UNIVERSIDAD CARLOS III DE MADRID working papers

Working Paper 02-51
Business Economics Series 20
October 2002

Departamento de Economía de la Empresa
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NEW SIZE MEASUREMENTS IN POPULATION ECOLOGY

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Abstract

In organizational ecology, we find the analysis of the impact exerted by competition between populations on vital ratios to be relatively under-developed. This paper intends to address this issue by developing new competition measurements whose common denominator is to give importance to organizational size. The application of these measurements in the case of competition between organizational forms in a population and their impact on mortality rates, demonstrates the usefulness of modelling competition on them. More specifically, results show how competition levels between firms in a population can be more adequately estimated when rival population mass is used (that is, the aggregate size of the organizations of which it is made up).

* Investigation funded by FEGA-FEOGA (CA099-019)

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Main text

INTRODUCTION

In organizational ecology investigations are carried out on how organizational populations change and develop through time, analysing processes of organizational founding, growth decline, transformation and mortality which occur internally. This perspective, in terms of the levels of analysis used, distinguishes between: organizational demography, population ecology and community ecology of organizations (Hannan & Freeman, 1977; Hannan & Freeman, 1989). Organizational demography refers to processes that apply at the levels of populations of organizations, population ecology refers to interactions between localized sets of populations, and community ecology refers to the processes that follow from the full set of population interactions in some systems (Carroll & Hannan, 2000: xx).

Although most of the published research in this field is identified as "ecological", this line of work has a strong demographic element. That is to say, the research on organizations in ecology has been fundamentally focused on the first level of analysis, since the second level has been insuficiently developed and even more so in the case of the third level (Astley, 1985; Ranger-Moore, Banaszak-Holl & Hannan, 1991; Hunt & Aldrich,1998; Ingram & Simons, 2000). Thus, the limitations found are reflected in 1) the limited number of papers developed in both population ecology and community ecology (second and third level of analysis) (Carroll & Hannan, 2000), and 2) an almost generalized absence of other types of tests due to the systematic application of density, or number of organizations in a population, as a basic variable to represent the size populations. In short, to the limited contributions made in population ecology, we must add the fact that no other types of variables have been applied to reflect the competitive potencial of a rival population.

In an effort to complete the previously defined problems, this paper develops several aspects: 1) go deeper into the second level of analysis, population ecology, and put forward a new test; 2) analyse the effects competition existing between two organizational forms classified in terms of ownership structures, that is, mutuals as opposed to stocks, on probability of survivorship (Barnett & Carroll, 1987; Ranger-Moore, Banaszak-Holl & Hannan, 1991; Hannan & Carroll, 1992; Haveman, 1992; Rao & Neilsen, 1992, Barron, West & Hannan, 1994, 1998) and 3) apply new measurements of competition between populations other than population density. The objective is to show the limitations of the cross effects of density model caused by the use of a dependent variable that does not allow us to represent the idiosyncrasies peculiar to the concepts which it sets out to measure in any given situation. For this reason, we will employ new variables which, despite being used in the first level of analysis (population mass, level of concentration) (Barnett & Amburgey, 1990; Carroll, 1985), have never been developed within the so called population ecology.

These new hypotheses will be tested using lifetime models with time-varying variables and they will be applied in the olive oil production industry in the province of Jaén during the period 1944 – 1998. The advantages of using this population are that not only does it belong to a new sector that has not previously been dealt with on a population ecology basis, but the official sources concerned have provided us with certain internal characteristics considered essential to be able to develop this type of research.

THE THEORETICAL BACKGROUND

Models of competition between populations.

The selection can come from either competion produced between organizations in a given population, or from competition produced between organizations belonging to different populations (Carroll & Hannan, 1995).

Growth of a population can frequently have a bearing on the survival chances of other populations. If two different populations rely on the same set of resources to survive, they will compete between themselves to obtain them. The more these necessary resources coincide for both populations, the greater the level of competition between them. If we define niche as the set of resources necessary for a population to survive (Hutchinson, 1957), two populations compete if, and only if, their fundamental niches intersect (Hannan & Carroll, 1992: 28). It could also be said that the greater the overlapping in the fundamental niches, the greater the competition between the populations (Barron, West & Hannan, 1998: 3).

In this way, the bigger the population, the more resources it will consume, and, therefore, the possiblity of them being consumed by another population will be reduced, increasing competition as a result (Rao & Neilsen, 1992). It is natural in this perspective to assume that the intensity of a competitive effect is proportional to the scale of the competing population. If the first population has a very small scale, the life chances of the second are not much affected. If the first grows in scale, then competition intensifies. In other words, ecological competition is *scale dependent* (Barron, West & Hannan, 1998: 13).

Traditionally, populational size has been measured by density, or number of organizations belonging to the population, developing the so called *cross effects of density* model (Hannan & Freeman, 1989) which establishes that the intensity of competition is proportional to the density of competing populations. This model arises as an extended version of the Lotka-Volterra framework used in biology to likewise register competition between populations. According to this model, two populations compete when the size of each population lowers the carrying capacity of the other; taking carrying capacity as the numbers that can be sustained in a particular environment in isolation from other populations (Hannan & Carroll, 1992: 29).

This model can be mathematically expressed as follows:

$$\frac{dn_1}{dt} = r_1 \times n_1 \times \left[\frac{K_1 - a_{12} n_2 - n_1}{K_1} \right]$$

$$\frac{dn_2}{dt} = r_2 \times n_2 \times \left[\frac{K_2 - a_{21} n_1 - n_2}{K_2} \right]$$

n_i being the population i of density, the growth rate for each population (dn_i/dt) is broken down in three components: 1) r_i , the intrinsic properties of the form that affect its speed of growth in the absence of resource limitations and competition, 2) K_i , the carrying capacity of each population and, 3) a_{ij}, competition with specific populations (Hannan, 1986: 6). Comparing these two equations we can observe how the presence of the competitor reduces the carrying capacity for the first population from K_1 to K_1-$a_{12}n_2$. The so called competition coefficients, a_{12} and a_{21} tell how the carrying capacity for each population declines with the density of the competitor (n_i).

The papers that test this model show that interdependences among populations have a direct influence on organizational viability, but not necessarily in the expected direction. Three types of interdependence can be distinguished (Hannan, 1986: 3-4; Hannan & Freeman, 1989: 96-97): 1) competitive, 2) predator form, and 3) mutualistic. The first is reserved for the situation in which the presence of a population reduces the growth rate of another (Baum & Oliver, 1991; Brittain, 1994). In other cases, competitive relationships can change to the predator form when the expansion of a population legitimates the other, but the growth of the second worsens the life chances of the first by eroding its resource base (Swaminathan & Wiedenmayer, 1991; Brittain, 1994). If balanced, coexistence is not possible, the second will invade the first's niche which will disappear (Hannan & Freeman, 1989). The relationships will be mutualistic when the expansion of one stimulates the expansion of another, and so reduce its mortality rate (Barnett, 1997; Ingram & Baum, 1997).

In several papers only one of the density cross effects is present. The papers devoloped by Carroll and Wade (1991) and Carroll and Swaminathan (1992) are examples of mutualistic relationships in one single direction. In papers by Hannan and Freeman (1988), Barnett (1990), Rao and Neilsen (1992) and Baum, Korn and Kotha (1995) the relationship is competitive.

A final possibility is that interdependence may be nonmonotonic. That is, growth in the density of a population could legitimate another one, until the density growth becomes so great that competitive interactions dominate. This can be confirmed in Silverman, Nickerson & Freeman's paper (1997), whilst in the papers by Hannan & Freeman (1989) and Staber (1992) opposite results can be deduced.

All these papers consider that the key variable to estimate the size of a rival population is the number of organizations (or the cross effects of density). It's possible that there are variables other than density that come doser to the concept of population size (Carroll & Harrison, 1994).

In organization and economic theory, it is believed that larger organizations generate stronger competition than their smaller rivals due to several factors, such as: 1) the ability to reduce their dependence on the environment and other organizations (Pfeffer & Salanzik, 1978; Thompson, 1967), 2) greater market power and superior access to resources (Aldrich & Auster, 1986; Haveman, 1993), 3) greater endurance in situations of resource shortages (Levinthal, 1991), 4) greater recognition (Edwards,

1955) and 5) the securing of benefits derived from economies of scale and scope (Scherer & Ross, 1990). Large organizations can also use predatory tactics to absorb smaller competitors (Scherer & Ross, 1990).

On the other hand, a population's growth rate, in a competitive situation with another, is conditioned by two factors: a) the smallest organizations of the rival population proliferate in number and b) the organizations in the second population grow to be large in size. This implies that competition between both populations could be better modelled using the rival population's global size instead of the cross effects of density, given the problem of the latter variable which considers all organizations in the same way without taking into account their individual size.

Using this global size, a model could be built which examines the competitive interactions produced between populations with similar resource necessities (that is, between populations with overlapping fundamental niches). That is to say, a model that, like the cross effects density model, uses the Lotka-Volterra framework to discover the effect the population global size has on the probability of organizational mortality rates in a second population with which it competes. Using similar terminolgy, this new model could be called *cross effects of mass* model.

Therefore, we will modify the Lotka-Volterra framework to model competition between populations using the aggregate of each population size (or population mass)[1]:

$$\frac{dn_1}{dt} = r_1 \times n_1 \times \left[\frac{K_{m1} - g_{12} M_2 - M_1}{K_{m1}} \right]$$

[1] To reformulate the Lotka-Volterra model we have based our work on Barnett & Amburgey's idea (1990) used to build the mass dependence model. Nevertheless, it would be possible to consider replacing the growth rate in numbers, which we have introduced into the formulae, with the growth rate in mass.

$$\frac{dn_2}{dt} = r_2 \times n_2 \times \left[\frac{K_{m2} - g_{21} M_1 - M_2}{K_{m2}} \right]$$

where n_i is the population i of density, dn_i/dt represents the growth rate in numbers of the population i, K_{mi} is the mass of the population i that can be supported in the niche with the level of resources held constant and M_i is the mass or aggregate size of the population i at a given time.

The growth rate in the population i can be reduced as a consequence of the two competitive processes mentioned: a) when the small organizations of the rival population increase in number, or b) when the organizations of the competing population increase in size. Through either of these two processes, competition between populations depends more on the rival population's mass (or the cross effects of mass) than on the cross effects of density.

In short, the presence of a second population in the same niche reduces the mass that can be sustained by this niche regarding the first population from K_{mi} to K_{m1}-$g_{12}M_2$. The coefficients γ_{12} and γ_{21} show how the mass that can be sustained by the niche for each population is reduced with the aggregate size of the competitor.

This model is built on the base of the original Barnett & Amburgey model (1990), called the mass dependence model, which establishes that the largest organizations are also stronger competitors, and, for that reason, global size increases of the population increase death rates (Delacroix & Rao, 1994). Continuing this line of reasoning, the cross effects of mass maintains that a population's competitive strength is proportional to its global size, and this strength is used to obtain the resources needed by its members, so reducing life chances of the elements making up the second population which share the same niche. In short, the increase in the global size of the largest organization should significantly increase the mortality rates in populations with smaller mass.

Ingram & Baum (1997) for the first time introduce the effects that the average size of a population can have on mortality rates in another. These authors, however, do not theoretically develop a model that uses cross effects of mass as a key prediction variable of organizational failure. Barron, West & Hannan (1998) explicitly introduce competitive interactions in terms of the rival population's mass. The competitive effect of cross effects of mass is introduced into the models to estimate the growth rate of the rival population. In this paper, nevertheless, cross effects of mass is used as a measure that adapts to the concept of competition between populations, affecting the mortality rates of each of them.

On the other hand, in numerous populations one can observe a tendency to increase their level of concentration, gradually and over a long period of time (Boone, Bröcheler & Carroll, 2000). In order to analyse the causes of concentration, it is necessary to understand the processes that effect variations in the number of organizations and organizational forms, as well as those affecting the distribution of resources amongst them (Hannan & Freeman, 1988). For this reason, it is vital to analyse how the level of concentration affects a population in the competitive environment of another when their fundamental niches intersect.

The variables used in the cross effects of density models and the cross effects of mass models, even when they are variables that indicate a population's competitive potential, are in themselves incomplete, since, having been measured in absolute size, they do not comtemplate the differences existing between members of the same population. That is to say, the first, density, takes into account the number of organizations but not the individual size of each one. On the contrary, mass takes into account the total volume of the organization but not the number of organizations. If we consider the information given by the mass variable, we can't discern if a population is composed of an infinite number of organizations of a relative size close to zero, or if it is one single organization that consumes all the resources. In order to measure both effects at the same time it is necessary to analyse the size distribution of organizations in a population through concentration (Boone & Van Witteloostuijn, 1995). Likewise, to understand the direction of population mass through time, it is necessary to associate it with many different distributions of organizational sizes that may exist (Barron, 1999: 427). As expected, the increase in mass arising from growth rates that are practically the same in all the organizations of a population is different from that which arises from the rapid growth of a small proportion of organizations. For this reason, attention should be paid not only to the evolution of density and mass, but also to the changes produced in the distribution of organizational sizes.

The cross effects of density and the cross effects of mass models consider that competition between populations is, respectively, a function of the number of organizations and the aggregate size in relation to the carrying capacity of the niche; however, they ignore an important characteristic of a population's competitive potential, such is the size distribution of organizations it possesses (Barron, 1999).

Therefore, if the fundamental niches of two populations intersect, the life chances of the members of one of them do not only depend on the level of concentration of its population, but also on the level of concentration of the rival population.

If we consider the internal composition of a population, that is, the differences that exist between the organizations of which it is made up, it may be possible to understand the competitive dynamics between populations. For this reason, it is vital to incorporate the internal power relationships that are produced between the members of a population, which could be obtained from the relationships between organizational sizes through concentration. To that end, we built a new model of competitive interactions that uses, as a fundamental exogenous variable, the level of concentration of each population, and to use the same terminology, we call the *cross effects of concentration model*. This models extends the Lotka-Volterra framework, introducing competition between populations in terms of the level of concentration of each of them. The key premise is that the level of concentration of a population determines its competitive potential in the search to obtain environmental resources, thereby having an influence on the life chances of the organizations that, having similar resource needs, belong to another population.

Given that competition intensity is proportional to the similarity in size of organizations (Hannan & Freeman, 1977; Hannan, Ranger-Moore & Banaszak-Holl, 1990), a reduced level of concentration would suppose strong rivalry between the organizations of the population, since there would be many organizations and the difference in size between them would be reduced. To relieve competitive tension existing in a population, a part of it would be transferred to a neighbouring population. Therefore, it is possible to identify the level of concentration of a population as an indicator of its competitive potential. As the level of concentration increases, the level of size difference of organizations also increases, thereby reducing the competitive tension within the population, and, as a result, their inclination to compete with other populations.

The *cross effects of concentration* model should not be confused with the resource partitioning model (Carroll, 1985). This author put forward the hypothesis that as market concentration increases, mortality rates in specialist organizations decline and in generalist organizations they rise. The exogenous variable is not the level of concentration that exists in each organizational form (or cross effects of concentration) but in the market in general. Competition between organizational forms is not, therefore, the driving force of the resource partitioning model (Boone, Bröcheler & Carroll, 2000)

Competition between organizational forms.

As we have already mentioned, if competition between populations is to arise it is essential that their fundamental niches intersect. Although there are diverse situations in which the niches of interacting populations do cross, in this paper we have concentrated on one particular case where the population is divided in two or more subpopulations in terms of the organizational forms found. The fact that two (or more) organizational forms can be considered subsets of a single population means that their niches intersect (Hannan & Carroll, 1992; Rao & Neilsen, 1992).

The organizational form is defined as a blueprint for organizational action, for transforming inputs into outputs (Hannan & Freeman, 1977: 935). The crucial assumption underlying the notion of organizational forms is that it is possible to identify relatively invariant organizational characteristics that make for stability over time, committing the organization to a recognizable set of environmental dependencies and to a limited range of plausible behaviours (Freeman & Lomi, 1994: 273).

Based on this definition population is conceived as all the organizations within a particular boundary that have a common form (Hannan & Freeman, 1977: 936). However, is it possible that various forms exist within a population? Yes. Empirical research in organizational ecology has proceeded on the assumption that more or less distinct organizational forms can be identified (Staber, 1992: 1192). In fact, one characteristic of the population is the diversity of forms of which it is composed

(Hannan & Freeman 1989). Now, the problem is which criteria should be used to differentiate the forms. Freeman and Hannan (1983) identify form with organizational strategy and in this way classify forms in specialists and generalists. On the other hand, Carroll (1984) justifies that there are no significant reasons to associate form with structure and organizational strategy. Organizational form means much more than the formal structure of the organization (Carroll & Swaminathan, 1992). Hannan and Freeman (1989) define organizational form using formally established limits such as: stated goals, forms of authority, core technology and marketing strategy. Thus we can observe that no consensus exists on the measurement of organizational form (Romanelli, 1991).

Virtually all theories of organization hold that some forms of organization have competitive advantages over other forms, although the particulars of the forms and the forces giving them advantage differ considerably by theory (Carroll & Harrison, 1994: 722). Weber (1968) considers that formalized structures per se are held to be inherently more efficient than informal structures. Contemporary theories focus primarily on differences among formal organizations. In resource dependence theory (Pfeffer & Salanzik, 1978), organizations with structures capable of reducing environmental uncertainty are depicted as having operating advantages. In transaction cost theory (Williamson, 1985) organizational structures that minimize costs are predicted to outperform others. In institutional theory (Meyer & Rowan, 1977; Meyer & Scott, 1983), organizations that are structured in a manner consistent with prevailing norms are thought to be favoured by authorities, customers and employees. And, in ecological theory (Hannan & Freeman, 1977, 1989), organizational forms that are better matched to their environmental conditions are seen as capable of outcompeting other forms.

It is important to recognize that each of these theories posits an underlying driving force that gives relative advantage to a particular organizational form. Researchers often assume that the existence or relative abundance of a particular organizational form represents the outcome of some process yielding competitive advantage for this organizational form. This process, according to the theoretical approach used, would be the reduction in uncertainty, transaction cost minimization, normative consensus, etc. (Carroll & Harrison, 1994).

For ecological research, it is important to classify forms taking into account ownership structures (Aldrich & Marsden, 1988: 58; Meyer & Zucker, 1989: 71). Following this criteria, we have classified forms in terms of property rights and governance system.

The structure of property rights defines the institutional basis of power relations among individuals in the production process within the organization, and in exchange between organizations (Bowels, 1984). The said structure affects the selection process of organizational form (Robbins, 1987; Lazerson, 1988) and, therefore, organizational diversity, which is the main topic of research for organizational ecology.

Using the criteria of structure of property rights, we can distinguish two organizational forms: stock form and mutual form. This classification has been frequently used in ecological research (Barnett & Carroll, 1987; Ranger-Moore, Banaszak-Holl & Hannan, 1991; Hannan & Carroll, 1992; Haveman, 1992; Rao & Neilsen, 1992, Barron, West & Hannan, 1994, 1998).

Both forms differ in: the nature and motivation of those who found the organization; the governance system (Barron, West & Hannan, 1994, 1998); the support received from public administration (Barron, West & Hannan, 1998); the way in which profits are shared and the taxation status applied (Barron, 1995; Barron, West & Hannan, 1998).

In the stock form, the underlying incentive is the possibility that owners have to obtain profits from a profitable investment. In the mutual form, the main incentive is satisfaction for the members of which it is made up, common needs and the feeling of solidarity. The main difference between a member of the mutual form and the participants in the stock form, is the dichotomy arising from the double condition of supplier/owner or customer/owner in one and the same person, thereby conferring a considerable portion of power to him/her within the organization. In the stock form, the supplier or customer and owner roles are normally undertaken by different people. In the stock form separation between ownership and control normally exists. Nevertheless, in the mutual form integration between the participation in a project and its codirection, supposes a considerable effort of "cooperative spirit" that has to be faced by the member (Staber, 1992: 1193).

With reference to power structure and governance system, the stock form is based on the binomial expression "vote-capital", the capital subscribers being those who, as owners, undertake the management of the enterprise (Morales, 1995). In the mutual form, the organizations are constituted as democratic organizations controlled by their members and run on the principle of one member, one vote, the value of each vote being the same, irrespective of the financial investment made by the member of the organization (Barron, West & Hannan, 1994). The members have full control, irrespective of the amount of capital invested which only serves to accredit them as owners. It is, in short, an effort to promote the human factor by giving each member a vote and relegating capital into a purely supporting role. (García-Gutiérrez, 1992).

The structure of those organizations integrated in the mutual form is determined by the cooperative principles stated by the Alianza Cooperativa Internacional (1995: 38-41) which, at the same time, constitute not only the spirit but the characteristic features of the running of an organization of this type.

With reference to profit-sharing, in the stock form, capital, as a priority production factor, is paid irrespective of its contribution to the fulfillment of organizational goals; in the mutual form, the idea is to reward the fulfillment of such goals, the creation of wealth, the creation of value added , highlighting the "person" as a production factor as opposed to others (Morales, 1995; 60-62; Jeantet, 2000).

Having proved the validity of the previous classification of organizational forms, the next step is to analyse if these forms compete. Beforehand, it is convenient to underline some of the elements which allow us to speculate about some of the possible links that exist between the organizational forms indicated. However, none of these speculations allow us to draw up formal hypotheses, which is consistent with other papers which have examined competition between populations and have also been unable to explicitly establish hypotheses (Carroll & Wade, 1991; Ranger-Moore, Banaszak-Holl & Hannan, 1991; Carroll & Swaminathan, 1992; Staber, 1992; Barron, West & Hannan, 1998; Lomi, 1995, 2000).

Populations are divided into segments that react heterogenerously to competitive and institutional processes (Lomi, 1995). This conclusion is consistent with the idea that it is difficult to believe that populations liken to a perfectly linked graph in which each organization affects and is affected by another (Lomi, 1995; Baum & Haveman, 1997). In the case that we are researching, the two organizational forms depend on similar sets of resources, with the absence of institutional or technological boundaries which could provoke further divisions. The high degree of overlapping of their niches is what gives rise to competition between both organizational forms (Baum & Singh, 1994; Ingram & Baum, 1997; Barron, West & Hannan, 1998).

In principle, one could suppose the mutual form to be less competition orientated than the stock form, due to the values and principles that determine the way it is run. Nevertheless, the idea of a common cooperative culture and tradition as the basis for cooperative and mutualist relations stands in contrast to the observation that cooperatives sometimes behave as "mini-capitalists" (Bradley & Gelb, 1983), competing with other organizations not only for material resources but also for political support and social legitimacy (Staber, 1992). Some case studies suggest that, especially in competitive environments, mutuals, rather than capitalist enterprises, are often pressured into adopting more efficient proceedures, and in this way obtain competitive advantages (Staber, 1992: 1194). These arguments lead us to believe that both forms should compete to obtain the resources they need to survive.

To confirm this supposition we will apply the models of competitive interactions mentioned in the previos section to the organizational forms found in a specific industry, which will so allow us test the validity of the newly designed models.

Organizational forms in the olive oil production industry.

To test the previous theoretical background we are going to use the olive oil production industry in the province of Jaén. The choice of this geographical environment is justified by the importance of production in this province, namely 28% of World production and 40% of European production (Consejo Oleícola Internacional, 1994).

Taking the oil mill ("almazara") ownership structure it is possible to distinguish the two organizational forms described in the theoretical background. On one side, there are mutual oil mills that mill their members' olives and generally belong to cooperatives, and on the other there are stock oil mills that are made up of organizations belonging to private enterprises that either mill the olives acquired from farmers through diverse contracts or mill the olives obtained from their own groves.

Therefore, both forms operate in the same business, in the same customer market but they differ, as we indicated in the theoretical background, in: 1) the nature and motivation of those who make up the organization, 2) the governance system, 3) profit-sharing, 4) the support recieved from public administration and 5) the taxation status (Barron, West & Hannan, 1998: 16).

The competition between these forms is established, theoretically, in a dual direction: on the one hand, through the acquisition of raw materials, olives, and on the other hand through the release of the final product, oil. However, reality shows that competition is almost exclusively reduced to the first of these environments, given that the commercial incapacity of the oil mills, both mutuals and stock, means that the production of virgen olive oil obtained is sold at the price set by the companies of the following stage in the agro-alimentary chain, multinationals that operate in a pseudo-oligopolio regime (Parras, 1997; Torres, 1997; Torres et. al, 2000).

The rapid decomposition of the fruit after it is harvested means that the process that transforms it into oil must be immediate so as to avoid a reduction in quality and, as a result, in its market value (Uceda & Hermoso, 1997). This obliges the oil mills to locate their plants close to their suppliers, which explains the high number (or density) of organizations in this industry. In figure 1, we show the evolution of the density of both organizational forms mentioned over the period of years from 1944 to 1998 inclusive.

INSERT FIGURE 1 HERE

To understand this figure we must indicate that the mutual form appears after the stock form (Hoogveld & Jurjus, 1990: 37). The development of the mutual form in the olive oil sector is relatively recent and coincides with a characteristic period of history (1950-1970) in which the Spanish economy and agriculture lived in complete autarky (López, 1982: 48). To this we must add the fact that public administration resolutely supported this organizational form (López, 1982).

For this reason, up until 1977 and, as can be seen in Figure 1, the number of stock oil mills was far higher than the number of mutual oil mills, 1954 being the year in which the difference between the density of both forms reached its maximum (a difference of 971 oil mills). After 1977 an important qualitative change took place in the structure of this industry converting the mutual form into the most important. Importance which increases over the years. In the meantime, the stock form moves in the opposite direction to that observed in the mutual form.

The loss of quality that the fruit undergoes from the moment it is delivered to the mill means that its transformation into olive oil must be undertaken as quickly as possible. This obliges the oil mill to install the adequate milling capacity. However, the difficulty entailed in predicting the exact amount of fruit available in any particular harvest and the need to guarantee its rapid transformation forces the oil mills to install productive capacities according to the maximum fruit delivery. To this we must add the technological change undergone in extraction systems used which have given rise to increases in the milling capacities installed.

To observe the evolution of the aggregate size of each organizational form (or population mass) we have drawn up Figure 2.

INSERT FIGURE 2 HERE

We can deduce that while the mutual form mass has not stopped growing through the study period, the stock form mass has remained practically constant. It can be proved that, as in the evolution of density, after the 70's the mutual form overtakes the stock form in what refers to transformation of raw material potential. After the 90's, both forms increase in size as a result of the technological change that takes place in the extraction systems used.

If we compare the two previous figures, we can see how the fenomenon in question occurs in the theoretical background. That is to say, while the number of organizations has drastically declined in the stock form, its population mass has remained relatively stable. But, in the case of the mutuals, the number of organizations integrated in this form has increased only slightly, or has indeed tended to decline at the end of the 60's, although the population mass has grown exponentially.

To finalize the characterization of the organizational forms that make up this industry, and considering the evolution in the number of participants and in the aggregate size of each of them, it is also necessary to observe the evolution of their levels of concentration. These levels appear in Figure 3, where the evolution, totally opposite in the concentration of both organizational forms, is represented. While in the mutual form concentration has declined to the point where it has remained constant; the stock form remained constant until the 70's when it began to increase. That is to say, while in the stock form the increase in concentration is due to the increase in size of a lower number of organizations but of a larger dimension, in the mutual form the decline in concentration is due to the fact that, on the whole, it has grown more in aggregate size than in the number of organizations.

INSERT FIGURE 3 HERE

Once again we can observe how it is in the 70's when an important qualitative change takes place in the composition of this industry. Nevertheless, we must make clear the excessive fragmentation that exists in both organizational forms, but mainly in the stock form, as shown by the low values obtained on the Herfindhal index during the period analysed.

METHODS.

Data sources and sample.

To develop this research we have built two data bases that contain information on each of the organizational forms found in the olive oil production industry in the province of Jaén for the period 1944-1998 inclusive.

The data base which includes the stock form is made up of 716 oil mills which have operated at some time during the study period. Of these oil mills, 392 are mills which have disappeared during the study period, while the rest are right-censored data (Lawless, 1982; Cox & Oakes, 1984). The second data base is made up of 303 mutual oil mills of which 70 disappeared[2] between 1944 and 1998.

The first conclusion drawn from the initial glance at these data bases is the higher rate of stock oil mills that disappeared (84.8% of the oil mills disbanded during the study period).

The data bases have been built using the following documentary sources:

- ***Register of agricultural firms held at the provincial office in Jaén of the Agriculture and Fisheries Department of the Andalusian Regional Government.***

[2] This number includes 11 mergers by takeover that were taken as disappearances in the years in which they occured.

This register is the main information source for these data bases and from it the following variables have been extracted for each oil mill: date of birth, date of closure (if applicable), milling capacity installed, explotation system and type of technology employed.

- ***Register of cooperatives held at the provincial office in Jaén of the Trade and Industry Department of the Andalusian Regional Government.*** The information extracted was used in the data base that contains the mutual form to test the data obtained in the previous register on the date of constitution and, if applicable, the date of the disappearance of the oil mill cooperatives.
- ***Agricultural Statistics Yearbooks*** published from 1946 to 1980 by the Ministry of Agriculture, and after that year by the Ministry of Agriculture, Fisheries and Food. From these yearbooks we have taken the annual olive harvests in the province of Jaén.
- ***Bernal, A.M. (1994), Ministerial Orders and Royal Decrees*** that annually set the price of electricity. From these sources we have calculated the cost of electric power. From the first we obtained the price of the Kw./hour for the years 1944 – 1992. From 1992 onwards we obtained the price from the Ministerial Orders and Royal Decrees published in the Official Gazette by the Ministry of Industry and Energy[3].

Variables

To carry out the empirical analysis we must define the endogenous variable and describe both the exogenous and control variables.

[3] Ministry of Industry & Energy: RD 1594/1992 23rd December (B.O.E. 30/12/1992); O.M. 1st January 1994 (B.O.E. 5/1/1994); O.M. 12 January 1995 (B.O.E. 14/1/1995); R.D. 2204/1995 28th December (B.O.E. 29/12/1995); O.M. 27th December 1996 (B.O.E. 28/12/1996); R.D. 2016/1997 26th December

Endogenous variable

Organizational age is the dependent variable. By using lifetime models with time varying variables, organizational age will enable us to identify the probability of survivorship or failure of an organization. If an organization was still running when the period of time covered by this paper finalized, it was taken as censored data (see Lawless, 1982).

The failure of an oil mill is considered to have occurred when it stops running, but not when its ownship or tradename changes, since, in these cases, there are no justified reasons to conclude that the whole organization is transformed and, in fact, it could continue using the same proceedures and routines (Baum & Mezias, 1992; Ingram & Inman, 1996).

Exogenous variables

Mutual as opposed to stock organizational form. As previously mentioned, we have divided the sample, taking into account the two organizational forms found, carrying out independent tests.

Density is measured as the number of active oil mills at the beginning of each year. This variable has been introduced into the model in lineal specification and quadratic specification dividing the result by 10. The reason for having included this variable with its quadratic specification is to attempt to register non-linear effects between the exogenous variables and the possibility of survivorship (Hannan & Carroll, 1992; Wade, Swaminathan & Scott, 1998; Dowell & Swaminathan, 2000). This variable has been calculated for both the mutual and the stock form.

Population mass. This variable takes into account the aggregate of the sizes of all the oil mills which were active at the beginning of each year. As with density, this variable

(B.O.E. 27/12/1997). The following abbreviations: B.O.E., O.M. and R.D. refer to the Official Gazette, Ministerial Orders and Royal Decrees respectively.

has been incorporated into the models in lineal specification and quadratic specification dividing the result by 100 (Barnett & Amburgey, 1990). It has also been calculated for both the mutual and stock form.

Concentration. This variable takes into account size equality of the oil mills that make up the respective organizational forms. It is measured using the Herfindhal index[4]. We have chosen this index for various reasons: 1) it verifies the properties required from the concentration indexes (Hannan & Kay, 1997; Encauoua & Jacquemin, 1980), 2) it has already been used as a measure of concentration in ecological literature (Barnett &

[4] The Herfindhal index for each of the organizational forms j (H_j) is calculated:

$$H_j = \sum_{i=1}^{n} S_i^2$$

With $S_i = a_i / A_j$ = Relative size of the organization i integrated in the organizational form j.
a_i = Size of the organization j.
A_j = Sum of the sizes of the organizations that make up the organizational form j.
n = Number of organizations integrated in the organizational form j.

Carroll, 1987; Wholey, Christianson & Sanchez, 1992) and 3) it is a suitable indicator of concentration since it gives more importance to the disparity of sizes between organizations than to the number of organizations. This variable has been introduced into the models in lineal specification and quadratic specification multiplied by 10,000, and independently calculated for each population as with density and mass.

Control variables

Two types of control variables have been calculated. Firstly, we developed the characteristics peculiar to the organizations that are not being studied in this paper, but which may affect their failure. Next, we developed the variables that, affecting the death probability, are the variables that characterize the environmental situation.

Explotation system. The way in which the business is exploited has a bearing on mortality rates (Boone, Bröcheler & Carroll, 2000). For that reason we have introduced a dummy variable that reflects, at every moment, if the oil mill is exploited by the owner (value 1) or if it is exploited under lease (value 0).

Organizational size. We have identified the milling capacity installed as a variable representing the size of each oil mill following the stream of investigation that, within organizational ecology, regards size as capacity (Barron, West & Hannan, 1994: 394-395). Within this stream of investigation, the empirical studies made include: storage capacity of wineries (Delacroix, Swaminathan & Solt, 1989; Delacroix & Swaminathan, 1991; Swaminathan, 1995), production capacity of breweries (Carroll & Swaminathan, 1992), license restrictions on the enrollment of day-care centers (Baum & Oliver, 1991) and room counts of hotels (Baum & Mezias, 1992). Moreover, the production capacity installed is the best measure of size in the research developed in organizational ecology, covering the niche space occupied by each organization (Winter, 1990). To this we should add that in the agricultural sector the transformation capacity of raw materials is the most representative variable of organizational size (Ministry of Agriculture, 1979: 27).

Types of technology. Technology has an influence on the performance of organizations, and signs of such influence are reflected in mortality rates (Barnett, 1990; Suárez & Utterback, 1995; Carroll & Teo, 1996). To control possible variations in probability of failure produced according to the type of technology used, we have introduced two dummy variables: obsolete and advanced technology. These variables take value 1 if the oil mill uses either of the two types of technology mentioned, and 0 in the opposite case. Both variables are introduced since they may both exist simultaneously in the same organization, although in different production lines.

In reference to environment control variables, we have introduced the following:

Niche saturation level. It is an exogenous factor related to the abundance of niche resources which directly affects the oil mills' life chances. The niche saturation level shows, at all times, the degree of depletion of the niches' resources. Despite not having been previously tested in organization ecology, it would be interesting to introduce the effect produced by the availability of niche resources. For this, we have set the niche saturation level as the difference between the total quantity of olives that the oil mills could have used in terms of their milling capacity installed and the annual olive harvests.

Electric energy cost. Electric energy is the power source that supplies the production system of an oil mill. This variable takes into account the cost of this supply in Pesetas/Kw/Hour. It therefore expresses the variable unit cost derived from the consumption of electric power. This variable has been introduced into following the approaches observed in other papers that, by estimating vital rates, control the incidence of the main organization cost (Barnett & Carroll, 1987; Mascarenhas,1996).

Institutional endorsement. Institutional theory advocates that the increase of embeddedness of a population in its institutional environment facilitates its growth and survival as time passes (Meyer & Scott, 1983). Ecologists agree that this connection increases a population's chances to survive and grow, improving the capacity of the population members to mobilize resources and increase their legitimation (Hannan & Carroll, 1992: 41). Several papers confirm that links with the institutional environment increase organizational survival chances (Singh, Tucker & House, 1986; Miner, Amburgey & Stearns, 1990; Baum & Oliver, 1991). Given that institutional endorsement could eliminate or reduce the limitations inherent to the environment, we have introduced a control variable which takes into account the years of governmental action implying endorsement of the constitution of organizations within the mutual form. In literature, such support has been represented by dummy variables associated with the approval received over a given period of time (Carroll & Hannan, 2000: 203-204). For this reason, we have used a dummy variable that takes into account the period effect derived from institutional endorsement of the mutual form and covers the period 1950-1970.

Analysis

To carry out the necessary tests, we have applied the lifetime model methodology with time-varying variables. Specifically, we have used the proportional hazard rate model (Cox, 1972) which allows the rate of failure to vary in an unconstrained way. Having used this model, all the estimated tests shown in the result tables (Tables 2 and 3) are expressed in the following way:

$$r(t) = e^{bX(t)}$$

where t is the organizational age measured in one-year spells, β the associated vector of coefficients and X the matriz of exogenous and control variables. If β has a positive sign the organization's failure probability will increase. On the contrary, if the sign is negative this probability will be reduced.

Following the methodology explained, in the *stcox* proceedure the statistical package Stata 6.0 (Stata Corporation, 1999) the values of the different variables were introduced in one-year spells and the coefficients β were estimated by maximum pseudo-likelihood.

RESULTS

In Table 1, we show the basic statistics and the correlations between exogenous and control variables for each organizational form. Tables 2 and 3 show the different models of competition between populations stated in the theoretical background, for each of the oraganizational forms analysed. With this our intention is to analyse how each organizational form has a bearing on the life chances of organizations that possess the alternative form, detecting, likewise, the most suitable model of competitive interaction.

INSERT TABLE 1 HERE

In Table 2, we present three piecewise exponential models of mortality in the stock form. Model 1 takes into account the cross effects of density model, revealing the impact that the number of mutual oil mills has on mortality rates in the stock form. We can observe that the only significant exogenous variable is the quadratic specification of the cross effects of density, indicating, thus, that competition within the stock form does not proceed from the oil mills of this type, but from the number of oil mills of the alternative form. We can deduce, therefore, that if the initial increases in density of the mutual form have a significant bearing on mortality rates in the stock form, albeit a mild effect, this effect will increase exponentially.

INSERT TABLE 2 HERE

To give a graphic idea of the magnitude of the effect of density of the mutual form on mortality rates in the stock form, we have calculated and graphically represented (Figure 4) the multiplier of the aforementioned density.

Mutual form density multiplier *= exp (0.0011072 x Mutual Form Density^2/10)*

INSERT FIGURE 4 HERE

We can see how the risk of failure of the stock oil mills increases at first more slowly, only to rise sharply later as mutual form density increases.

In Model 2 we can see how the mutual form mass exerts a positive effect on mortality rates of stock oil mills. That is to say, when the aggregate of the sizes of the mutual form increases, competition between both forms intensifies, so augmenting the risk of failure in the stock form.

Comparing the first two models, we can deduce that the scale or global size of the organizational form with which it competes has a significant impact on probability of failure. However, when the said scale is represented through mass, a more accurate model is achieved to explain the mortality which occurs in the stock form (for the same degrees of freedom, there is a difference of χ^2 = 6.27 compared to model 1). In accordance with this, competition between populations is more accurately represented when the explanatory variable used measures the scale of the competing population taking into account the aggregate size of the organizations that make it up.

The previous interpretation would be incomplete if we didn't take into account the direction of this impact by calculating the cross effects of mass multiplier and representing it graphically (Figure 5).

Mutual form mass multiplier *= exp (0.0009723 x Mutual Form Mass)*

INSERT FIGURE 5 HERE

We can prove how the failure risk for stock oil mills rises as the mutual form aggregate size increases.

In Model 3 we can observe the highly significant impact mutual form concentration has on stock form mortality rates. In this case, both the lineal and the quadratic component of the cross effects of concentration are significant.

To identify the design that stock form mortality rates follow in terms of the level of concentration of the mutual form we have calculated its multiplier:

Mutual form concentration multiplier *= exp (-207.71 x Mutual Form Concentration + 223.78 x Mutual Form Concentration*^{2} *x 10,000)*

In Figure 6 we graphically reproduce the behaviour of this multiplier, observing that it follows a nonmonotonic U-shaped design, which means that probability of failure in stock oil mills is reduced with mutual form concentration until it reaches a certain level, after which probability of failure of the stocks increases exponentially.

INSERT FIGURE 6 HERE

Comparing this model with the previous one we can conclude that the cross effects of concentration model presents a more complex design of competition between both forms (nonmonotonic design). Despite this, the cross effects of concentration model is the least accurate in the influence of competition between populations on failure probability. That is to say, we can demonstrate that the level of concentration clearly has a bearing on death probability. Nevertheless, the capacity to predict is inferior to that of either of the other two exogenous variables: population density and mass.

In Table 2 it is also possible to detect the significant repercussions the organizational control variables have on stock mill probability of failure.

More specifically, in all three models we can see how the size of a stock oil mill has a highly significant negative impact on its death probability. These results are consistent with those obtained in previous research which demonstrates that size is a variable that cushions organizational death probability (Carroll & Hannan, 2000).

Another organizational variable that generates a significant negative impact on stock oil mill failure probability, is the type of technology used in the transformation phase. Oil mills that use the most advanced technology in their production system, run lower risks of failure. This is due to the reduction in extraction costs and the obtaining of greater quantities of the final product thanks to the use of such technology (Hermoso, et. al, 1994).

With reference to the impact of the environmental control variables, we can see that niche saturation has a significant and positive effect on the risk of failure. The fewer resources available in the niche, the greater the probability of death for the oil mills that make up the stock form. However, the cost of electric power does not have a clear bearing on stock form mortality rates, since its statistical significance is reduced to just one of the models. The third environmental variable, institutional endorsement received by the mutual form, has a positive influence on the failure probability of stock oil mills. Institutional endorsement received by the mutual form encouraged the constitution of this type of oil mill, so having a negative impact on the continuity of the existing stock oil mills.

In Table 3, we present models of mutual form mortality. Models 4 and 5 take into account models of competitive interactions using the absolute size of the stock form. In both cases, we can see how size does not have a significant influence on mutual oil mill mortality rates. That is to say, neither the number nor the aggregate size of the oil mills that make up the stock form modifies the risk of failure in the mutual oil mills.

INSERT TABLE 3 HERE

In the last model of this Table (Model 6) we observe that the only sign of competition between both forms appears in the cross effects of concentration. In fact, we can demonstrate how the level of concentration of the stock form has a significant and positive influence on mutual form mortality rates. Now, in order to detect more specifically how the risk of failure evolves as stock form concentration increases, we must use the calculation of its multiplier and its graphical representation (Figure 7).

Stock form concentration multiplier = *exp (590.14 x Stock Form Concentration)*

INSERT FIGURE 7 HERE

In this graph we can see how mutual oil mill probability of failure increases with the level of concentration of the stock form, at first only slightly and later strongly.

In any case, the only model which allows us to deduce the competition exerted on the mutual form by the stock form is the cross effects of concentration model. The cross effects of density and mass models are not able to detect the existence of competition between both forms. Therefore, partial competition is produced between them which is only revealed using the difference in size of the stock form.

However, the lack of significance of the cross effects of density and mass models could be caused by a certain degree of multicolineality between the exogenous variables in lineal terms and in their quadratic specification. Nevertheless, in order to maintain the same criteria as in the previous analysis, and given that the goodness of fit of the models did not substantially improve after the elimination of the quadratic specification, we opted to keep the most complete models.

In relation to the control variables used only two have been found that have a significant influence on mutual oil mill failure probability. On the one hand, and as occured with the stock form, the size of the oil mill is inversely related to the risk of failure. On the other hand, and in relation to the specific nature of the mutual form, we can see how owner management reduces the probability of death.

DISCUSSION AND CONCLUSIONS

This paper represents an effort to put forward new measures of the competition concept. Fundamentally, organizational ecology has concentrated on understanding competition as the fight between members of a population to obtain the resources they need, and analysing how such competition affects foundation, mortality and organizational growth rates. This concept of competition is limited by not including competition proceeding from organizations that belong to another or other populations with similar resource needs. This paper intends to cover this deficiency by examining the rivalry that exists between localized sets of populations. The results achieved show how, on some occasions, the competition for resources does not proceed from the members that make up the population, but from organizations integrated in a different population.

From a methodological point of view, organizational ecology assumes that competition between populations is, principally, the role of density or the number of organizations in competing populations. In this paper competition between populations has been modelled using density, but also, using other representative variables of a population's competitive potential. Thus we have considered, independently, that the threat of competition in population depends on both the aggregate size of its members and the size distribution of each population or level of concentration.

The results obtained confirm the usefulness of modelling competition between populations using these last two approaches. We can demonstrate, therefore, that the cross effects of mass model is the most accurate to deduce both the existence of interaction between organizational forms that make up the olive oil production industry, and the type of interdependence that exists between them (in this case, of a competitive nature).

On the other hand, of the three competitive interaction models, the concentration model is the only one that allows us to detect the impact of one form on the other in each of the organizational forms. More specifically, in the mutual form this model allows us to understand the type of influence the stock form has on the survival chances of mutual organizations. In this case, the cross effects of density model and the cross effects of mass model do not have sufficient capacity to reveal the influence of one form on the other. These two models analyse competition in a superficial way since they do not examine thoroughly the power relationships produced between the members of the organizational form, so ratifying the usefulness of designing the cross effects of concentration model. That is to say, it is possible to see how and in what way concentration has a bearing on probability of failure. However, this model is less accurate for this probability. The lack of significance in the cross effects of density model and mass model could be caused by multicollinearity degree between the variables without and with quadratic transformation. Nevertheless, as the elimination of the quadratic transformation did not improve the models, we choose to keep the broadest tests. Thus, it is possible that concentration is a measure of a dimension other than the concept of competition, a concept of competition related to the degree of similarity between enterprises. A hypothetical case could arise in which all the organizations of a population are clonal with very little relevance as regards to their weighting in the niche. In this case, the cross effects of density model would coincide with the cross effect of mass model given that the latter measurement would be a multiple of the former. On the contrary, if there is a big degree of difference between organizations, the cross effects of density and the cross effects of mass models measure different things. In our modest opinion, and it appears that the results support this idea, the degree of competition is more accurately represented by the population mass variable.

Applying the competitive interaction models we can determine two basic questions that affect the success and survivorship of the organization in each form. On one side, we detect the existence of interdependence between the organizational forms which make up the industry under analysis, on the other it becomes evident that the mutual form is ecologically the stronger, as indicated by the significant and positive impact produced by the cross coefficients. That is to say, both forms fight to obtain the resources needed, but the mutual form is the one that triumphs. In any case, the complex relationship existing between the ownership structure and the competitive processes between the organizational forms described becomes evident.

We can conclude that organizational size should be incorporated in the measurements used to model competition between populations, either by summing up organizational sizes or through the level of concentration of the rival population. Moreover, the models developed using these measurements form a common link between researchers in the field of industrial organization and organizational ecology (Boone & Van Witteloostuijn, 1995).

The validity of the results obtained is conditioned by the development of similar papers in different environmental contexts, and in populations of other industrial sectors and services. The obtaining of statistically significant results would allow us to validate the competitive interaction models designed in this paper.

Another limitation of this paper, although of a statistical nature, proceeds from the reduced number of failures observed in the mutual form of the industry under analysis (70 failures). It could be difficult to prove that these failures are caused by the competitive threat attributed to the rival form (Barron, West & Hannan, 1998: 13). However, it is a minor limitation if we take into account the acceptance of the mutual form in this industry, which reduces the number of factors that can be detrimental to it.

On the other hand, the significance given to organizational size by the cross effects of mass and concentration models could have its disadvantages, as there is no direct proof of causal mechanisms associated with organizational size (Barron, 1999). Size is correlated to many other organizational characteristics and, for that reason, we must be cautious in using this variable as an explanitory causal factor of mortality in the competition between populations models.

Despite these limitations, the results obtained allow us to point out some leads in this paper to be followed up in the future. On the one hand, the competitive interaction models could be applied in the third level of analysis of ecological theory, community ecology, to observe the evolution of population communities. More specifically, and within the sector in question, we could examine how populations found at different stages of the olive oil agroalimentary chain interact. For example, analyse what influence the population of refinery and bottling enterprises has on oil mill populations. On the other hand, we should analyse the behaviour the cross effects of mass and the cross effects of concentration models in the area of organizational founding. Lastly, it would also be necessary to examine the prediction potential of the cross effects of concentration model when organizational growth rates are estimated.

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Figure 1. Number of mutual and stock olive oil mills during the period 1944-1998

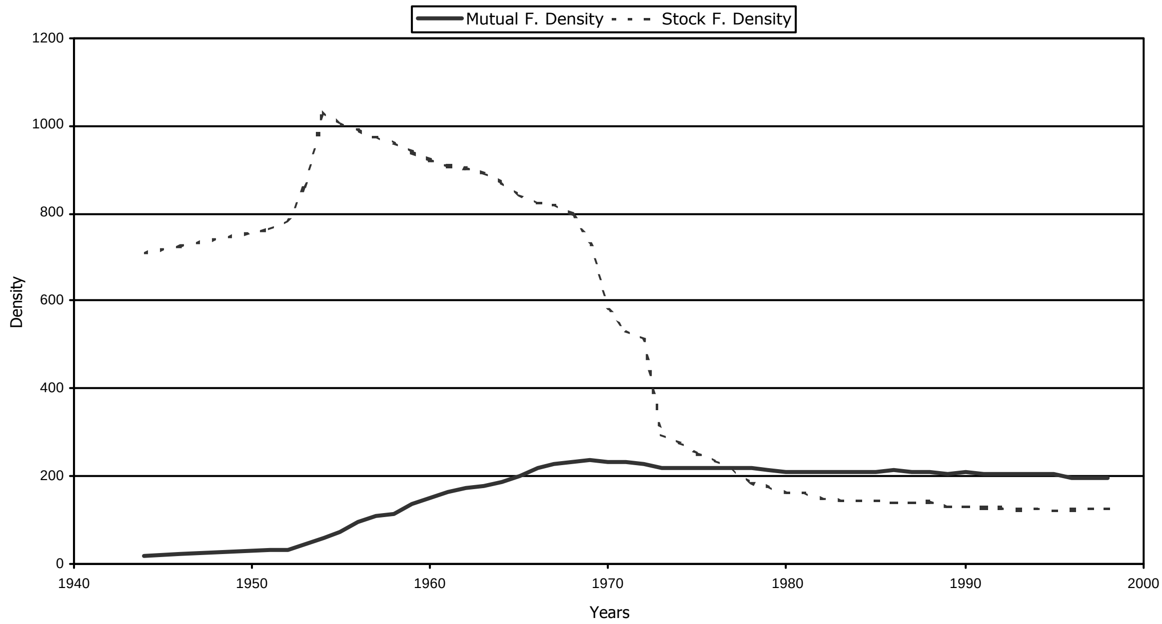

Figure 2. Aggregate size of the mutual and stock form durign the period 1944-1998

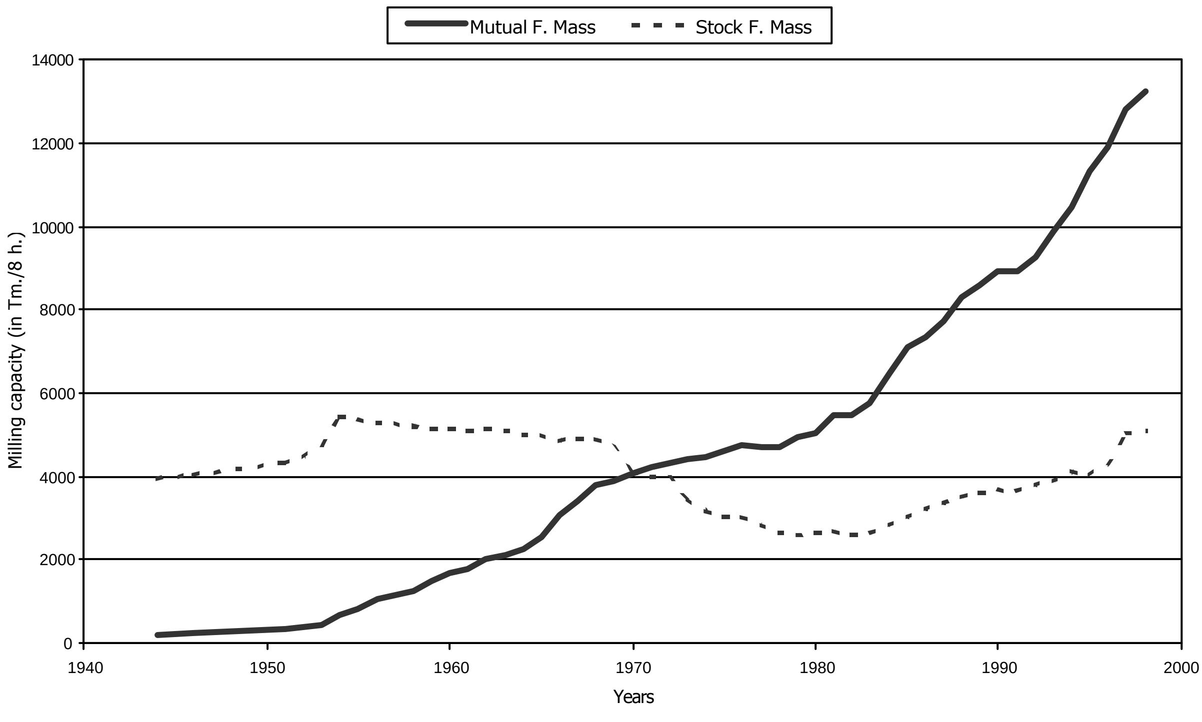

Figure 3. Concentration levels in the mutual and stock form during the period 1944-1998

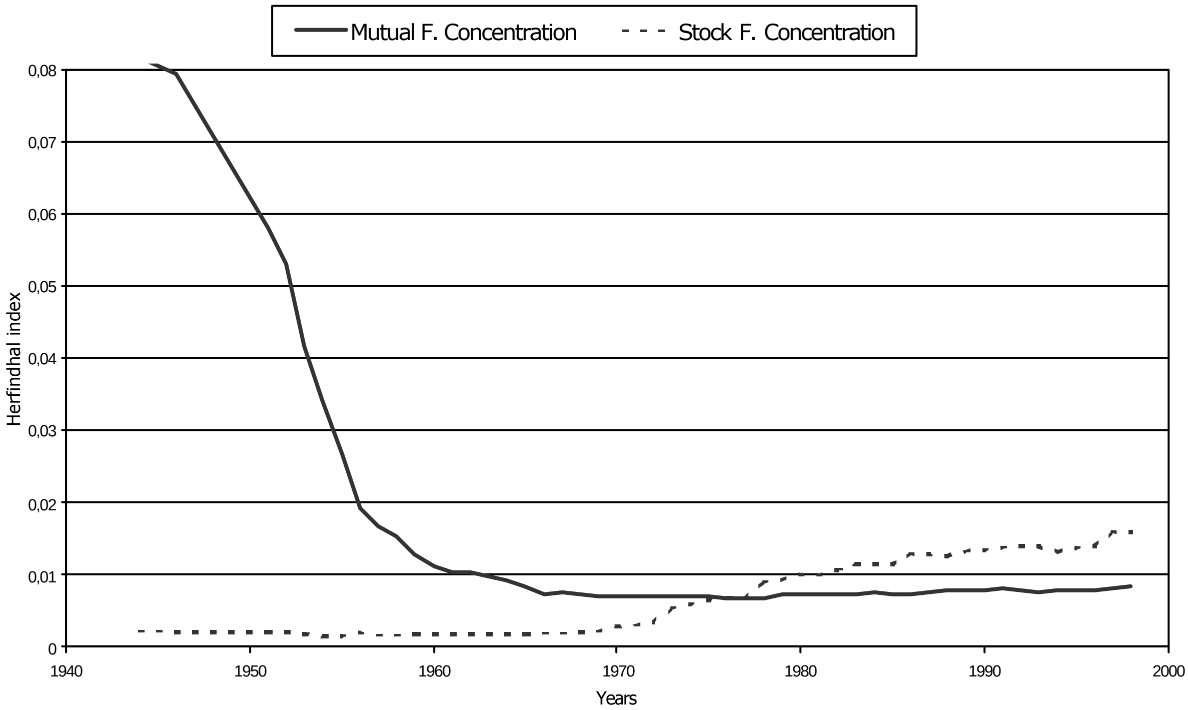

Figure 4.
Cross effects of density impact on organizational failure probability of stock form

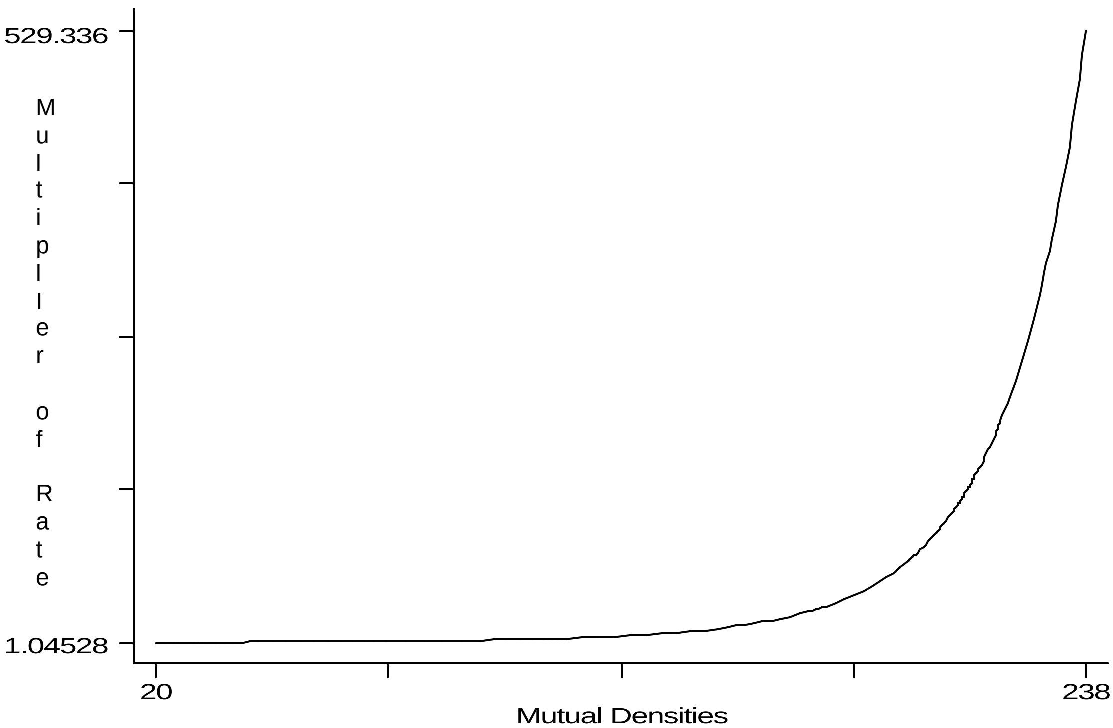

Figure 5.
Cross effects of mass impact on organizational failure probability of stock form

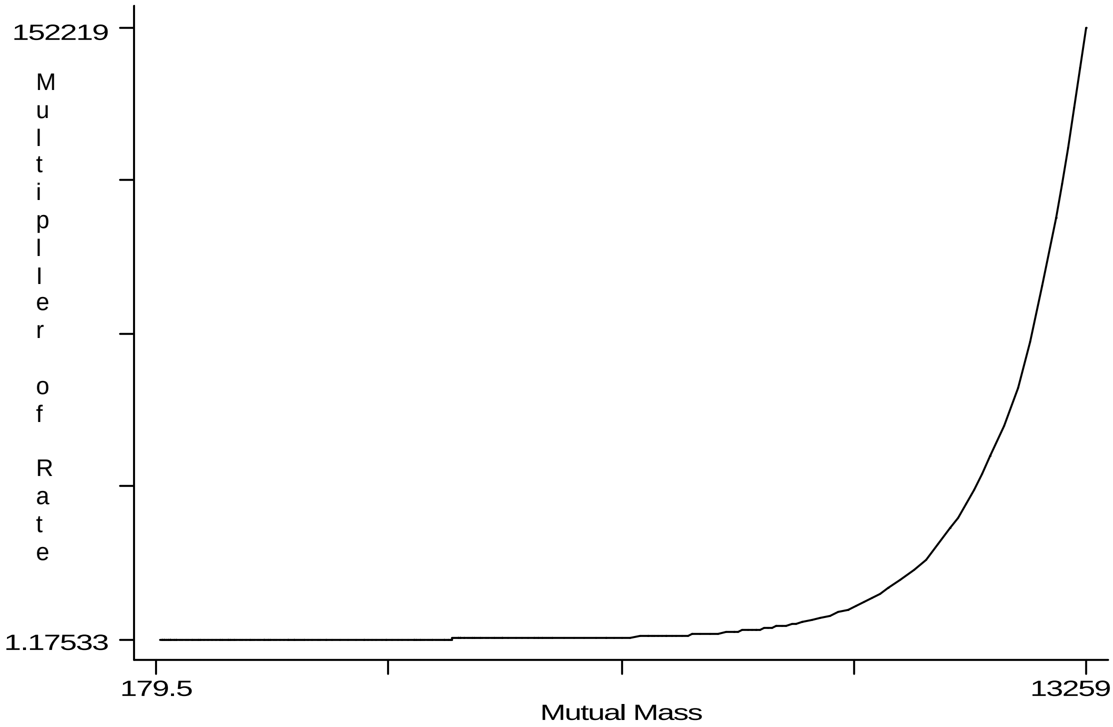

Figure 6.
Cross effects of concentration impact on organizational failure probability of stock form

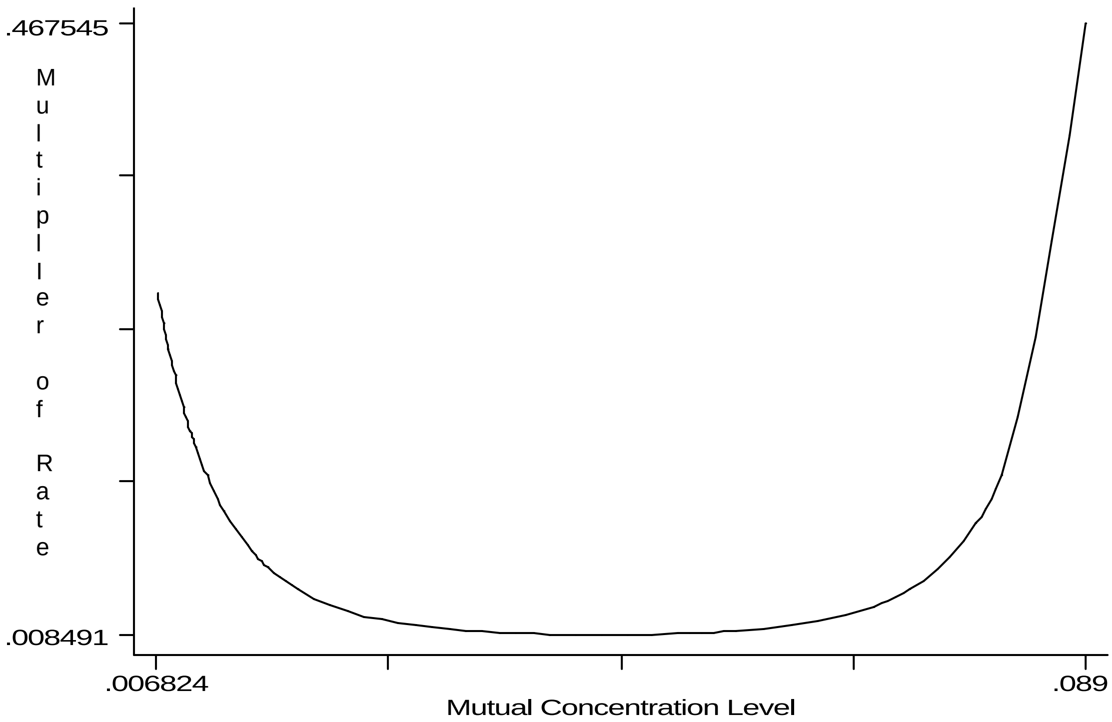

Figure 7.

Cross effects of concentration impact on organizational failure probability of mutual form

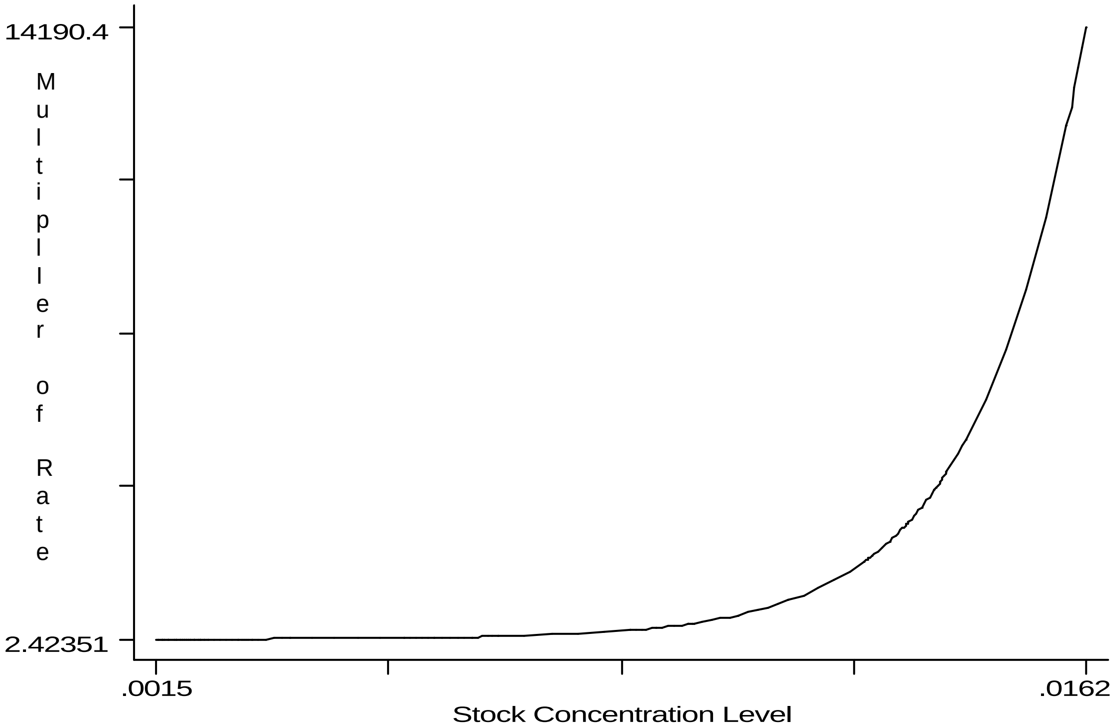

TABLE 1

Basic statistics and correlations between exogenous and control variables (a)

Variables	Mean Stock Form	S.D. Stock Form	Mean Mutual Form	S.D. Mutual Form	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. Stock form density	687.35	290.30	406.5	323.9		.98	-.46	-.44	.76	.78	-.79	-.65	-.90	-.81	.32	.22	-.01	-.39	-.14	.47	-.41	-.74	.92
2. (Stock form density)^2/10	55672	32586	27024	33525	.98		-.51	-.52	.78	.81	-.75	-.59	-.84	-.74	-.59	.32	-.00	-.36	-.13	.42	-.37	-66	.92
3. Mutual form density	136.71	80.64	197.34	43.36	-.46	-.42		.97	-.39	-.40	.39	.19	.29	.21	-85	-.72	.10	.13	-.00	-.10	.08	.20	-.31
4. (Mutual form density)^2/10	2519.5	2064.3	4082.3	1263.7	-.52	-.51	.98		-.42	-.45	.34	.13	.23	.15	-.74	-.37	.08	.10	-.00	-.05	.04	.13	-.32
5. Stock form mass	4421.4	790.6	3910.0	912.6	.85	.89	-.20	-.30		.99	-.22	-.01	-.47	-.29	.20	.09	.20	-.06	-.08	.06	-.03	-.21	.76
6. Stock form mass^2/100	201735	65561	161215	72171	.85	.90	-.17	-.28	.99		-.25	-.04	-.49	-.32	-.04	.19	.17	-.08	-.09	.08	-.04	-.24	.78
7. Mutual form mass	2718.9	2807.5	5608.4	3290.7	-.80	-.73	.71	.71	-.40	-.39		.96	.91	.94	-.37	-.30	.25	.53	.12	-.65	.59	.92	-.65
8. Mutual form mass^2/100	152748	299750	422831	447934	-.72	-.64	.44	.44	-.29	-.29	.93		.84	.91	-.21	.18	.26	.53	.11	-.66	.61	.89	-.53
9. Stock form concentration	.00385	.0038	.0077	.0050	-.90	-.81	.44	-.30	-.61	-.59	.89	.88		.98	-.27	-.21	.10	.48	.14	-.62	.55	.92	-.78
10. (Stock form concentr.)^2*10000	.00029	.0005	.0008	.0008	-.82	-.72	.38	-.28	-.47	-.46	.89	.93	.98		-.19	-.81	.14	.51	.14	-.66	.59	.95	-.68
11. Mutual form concentration	.02707	.0270	.0102	.0109	.23	.13	-.89	-.81	-.06	-.11	-.59	-.35	-.33	-.31		.97	-.13	-.13	.02	.13	-.11	-.22	.15
12. (Mutual form concen.)^2 x 10000	.01464	.0231	.0022	.0085	.14	.03	-.80	-.70	-.15	-.20	-.52	-.30	-.31	-.21	.97		-.13	-.11	.03	.11	-.09	-19	.03
13. Saturation of niche	381512	288372	459042	349152	-.05	-.00	.40	.37	.17	.17	.33	.26	.14	.17	.26	-.42		.14	.00	-.18	.17	.28	.01
14. Organizational size	9.50	14.00	27.87	29.30	-.41	-.36	.22	.22	-.21	-.21	.47	.49	.48	.49	-.18	.17	.12		.12	-.50	.33	.51	-.32
15. Explotation system	.781	.413	.946	.225	.05	.04	-.18	-.18	.01	.00	-.11	-.05	-.05	-.04	.18	-.15	-.00	-.01		-.10	.08	.13	-.13
16. Obsolete technology	.940	.236	.737	.440	.37	.32	-.15	-.15	.13	.13	-.48	-.55	-.49	-.53	.12	.10	-.13	-.37	-.00		-.82	-.67	.38
17. Advanced technology	.039	.194	.197	.399	-.38	-.33	.16	.16	-.12	-.13	.51	.58	.51	.55	-.14	-.12	-.14	.36	.01	-.80		.59	-.33
18. Energy cost	2.16	3.50	5.527	5.124	-.75	-.66	.41	.40	-.38	-.37	.90	.92	.93	.96	-.35	-.30	.27	.49	-.05	-.54	.56		-.60
19. Institutional endorsement mutual form	.586	.492	.316	.465	.76	.78	-.02	-.11	.80	.81	-.41	-.43	-.60	-.53	-.25	-.37	.11	-.25	-.02	.23	-.24	-.45	

(a) The values above the matrix diagonal correspond to the mutual form and those below to the stock form

Correlations ≥ |0.01| are significatives al $p < 0.00001$

TABLE 2
Piecewise Exponential Models of mortality in stock form, 1944-1998 (a)

Independent Variables	Model 1	Model 2	Model 3
1. Stock form density	-.0011		
	(.0034)		
2. (Stock form density)^2/10	-.00002		
	(.00003)		
3. Mutual form density	-.0208		
	(.0138)		
4. (Mutual form density)^2/10	.0011*		
	(.0005)		
5. Stock form mass		.0020	
		(.0011)	
6. Stock form mass^2/100		-.00003*	
		(.00001)	
7. Mutual form mass		.0009****	
		(.0001)	
8. Mutual form mass^2/100		-1.37E-06	
		(1.43E-06)	
9. Stock form concentration			812.82****
			(221.2941)
10. (Stock form concentration)^2*10000			-6274.58***
			(1898.59)
11. Mutual form concentration			-207.71****
			(43.84)
12. (Mutual form concentration)^2 x 10000			223.78****
			(54.53)
13. Explotation system	-.0761	-.0773	-.0593
	(.1114)	(.1115)	(.1112)
14. Organizational size	-.1332****	-.1354****	-.1317****
	(.0134)	(.0134)	(.0133)
15. Obsolete technology	-.2202	-.0916	-.2635
	(.4572)	(.4677)	(.4580)
16. Advanced technology	-2.049*	-2.031*	-2.119*
	(.8434)	(.8442)	(.8430)
17. Saturation of niche	8.26E-07*	7.91E-07*	6.90E-07*
	(3.23E-07)	(3.17E-07)	(3.41E-07)
18. Energy cost	-.0585	-.3784****	.2226
	(.0466)	(.0584)	(.1267)
19. Institutional endorsement mutual form	1.059*	1.228***	.4996
	(.4089)	(.3722)	(.3990)
Chi-squared (χ^2)	314.91****	321.18****	251.43****
D.f.	11	11	11

**** = $p < 0.0001$; *** = $p < 0.001$; ** = $p < 0.01$; * = $p < 0.05$

(a) Standard errors are in parentheses

TABLE 3
Piecewise Exponential Models of mortality in mutual form, 1944-1998 (a)

Independent variables	Model 4	Model 5	Model 6
1. Mutual form density	-.0532		
	(.0281)		
2. (Mutual form density)^2/10	.0021*		
	(.0010)		
3. Stock form density	-.0067		
	(.0059)		
4. (Stock form density)^2/10	.00004		
	(.00005)		
5. Mutual form mass		.0004	
		(.0003)	
6. Mutual form mass^2/100		-1.85E-06	
		(2.53E-06)	
7. Stock form mass		.0015	
		(.0021)	
8. Stock form mass^2/100		-.00002	
		(.00002)	
9. Mutual form concentration			-64.59
			(87.71)
10. (Mutual form concentration)^2*10000			72.15
			(114.92)
11. Stock form concentration			590.14*
			(300.3)
12. (Stock form concen.)^2 x 10000			-4047.7
			(2149.34)
13. Explotation system	-1.260****	-1.255****	-1.276****
	(.3108)	(.3108)	(.3095)
14. Organizational size	-.0733****	-.0736****	-.0718****
	(.0154)	(.0154)	(.0154)
15. Obsolete technology	-.0342	-.0680	.0047
	(.7498)	(.7518)	(.7502)
16. Advanced technology	-1.284	-1.269	-1.226
	(.8520)	(.8524)	(.8504)
17. Saturation of niche	6.89E-07	6.29E-07	5.20E-07
	(4.12E-07)	(4.10E-07)	(4.30E-07)
18. Energy cost	.0440	-.0119	.1997
	(.0605)	(.0928)	(.1414)
19. Institutional endorsement mutual form	.5608	1.132	.6371
	(.8035)	(.7115)	(.7545)
Chi-squared (χ^2)	99.23****	97.23****	92.41****
D.f.	11	11	11

**** = $p < 0.0001$; *** = $p < 0.001$; ** = $p < 0.01$; * = $p < 0.05$

(a) Standard errors are in parentheses.