregation remains based on weak theoretical grounds. One of the main reasons for this ambiguity lies in the multi-dimensional aspect of what organizational ecologists call 'the carrying capacity' of a population. The different dimensions of this concept may impose different boundaries on the population, which is assumed to be homogenous. For instance, the carrying capacity of a population of semi-conductor start-ups consists of the universities available (technical resources), financial support available (venture capitalists, public market, etc...), human resources available (Ph.D.'s, etc.) and suppliers available. Some of these dimensions are very local (for instance, it is known that highly trained personnel prefers to stay in the cities where they graduated or where first rate universities are available), whereas other dimensions are rather global (e.g. US venture capitalists operate in the whole US). Unfortunately very little research has been done so far to analyze the multi-dimensionality of the carrying capacity concept. We will come back to this and some other problems with carrying capacity in the conclusion of this paper.

A much better theoretical explanation exists for dividing organizations in different niches based on size. Resource partitioning launches the idea that organizations of different sizes use different strategies and structures, although they are engaged in similar activities. Therefore, organizations tend to compete most heavily with similarly sized organizations. Hannan and Ranger-Moore (1990) have proposed a way of measuring this kind of localized size-density, based on the Euclidean distances between the sizes of organizations that operate within a particular size-window (see the empirical part of this paper for a more detailed explanation of how to construct such a window).

The boundaries of the size window then co-incide with the boundaries of a niche. Although it is clear *why* such niches exist, organizational ecology gives little guidance in *how* to define the boundaries of these niches. Following Hannan and Ranger-Moore (1990), Baum and Mezias (1992) and Haveman (1993) have empirically determined the relative boundaries of a size window. However, there is no conceptual reason why in the first place these boundaries should be relative to the size of each organization nor what the relative borders of these windows should be (e.g. does an organization still compete with organizations which are twice as big, or is this the cut-off point). Therefore, the operationalization of these niches along the size distribution remains arbitrary. Part of the problem lies in the fact that size is used both as an underlying dimension and as a criterion to define the cut-off point. It would be more interesting to use other instruments (e.g. level of diversification, publicly traded or not, etc.) to determine cut-off points on the size distribution. In other words, if for instance larger organizations indeed compete in another manner than small ones, then those variables that characterize these organizations as big can be used as instruments to define cut-off points along the size distribution (e.g. financial resources, product portfolio).

Finally, a number of studies have used the 'market' as an underlying dimension to define niches. In doing so, they assume that the market can be used as an indirect measure of heterogeneity in resources. Baum and Mezias (1992, 1993) have segmented the Day Care Centers in Toronto according to the different age categories which those Day Care Centres were licensed to serve. This segmentation of markets only differs from a pure commercial one in the sense that Baum and Mezias use an 'institutional factor' (licenses issued) to form niches. Of course, if this institutional factor is treated as an endogenous variable (i.e. if one assumes that existing Day Care Centers can receive new licenses for other segments without much difficulty or cost), then even this institutional segmentation turns out to be a commercial one. Barnett (1991), in his study of the CEPS industry, has made a pure commercial distinction between different segments of the customer premises and service sector (1981-1986). Using markets or potential markets as a way to create niches links organizational ecology with strategic management research on differentiation and multi-point competition (Wernerfelt, 1984).

Barnett (1991) has explicitly made this link with the strategic management theory and has modelled the effect of differences between multi- and single-point competitors. Baum and Mezias (1992, 1993) did not go into such detail, although they have modelled the extent to which niches overlap (and hence organizations belong to different niches, we refer to the empirical part of this paper for a detailed explanation of this construct).

Table 4 gives a selected overview of the most important findings of those studies that have incorporated a disaggregation of the density variable.

----INSERT TABLE 4 ABOUT HERE----

In the previous paragraphs, we have occasionally referred to emerging links between organizational ecology and other intellectual streams such as institutional theory, industrial economics and, more in general, the strategic management literature. 'Unobserved heterogeneity' as a technical term, or the inability of the basic density dependence model to explain sufficiently founding and mortality rates within a population has stimulated researchers to incorporate hypotheses both from within and across the boundaries of density dependence. In the previous paragraphs we have mainly discussed the extension of the density dependence model with theoretical concepts that were isolated streams of research within the population ecology boundaries. In the next three sections, we will concentrate on a discussion of how population ecologists have started to use concepts from other fields and how, in turn, scholars that belonged to these other fields incorporated ecological concepts in their models of thought.

I.2.3. THE BLURRING BOUNDARIES OF ORGANIZATIONAL ECOLOGY: MAKING THE BRIDGE WITH INSTITUTIONAL THEORY, INDUSTRIAL ECONOMICS AND STRATEGIC MANAGEMENT THEORY

Organizational Ecology and Institutionalist Theory: On the Convergence of Small and Large Organizations.

From its first appearance on, population ecology has been seen as a potential supplement to the institutional theory (Zucker, 1987). Meyer and Rowan (1977) already hypothesized that the probability of survival increases when the organization is embedded in an institutionalized environment. However, traditionally, institutionalism has been a theory for large organizations. Organizational ecology provided the opportunity to apply the institutional concepts to a population which consisted both of small and large organizations. Carroll and Huo (1986) were among the first to model the institutional environment as an explanatory variable for mortality rates in a population of newspapers. Following them, most organizational studies included changes in the regulatory environment at least as a control variable in their density dependence model. It took until 1991 before hypotheses were tested at the organizational level of analysis. Baum and Oliver (1991) and Miner, Amburgey & Stearns (1990) measured the impact of the 'institutional' embeddedness on mortality rates. Both studies have found support for Meyer and Rowan's hypothesis that institutional embeddedness in general enhances chances to survive. In addition to this, Baum and Oliver (1991) have investigated the interaction between intensity of competition and institutional embeddedness. They have found that institutional embeddedness is most beneficial under conditions of dense competition.

Despite these promising efforts, the convergence between institutionalism and ecology has been disappointing, so far. Much effort has been put in the debate of legitimacy, which has been focused mainly on the issue of left-censoring of a population's history. In the meanwhile, appealing opportunities have been left aside. Aldrich and Fiol (1994) recently developed an interesting framework for research at the population level which states that the extent to which entrepreneurs succeed both in building intra- and inter-industry links with other organizations (besides linkages with the regulated environment) will affect the legitimacy building period in emerging industries. In this way, they provide a direct measure of legitimacy building beyond the mere count of numbers, which is proposed by organizational ecologists. It is also useful to extend this line of thought to the firm level to look how inter-firm differences in social actions affect the individual survival chances of an organization.

In line with the institutional tradition on the adoption of innovation which states that adoption can only be explained on a rational basis for the pioneering organizations but that as diffusion proceeds the explanatory power of the variables decreases significantly (Zucker 1987:453), Haveman (1993a) argued that the decision to diversify (or enter a new, related, subdomain) is largely based on irrational factors such as 'mimetic isomorphism' (Powell and Dimaggio, 1983). In doing so, she includes the institutional argument in the density dependence model, applied to a field which was classically the work terrain of strategic management scholars, namely that of diversification. This increasingly important link between the two fields will be the subject of our next paragraph.

----INSERT TABLE 5 ABOUT HERE----

Organizational Ecology and Studies of Strategic Change: Incorporating Strategic Management in Population Dynamics.

Disaggregating the density variable towards the niche level of analysis and changing the focus of analysis towards the organizational level opens the door to the strategic management literature, which has traditionally focused on these levels of analysis. The convergence of certain domains in both fields also results from the renewed interest that organizational ecologists have shown in strategic change. Research on strategic change is not new in organizational ecology however.

Hannan and Freeman (1984) posed three main research questions regarding strategic change: (1) does the probability of organizational change increase when confronted with environmental changes? ; (2) does the probability of organizational change decrease over an organization's life cycle? and (3) does the probability of organizational failure increase as a result of organizational change? In their model of structural inertia, they suggest that forces of inertia will have a different impact on the probability of strategic change in the core activities versus strategic change in the peripheral activities of organizations. Age and size, which are both used as proxies for bureaucratic inertia, are hypothesized to have a positive effect on change in the peripheral activities but a negative one on change in the core activities. It should be noted that the distinction between core and peripheral activities is very much related to the resource-based view of the firm which is gaining increasing attention in the strategic management literature (Wernerfelt, 1984).

Hannan and Freeman's hypothesis is further investigated in Kelly and Amburgey's study of the US certificated air carrier industry between 1938 and 1987 (Kelly and Amburgey, 1991). They did not find any support for the hypothesis that change in the environment affect the rate of strategic change, but they found a negative relationship between bureaucratic inertia and change in core activities and a positive one between bureaucratic inertia and change in the peripheral ones. Similar hypotheses were tested in a study of Finnish newspapers between 1771 and 1963 by Amburgey, Kelly and Barnett (1993). In this study, they also found support for the hypothesis that environmental changes affect the rate of change, but the different operationalization of the main constructs makes both studies very difficult to compare.

It is interesting that both of the above studies typically define strategic change as the transformation of a 'generalist' towards a 'specialist' organization. These questions are directly related to the wide stream in the strategic management literature which examines the reciprocal question about the motivations to 'diversify' (or to generalize). Ecological studies on strategic change and strategic management studies on diversification differ mainly on the methodological dimension: Whereas the former approach studies the hypothesis in a longitudinal framework that includes the 'population' of organizations, most strategic diversification studies have been cross-sectional and only include a sample of large organizations (which they hypothesize as being representative for the whole industry). However, spill-overs start to emerge. Hill and Hansen (1991) stressed the importance of longitudinal research in studies of diversification within the boundaries of one industry (or population). They have found in a study of the US Pharmaceutical industry between 1977-1986 that avoiding the uncertainty of investing in risky projects (which is related to what organizational ecologists call bureaucratic inertia) is the main causal factor behind the decision to diversify (or to become more generalized as an organization).

This important finding is at first sight contradictory with the organizational ecology one which stresses the negative influence of bureaucratic inertia on strategic change or diversification. However, organizational ecologists assume that the null hypothesis is no change at all. It seems acceptable that in certain populations change becomes so institutionalized that (e.g. through processes of mimetic isomorphism, Haveman 1993a) the null hypothesis is not valuable anymore and there has to be formulated a naive hypothesis such as the choice which involves the least risk (in this case diversification). Organizational ecology in turn may be able to translate this question to the whole population of organizations: in other words, is this hypothesis also valid for small organizations?

In addition to the social argument of bureaucratic inertia, organizational ecology can also benefit from incorporating arguments formulated by the different rational choice theories developed in the strategic management literature. Resource based theories of the firm stress the importance of an excess in resources as a reason to diversify (Penrose, 1959). For instance, in a longitudinal case study on the history of one firm, Baker (1992) has shown how changes in both the capital market and the number of MBA's mainly have affected the reasons to diversify and to divest. Since the capital markets in many populations form a dimension of what organizational ecologists call the carrying capacity of that particular population, including these variables in a model would allow to model changes in that carrying capacity as suggested by Brittain (1994). Of course, to do so, we have to assume that these changes are exogenous to the model (we will discuss this caveat later on in this paper).

As discussed in the previous paragraphs, organizational ecology shows also some similarities with the theory on strategic grouping. We refer to the previous discussion on the formation of niches and the impact of multi-point and single-point competition (Carroll, 1991).

Of course, in order to intensify the link between strategic management theory, organizational ecologists have to adjust their theory to larger organizations. Unlike small organizations, large ones have different levels of operation: there is the parent, the subsidiary, the division. Moreover, each of these operational units probably has a different date of founding. Small organizations die, but large organizations 'divest'. Small organizations are founded, but large organizations 'expand' or 'diversify'. While foundings and failings belong to the domain of the organizational ecologists, diversification and divestment (either through merger, acquisition or simply dissolution) are the domain of the strategic management scholar.

Mitchell's study on the American medical sector product market between the 1950s and the 1980s (Mitchell, 1993 ; 1994) is one of the first empirical efforts which further distinguishes between these different categories of entry and exit. Following Shary (1992), he shows that age, size and density have very different effects on the founding rates of small organizations versus the entry rates of diversifying established firms. Furtheron, the relationship between these variables with failure rates is shown to be very different from their impact on rates of divestiture.

More work is needed in organizational ecology to distinguish between these different entry and exit categories. However, industrial economists also turned their attention to this aspect (e.g. Shary, 1992 ; Dunne, Roberts and Samuelson, 1988). The link between industrial economics and economic theory in general with organizational ecology is the subject of the next paragraph.

Organizational Ecology and the Renewed interest in Industrial Organization for Dynamic Studies of Industry Evolution

Over the past decade, industrial economists have increasingly renewed their interest in longitudinal (dynamic) studies of industrial evolution (Jovanovich, 1982; Klepper and Grady, 1990; Jovanovich and MacDonald, 1994; Evans, 1987; Dunne, Roberts and Samuelson, 1988). In the models they developed, more and more attention is devoted to the competitive forces that determine the selection process in an evolving industry. Much of the debate between organizational ecologists and industrial economists has been focused on which forces create 'competition'. Organizational ecologists typically argue that competition directly results from the number of organizations in the population whereas industrial economists use more complex models of competition in which larger organization may influence the intensity of competition. Both intellectual streams use competition as an explanation for failure, foundings and growth in an industry/population.

In the density-dependence model, the intensity of competition depends simply on the number or density of organizations in a population. Although density might be a good count of selective pressures in biology, in economics, differences in organizational size are likely to alter the pattern of selection. Winter (1990:289) formulated two reasons why a mere count of numbers is too weak to capture the dynamics of competition: (1) large firms tend to be 'a lot larger' than small firms (several studies report a lognormal distribution of sizes). This means that large firms have a disproportionate impact in shaping the environment of the population and (2) entry and exit patterns are concentrated in the smaller size categories (this hypothesis is strongly confirmed by the empirical studies of Dunne, Roberts and Samuelson, 1988 ; Pales and Ericson, 1990).

Barnett and Amburgey (1990) introduced the concept of 'mass dependency' (see Figure 1, part B) to model the moderating effect of size on selection. The mass of a population is defined as the sum of the sizes of all organizations in this population. Selection may then result from two population dynamics : first, increases in the number of organizations (the density argument) affect the exit rates and second, also increases in the mass of these organizations, regardless whether this mass increase stems from the growth of one incumbent or from the entry of small organizations, can cause failure if the carrying capacity of the population is reached. In order to model the different impact that this mass variable has on the probability of failure of each individual organization, they operationalize mass at the organizational level as the total mass in the population minus the size of the focal organization at each of period of observation. Hence, mass has a smaller impact on relatively large organizations than on small ones.

In a study on US telephone companies (see Table 5), Barnett and Amburgey (1990) have found that mass did not suppress the selective effect of density. They came to the conclusion that 'mass' both had a negative effect on failure rates and a positive one on founding rates. In other words, large organizations decrease competition. Although these empirical results were unexpected in the organizational ecology framework, they are very consistent with Jovanovich's economic model on industry selection (Jovanovich, 1982). Much has to do with the operationalization of the 'mass' variable and the selection of the industry or population. Barnett and Amburgey defined mass as the sum of sizes defined as the number of telephones sold. This mass variable is little more than the demand function used by economists (see also Winter, 1990). As shown by figure 4.2 in Barnett and Amburgey (1990:88), this demand function is increasing over most of the relevant period of observation. The question of founding can then be re-formulated as what fraction of the increase in output (to match demand) is due to output changes by incumbent firms as opposed to changes -- through entry and exit -- in the number of firms. Jovanovich (p. 654) then predicts that, if price is constant over time and if incumbents choose to produce less on average in the next period due to expected decreases in efficiency[2], then increases in demand should be met by new

[2]see Jovanovich (1982:652) for a formal description of the conditions under which this happens.

entrants (these two conditions are very likely to be met if no technological breakthroughs take place which affect both expected efficiency and price and if the industry is not subject to ever increasing returns to scale). In the particular case of ever increasing returns to scale (or natural monopolies), Baumol, Panzar and Willig's (1982) contestable market theory might be applied. Consistent with Jovanovich (1982), this theory predicts that large increases in demand are likely to be met by new entrants in the industry which occupy (temporarily) contestable niches.

Also the negative impact of mass on failure rates can be explained by an economic model. Jovanovich (1982) basically presents a learning model in which organizations 'learn' their distinctive capabilities gradually during their stay in the industry. The more a particular number of companies 'learns' that they are more efficient, on average, the more they will increase their output and the larger they will be. As a result, the less efficient ones will exit early in the industry life cycle and concentration will occur when the industry matures. This means that there will be lesser exits if mass increases. Because the economic models are derived from analytic reasoning which has predictive power under certain assumptions whereas the population ecology theories are basically post hoc explanations for empirical findings, it is unclear if populations ecology really can add value in this case.

As shown in the previous paragraphs, competition is not only embodied in the foundings and disbandings, but also in the growth of individual companies. Studies of growth in economics have a long history, at least going back to Kapteyn's (1903) statements that growth is proportional to size and the factor of proportionality is random. In 1931, Gibrat argued that the size distribution of firms should be lognormal because of Kapteyn's growth process, better known as Gibrat's law. An extensive literature has tested Gibrat's law with mixed success (see Hannan and Ranger-Moore (1990) for an overview). As argued by Evans (1987), studies based on data for the late 1940s and 1950s typically find a positive relationship between size and growth (in other words, large organizations grow more than small ones), while studies based on data after the sixties typically show a negative relationship between size and growth.

Hannan and Ranger-Moore (1990) and Hannan, Ranger-Moore and Banaszak-Holl (1990) introduced a number of population ecology concepts in these models of growth. First, they have used the concept of carrying capacity to place an 'upper limit' on the growth of a population given a set of social, political and economic conditions (economists typically did not use such an upper limit). In this model, the growth of each organization depends on the sizes of all others (in the limit, when a population reaches the maximum carrying capacity, growth of one organization only goes at the expense of other organizations). As a result, carrying capacity causes a decline in mean size, when the size of the largest organization grows (for a formal description of the model, see Hannan, Ranger-Moore and Banaszak-Holl. 1990: 251).

In a next step, Hannan et al. included entries and exits in the model. Entries were modelled as a constant rate Poisson process which resembles the model used by Simon and Bonini (1958). Furtheron, they modelled a mortality process that reflects the 'liability of newness' and the 'liability of smallness' hypotheses which we have discussed above.

Interestingly, the results of their simulations suggest that the combination of the entry process, the mortality process and the concept of carrying capacity produces a mixture or a (split) distribution. Among other results, they report that (Hannan et al., 1990:253):

> '...The region to the left contains a subdistribution of new and recent entrants whose size distribution is essential lognormal. To the right there are a small number of older, larger organizations. As long as the flow of entrants continues unabated, the two subdistributions persist. The combined distribution is far from lognormal...'

In a second simulation, they relax "Gibrat's Law" which holds that growth rates are statistically independent of size to introduce growth rates that decline with size (still assuming a constant variance of the growth rate). The results are very different. The relaxation of Gibrat's Law produces a size distribution of firms which is not (statistically) distinguishable from a lognormal, but which shows an extreme concentration of the distribution. In other words, a large bunch of organizations has similar sizes. This is where organizational ecology again comes into the picture.

As discussed above, resource partitioning theory suggests that organizations in the 'middle of the size distribution' compete most intensely. They compete for resources both with the 'large' organizations and with the 'small' organizations. However, if this is true, this would result in a distribution with a center that is sparse, relative to the lognormal. The explanation of this result would lie in the concept of size-localized competition, which we have described in the previous paragraphs. When introducing size-localized competition (limited to discrete size windows), Hannan et al. (1990) find that the model with entries, mortality and carrying capacity indeed produces the expected results (at least under the assumption that Gibrat's Law holds). When relaxing Gibrat's Law to include rates of growth that decline with size, the model produces two isolated subpopulations, characterized by mean sizes that are lower than the ones expect under the lognormal distribution and with many more organizations in the global population than initially expected.

Building on these exploratory results, two empirical studies (the methodology of which we will discuss into greater detail in the empirical section of this paper) have analyzed the relation between location in the distribution, density dependence and growth rates. The first one analyzes Day Care Centers in Metropolitan Toronto between 1971 and 1989 (Baum and Mezias, 1993) and the second one analyzes Credit Unions in New York City between 1914 and 1990 (Barron, West and Hannan, 1994). Baum and Mezias (1993) found a significant relationship between size-localized density (in a discrete size window) and growth rates. Barron et al. (1994) did not look at size-localized density but tested the global density dependent model. They found an inverted-U shaped relationship between density and growth (but these results may be affected by a sample selection bias, see empirical section). They also found support for a relaxation of Gibrat's Law towards rates of growth that decrease with the size of organizations. See Table 5, for an overview.

Of course, although the empirical techniques (which will be discussed in detail in Part II of this paper) tend to converge between organizational ecologists and industrial economists, one can ask what the theoretical contribution is of organizational ecology to the theory of industrial organization. As shown in the previous paragraphs, organizational ecology seems little to add in our understanding of the competitive process embodied in foundings and disbandings *and* the only concept it adds to the studies of growth is the upper limit of growth, namely the carrying capacity of a population. Liability of newness and liability of size are post-hoc explanations for an empirical finding, which economists have modelled in a much more profound way (see e.g. the learning model of Jovanovich, 1982). Hence, can organizational ecology give some new insights?

Much of the controversy between both streams arises from the fact that both explanations are seen as substitutes to each other. However, we argue that much more can be gained if they are considered complements. Economists have a long tradition of studying existing industries, where demand is the central concept. Price competition, selection, etc all result from matching supply to demand. Operationalizing the concept of carrying capacity to industries or populations which are so demand driven (e.g. telephone industry) seems to add little value. Not an abstract concept of carrying capacity limits the growth of an organization, but demand does. Indeed, the empirical operationalization of 'mass' in Barnett and Amburgey's paper (1990) simply reflects demand. In its essence, demand is just what makes an organization independent from its 'resource environment'. Demand generates cash flow, which enables the organization or industry to influence its carrying capacity and to make it endogenous to the growth of the industry itself.

But not every industry or population has such a well-defined demand, nor does demand have an equal impact during the entire life cycle of the industry or population. It is exactly there, where demand and hence neo-classic economics fails to explain the selection process, that organizational ecology can make its largest contribution. First, some populations can be classified as 'non-commercial' such as the Labor Unions or Day Care Centers. In these populations, demand always plays a lesser role and neo-classic economics has little to say. Not surprisingly, the density dependence model has received most support in exactly those idiosyncratic populations.

Second, there are the populations or industries which are demand-driven during certain periods in their life cycle but not always. Most industries represent this category. Let us take the biopharmaceutical industry as an example. Economists will define the biopharmaceutical industry as those companies that *sell* biopharmaceutical products. Only revenues from product sales are taken into account and it is assumed that the total demand is sufficient to sustain the industry. However, more than a decade had passed after the founding of the first biotech start-up (Genentech, 1971) before the first biopharmaceutical product was sold on the US market (human insulin by Eli Lilly in 1982), another five years or so had passed before the first biotech start-ups started to sell a biopharmaceutical product (Genentech started to sell Protropin in 1986) and even in 1995 no more than 20 companies sell biopharmaceutical products and it may take another decade before product revenues are sufficient to sustain this industry. During those 25 years however, about 500 companies (both small biotech ones and large pharmaceutical ones) are estimated to be or have been active in biopharmaceuticals (see e.g. Ernst & Young, 1995). It is exactly during this period of the industry life cycle that the density dependence model can contribute most in explaining failure and success. Economic models can in turn gain from the density dependence findings to correct their sample selection problem which results from the fact that they treat this early period as non-existent. Although rather recent economic studies such as Evans (1987) and Hall (1987) have started to correct for sample selection bias due to failure in their models of growth, no one has ever corrected for this bias due to failure before industry entry (this means before a company ever sells a product, we refer to the empirical part of this paper for the technical details on sample selection bias).

But not only in the beginning of the industry life cycle, also at the end of the life cycle demand decreases in importance. In industries, which reach maturity, there is often a need to 're-legitimate' the industry. Both the brewery sector and generic pharmaceuticals are examples of such industries. In the brewery sector, a couple of large powerful breweries try to 'promote' the use of beer in order to increase aggregate demand. In doing so, they create externalities for local microbreweries that can only exist if the larger breweries spend money on generic advertising. In the generic pharmaceutical sector, the same thing happens. If an ethic pharmaceutical drug comes off-patent, then a small number of generic manufacturers promote this generic product and a large number of small local generic ones benefit from this generic advertising. But also the large companies need the small ones in this case. The small companies procure that the supply of the product is sufficient enough so that the generic advertising is effective. For instance, the large generic houses may only be interested to supply the product to the large warehouses for which they have a distribution network, but the small manufacturers can also sell the product to local pharmacies. A physician will only prescribe the product if he is certain that it will be sold in *each* pharmacy. The neo-classic economic models which use price competition as the driving force behind industrial evolution have much difficulty in explaining this mutualism. On the organizational ecology side however, resource partitioning theory exactly describes this mutualism between large and small firms.

We have found only one recent empirical organizational ecology study which more or less goes in the direction of such a life cycle hypothesis, namely Baum, Korn and Kotha's (1995) analysis of the Telecommunications Services industry. The main hypothesis in this study is derived from Utterback and Suarez's (1993) finding that pre-dominant design organizations increase their market power once a dominant design is established and therefore deter entry and increase failure rates among the cohort of new post-dominant design entrants. During the period before a dominant design is established, it is known that product sales are not sufficient to sustain the industry. A lot of organizations during this period do not even have sales (although they are members of the population). Baum, Korn and Kotha (1995) have found that the density of the cohort of organizations that were active in the industry *before* the dominant design was established, affected the number companies that entered the industry *after* this dominant design (see Table 5 for a summary).

Finally, also Haveman's (1993b) study on the Loan and Savings Industry is noteworthy in this respect. This study contrasts the theory of bureaucratic inertia which was developed by Hannan and Freeman (1984) with the economic and institutional theory of market power. Although not explicitly modelling the life cycle hypothesis discussed above, Haveman (1993b) is interested in the entry decision of Californian Loan and Savings companies in non-traditional markets. In this sense, the study analyzes the decision to invest in a market where no demand is available yet. First, theories of bureaucratic inertia predict that large organizations will be very reluctant to make changes (the rigidity of size hypothesis) while theories of market power predict that larger organizations will both have more incentives to introduce change in order to sustain their market power and more slack resources which they can use to generate change[3] (the fluidity of size hypothesis). Haveman suggests that these two contradicting powers will generate an inverted-U shaped relationship between size and change.

[3]This seemingly contradiction has been investigated in the narrower context of technological innovations by Henderson (1993).

PART II: EMPIRICAL METHODS AND VARIABLE MEASUREMENT

Organizational ecologists have developed a wide range of models to test their hypotheses. It would be impossible to give an exhaustive overview of all variations of models which have been used in their studies. Almost each new empirical study uses another variation. Instead, we will discuss the three "baseline" models which most studies depart from. These models can be classified according to the dependent variable, which is analyzed, namely organizational failures, organizational foundings or a continuous variable such as organizational growth. We will discuss in this part how these models have been refined and adapted to certain contexts. In addition to this, we will analyze whether and how organizational ecologists have dealt with statistical problems such as specification errors or unobserved heterogeneity, sample selection bias, serial correlation and heteroskedasticity. Special attention will be given to how organizational ecologists have gradually adapted econometric techniques developed for longitudinal data analysis (e.g. fixed and random effects models) as a supplement to the classic event history models.

Furthermore, in the theoretical part we have introduced a number of theoretical concepts such as liability of smallness and newness, size-localized competition, overlap density, etc... and we have explained their theoretic rationale. In this part, we will show how these concepts are operationalized and measured in a number of different populations. We will discuss the strengths and weaknesses of these operationalizations.

The remainder of this empirical part is organized as follows: In a first section, we will discuss the stream of research which has focused on mortality or exit as the dependent variable. We will consecutively focus on the baseline empirical model, the extensions to this model, the problems associated with the model and the introduction of new explanatory variables. Next, we will analyze studies of organizational foundings in the same way as the previous studies of mortality. Finally, we turn to the studies of growth and change which use a continuous dependent variable. Again, we will use the same sequence of analysis.

II.1. ORGANIZATIONAL ECOLOGY STUDIES OF MORTALITY

II.1.1. DISCUSSION OF THE BASELINE HAZARD MODEL

Nearly all studies of organizational mortality use the instantaneous rate of failure[4] as the fundamental dependent variable. This continuous hazard rate $h(t)$ can be defined as follows:

[4] In other words, a hazard rate measured in a continuous time interval.

$$h(t) = \lim_{\Delta t \to 0} \frac{\text{prob}(t, t+\Delta t)}{\Delta t} \qquad (1)$$

where $\text{prob}(t, t+\Delta t)$ is the probability of failure in the interval $(t, t+\Delta t)$ given that the organization was still alive at time *t*. Depending on the shape of the hazard rate function $h(t)$, a number of different variations is used. One of the simplest (and most frequently used models) sets the hazard rate function $h(t)$ equal to a log linear function[5] of the explanatory variables, while holding it constant over time. The following specification can then be used to estimate the hazard rate:

$$h(t) = \exp[bX(t)] \qquad (2)$$

where $h(t)$ is the instantaneous rate of failure, $X(t)$ is a vector of the covariates at time *t* and *b* is the vector of coefficient estimates. It is clear that under this specification, the hazard rate is assumed to be constant over time. Two other frequently used models are the Weibull (log of the hazard is allowed to increase/decrease linearly with time) and the Gompertz (log of the hazard is allowed to increase/decrease linearly with the log of time). Because of the linearity between the hazard and the time/log time variable, the Weibull, Gompertz and Exponential model are called 'proportional hazard' models. Besides these parametric models, there are two other 'families' of models used in organizational ecology studies: a first one is the semiparametric model, called Cox's proportional hazard model which allows any function between the hazard rate and time; a second family includes the accelerated time failure models which allow other distributions such as the lognormal, the gamma and the loglogistic. Allison (1984) gives an excellent introduction to each of these models, while Hannan and Tuma (1984) give a more detailed description. The empirical studies on failure data show that the relationship between time and the hazard rate is very dependent upon the population of study. Table 6 gives an overview of the models chosen in a selection of recent studies.

— INSERT TABLE 6 ABOUT HERE—

Most of the more recent studies use a multiple-spells formulation of the model to permit the incorporation of time variation in the co-variates. In this formulation, the event history of the organization is broken down into yearly (or monthly) observations in which the organization is at risk of failure. Like in any other pooled data set, the level of analysis is then the 'spell' (every observation-period) rather than the organization

[5]The relationship is set loglineair to avoid that the hazard rate takes values which are less than 0.

itself. As long as the organization did not exit, each of these spells is treated as right censored.

The parametric models are then estimated using maximum likelihood estimation. Maximum likelihood combines the censored and uncensored data in such a way that the estimates are asymptotically unbiased, normally distributed and efficient (see Kalbfleisch and Prentice, 1980 for a more detailed analysis). In order to estimate the semi-parametric one, Cox has developed a partial likelihood estimator which has excellent large sample properties (see Allison, 1984 for a review).

It should be noted here that the hazard models do not have a random disturbance term. Still, these models are not deterministic because there is random variation in the relationship between the unobservable dependent variable $h(t)$ and the observed length of the time interval. However, the absence of the random disturbance term remains controversial and brings us back to one of the major weaknesses in the density dependence models of mortality, namely 'unobserved heterogeneity'.

As discussed in the theoretical part of this paper, the density dependence model predicts a U-shaped relationship between organizational density and mortality rates. It is especially the first part of this U-shape, the decrease in mortality through the process of legitimation, that is the subject of criticism. Petersen and Koput (1991) have shown that even if the 'real' mortality rate is constant over time for each organization, unobserved differences in organizations tend to produce a decrease in the mortality rates. The intuition behind this finding is straightforward: organizations with high hazard rates drop out of the population very early and are then eliminated from the risk set. This process yields risk sets that contain individuals with predominantly lower risks until population density becomes so high (through free entry and lower exit) that the hazard rate starts increasing again. There are three ways to deal with this problem. (1) One can create a random disturbance term which captures the unobserved heterogeneity. Heckman and Singer (1982) have introduced an extended Weibull model which includes a random error term. Early findings have shown that the coefficients in this model are very sensitive to the distribution choice for the random error term (Allison, 1984:33). Hence, the usefulness of this model has to be proved yet. (2) One can introduce more explanatory variables in the model. As discussed in the theoretical part, organizational ecologists have included organizational-level variables such as size and age to control for this heterogeneity problem. One can also think of other variables such as access to resources as important additional covariates. (3) One can start to disaggregate the density variables based on the observed variables. The conceptual models behind solution (2) and (3) have been discussed in the theoretical part, but the operationalization of some of the most important variables receives some further attention in the next paragraph.

II.1.2. Disaggregation of the Density Variable

As discussed in the theoretical part of this paper, density has been disaggregated along a number of dimensions. A first dimension was the geographic location. In their study on Bavarian Breweries, Swaminathan and Wiedenmayer (1991) assume that the density variable may behave different at lower levels of analysis than at the higher ones. They introduce three levels: the national, the state and the city level. The hypothesis is as follows: the lower the level, the more different subpopulations and the higher the impact of the density variable at the subpopulation level on organizational failure rates. Although appealingly simple, this kind of disaggregation has a major limitation: the concept can only be applied to those populations where geographic locations play an important role in terms of competition (e.g. in the case of hotels or restaurants for which the demand is mainly local). Swaminathan and Wiedenmayer found empirical support for this disaggregation at the state level but not at the city level (see Table 6 for a summary).

In a very appealing study, Baum and Singh (1994) have used the demand dimension to disaggregate the density variable. In their study on Toronto Day Care Centers, they have split up the population in different niches based on the age category of children they were licensed to accept. By using the demand side as a criterion for niche formation, they make a first link with the extensive literature on strategic group formation (see McGee and Thomas, 1986 ; Thomas and Venkatraman, 1988 for a review). Because some organizations compete in more than one niche, a simple disaggregated measure of density at the niche level is not sufficient. To address this problem, Baum and Singh (1994) introduce the concept of overlap density (1994:352) and nonoverlap density (1994:353).

$$\text{overlap density}_{it} = N_{it} + \Sigma_{i \neq j} w_{ij} N_{jt} \qquad (3)$$

where N_{it} is the number of organizations in organizational niche i at time t, N_{jt} is the number of organizations in organizational niche j at time t and w_{ij} is the organizational niche overlap weight of organizational niche i with organizational niche j. w_{ij} lies always in the {0,1} interval with $w_{ij} = 0$ when there is no potential for competition and $w_{ij} = 1$ when organizations occupy the same niche. w_{ij} is then measured as the ratio of overlap between *i* and *j* and the width of niche *i*. The width of the niche is then a function of the part of the demand served by that niche (for instance 0-3 year, i.e. 36 months in the case of daycare centers) and the overlap consists of that part of the demand that is served by both niches (e.g. another niche serves the 3-6 year ones, but there can be a 6 month overlap). It should be noted here that the concept of niche overlap can also be used in those studies that disaggregate the density variable along the geographic dimension.

Nonoverlap density is exactly the reverse of overlap density and can easily be defined in the following way:

$$\text{nonoverlap density}_{it} = N_t - [N_{it} + \Sigma_{i \neq j} w_{ij} N_{jt}] \qquad (4)$$

The concept of niche overlap and niche nonoverlap has some similarities with the concept of strategic groups and market segmentation in the strategic management literature. Still, both approaches remain very different in the way they identify groups of competitors. The strategic management literature typically groups organizations along a number of dimensions which represent the outcomes of strategic actions (e.g. age, products, employees) whereas the ecology literature tends to define niche based on the resources with which organizations enter the strategic battle. Hence, overlap density does not capture actual or realized competition but focuses on the potential for competition.

Both disaggregation along the geographic and demand dimension solely operate at the niche or subpopulation level of analysis. In fact, little or no data is needed at the organizational level. Hannan, Ranger-Moore and Banaszak-Holl (1990) disaggregated the density variable even further to the organizational level of analysis and operationalized it as size-localized competition.

Organizational ecology suggests that organizations of different sizes typically employ very different strategies and structures and therefore draw on different resources. For instance, large organizations may have a very generalist strategy, while small organizations have a specialist niche-oriented strategy. These unobserved differences in strategy may affect the failure rates of the different groups of organizations. In order to deal with this kind of 'unobserved heterogeneity', Hannan, Ranger-Moore and Banaszak-Holl (1990:256) have introduced the concept of 'size-localized competition' (see also the theoretical part of this paper). Size-localized competition assumes that organizations compete most intensely with organizations of the same size. Hence, competition between pairs of organizations is a decreasing function of differences in their respective sizes. One way to model this variable in a continuous way is to use the Euclidean distance of each organization from all others in terms of size. However, one can argue that organizations only compete with each other when they belong to a certain "size window". For instance, the largest organization in the industry is very unlikely to compete with the smallest one if the difference in sizes is very large. Therefore, size localized competition has been computed in a number studies (see Table 6, for an overview), using equation 5:

$$D_{it}^{m} = \sqrt{\sum_{|s_{it}-s_{jt}|\leq m}^{m} \left(s_{it}-s_{jt}\right)^2} \tag{5}$$

where m is the width of the window, i stands for the i-th organization, j for the j-th organization, t for the time period and s for the size of the organization. The boundaries of the size-windows are arbitrarily determined as a function of the absolute size of a particular organization. Most often m is set equal to $s_{it}/2$.

Variations on this size-localized competition variable have been proposed in Baum and Mezias (1992). They have substituted the size variable by an 'average price' variable to capture price-localized competition and a physical distance variable to capture geographic-localized competition between hotels in Manhattan. See also Table 6.

II.1.3. Further Categorization of the Dependent Variable

As shown in Table 6, most ecological studies spend very little attention to the definition of 'failures'. However, in an industrial context, 'failure' or 'exit' is not always straightforward to define. But not only the ecology literature suffers from this weakness, Shary (1991) criticized the industrial economic studies exactly for the fact that they treated 'exit' as a homogenous category. She introduced a theoretical model which distinguishes between three different kinds of exits, namely voluntary liquidation, involuntary bankruptcy and merger. From an empirical point of view however, it is very difficult to get data which clearly show the distinction between 'voluntary liquidation' or 'involuntary bankruptcy'. In a very appealing study, Mitchell (1994) analyzed the difference between 'dissolution' and 'divestiture' rates, both for start-up firms and subsidiaries of existing companies. Interestingly, his study is among the first to make a distinction between 'business units' and 'parent firms'. He operationalized divestiture as the 'event' that a business unit is acquired by another firm or that it is sold to another firm. He modelled 'dissolutions' and 'divestitures' as *competing risks* in the baseline hazard model. In other words, in the hazard model of divestitures, dissolutions are treated as right-censored observations while in the model of dissolutions, divestitures are right-censored. Technically, this means that dissolution and divestiture are statistically unrelated to each other (which might be too stringent from a conceptual point of view). Among other results, the study shows that age has a positive effect on divestiture rates of subsidiaries and start-up firms, even after controlling for size, while the age variable had a negative effect on dissolution rates for start-up firms (for an oversight, see Table 6). This means that in future studies it will be increasingly important to make a distinction between different kinds of exits.

II.2. ORGANIZATIONAL ECOLOGY STUDIES OF FOUNDING

Organizational ecologists have traditionally produced many more empirical studies of mortality rates than of founding or entry rates. One of the main reasons for this lack of attention lies in the fact that the density dependence model provides a very weak guidance to describe structural characteristics within a population (or a market) beyond the mere count of numbers. Exactly those 'market characteristics' have been the focus of attention in most economic studies of entry such as Baumol, Panzar and Willig's (1982) study of 'hit and run' entry by start-up firms in contestable niches and Caves and Porter's (1977) study on entry by established firms in oligopolistic market segments.

Recently, the study on entries and foundings has taken two new directions: First, at the market or population level of analysis, the disaggregation of the density dependence variable has raised new questions about entry or founding in different niches or subpopulations. Second, splitting the entry variable up into foundings of start-up firms and entry decisions of firms that are already active in another market has created the possibility to analyze the entry decision at an organizational level (for existing firms) and to include idiosyncratic variables for each of the entering firms. In the latter case, the baseline model is exactly the hazard model as discussed in the previous section. In the former however, organizational ecologists tend to make use of a Poisson or Negative Binomial Model which will be discussed below. Table 7 gives a selected overview of the most recent studies of organizational entry or founding and the models used in these studies.

— INSERT TABLE 7 ABOUT HERE —

II.2.1. MODELS USED TO ANALYZE PROCESSES OF ORGANIZATIONAL FOUNDING

There are several caveats in the definition of organizational foundings. One of these is the estimation of the exact time when a founding takes place. If one uses the hazard model (or a related accelerated failure time model) to model the process of foundings, then one assumes that the time between two founding dates is the dependent variable of interest. In other words, one defines a founding as a discrete event which takes place at a well-known, well-defined point of time. Of course, both from a conceptual and an empirical point of view, this assumption is very difficult to hold. Which date is "the" date? The founding of an organizations seems to be more of a process than of an exact event. Hence, it makes more sense to estimate the number of organizational foundings that are expected to occur *within a certain time interval*, than to model the exact date.

As shown by Barnett and Amburgey (1990), a Poisson process then provides a natural baseline model for organizational founding. The basic Poisson model for event count data can be described as in equation 6:

$$Pr(Y_t = y_t) = e^{-\lambda(x_t)}\left[\frac{\lambda(x_t)^{y_t}}{y_t!}\right] \quad (6)$$

The Poisson model holds the strong assumption that both the variance and the mean $Pr(Y_t = y_t)$ of the number of events are equal. This assumption is often found to be too stringent in an analysis of founding rates (see Ranger-Moore et al., 1991). Unobserved heterogeneity in the model always leads to overdispersion. A first way to correct for this heterogeneity would be to adopt a 'fixed effects approach' by including dummy variables which are niche-specific (e.g. a dummy variable for each of the different geographic locations or market niches). The fixed effects approach is very attractive when no real conceptual model is available which explains the distribution of the heterogeneity. However, the main disadvantages of these models are (1) they absorb a lot degrees of freedom (one for each dummy variable) and (2) parameters of the time-invariant covariates, if any, contaminate with the dummy variables and are therefore very difficult to estimate. Hausman, Hall and Griliches (1984) have proposed to overcome these problems by letting λ vary randomly across individual units. A common way to do so is by including equation 7 in equation 6 (the Poisson model), or if overdispersion is a problem, by incorporating equation 7 in the negative binomial specification which can be derived from the baseline model (see Hausman, Hall and Grilliches, 1984:921):

$$\lambda_{it} = \exp(p' x_{it})\varepsilon_{it} \quad (7)$$

where the error term ε_{it} is assumed to follow a gamma distribution, *i* can be the number of different niches or populations and *t* is the time variable. Of course, the value of this random effects largely depends on the assumption that the errors really follow a gamma-like distribution, or in other words, that the errors will be larger for larger of λ_{it} (in this case the number of foundings/niche/period of time).

In a very recent study on founding rates, Lomi (1995) has estimated a semi-parametric random effects Poisson model, which was initially presented by Brännäs and Rosenqvist (1994). In this model, the error term is not assumed to follow a particular distribution, but falls in a number of *k* discrete classes (or support points) and can therefore be represented by ε_k. An iterative procedure adds classes or points until the inclusion of an additional class or point does not significantly improve the likelihood of the model anymore. For each model the number of classes will be different.

It should be noted that the event count models are used to estimate the impact of variables at population (market) or subpopulation (market segment) level of analysis. This level of analysis is the only one possible, when analyzing founding dates of start-ups (no information is available on this organization *before* its start-up). However, when analyzing the foundings of new business units by existing companies or entry of these firms in new markets, organization level information *is* available. Then, not event count models are the logic choice, but a probit, logit or simple hazard model (the latter under the assumption that the exact times of entry or founding are known).

II.2.2. Disaggregation of the Density Variable and Unobserved Heterogeneity in Studies of Founding

The disaggregation of the density variable based into market niches and geographic segments has also been applied to studies of organizational founding by Baum and Singh (1994, market niches) and Lomi (1995, geographic niches). Baum and Singh were especially interested in the effects of overlap and non-overlap density on founding rates, but did not control for unobserved heterogeneity between the different niches (their random effects model only controls for unobserved heterogeneity on the time dimension). A summary of both studies is given in Table 7.

Following Aldrich and Fiol (1994), Debackere, Clarysse and Manigart (1995) have expanded the density dependence model to analyze not only the influence of the competitive structure of a population (represented by the density variable) on founding rates, but also the effect of the *social* structure of that population. Using social network analysis, they model the contacts between research groups in transgene plants and the exchange relations between venture capital organizations in the Dutch venture capital industry. Among other results, they find that the more incumbents belong to an industry-wide network, the lesser foundings occur, but on the other hand a high concentration of network prestige among a few top organizations increases founding rates again.

Since no information is available for start-up firms at the organizational level, one can only adopt a market or niche perspective as the appropriate level of analysis. In order to analyse organization-level effects, some recent studies have specifically eliminated those start-up foundings from their sample and looked at entries by companies that were already active in another market. Haveman (1993) modelled the processes of mimetic isomorphism by looking whether large firms were attracted to enter an emerging niche because similarly sized firms had already entered this niche. From a totally different perspective, Mitchell (1989) analyzed whether an incumbent is likely to enter a new subfield if its core products are threatened or if it possesses the complementary (specialized) assets to develop, manufacture or market the product in the new emerging subfield.

II.3. ORGANIZATIONAL ECOLOGY STUDIES OF GROWTH AND CHANGE: FROM SURVIVAL MODELS BACK TO REGRESSION

As described in the theoretical part, organizational ecologists have recently focused their attention on studies of growth and change. As long as these variables are defined as discrete steps (e.g. growth from a generalist towards a specialist organization as a discrete step point in time), the baseline hazard model as discussed in section 1 of this part can be used (e.g. Amburgey, Kelly and Barnett's study of Finnish newspapers, 1993). However, if these variables are measured continuously, then fixed and random effect regression models are the most appropriate. The use of these techniques, requires additional caution with econometric problems such as serial correlation, sample selection biases and heteroskedasticity problems. Reviewing these techniques and their possible solutions is way beyond the scope of this paper. This section aims only to review briefly how careful these recent ecology studies have selected the models and corrected these errors, which traditionally were the playground of econometricians. A brief overview of the studies discussed in this section is presented in Table 8.

— INSERT TABLE 8 ABOUT HERE —

Haveman (1993) introduced 'rate of change' as a continuous variable in her study of the California Savings and Loan Industry (in contrast to the previous studies which analyzed discrete steps of change). Unobserved heterogeneity is assumed to be organization-specific, but no distribution is hypothesised for the error terms. Fixed effects are included in the model by subtracting the within regression means for each of the organizations (this way, one can avoid loosing too many degrees of freedom). Even after correction for these organization-specific effects, she finds heteroskedasticity of the errors (proportional to organization size), which she corrects using weighted least squares. One can raise the question here why no distribution could be defined for the error term which would solve for this whole problem in a random effects model. This preference for a random effects model is only re-enforced by the serial correlation where she corrects for by using pseudo-generalized least squares. The dataset in this study also shows a problem which has received increasing attention in economic studies, namely that of sample selection. The large amount of entry and exit in the population (see Haveman, 1993:23) may indicate that the population is biased towards the stronger organizations (for a good description of different kinds of sample selection problems and their solutions, we refer to Winship and Mare, 1992).

Besides studies of strategic change, organizational ecologists have also started to study the processes of organizational growth, which have traditionally been studies by industrial economists (Evans, 1987; Hall, 1987). We have identified the studies by Baum and Mezias (1993), Barron, West and Hannan (1994) and Barnett (1994) as recent empirical efforts by organizational ecologists to model growth. Following the extensive economic literature on growth, each of studies uses a power function as a baseline model. The reduced form of this function (which can be estimated by OLS) can then be written as in equation 8:

$$\log(S_t)=b_1(\log(S_{t-1}))+b'X_{t-1} \qquad (8)$$

where S_t is the size of an organization in period t, S_{t-1} its size in period t-1 and X_{t-1} vector of covariates for that in period t-1 organization which are supposed to affect its size in t (e.g. the age of that organization, or its level of innovative efforts). Baum and Mezias (1993:140) used a least squares dummy variable version of fixed effects models, because they did not have a clear idea of the distribution of errors due to unobserved heterogeneity (see Sayrs, 1989 for a review). For the same reason, Barron, West and Hannan (1994) and Barnett (1994) choose the fixed effects model. However, to avoid a large loss in degrees of freedom they subtract the within-organization mean from each observation. Baum and Mezias (1993) checked for heteroskedasticity, but did not find any (which supports the assumption that the error term can be decomposed in an organization-specific intercept and a homoskedastic serially uncorrelated random disturbance term). Barnett (1994) however found autocorrelation and heteroskedasticity to be a problem an corrected for this by first order differentiation and weighted least squares respectively. Interestingly, both Barnett (1994) and Baum and Mezias (1993) have corrected for a sample selection bias which might have resulted from failure of those organizations that had lower growth rates[6].

By means of conclusion for this section, we can say that (1) there is an empirical *and* theoretical need to further investigate the distribution of the errors resulting from unobserved heterogeneity. As shown in the previous paragraphs, the fixed effects models which are used in most studies are not always sufficient to correct for heteroskedasticity and serial correlation. And (2) although half of the studies discussed correct for sample selection bias, little attention is given to Mitchell's (1994) finding that organizations with different patterns of entry (or maybe even different patterns of exit) have different organizational life cycles.

PART III: CONCLUSION AND SUGGESTIONS FOR FURTHER RESEARCH

As shown in the paper, population ecology and in its newer form, organizational ecology, has evolved from a collection of more or less unrelated theoretical concepts towards an integrated theory of organizational failure and founding. The density dependence model can be seen as the backbone of this theory. Researchers of this density model have integrated other ecology concepts such a liability of newness and size, resource partitioning and niche formation in a very creative way to address the fundamental critic of unobserved heterogeneity and to look for alternative explanations of failure and founding. The result is a theory, which not only models the effects on the population level of analysis, but beyond these population dynamics also focuses on organizational differences and on niche characteristics at the mezzo-level of analysis.

But additional theoretic explanations for failures and foundings should not always be found within the boundaries of organizational ecology itself. The closest related intellectual stream in this respect is institutional theory, which has since long been hypothesized as being complementary to the ecological ideas (Zucker, 1987). Institutional theory stresses, among other, the importance of the institutional environment in explaining founding and failure. The majority of organizational ecology studies have included changes in the regulated environment as a control variable, but

[6]This may result in an over-estimation of the growth rates. In this case, the sample selection is biased towards the faster growing organizations.

very few explicitly modelled institutional embeddedness as an explanation. Only two studies really integrate institutional theory with organizational ecology: Baum and Oliver (1991) explicitly investigated linkages to the regulated environment as a main explanation for mortality and Tucker, Singh and Meinhard (1990) modelled institutional change (in the regulated environment) as a determinant of organizational foundings. However, the institutional environment represents not only the regulated environment but also the network of inter-organizational relations which are developed along the life cycle of a population or industry. Even less empirical work has been done to model these linkages in the density dependence model. As far as we know, only one very recent study by Debackere, Clarysse and Manigart (1995) has investigated the effect of social structure on founding rates. But it is exactly the formation of this social structure which can have most potential in explaining differences in legitimacy building both at the industry (Aldrich and Fiol, 1994) and the organizational level. Social structures do not only modify competition, they also determine the potential for future competition. Future research, which incorporates this dimension in the density model, will be very promising.

Of course, although the use of institutional theory can enrich the density model, it does not really challenge its basic assumptions. On the contrary, the implementation of strategic management concepts and especially the integration with industrial economics can give organizational ecology a different face. Let us begin with strategic management theory. As shown in the paper, this stream of research includes at least two subdomains which have natural linkages to organizational ecology: the theory of differentiation and the literature on strategic groups. Recently, researchers on differentiation have argued that the real question of interest is not 'whether' organizations change strategically or not, but rather, if change is an institutionalized process in an industry, 'how' they change. More specifically, Hill and Hansen (1991) have shown how the choice to differentiate in the context of the pharmaceutical industry, is driven by bureaucratic inertia and uncertainty avoidance. Since change is nowadays so institutionalized in this industry, managers can not motivate not to change anymore, but can choose to change in a conservative (differentiation) or in a more risky way (innovation). This has major implications for the density dependence model which assumes that bureaucratic organizations do not change at all. Future research should analyze what the effect is of altering this null hypothesis of no change towards a naive hypothesis of 'change with the least risks'.

But the theory of differentiation has also another major implication for organizational ecologists: differentiation can be seen as the way 'large organizations' enter new markets (Haveman, 1993a; Mitchell, 1994). The antipode of differentiation, namely divestment, represents the way how large organizations exit. In other words, founding and failure of large organizations is much more complex than initially presented by organizational ecologists. As argued in the previous paragraph, differentiation or entry in new markets may be the result of a strategic decision which has very little to do with the legitimation or competitive structure of that market. But also the decision to 'divest' may be caused by totally different arguments than the competitive structure of that population. Therefore, much more work should be done in introducing the complexities of large organizations in the theory of organizational ecology. The pioneering efforts of Mitchell (1994) and Shary (1991) include additional guidelines for future research in this area.

Furtheron, the disaggregation of the density variable into different niches or subpopulations is clearly related to one of the major weaknesses in the theory of organizational ecology, namely the multi-dimensionality of the 'carrying capacity' concept. Although carrying capacity is the central argument in the density dependence model, it is seldom explicitly mentioned or modelled in empirical studies. So far, organizational ecologists have picked one dimension such as the geographic location on which they disaggregate the population into different niches or subpopulations[7]. In doing so, they assume that this dimension is the only one along which the niches differ. It is clear that this assumption is a very stringent one. Other dimensions such as market or new ones such as financial resources can introduce heterogeneity in the model if they are important for the carrying capacity of the population. Although the resource based niche concept has clear advantages over the strategic group concept which is being criticized for having lost each feeling with reality, organizational ecologists might benefit from the multi-dimensional approach developed by strategic group researchers. To do so, future research should pay much more attention to which dimensions are important both as sources of heterogeneity and as homogene elements of the carrying capacity in different populations. Related to this is the critique which organizational ecologists have received from economists (among others) that exactly those populations are studied in which 'carrying capacity' or the resource environment plays an important role (Winter, 1990).

Indeed, most of the studies discussed in this review comprise relatively small organizations such as hotels, Day Care Centers, Newspapers or Credit Unions. Baum and Mezias (1993:132) for instance state in their introduction:

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[7]in this paper, we chose not to mention the community-population relation because, at a conceptual level, there is no clear distinction between this relation and the population-niche one.

> '...From an ecological standpoint, DCCs provide an appropriate setting for the study of competitive processes because they exhibit a common dependence on the material and social environment. DCCs compete for similar material and social resources in a well-defined geographic area ...'

The question is whether this critique should be seen as an advantage or a disadvantage for organizational ecology. In other words, should organizational ecology be considered as a theory which 'competes' with industrial organization to explain the evolution of industries or as one that complements the economic models?

As argued in the section of this paper which discusses the links of organizational ecology with industrial organization, we clearly think that both should be seen as complements to each other. Indeed, industrial organization has little to say about the evolution of those industries or populations where demand is of minor importance or does not exist as yet. This review has shown that it were exactly those populations that have been the focus of interest during the past decade.

However, we have also argued that both intellectual streams can be integrated along the life cycle of an industry. Economists typically study the evolution of an industry from the moment on that demand is present or, in other words, that products are sold in the market. It is exactly from this point on that carrying capacity becomes endogenous to the density model (see also Brittain, 1994). Product sales generate internal cash flow to the organization or at a higher level of analysis, to the industry, which in turn can be used to enlarge the carrying capacity of the environment. A large body of anecdotal information on this endogenization process is available in qualitative studies of regional development such as Saxenian's analysis of Silicon Valley and Route 128 (Saxenian, 1994). But before demand is sufficient to guarantee the survival of the industry, it is the resource environment which determines the selection process of organizations. As argued in the paper, this period before product sales sustain the industry and hence before endogenization of carrying capacity takes place, can have important implications for analyzing the further growth of the industry once demand is generated.

The nature of this problem is related to the sample selection bias which has received so much attention among labor economists, analyzing the determinants of labor supply (Heckman, 1979). The focal question of interest in these studies is how wages affect the amount of labor supplied (measured in hours) by each individual. However, this equation is by definition conditional upon participation in the labor force. If one only includes those people that work in the sample, then the study suffers from a sample selection bias. Therefore, labor economists started to estimate a labor participation equation which they integrate in the labor supply model. Of course, other factors may determine the choice to work or not than the amount of work one wants to do. Similar to the labor economics example, other processes may determine the growth of an organization's product sales than its participation decision in an industry. The density dependence model has most value to estimate the industry participation decsion whereas economic models provide most insight in the determinants of growth equation. Integrating density dependence models with economic theory along the industry life cycle is a very promising area of further research.

Also when an industry matures, demand decreases in importance again and organizations become again more dependent on the carrying capacity of the resource environment, which however may consist of totally different dimensions that the one in the emerging stages of an industry. We have given the populations of generic manufacturers and breweries as two examples of such maturing industries.

Finally, the empirical part of the paper has shown that despite the fact that organizational ecology uses increasingly complex and better suited techniques to study the evolution of populations, one main caveat remains: the distribution of errors which result from unobserved heterogeneity. This problem should be addressed both at a theoretical and an empirical level. At the theoretical side, further exploring the multi-dimensionality of the carrying capacity concept can provide some further insights in this problem, which in turn may provide the necessary input to empirically determine appropriate distributions.

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TABLE 1: SELECTED OVERVIEW OF THE CLASSIC STUDIES OF 'DENSITY DEPENDENCE'

Industry/Population	**Hypotheses tested**	**Bibliography**
Argentine Newspapers, 1800-1900	foundings, disbandings	Delacroix and Carroll (1983)
US national labor unions, 1836-1985	disbandings	Hannan and Freeman (1988)
American Brewing Industry 1633-1988	foundings, disbandings	Carroll and Swaminathan (1991)
Bavarian Breweries, 1900-1981	disbandings	Swaminathan and Wiedenmayer (1991)
US Breweries, 1800-1988	foundings, disbandings	Carroll and Wade (1991)
Banks and Life Insurance Companies	foundings	Ranger-Moore et al. (1991)

FIGURE 1: THE INTEGRATED DENSITY DEPENDENCE MODEL

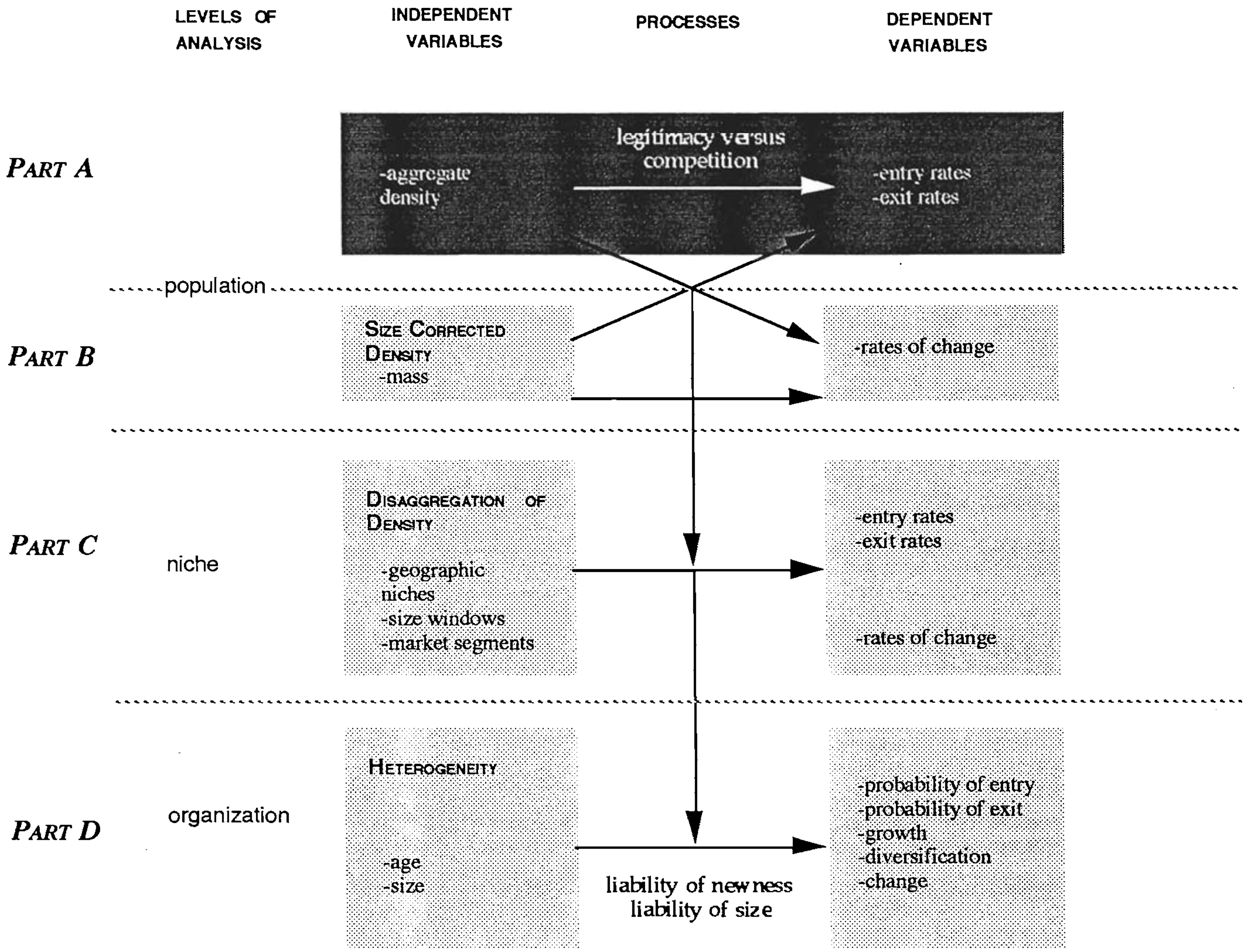

TABLE 2: EXTENSIONS OF THE DENSITY DEPENDENCE MODEL: LIABILITY OF NEWNESS

Industry/Population	Hypotheses tested	Bibliography
--	theoretical model	Fichman and Levinthal (1991)
Metro Toronto voluntary social Service organizations, 1970-1982	-liability of newness -non-monotonic relationship, inverted U-shape, supported -age as time elapsed since organizational founding	Singh, Tucker and House (1986)
Credit Unions, 1914-1990	-liability of senescence -after controlling for size, non-monotonic relationship, U-shape, supported -age as time elapsed since organizational founding	Barron, West and Hannan (1994)
CPES-market 1981-1986	-positive monotonic relationship, supported -age as time elapsed since market entry)	Barnett (1991)
Microbreweries, 1975-1990	-after controlling for size, positive monotonic relationship but not significant -age as time elapsed since organizational founding	Caroll and Swaminathan (1992)
Credit Unions 1981-1989	-after controlling for size, positive monotonic relationship, supported, but only marginally significant -age as time elapsed since organizational founding	Amburgey, Dacin and Kelly (1994)
	-liability of newness -non-monotonic relationship, inverted-U shape -age as time elapsed since organizational founding	Bruderl and Schussler (1990)

TABLE 3: EXTENSIONS OF THE DENSITY DEPENDENCE MODEL: LIABILITY OF SMALLNESS

Industry/Population	Hypotheses tested	Bibliography
Telephone Companies in Pennsylvania, 1877-1933	-negative monotonic relationship not supported	Barnett and Amburgey (1990)
Manhattan Hotel Industry, 1898-1990	-negative monotonic relationship supported	Baum and Mezias (1992)
Credit Unions 1981-1989	-cubic relationship supported	Amburgey, Dacin and Kelly (1994)
Credit Unions, 1914-1990	-negative monotonic relationship, supported	Barron, West and Hannan (1994)
Group Practice HMO's in the US, 1976-1991	-non-monotonic effect of size, inverted U-shape supported	Wholey, Christianson and Sanchez (1992)
California Wine Industry	-negative monotonic relationship, supported	Delacroix and Swaminathan (1991)

TABLE 4: DISAGGREGATING THE DENSITY VARIABLE: GEOGRAPHIC, SIZE AND OVERLAP NICHES

Industry/Population	Hypotheses tested	Bibliography
Rural Cooperative banks in Italy	-analysis of foundings -geographic disaggregation: -13 different regions -supported	Lomi (1995)
Manhattan Hotel Industry, 1898-1990	-analysis of foundings, failings -market and size disaggregation -supported	Baum and Mezias (1992, 1993)
California Savings and Loan Industry, 1977-1987	-analysis of foundings -size localized density (size window) -supported	Haveman (1993)
American Brewing Industry	-analysis of foundings -geographic disaggregation: -state and regional levels supported -city level, not supported	Carroll and Wade (1991)
Bavarian Breweries, 1900-1981	-analysis of mortality rates -geographic disaggregation: -national, state and city level -mixed support	Swaminathan and Wiedenmayer (1991)
Customer Premise Equipment and Service (CEPS), 1981-1986	-analysis of market exit rates -market disaggregation -distinction between multiple- and single-point competitors -supported	Barnett (1991)

TABLE 5: INTEGRATION OF ORGANIZATIONAL ECOLOGY WITH INSTITUTIONALISM, INDUSTRIAL ECONOMICS AND STRATEGIC MANAGEMENT THEORY

Industry/Population	Hypotheses tested	Bibliography
ECOLOGY AND INSTITUTIONALISM		
Day Care Centers in Toronto, 1971-1989	-institutional embeddedness on survival -supported	Baum and Singh (1992)
Newspaper Organizations, 1870-1980	-impact of changes in the institutionalist environment on mortality -supported	Carroll and Huo (1986)
California Savings and Loan Industry, 1977-1987	-mimetic isomorphism as a process which explains diversification -supported	Haveman (1993a)
ECOLOGY AND STRATEGIC MANAGEMENT		
Seven Medical Equipment Product Markets, 1952-1982	-difference between dissolution and divestiture as exit pattern ; -difference between new and old firms when analyzing entry patterns -in each of the four groups, different variables are significant	Mitchell (1994)
US Certified Air Carrier Industry, 1938-1978	-bureaucratic inertia and strategic change -age hypothesis supported -size hypothesis not supported	Kelly and Amburgey (1991)
Customer Premise Equipment and Service (CEPS), 1981-1986	-analysis of market exit rates -market disaggregation -distinction between multiple- and single-point competitors -supported	Barnett (1991)
Finnish Newspapers, 1771-1963	relationship between size, age and strategic change ; negative effect supported	Amburgey, Kelley and Barnett (1993)

Ecology and Industrial Economics

Telephone Companies in Pennsylvania, 1877-1933	-mass dependency -negative effect found of mass on failure -positive effect found of mass on founding -mass does not suppress the density results	Barnett and Amburgey (1990)
California Savings and Loan Industry, 1977-1987	-analysis of strategic change -bureaucratic inertia versus market power theory -inverted-U shaped relationship between size and rate of diversification -supported	Haveman (1993b)
Facsimile Transmission Service Organizations in New York, 1965-1992	-cohort density of organizations active during the pre-dominant design period influences entry of new organizations in the post-dominant design period -hypothesis supported	Baum, Korn and Kotha (1995)
Credit Unions in New York City, 1914-1990	-density dependence and growth -liability of newness, smallness and growth -test of Gibrat's Law (not supported)	Barron, West and Hannan (1994)
Day Care Centers in Toronto, 1971-1989	-density dependence and growth -size-localized competition -> growth -institutional linkages -> growth	Baum and Mezias (1993)

TABLE 6: A SELECTED OVERVIEW OF MORTALITY STUDIES

DATASET/STUDY	KEY VARIABLES	MODEL USED
Day Care Centers in Toronto, 1971-1989 ; Baum and Singh (1991 ; 1992)	**Dependent Variable** failings, no further info reported **Independent Variables** *overlap density:* (+) *nonoverlap density:* nonoverlap density$_t = N_t - [N_{it} + \sum_{i \neq j} w_{ij} N_j]$ (-) *institutional linkages:* POSA-agreement or SSA agreement (-) **Control Variables** *age*: number of years, since year of founding (+) *size*: licensed capacity (-) *left Censor*: dummy for left censoring , about 20% was left censored (n.s.)	Loglinear
Semiconductor Industry, 1946-1984, Freeman (1990)	**Dependent Variable** exits, defined as 'stopping to sell semiconductors' **Independent Variables** *exits*: lagged number of exits (U-shape, significant) *entries*: lagged number of entries (no pattern) *age*: time since entry (-) *size:* sales (-) **Control Variables** exit rate split up between subsidiary and independent firm exit -> significant difference of the models	non-parametric Cox's partial likelihood
Bavarian Breweries, 1900-1981, Swaminathan and Wiedenmayer (1991)	**Dependent Variable** failures, no real distinction between acquisitions, exits or bankruptcies **Independent Variables** Density variable split up at the city, state and national level (same results for each variable, U-shaped relationship) **Control Variables** *age:* number of years since founding (-) *left Censor*: dummy for left censoring (n.s.)	Gompertz

Finnish Newspapers, 1771-1963, Amburgey, Kelley and Barnett (1993)	**Dependent Variable** failures, mergers and acquisitions were treated as competing risks. **Independent Variables** *content changes*: changes in activity (n.s.) *frequency changes*: (-) *age*: time since founding (-) **Control Variables** various environmental characteristics	Loglinear
Seven Medical Equipment Product Markets, 1952-1982, Mitchell (1994)	**Dependent Variables** Dissolutions including both voluntary liquidations and bankruptcies and Divestitures **Independent Variables** *Age :* time elapsed since founding of the organization (+ in the divestiture case, - in the dissolution case, but only for start-up firms) **Control Variables** *Size:* sales (- on dissolution rates, but n.s. on divestitures) *Difference between Start-up and Diversifying Firms.*	Loglinear
Pennsylvania Telephone Companies, 1877-1933, Barnett and Amburgey (1990)	**Dependent Variable** failings, no further info reported **Independent Variables** *mass:* sum of the sizes of all organizations in the population (n.s.)	Gompertz
Credit Unions in New York City, 1914-1990, Barron, West and Hannan (1994)	**Dependent Variable** failings, all other exits were treated as censored observations **Independent Variables** *size*: assets (consumer loans) (+) *age* : years since founding (+, nonmonotonic) **Control Variables** *environment*: Dummy variable, with linear trend after change (-)	Weibull

Manhattan Hotel Industry, 1898-1990, Baum and Mezias (1992)	**Dependent Variable** failures, no further info reported **Independent Variables** *size localized competition:* Euclidean distance between sizes within a size window , $D_{it}^{a} = \sqrt{\sum_{\lvert s_{it} - s_{jt} \rvert \le a} (s_{it} - s_{jt})^2}$ (-) *price localized competition:* Euclidean distance between sizes within a size window (-) *geographically localized competition:* Euclidean distance between sizes within a size window (-) **Control Variables** *demand*: number of visitors to NYC (-) ; GNP growth rate (-) *size:* number of hotel beds (-) *age:* years since founding (+) *left Censor*: dummy for left censoring , about 25% was left censored (n.s.)	loglinear

Legend:

(+) means a statistically significant (p<.05) positive sign.

(-) means a statistically significant (p<.05) negative sign.

(n.s.) means not significant at the .05 level.

TABLE 7: A SELECTED OVERVIEW OF STUDIES ON ENTRY AND FOUNDING

DATASET/STUDY	**KEY VARIABLES**	**MODEL USED**
Day Care Centers in Toronto, 1971-1989 ; Baum and Singh (1994)	**Dependent Variable** foundings, no further info reported **Independent Variables** *overlap density:* (-) *nonoverlap density:* (+)	Negative Binomial Regression, random effect (only time) with gamma distribution
California Loan and Savings Industry, 1977-1986, Haveman (1993)	**Dependent Variable** entries in emerging subfields in the Loan and Savings Industry by Incumbents **Independent Variables** *mimetic isomorphism :* number of 'large' firms in the subfield (inverted-U shape, significant) *size*: financial assets (+) **Control Variables** several environment-specific variables	Loglinear Hazard Model
Transgene Plant Community, 1974-1994 & Dutch Venture Capital Industry, 1980-1994, Debackere, Clarysse and Manigart, (1995).	**Dependent Variable** foundings of research groups, Dutch venture capital firms. **Independent Variables** *Clique Membership:* relative number of organizations that belong to an industry-wide exchange network (-) *Mimetic Isomorphism :* concentration of network prestige (+) **Control Variables** *environment specific variables.*	Poisson and Negative Binomial for transgene plants, random effects only for the time dimension; Hazard model (loglinear) for Dutch venture capital foundings
US Biotech Industry, 1974-1987 ; Shan, Singh and Amburgey (1991)	**Dependent Variable** foundings of new biotech firms. **Independent Variables** *Density*: inverted-U shaped relationship (significant) **Control Variables** venture capital availability (+) GNP (n.s.) NYSE (n.s.)	Loglinear Hazard Model

Rural Cooperative Banks in Italy, 1964-1988 ; Lomi (1995)	**Dependent Variable** foundings, no further info available. **Independent Variables** *geographic density:* density in well-defined geographic niches (+) **Control variables** general economic and social conditions such as Agricultural employment (n.s.) Core Bank's share (+)	Semi-parametric Random Effect Poisson Models (taking into account both unobserved heterogeneity along the time dimension and between the niches)
Seven Medical Equipment Product Markets, 1952-1982, Mitchell (1994)	**Dependent Variables** entry by industry incumbents into emerging technological subfields **Independent Variables** *Specialized Assets, defined as* industry market share (+, in the logistic regression) industry experience (n.s.) direct distribution system (+, in the logistic regression and -, in accelerated time failure model) **Control Variables** *Potential Rivals* (-, in time failure models)	Logistic Regression and Accelerated Time Failure Models (Weibull)
Pennsylvania Telephone Companies, 1877-1933, Barnett and Amburgey (1990)	**Dependent Variable** foundings **Independent Variables** *mass:* sum of the sizes of all organizations in the population (+)	Negative Binomial Regression, random effect (only time) with gamma distribution

Legend:

(+) means a statistically significant (p<.05) positive sign.

(-) means a statistically significant (p<.05) negative sign.

(n.s.) means not significant at the .05 level.

TABLE 8: A SELECTED OVERVIEW OF STUDIES ON CHANGE AND GROWTH

DATASET/STUDY	KEY VARIABLES	MODEL USED
Day Care Centers in Toronto, 1971-1989 ; Baum and Mezias (1993)	**Dependent Variable** growth, measured as the relative change in licensed capacity **Independent Variables** *size-localized competition:* (+), dense areas in the size distribution inhibit growth. *institutional linkages:* (+), institutional linkages have a strong positive effect on growth. *mass density :* (n.s.), mass has no effect on growth. **Control Variables** *lagged organizational size:* (<1), rejection of Gibrat's Law, growth monotonic declines with increasing size. *age :* (-) growth was significantly lower for older organizations. *several environmental control variables*	structural equation: fixed effects model selection equation: probit model to correct for sample selection bias using the Heckman two step procedure
California Loan and Savings Industry, 1977-1986, Haveman (1993)	**Dependent Variable** rate of investment in a non-traditional market. **Independent Variables** *size:* total assets, hypothesized inverted-U shaped relationship, confirmed in four of the seven markets. **Control Variables** *organizational age:* the number of years since incorporation. *level of diversification:* Herfindahl index of concentration.	Linear Partial Adjustment Model, Fixed Effects Model (corrected for autoregressio n and heteroskedast icity, but not for sample selection biases)

Credit Unions in New York City, 1914-1990 ; Barron, West and Hannan (1994)	**Dependent Variable** growth in terms of assets **Independent Variables** *lagged size:* assets for each Union (<1, rejection of Gibrat's Law, monotonic decreasing influence). *age:* time elapsed since founding of the Union (n.s. for the piecewise and Weibull model). *lnage:* significant (-). **Control Variables** Density variables (inverted U-shape relation with growth).	fixed effects model, no further correction for autocorrelation, heteroskedasticity and sample selection bias
American Telephone Companies, invention of the telephone -> 1934	**Dependent Variable** Growth **Independent Variables** *Competition from Bell* : number of subscribers to Bell (+) *Technologies Used* number of companies that use the superior or inferior technology (+) *Age:* time elapsed since founding	Fixed effect regression model, correction for heteroskedasticity and serial correlation, correction for sample selection bias

Legend:

(+) means a statistically significant (p<.05) positive sign.

(-) means a statistically significant (p<.05) negative sign.

(n.s.) means not significant at the .05 level.