THE EFFECTS OF THE BREWERY INDUSTRY ON THE EVOLUTION OF THE METAL CAN INDUSTRY

by

Moshe Yanai

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Moshe Yanai
Head of The environmental statistics division, The Israeli Bureau of Statistics
E-mail: yanai_77@netvision.net.il

ABSTRACT: Positive interactions in business have received little attention in recent years. I propose a set of definitions and research tools for analyzing these types of interactions among organizations. These proposed tools are applied in a study of the interaction between the metal can and large breweries industries. Although the proposed set of propositions was not supported by the data, there is some evidence that positive interactions do play a role in determining the fate of organizations. Future research is needed for better understanding and generalization of the conditions in which positive interactions are more likely to occur, and the consequences of positive interactions for organizations.

1. Introduction

Organizational ecology, the arena that studies temporal evolution and diversity of human organizations, has focused primarily on competitive (i.e. negative) interactions among organizations and organizational populations (Carroll 1984). Positive interactions have drawn increasing attention in theory and research in biological ecology in recent years (Bronstein 1994). Organizational ecology, which has roots in biological ecology (mainly with regard to the concept of natural selection), did not follow suit in this respect, although positive interactions play a central role in social and economic systems along with competitive interactions. As Beard and Dess (1988) state "positive interactions are the main way in which environments make resources available to organizations, whereas competition is the main way in which environments withhold resources."

Few studies in organizational ecology have looked at positive interactions among organizations. For example, Barnett and Carroll (1987) studied competition and mutualism among early American phone companies; Baum and Singh (1994) studied positive and negative interactions among day care centers in Canada, while Swaminathan (1995) examined negative and positive interactions within the American wine industry. None of these studies focused on positive interactions alone. The terminology used to describe positive interactions was incoherent and confusing, where terms such as mutualism, symbiosis and commensalism were used alternately without a clear definition.

In order to study in detail positive interactions among human organizations we first need to agree upon a clear and reliable classification system for these interactions. I propose a classification scheme (table 1) developed by the biologist Burkholder (1952). This scheme defines interactions between two biological species using two identifying phases: the “on” phase that refers to situations in which the species interact, and the “off” phase that refers to conditions in which the species stop interacting. The interaction outcomes for the species are measured in terms of productivity for each population and are symbolized by +, - and 0, representing increase, decrease and no change in the population’s productivity, respectively. The scheme identifies nine possible biological interactions, from which five positive interactions are revealed (Positive interactions include all the non-negative interactions in the “on” phase, in which at least one of the populations is positively affected.) From these five, three are well recognized: mutualism, protocooperation, and commensalism. The other two are very rare in nature and have never been scientifically named.

This biological scheme can be easily transformed into organizational ecology using accepted operational measuring tools in this arena. The productivity effects on interacting organizational populations can be measured in terms of performance (e.g. profit or sales volumes) in the short run and viability (birth and mortality rates of organizations) in the long run. The ”on” phase, which stands for the outcomes of the interactions can be measured in terms of performance or birth rate effects on each population. The “off” phase, which stands for the outcomes of no interaction and, therefore, represents the level of dependency between the interactors, can be measured in terms of mortality effects on the populations. Based on the biological terminology (table 1), we can draw the following definitions for two interacting organizations or organizational populations:

Mutualism is an interaction in which both entities have reciprocal positive (+) effects on each other in terms of performance, birth rates, and mortality (i.e. higher performance, birth rate and mortality in one population lead to higher performance, birth rate and mortality in the other population, respectively). This interaction type includes a special case of “symbiosis” (Cushman and Beattie 1991) that refers to mutualistic interactions in which the interactors are physically integrated (possibly, cases of mergers and vertical integration).

Protocooperation is an interaction in which both entities have reciprocal positive effects regarding performance and birth rates, but have no effect on each other's mortality rates.

Commensalism occurs when entity A has positive performance, birth rate, and mortality effects on entity B, while the entity A is not affected by entity B in any way.

Note that this set of definitions requires testing the effects on both interactors before determining their type of interaction. In some occasions this process can be very labor intensive, however, accurate identification can be very helpful for better understanding and analysis of the different types of interactions and their outcomes.

The next section will discuss the application of positive interactions at the population level in business. Then, a brief historical review of the studied organizational populations, the metal can and the brewery industries, will be presented. Finally, a case study regarding the interactions of these populations will be presented analyzed and discussed.

2. Positive interactions between suppliers and their business customers

Under the assumption of rational behavior, organizations that exchange services or goods are expected to positively affect each other. Otherwise, it would not be worthwhile for the interacting parties to keep the trade going. However, the parties may also develop dependency through long-term contracts and a network of personal relations. Organizations may choose to locate their facilities next to other organizations with which they regularly exchange goods or services in order to reduce transportation and coordination costs. Once this dependency is created, a shift to an interchange with different organizations might be costly. For example, when one of the long-term partners in a business exchange closes down, the other partner may try to replace it with a new partner. However, in order to make this switch, the surviving partner might have to update its equipment, relocate some of its facilities, face higher transportation, coordination and legal costs, and/ or compete with new superior organizations for a new partnership. Furthermore, the organization may also face the risk that a replacement is not to be found and hence, it will have to reduce its production or, in extreme cases, even close down.

When aggregated into the organizational population level, both interacting populations are expected to positively affect each other's production and birth rate. However, higher dependency costs are expected to increase mortality rates in these mutually interrelated populations as well. In other words, these populations may be involved in an interaction classified as mutualism. The mutual interaction effects are not expected to be symmetrical since the supplier population and the customer population can rarely affect each other equally. The dependence and benefit levels for each population are determined by the proportion of production attributed to the other population. In addition, the environmental conditions and resource availability can change the nature of the relationship and even shift it into a different type of interaction. This set of ideas has never been tested within the framework of organizational ecology. In order to test these ideas, two organizational populations that are involved in economic exchange were studied: the metal can industry and the large breweries.

3. The Metal Can Industry

The history of canning dates back to 1795 (Can Manufacturers Institute 1998) when the Frenchman Nicholas Appert invented a method of storing food for long periods of time using airtight bottles sealed with cork stoppers. The invention was tried on the French army, and the emperor Napoleon Bonaparte, who claimed that “an army marches on its stomach”, rewarded the inventor with a prize of 20,000 francs.

Fifteen years later, the invention reached Britain, where it was extended into using metal and tin containers as well. Tin cans were more advantageous than bottles for military use since they were not breakable and were easier to handle. In 1812, the first canning plant was established in the United States. The gold rush (1849) and the civil war (1861) greatly helped spread the industry into new frontiers. By the end of the civil war, the production in the U.S. alone had reached 30 million cans per year.

Still, the process of canning was labor intensive, and remained so for the next 60 years. Cans were made by hand, and a can maker could make a maximum of 10 cans a day. Progress in can-making production began in the early 1920’s when American engineers introduced a series of technical improvements that enabled speeding up the production to as many as 250 cans per minute. In the early1940’s manufacturers started adapting cans to pack carbonated soft drinks and beer by improving the cans' internal coating. Canning carbonated soft drinks introduced problems of corrosion, color changes, and leakage to the can developers. Preserving beer was somewhat easier since beer is less corrosive, ages naturally, and has a limited shelf life of about three months in any package. The commercial adaptation for beverage cans took place only towards the mid 1950's due to wartime material limitations during World War II and the Korean War.

In 1965, the metal can industry received a great boost with the introduction of the aluminum can. Aluminum beverage cans have several advantages over the traditional steel cans. The aluminum cans are formed from only two pieces, a body and an end. This structure enables 360 degree printing on the can body and enhances its display appeal. In addition, aluminum cans are easier to model, have better support for carbonation pressure, are lighter, and resist corrosion. The steel manufacturers tried to stay updated and came up with their own version of a two-piece steel can. However, the steel cans were never fully accepted by brewers and soft drink bottlers.

In the late 1960's, with the rise of environmental awareness, both steel and aluminum can producers started facing an increasing public pressure regarding the environmental damages cans cause in the areas of mining and refuse disposal. As a result, by 1970 can makers began recycling cans. Aluminum cans had proven to be more economical in their recycling process than steel cans. Along with the other advantages of aluminum cans, this led to a full domination of the aluminum can in the industry by 1985.

The metal can industry has kept developing since then. In 1997 production of cans in the U.S had reached an annual rate of 133 billion cans, a recycling rate of 66.8% for aluminum cans, and $8 billion in income for beer sales.

4. The American Brewery Industry

The history of the brewing industry in the U.S goes back to about 1633 (Carroll and Swaminathan 1991). In similar fashion to the metal can industry, American brewing also started as a small craft-based industry and remained so for a long time due to technical limitations. The industry started expanding in the 1840's; however, this expansion was interrupted by a prohibition on alcohol imposed initially by various states and later by the federal government. It was not until 1933, when federal prohibition ended, that the production of beer started increasing again. However, until the mid 1980's, the number of breweries kept declining. This process occurred mainly through acquisitions and mergers and demonstrated strong economies of scale and high concentration in the industry. Since 1983, the number of breweries has been rising. Most of the new entries to the industry have been in the form of small microbreweries and brewpubs. Recent studies describe this process as resource partitioning, in which the large and generalist organizations capture the core of the market and leave the remote margins to the small specialist ones (Carroll and Swaminathan 2000). The records show that by 1995, the total sales of the brewery industry had reached 190 million barrels with more than 99% of this volume derived from 25 large breweries. The remaining 1% came from 709 small breweries. Since then, the number of small breweries has almost doubled, while the number of large breweries has remained stable.

5. The Interaction Effects on the Metal Can Industry: Propositions

The distinction between the large and small breweries populations provides a great opportunity to study the net effects of the interaction with the metal can industry. Generally, only the large breweries use cans to pack their products, and therefore they can be used as a test group. The small breweries, which rarely can their products, can be used as a control group because they are affected by similar environmental factors, but do not interact directly with the metal can producers.

Previous research in organizational ecology thoroughly studied mortality and formation of organizations within organizational populations as a function of their density (Singh and Lumsden 1990). Although past research considered both positive and negative interactions, its main focus has been on competition and selection processes (Hannan and Freeman 1984). The current study is designed to examine the consequences of the interaction with the large brewery industry for the metal can industry in terms of mortality and birth rates within a perspective of positive interactions.

Hypotheses of Positive Effects: The following line of propositions examine the positive effects of the large breweries population on the metal can industry, while controlling for negative and positive effects within the metal can industry. It is hypothesized that the two industries are engaged in a mutualistic interaction. However, since the definition of mutualism requires the examination of both interactors on each other, the precise nature of the interaction can be revealed only after examining the effects of the metal can industry on the large breweries as well.

The metal can industry benefits from the brewery industry's demand for cans, and hence, new formations of large breweries are expected to increase the overall demand for metal can products, and provide an enhanced business opportunity for new entrepreneurs in the metal can industry. This leads to the following proposition:

Proposition 1: An increase in the annual rate of formation of large breweries will positively affect the annual rate of formation in the metal can industry.

The creation of new large breweries may provide an opportunity for existing or new metal can firms to capture a new pocket of demand for cans. The opportunity for new metal can firms to capture the free demand is especially high when there are no other metal can firms in their area. However, once existing or new metal can firms capture the demand and long-term contracts are established, the opportunities for expansion or new formations diminish, and therefore:

Proposition 2: The positive effect of formation of large breweries on the formation of metal can firms will diminish over time.

For the last ten years, beer cans constituted about 30% of the metal can industry production (Can Manufacturers Institute 1990,1993,1996). In addition, some metal can plants are located adjacent to their main customers (Swaminathan, personal communication). Therefore, the metal can industry seems to be somewhat dependent on the demand for cans from the large brewery industry. Mortality of large breweries is expected to decrease this demand, and hence, the metal can industry is expected to suffer negative effects as a result of mortality of large breweries.

Proposition 3: Mortality of large firms in the brewery industry will positively affect (i.e. increase) mortality in the metal can industry.

Metal can firms may switch to alternative customers as a result of large breweries' mortality. However the switch might be costly and sometimes impossible. Therefore, the risk of mortality for metal cans firms, especially in the same area, may increase as a consequence. However, once firms have succeeded in adjusting their production and facilities or found alternative customers, the effects of the breweries' mortality is expected to diminish.

Proposition 4: The positive effect of mortality of large breweries on mortality of metal can firms will decline over time.

In both ecology and business, the intensity of interactions can be affected by spatial distribution of the interactors. Populations that are spatially proximate to each other tend to compete more intensely for common resources (Baum and Mezias 1992). Therefore, proximate populations may endure greater reciprocal benefits and dependency effects when their resources do not overlap. This assumption yields the following proposition:

Proposition 5: The positive effects of mortality of large breweries on mortality of metal can firms will be greater for firms that operate in the same geographical region (i.e. East, Midwest, and West coast).

The temporal dimension may also play an important role in determining the intensity of interactions between organizational populations. In the beginning of the interaction, long-term contracts, marketing channels, and personal networks are still undeveloped. When the interaction matures, these associations become more institutionalized, and major changes are less likely to occur. Whenever major changes do occur, they might be very costly and even dangerous. For example, a metal can firm that is forced to switch to a new major customer after a long-term contract had been terminated with one of its main clients may face higher than average marketing, legal, and equipment costs, and hence, a higher mortality risk. The significant interaction between the metal can and the brewery industries started in the mid with the introduction of the aluminum can. If dependency increases with time, the following proposition may apply:

Proposition 6: The mortality effects of the large breweries industry on the metal can industry will be weaker during the 1960's than during the 1970's 1980's or 1990's.

According to the biologists Brooker and Callaghan (1998), there appears to be an active relationship between the severity of the environment (i.e. the levels of disturbance and resource scarcity) and the overall direction, either positive or negative, of plant species interactions. In their view, competition becomes less important with increasing levels of severity, while positive interactions become more important under these conditions. This trend is explained by changes in environmental selective forces along severity gradients.

The notion that the severity of the environment may affect the balance between negative and positive interactions can be implemented into the business arena. In order to test this argument in business, the metal can cost index was used as an indicator for resource scarcity, where high cost index represents greater resource scarcity. Higher production costs may lead to higher prices and lower demand for the final product. In addition, higher costs may increase competition within the industry for the reduced resources. Overall, this trend may drive the less efficient firms in the industry out of business. When resources are scarce for a long period of time, mortality of a main customer may have a greater effect on the risk of failure. When aggregated to the population level, the dependency of metal can firms on their customers is expected to be greater in stressed conditions than in unstressed conditions. These arguments lead to the following proposition:

<u>Proposition 7</u>: The effects of mortality of firms in the large breweries industry on mortality of firms in the metal can industry will be greater during periods of above average production cost in the metal can industry.

A similar argument can be claimed for the effects of system disturbance on the risk of failure. When an economic disturbance strikes, the overall demand for products decreases and unemployment rates rise. Under reduced demand, the dependency on customers may be more important and crucial for the organization's survival. This argument yields the following proposition:

<u>Proposition 8</u>: The effects of mortality of firms in the large breweries industry on mortality of firms in the metal can industry will be greater during periods of above average unemployment rates.

To test these propositions, a model will be developed, in the next section, and appropriate data assembled to empirically implement the model.

6. Method

6.1 Data Sources

The data for the metal can industry were collected using two business directories: The Poor's Register directory (Standard Poor's Register, various years), and the Million Dollar Directory (Dun & Bradstreet, various years). The former was used in order to compile yearly life-history data regarding formations, mortality and location for each organization registered within the SIC classification for the metal can industry. There is no differentiation between mergers, acquisitions and dissolution; they were all considered as mortality. The Million Dollar Directory was used in order to verify the data from the Poor's directory, and also to obtain additional data for the organizations regarding their yearly size and sales volumes.

The primary data for the brewery industry were received electronically (Carroll and Swaminathan 2000). These data included yearly entries for breweries at the firm level for both small and large breweries. Each entry included information regarding birth date, mortality date, size, type of brewery, and location. Since many of the large breweries operated multiple plants, the Modern Brewery Age directory (Modern Brewery Age, various years) was used to collect additional data regarding foundings and mortality at the plant level. In addition, sales volumes were collected at the firm level because they were not available at the plant level.

The data for both industries cover the years 1962 to1996 within the United States (excluding Alaska and Hawaii). The year 1962 was selected as a starting point, because data on the life history of the metal can industry became available only then. The ending year was set to 1996 due to limitations of the brewery data.

6.2 Data Manipulation

The data for the mortality analysis were combined from unique observations regarding each registered firm that operated during the study period in the metal can industry. Each observation contained multiple records for each year of operation, from the firm's birth until its dissolution, or until the end of the study if it was in operation at that time. The dependent variable was the failure rate, with no distinction as to the form of the dissolution. The independent variables included a set of characteristics of the firm for each year, such as size, age, and location. In order to measure the inter-population effects, the records of firms for each organizational population (metal can, large breweries, and small breweries) were aggregated with regard to their yearly counts of births, mortality and total densities. These counts were merged into the basic data file, specified by time, as additional independent variables. Finally, a set of economic indices was combined into the file as well. All the population-level independent variables were entered with a one-year lag, in order to retain a cause and effect relationship between the dependent and the independent variables (Jim Wade, personal communication 2000). The selected one-year lag was used because exploratory analysis with longer lags showed weaker correlation between the dependent and the independent variables along the time axis. In order to test the regional effects, three data sets were derived from the basic data set, depending on the location of the firm (East Coast, Midwest, and West). The process of population-level counting was repeated for each region separately. Then, the counts and the economic indices were merged into each data set in the same way as described above for the national data.

The formation data set was derived from the aggregated counts of births in the metal can industry, where each year of study represented one observation. Since there were only 33 years of data available, the power of the analysis at the national level would be inadequate. Therefore, a data set was compiled that contained formations at the state level. Each observation represented a year-state entry (Jim Wade, personal communication 2000). Only states where both large breweries and metal can firms operated at any time point within the study period were included in the analysis. Each participating state had 33-year records. As in the case of the mortality data sets, population-level counts and economic indices were merged into the data set with a one-year lag.

6.3 Model Specification and Estimation

In order to test the inter-population effects on organizational mortality and formation, accepted models were used from within the organizational ecology arena. The models were estimated by specifying the mortality and birth rate as a function of time *t*, a vector of covariates *A* that measure various metal can industry characteristics, and vector of covariates B that measure various characteristics of the brewery industry:

$$r(t) = f(t, A, B) \quad (1)$$

For the mortality models, event history methodology was used, where the dependent variable is the instantaneous rate of a firm's failure, defined as:

$$r_{jk}(t) = \lim\{q_i(t, t+\Delta t)/\Delta t\} \qquad (t \to 0) \quad (2)$$

where q_j is the discrete probability of organization j to experience a failure (k) event between (t +Δt), conditional on being at risk for the event at time t. Propositions 3, 4, and 5 were tested using log-linear models (Amburgey and Barnett 1993) of the general form:

$$r_k = \exp\{\beta X_t\} \quad (3)$$

where X_t is a vector of time-varying variables, and β is a vector of parameters indicating the effects of the independent variables on the rate of transition to a failure state. This rate is assumed to remain constant over time. Propositions 6, 7, and 8 were tested using a piece-wise constant rate model (Carroll and Swaminathan 2000), which is a generalization of the previous model, but allows the transition rates to change across different periods. The models were estimated with maximum likelihood procedures using the TDA statistical package (Blossfeld and Rohwer 1995).

As to the formation set of propositions (propositions1 and 2), there were no data available regarding the exact timing and order of events within years. Therefore, the population was defined as the unit of analysis and firm formations were treated as events in a point process (Swaminathan 1995). As in the mortality models, a constant transition rate was assumed (i.e. formation rate) with a log-linear dependence on a set of covariates. Common practice was followed by using the Poisson model, which assumes that the number of formations in a given year can be depicted with a Poisson distribution. The number of formations in the year t, Y_t, is determined by the probability law:

$$\Pr(Y_t = Y_t) = \exp(-\lambda_t)\lambda_t Y_t / Y_t! \quad (4)$$

The relationship between the founding rate λ_t , and the vector of covariates X_t is specified as follows:

$$\mathrm{Ln}\lambda_t = \alpha + \beta X_t \tag{5}$$

Past studies in organizational ecology used an extension of the Poisson model, the negative binomial model (Carroll and Swaminathan 2000), to correct for over-dispersion problems. Exploratory analysis did not reveal such effects in my data, and therefore only the results of the Poisson models are reported. This set of models was estimated using the statistical package Limdep 7.0 (Econometric Software, Inc).

Exploratory analysis also revealed that the aggregated counts of formations and failures of large breweries at the firm level were insignificant in the mortality and the formation models. This may be attributed to the fact that the number of large breweries declined drastically during the last few decades and remained almost stable in recent years. Therefore, the aggregated counts for large breweries were analyzed at the plant level, which demonstrated higher variation over time. Exploratory analysis did not show any significant effects at either level for density squared (Carroll and Swaminathan 2000). Density squared measures environmental legitimization effects, or in other words, social acceptance of a new form of organization. Therefore, this covariate was not included the analysis.

6.5 Independent Variables

The independent variables for the mortality analysis were examined in sets of models. The first model in each set contained a set of independent variables mostly within the metal can industry. One of these control variables is density of metal can firms. In previous research, this independent variable demonstrated a curvilinear relationship with mortality over time (Carroll 1984). In addition, the model included firm's characteristics such as size, age, and density at the time of the firm's birth. These covariates showed significant effects on mortality in a number of past studies (Singh and Lumsden 1990). The first model also included counts of failures and formations and total dollar sales for the metal can industry, in order to keep a symmetric structure with later models that included similar large breweries covariates. Finally, a control variable was incorporated for mean-replaced missing size values, and economic indicators concerning unemployment rate and metal can cost index. The second model in each set included the significant covariates from the previous batch (except a few covariates that were dropped due to collinearity problems) and also density, number of failures, formation at the plant level, and total sales in dollars of the large breweries population. The third model included all the covariates from the previous batch plus a similar set of covariates for the control group, the small breweries. Overall, this process of modeling was repeated for all the mortality propositions, and for the formation propositions as well.

7. Results

Overall, the mortality and the birth models reveal very weak effects for both between and within population effects. Even though some coefficients in these models are significant, most of the covariates that are included in the models do not significantly contribute to the explanation of the variation of the dependent variables. The results reveal very few consistent trends across models, where very few covariates remain significant and bear a consistent sign across models.

As to the detailed results, the correlation matrix for the independent variables at the national level is presented in table 2. Several correlations fit the general direction of the prior predictions. Metal can sales are highly negatively correlated with the mortality of large breweries (plants) in the previous year. The number of metal can firms is slightly negatively correlated with mortality of large breweries (plants) in the same year. Yearly sales of metal cans and beer are almost perfectly linearly correlated. Yearly sales of beer are also highly correlated with the number of metal can firms in the same year; however, other correlations do not fit the predicted pattern. The number of large breweries plants is negatively correlated with metal can sales and the number of metal can firms in the same year. The yearly density of small breweries and the number of small breweries formed in the previous year are positively correlated with metal can sales. Metal can sales are also positively correlated with mortality in the same and previous year for small breweries. Sales of small breweries and metal cans are positively correlated as well. Finally, the unemployment rate is positively correlated with metal can sales and density of metal can firms.

The descriptive statistics are presented in table 3. From this table, it can be seen that the average mortality rates and birth rates are almost equal within the large breweries (firms) and the metal can firms' populations. Also, for both large breweries firms and metal can firms, the average within population birth and mortality rates are approximately equal. At the plant level however, large breweries died on average three times more than new plants births.

Figure 1 presents the temporal evolution of densities of the metal can and the brewery industries over the study period. From the figure, we can see that the large breweries (plants) and the metal can firms follow a relatively similar pattern, especially since the mid 1970's. The small breweries show an entirely different pattern of constant growth since the mid 1980's.

Table 4 presents several descriptive statistics for the metal can industry at the firm level; note that metal can sales and metal can firms size have standard deviations that are greater than their mean. Table 5 presents the Poisson models results for births of metal can firms. From the results we can see that propositions 1 and 2 were not supported. Birth of new breweries did not significantly increase the number of births in the metal can industry. As to the small breweries, as predicted, they had no significant effects on metal can firms' births. The coefficient for density of metal can firms was found to be significantly negative in both first and third models, indicating within industry competition. This finding is consistent with previous studies of density dependence in organizational ecology (Singh and Lumsden 1990). The coefficient for unemployment disturbance is unexpectedly positive in all three models. In the first model this coefficient is also significant. It is possible that this coefficient interacted with unobserved factors that masked its effects on the metal can industry.

Table 6 presents the results of the mortality models of metal can firms at the national level. The results indicate that propositions 3 and 4 were not supported. The coefficient for large breweries mortality is positive as predicted, but it is insignificant. The coefficient for large breweries sales is negative and significant in the third model. Accordingly, births of new brewery plants and beer sales significantly decreased the risk of mortality for firms in the metal can industry. As to the control variables within the metal can industry, age has negative and significant coefficients across all three models, as expected, indicating decreasing mortality risk with increasing age. Mortality of metal can firms has negative and significant coefficients across the three models as well, indicating reduced competition effects within the metal can industry. Births of metal can firms and metal can sales have negative and significant coefficients in the first model; however, these covariates were excluded from the other two models due to collinearity problems. The yearly change in the metal can cost index is, as predicted, positive and significant across the three models. Also as predicted, small breweries do not show any significant effects on metal can firms' mortality. Table 7 presents the results of the mortality models for the metal can firms in the eastern region of the United States. Paralleling the models at the national level, births of large breweries has a negative and significant coefficient in the second model, but this coefficient becomes insignificant in the third model. Unexpectedly, in both second and third models, density and sales of large breweries have a positive and significant effect on metal can mortality risk in the eastern region. Table 8 presents the results of the mortality models for the metal can firms in the Midwest. None of the large breweries covariates is significant in any of these models. Regional density of metal can firms shows a significant positive effect across the three models. The yearly change in the metal can cost index has unexpected negative and significant coefficients across all three models.

Table 9 presents the results of the mortality models of the metal can firms in the western region of the U.S. From looking at the table we can see that none of the coefficients in any of the models is significant. This trend is possibly due to the small size of the observations in this region (only 233 records with 13 mortality cases).

In conclusion, the three regional sets of models did not support proposition 5 regarding enhanced effects of regional mortality of large breweries on the mortality of metal can firms. In addition, other factors from within the metal can industry and from the brewery industry did not seem to be more powerful at the regional level.

Table 10 presents the results of the mortality piece-rate models for decades' effects; it is clear that proposition 6 was not supported. Mortality, birth and density of large breweries did not show any significant effect in any of the models and during any of the decades. Sales of metal cans have a slightly positive and significant coefficient in the first model of the third period, but the rest of this covariate's coefficients are insignificant and bear mixed signs.

Table 11 presents the results of the mortality piece-rate models for metal can cost index stress effects. Period 1 and 3 represent unstressed conditions, and period 2 represents stressed conditions. The results indicate that proposition 7 was not supported; mortality of large breweries was not significant in any of the periods and showed mixed signs across periods and models. Births of large breweries has a significant negative effect in the second model of the stressed period, but this coefficient becomes insignificant after controlling for small breweries effects. Density of large breweries has mixed and insignificant coefficients across periods. The small breweries covariates show a positive significant effect in the second period. These results, however, should be interpreted with great caution since the small breweries population was very small during this period and its sales volumes were almost negligible. The growth of this population and its sales volumes started only in the third period, towards the late 1980's. Therefore, the significant coefficient for this covariate may represent an anomaly or an interaction with unobserved factors. Finally, the unemployment rate has inconsistent effects across models. This trend revealed it as an inadequate indicator for stress and led to the exclusion of the models that examined proposition 8 regarding the effects of unemployment disturbance. Trials to replace the unemployment covariate with alternative indicators, such as the interest rate, did not yield any significant or consistent results either. It is possible that the metal can industry did not suffer a major disturbance during the study period. Figure 1 depicts a relatively stable trend for the evolution of the industry where no major drops in density are revealed during the study period.

8. Discussion

Overall, the results reported in the previous section did not support the set of propositions regarding mutual effects between the metal can industry and the large brewery population. Births and mortality of organizations in the large brewery industry did not positively and respectively affect births and mortality of metal can firms. Still, few unexpected positive effects were found. Births and sales of large breweries significantly decreased the risk of mortality of metal can firms during the study period. As predicted, the small breweries' population was not found to have notable effects on the metal can industry in any of the studied dimensions.

Although some correlations did occur between the industries' figures, most of these correlations disappeared after controlling for the industries' environments within the tested set of models.

Births of metal can firms were found to be affected only by competition from within the metal can industry. The greater the number of metal can firms that were operating in the industry, the less likely it was for new firms to be born. It is possible that existing metal can firms were operating under their optimal capacity, and therefore were able to adjust their production levels when new large breweries were formed or when sales of canned beer increased. The high correlation between the two industries' sales figures provides support for this line of thought.

At the national level, mortality of large breweries' plants did not affect mortality of metal can firms. Therefore, it seems that the metal can industry was not significantly dependent on the large brewery population for acquiring its crucial resources. This lack of dependency may be attributed to the fact that most of the production of cans is sold to the soft drink industry. This industry can be an alternative source of income when troubles occur in the brewery industry. Since the soft drinks industry was not included in this study, this proposition remains to be tested. An additional explanation for the insignificant mortality effect is that during the study period, the brewery industry became more concentrated, where less firms controlled more and more of the industry production volumes. Thus, a decrease in the number of operating large breweries might not necessarily represent a decrease in beer production, and a reduced demand for cans. The strong negative significant correlation between the large brewery sales and mortality rates provides some support for this assumption. Although the analysis did not reveal any dependency effects, there was evidence of some positive consequences; births and sales of large breweries negatively affected mortality of metal can firms at the national level. This finding supports the idea that metal can firms were able to adjust their production levels when the demand for beer cans had increased. The increased demand provided additional resources that strengthened the firms and reduced their risk of mortality. Another factor that contributed to a decreased risk of mortality was mortality of metal can firms. This may indicate that the exiting firms provided the surviving firms with extra resources that enabled them to override difficulties during their lifetime. No evidence of direct competition was found at the national level. Density of metal can firms did not have a significant positive effect on mortality within the industry.

There was even some evidence that births and sales of metal can firms reduced mortality within the industry. These findings may indicate that, overall, within the study period, resources were abundant and competition did not play a major role in the metal can industry at the national level.

Similar to the national level, the regional analysis did not reveal any dependency effects of the metal can industry on the large breweries' population. Mortality of large breweries did not affect mortality of metal can firms in any of the studied regions. Overall, it seems that neither competition, nor positive interactions were stronger at the regional level. The lack of stronger regional effects may have several explanations. First, it is possible that the interactions between metal can firms and large breweries occurred mostly at the national level, since most of the large breweries have operated plants nationwide. Alternatively, it is possible that the regional categorization was too broad for identifying effects at the local level. Finally, it might be that the regional analysis lost a considerable amount of explanatory power due to the reduced number of observations and mortality events in the regional models.

The temporal analysis did not reveal any inter-population effects. It is possible that time alone had no effect on the strength or direction of the interaction between the two populations. It is also possible that other factors, that were not included in this study, masked the effects of time. As in the regional analysis, the categorization into decades was arbitrary and therefore could fail to capture some of the actual temporal patterns of the interactions. The stress analysis did not reveal any consistent trend regarding interaction effects. Several explanations are possible. First, it might be that there was not a notable amount of stress during the study period. Overall, the industry grew constantly during the study period, and availability of resources did not seem to be a major problem. The development of the recycling process may have contributed to this trend as well. Secondly, it is possible that cost did not represent "real" stress conditions in the system.

In summary, the large breweries and the metal can industry were not found to be engaged in a mutualistic interaction, even though some positive effects were observed. In order to determine precisely what kind of interaction is involved , we need to test the effects on the large breweries population as well.

Although mortality of large breweries did not affect mortality of metal can firms, it is possible that some short-term effects did occur. In order to complete the puzzle of interactions for the metal can industry, future research can examine its interaction effects with the soft drinks industry as well. A similar set of propositions can be tested in order to examine the similarities and differences with the findings of this study. In addition it might be useful to take into account the changes in consumption patterns of canned beverages and canned beer over time, since these changes can affect the overall demand for cans and the fate of the organizations that manufacture them.

Future research can also implement this set of propositions to an entirely different group of industries with various degrees of dependency, study the interactions over a longer period of time, and examine industries that demonstrate more variation regarding their failure and birth rates. This study demonstrates how little we know about positive interactions in business environments. Future research is needed in order to construct a general and coherent theory regarding the effects of positive interactions on organizations.

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Table 1-Positive and negative interactions in ecology

Name of interaction	On A	On B	Off A	Off B
Positive Interactions				
1. Mutualism	+	+	-	-
2. Protocooperation	+	+	0	0
3. Commensalism	+	0	-	0
4. Unnamed	+	0	0	0
5. Unnamed	+	+	0	-
Non-Positive Interactions				
1. Competition	-	-	0	0
2. Parasitism, predation, herbivory	+	-	-	0
3. Amensalism	0/+	-	0	0
4. Neutralism	0	0	0	0

(Source: Burkholder 1952)

Notes: all possible ecological interactions in ecology. "A" and "B " are the participating parties in the interaction. The number of interactors in each type of interaction was determined as two for simplicity reasons. (+) represents positive effect, (-) represents negative effect and (0) represents no effect. The columns "On" and "Off" denote the effects when the interaction is taking place and when it is absent, respectively. Unnamed categories refer to rare interactions that have never been scientifically named.

Table 2- Correlations for the independent variables at the national level

Correlations, Pearson's r (N=35)

	Small breweries died	Small breweries died year -2	Samll breweries sales in $	unemploy-ment rate	Small breweries born year -2	intrest rate	Yearly change in metal can cost index
Large breweries born (plants)	-.311	-.248	-.291	.030	-.257	-.014	-.194
Large breweries born (plants) year -2	-.148	-.245	-.222	-.100	-.221	-.108	-.153
Large breweries died (plants)	-.530**	-.587**	-.492**	-.275	-.499**	-.158	-.686**
Large breweries died (plants) year -2	-.466**	-.546**	-.507**	-.375*	-.468**	-.186	-.659**
Large breweries sales in $	.547**	.573**	.503**	.580**	.537**	.477**	.980**
Metal can firms born	-.147	-.083	-.262	.203	-.188	.266	-.021
Metal can firms born year -2	-.011	.070	-.092	.289	-.047	.005	.028
Metal can firms died	.117	.329	.233	.063	.259	.051	.382*
Metal can firms died year -2	.301	.092	.261	-.023	.271	-.005	.321
Metal can firms sales in $	.558**	.563**	.500**	.580**	.540**	.459**	.994**
Number of metal can firms	-.086	.051	-.144	.771**	-.135	.674**	.618**
Total number of large breweries (plants)	-.520**	-.533**	-.472**	-.508**	-.506**	-.467**	-.918**
Number of small breweries	.914**	.788**	.994**	-.023	.985**	-.194	.512**
Small breweries born	.878**	.685**	.978**	-.055	.976**	-.156	.484**
Small breweries died	1.000**	.701**	.884**	.086	.899**	-.107	.533**
Small breweries died year -2	.701**	1.000**	.795**	.135	.758**	-.184	.564**
Samll breweries sales in $	.884**	.795**	1.000**	-.024	.969**	-.214	.487**
unemployment rate	.086	.135	-.024	1.000**	-.019	.663**	.550**
Small breweries born year -2	.899**	.758**	.969**	-.019	1.000**	-.140	.530**
intrest rate	-.107	-.184	-.214	.663**	-.140	1.000**	.449**
Change in metal can index	.533**	.564**	.487**	.550**	.530**	.449**	1.000**

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 2- Correlations for the independent variables at the national level (continued)

Correlations, Pearson's r (N=35)

	Metal can firms died	Metal can firms died year -2	Metal can firms sales in $	Number of metal can firms	Total number of large breweries (plants)	Number of small breweries	Small breweries born
Large breweries born (plants)	-.106	-.147	-.189	.196	.217	-.295	-.291
Large brews born (plants) y -2	-.248	-.094	-.148	.104	.164	-.224	-.231
Large breweries died (plants)	-.229	-.204	-.698**	-.375*	.697**	-.505**	-.450**
Large brews died (plants) y -2	-.172	-.220	-.678**	-.299	.587**	-.497**	-.452**
Large breweries sales in $	.305	.270	.987**	.638**	-.965**	.525**	.496**
Metal can firms born	-.108	-.049	-.051	.170	.049	-.232	-.249
Metal can firms born year -2	-.132	-.091	.038	.202	.005	-.077	-.134
Metal can firms died	1.000**	-.082	.355*	.191	-.253	.232	.230
Metal can firms died year -2	-.082	1.000**	.288	-.153	-.223	.268	.286
Metal can firms sales in $	.355*	.288	1.000**	.642**	-.935**	.524**	.494**
Number of metal can firms	.191	-.153	.642**	1.000**	-.629**	-.146	-.169
N of large brews (plants)	-.253	-.223	-.935**	-.629**	1.000**	-.495**	-.465**
Number of small breweries	.232	.268	.524**	-.146	-.495**	1.000**	.984**
Small breweries born	.230	.286	.494**	-.169	-.465**	.984**	1.000**
Small breweries died	.117	.301	.558**	-.086	-.520**	.914**	.878**
Small breweries died year -2	.329	.092	.563**	.051	-.533**	.788**	.685**
Samll breweries sales in $	.233	.261	.500**	-.144	-.472**	.994**	.978**
unemployment rate	.063	-.023	.580**	.771**	-.508**	-.023	-.055
Small breweries born year -2	.259	.271	.540**	-.135	-.506**	.985**	.976**
intrest rate	.051	-.005	.459**	.674**	-.467**	-.194	-.156
Change in metal can Index	.382*	.321	.994**	.618**	-.918**	.512**	.484**

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 2- Correlations for the independent variables at the national level (continued)

Correlations, Pearson's r (N=35)

	Large breweries born (plants)	Large breweries born (plants) year -2	Large breweries died (plants)	Large breweries died (plants) year -2	Large breweries sales in $	Metal can firms born	Metal can firms born year -2
Large breweries born (plants)	1.000**	.150	.232	.196	-.227	.324	.383*
Large brews born (plants) y -2	.150	1.000**	.119	.200	-.190	-.274	.285
Large breweries died (plants)	.232	.119	1.000**	.580**	-.701**	.123	.075
Large brews died (plants) y -2	.196	.200	.580**	1.000**	-.678**	.163	.069
Large breweries sales in $	-.227	-.190	-.701**	-.678**	1.000**	-.020	.002
Metal can firms born	.324	-.274	.123	.163	-.020	1.000**	.167
Metal can firms born year -2	.383*	.285	.075	.069	.002	.167	1.000**
Metal can firms died	-.106	-.248	-.229	-.172	.305	-.108	-.132
Metal can firms died year -2	-.147	-.094	-.204	-.220	.270	-.049	-.091
Metal can firms sales in $	-.189	-.148	-.698**	-.678**	.987**	-.051	.038
Number of metal can firms	.196	.104	-.375*	-.299	.638**	.170	.202
N of large brews (plants)	.217	.164	.697**	.587**	-.965**	.049	.005
Number of small breweries	-.295	-.224	-.505**	-.497**	.525**	-.232	-.077
Small breweries born	-.291	-.231	-.450**	-.452**	.496**	-.249	-.134
Small breweries died	-.311	-.148	-.530**	-.466**	.547**	-.147	-.011
Small breweries died year -2	-.248	-.245	-.587**	-.546**	.573**	-.083	.070
Samll breweries sales in $	-.291	-.222	-.492**	-.507**	.503**	-.262	-.092
unemployment rate	.030	-.100	-.275	-.375*	.580**	.203	.289
Small breweries born year -2	-.257	-.221	-.499**	-.468**	.537**	-.188	-.047
intrest rate	-.014	-.108	-.158	-.186	.477**	.266	.005
Change in metal can index	-.194	-.153	-.686**	-.659**	.980**	-.021	.028

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 3- Descriptive statistics at the population level

Table 4.3 Descriptive Statistics at the population level

	N	Minimum	Maximum	Mean	Std. Deviation
Large breweries born	35	.00	3.00	.4571	.7413
Large breweries born east (firms)	35	.00	1.00	.1143	.3228
Large breweries born midwest (firms)	35	.00	3.00	.2286	.5983
Large breweries born west (firms)	35	.00	1.00	2.857E-02	.1690
Large breweries died (firms)	35	.00	16.00	4.5714	4.3944
Large breweries died east (firms)	35	0	4	1.49	1.31
Large breweries died midwest (firms)	35	0	12	2.60	3.04
Large breweries died west (firms)	35	0	2	.49	.74
Number of large breweries (firms)	35	23.00	172.00	62.0000	43.6193
Number of large breweries east (firms)	35	8	57	23.14	14.81
Number of large breweries midwest (firms)	35	13	95	32.69	23.76
Number of large breweries west (firms)	35	2	18	5.86	4.94
Large breweries born (plants)	35	.00	8.00	2.2286	1.9865
Large breweries born east (plants)	35	.00	3.00	.8571	.9438
Large breweries born midwest (plants)	35	.00	4.00	.8857	.9933
Large breweries born west (plants)	35	.00	4.00	.4857	.8869
Large breweries died (plants)	35	.00	17.00	6.7143	4.9323
Large breweries died east (plants)	35	.00	10.00	2.2571	1.9903
Large breweries died midwest (plants)	35	.00	13.00	3.4286	3.2293
Large breweries died west (plants)	35	.00	4.00	1.0286	1.1242
Total number of large breweries (plants)	35	44.00	227.00	96.7429	50.3776
Valid N (listwise)	35				

Table 3- Descriptive statistics at the population level (continued)

Table 4.3 Descriptive Statistics at the population level (continued)

	N	Minimum	Maximum	Mean	Std. Deviation
Number of large breweries east (plants)	35	20.00	79.00	36.7429	15.9657
Number of large breweries midwest (plants)	35	18.00	120.00	46.2571	27.9130
Number of large breweries west (plants)	35	6.00	28.00	13.7429	6.8055
Metal can firms born	35	.00	10.00	4.0000	2.4254
Metal can firms born east	35	.00	8.00	2.1429	1.7846
Metal can firms born midwest	35	.00	5.00	1.4857	1.2689
Metal can firms born west	35	.00	3.00	.3714	.6897
Metal can firms died	35	.00	10.00	3.9714	2.4792
Metal can firms died east	35	.00	7.00	2.0000	1.6270
Metal can firms died midwest	35	.00	5.00	1.6000	1.3547
Metal can firms died west	35	.00	2.00	.3714	.6456
Number of metal can firms	35	54.00	79.00	65.0571	7.2027
Number of metal can firms east	35	21	37	29.31	5.22
Number of metal can firms midwest	35	22	33	29.06	2.38
Number of metal can firms west	35	3	11	6.69	2.49
Small breweries born	35	.00	239.00	22.8571	49.1403
Small breweries born east	35	.00	82.00	6.1429	15.8210
Small breweries born midwest	35	.00	70.00	6.0000	14.4507
Small breweries born west	35	.00	87.00	10.7143	19.7210
Small breweries died	35	.00	30.00	3.5143	6.7622
Small breweries died east	35	0	8	.71	1.74
Valid N (listwise)	35				

Table 3- Descriptive statistics at the population level (continued)

Table 4.3 Descriptive Statistics at the population level (continued)

	N	Minimum	Maximum	Mean	Std. Deviation
Small breweries died midwest	35	0	11	.80	2.04
Small breweries died west	35	0	11	2.09	3.39
Number of small breweries	35	1.00	709.00	77.8571	157.8518
Number of small breweries esat	35	0	198	17.69	40.94
Number of small breweries midwest	35	0	193	17.94	41.21
Number of small breweries west	35	1	318	42.23	76.75
unemployment rate	35	3.49	9.71	6.1264	1.5141
Yearly change in metal can cost index	35	.93	1.22	1.0411	5.650E-02
Large breweries sales in $	35	79720.31	190253.04	146098.3	38818.34
Metal can firms sales in $	35	2075.00	12449.60	7730.4171	3981.8092
Samll breweries sales in $	35	.00	1622.00	172.1389	370.6865
Valid N (listwise)	35				

Table 4– Descriptive statistics for the metal can industry at the firm level

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Sales in $	1111	1.0	6510.0	478.519	1001.350
size (number of employees)	1912	2	72000	4086.50	10024.88
density at birth	2277	54.00	79.00	60.4480	7.5896
AGE	2277	1.00	75.00	12.1866	11.4560
state at the end of year (1=died, 0=alive)	2277	.00	1.00	6.148E-02	.2403
Valid N (listwise)	1111				

Table 5- Poisson birth models

(Standard errors in parentheses)

Covariates	1. Metal can	2. Metal can and large breweries	3. Metal can plus large and small breweries
Metal can firms died	0.017 (0.046)		
Yearly change in metal can cost index	1.988 (1.300)	1.557 (1.768)	2.265 (1.847)
Metal can firms total sales	0.000 (0.000)		
Density of metal can firms	-0.086** (0.029)	-0.057 (0.034)	-0.106** (0.040)
Unemployment rate	0.246* (0.109)	0.169 (0.115)	0.210 (0.122)
Large breweries born (plants)		-0.044 (0.063)	-0.023 (0.066)
Large breweries born year –2 (plants)		-0.050 (0.062)	***
Large Breweries died (plants)		0.020 (0.029)	-0.013 (0.034)
Large breweries sales		-0.000 (0.000)	0.000 (0.000)
Density of large breweries (plants)		-0.003 (0.006)	0.002 (0.007)
Density of small breweries			-0.002 (0.013)
Small breweries born			0.016 (0.015)
Small breweries died			0.067 (0.075)
Small breweries total sales			-0.003 (0.004)
Number of observations	627	627	627
Log likelihood	-293.756	-293.756	-293.756

- P<0.05, **P<0.01

*** Covariates were dropped due to collinearity problems.

Table 6- Mortality models at the national level
(Standard errors in parentheses)

Covariates	**1. Metal can**	**2. Metal can and large breweries**	**3. Metal can plus large and small breweries**
Constant	-6.546** (1.509)	-4.853 (2.971)	-4.740 (3.801)
Age	-0.100** (0.016)	-0.107** (0.012)	-0.108** (0.012)
Density at birth time	0.010 (0.018)		
Dummy for size replacement	0.959** (0.185)	0.996** (0.184)	0.997** (0.185)
Metal can firms born	-0.092* (0.042)	***	
Metal can firms died	-0.107* (0.042)	-0.113** (0.043)	-0.150** (0.052)
Yearly change in metal can cost index	0.104** (0.024)	0.057** (0.014)	0.070** (0.017)
Metal can firms total sales	-0.001** (0.000)	***	***
Density of metal can firms	0.0253 (0.024)	0.025 (0.020)	0.063 (0.033)
Size	0.000 (0.000)		
Unemployment rate	0.087 (0.098)		
Large breweries born (plants)		-0.134* (0.055)	-0.152* (0.063)
Large Breweries died (plants)		0.017 (0.025)	0.021 (0.029)
Large breweries died year –2 (plants)		-0.011 (0.029)	-0.017 (0.039)
Large breweries sales		0.000 (0.000)	-0.000* (0.000)
Density of large breweries (plants)		0.010 (0.010)	0.007 (0010)
Density of small breweries			0.065 (0.021)
Small breweries born			0.020 (0.033)
Small breweries born year –2			-0.022 (0.024)
Small breweries died			-0.049 (0.071)
Small breweries died year –2			0.037 (0.092)
Small breweries total sales			-0002 (0.004)
Number of spells	2227	2227	2227
Number of events	140	140	140
Log likelihood	-768.304	-763.878	-771.244

* P<0.05, **P<0.01
*** Covariates were dropped due to collinearity problems.

Table 7- Mortality models for the eastern region
(Standard errors in parentheses)

Covariates	**1. Metal can**	**2. Metal can and large breweries**	**3. Metal can plus large and small breweries**
Constant	-2.361 (3.220)	-15.832** (3.428)	-16.377** (3.574)
Age	-0.117** (0.023)	-0.109** (0.023)	-0.109** (0.023)
Density at birth time	0.028 (0.023)	0.032 (0.022)	0.034 (0.022)
Dummy for size replacement	0.833** (0.250)	0.816 (0.247)	0.825 (0.249)
Metal can firms born east	0.017 (0.090)		
Metal can firms died east	-0.088 (0.092)		
Yearly change in metal can cost index	-2.331 (2.786)		
Metal can firms total sales	0.000 (0.000)		
Density of metal can firms east	-0.060 (0.070)		
Size	0.000 (0.000)		
Unemployment rate	0.037 (0.125)		
Large breweries born east (plants)		-0.340* (0.155)	-0.274 (0.157)
Large Breweries died east (plants)		-0.046 (0.061)	***
Large breweries sales		0.000** (0.000)	0.000** (0.000)
Density of large breweries east (plants)		0.107** (0.033)	0.108** (0.033)
Density of small breweries east			-0.023 (0.017)
Small breweries born east			0.054 (0.037)
Small breweries died east			0.120 (0.123)
Small breweries total sales			***
Number of spells	1032	1032	1032
Number of events	73	73	73
Log likelihood	-389.519	-384.846	-383.363

* P<0.05
**P<0.01
*** Covariates were dropped due to collinearity problems.

Table 8- Mortality models for the Midwest
(Standard errors in parentheses)

Covariates	**1.Metal can**	**2. Metal can and large breweries**	**3. Metal can plus large and small breweries**
Constant	2.470 (4.806)	0.360 (4.963)	4.318 (6.269)
Age	-0.089** (0.025)	-0.088** (0.019)	-0.089** (0.019)
Density at birth time	-0.001 (0.033)		
Dummy for size replacement	1.666** (0.331)	1.683** (0.327)	1.699 (0.328)
Metal can firms born mid-west	-0.237 (0.132)		
Metal can firms died mid-west	-0.237* (0.119)	-0.305* (0.145)	-0.379* (0.171)
Yearly change in metal can cost index	-10.967* (4.273)	-8.849* (3.814)	-12.233* (5.653)
Metal can firms total sales	-0.000 (0.000)		
Density of metal can firms mid-west	0.169* (0.080)	0.167* (0.073)	0.165* (0.083)
Size	0.000 (0.000)		
Unemployment rate	0.127 (0.134)		
Large breweries born mid-west (plants)		-0.227 (0.157)	-0.283 (0.182)
Large Breweries died mid-west (plants)		0.004 (0.055)	-0.001 (0.056)
Large breweries sales		0.000 (0.000)	0.000 (0.000)
Density of large breweries mid-west (plants)		0.005 (0.019)	0.002 (0.019)
Density of small breweries mid-west			-0.043 (0.100)
Small breweries born mid-west			0.089 (0.102)
Small breweries died mid-west			0.125 (0.284)
Small breweries total sales			0.000 (0.008)
Number of spells	1012	1012	1012
Number of events	54	54	54
Log likelihood	-297.688	-299.237	-298.206

* P<0.05
**P<0.01
*** Covariates were dropped due to collinearity problems.

Table 9- Mortality models for the western region
(Standard errors in parentheses)

Covariates	**1. Metal can**	**2. Metal can and large breweries**	**3. Metal can plus large and small breweries**
Constant	-2.730 (16.133)	-14.467 (11.404)	-18.731 (12.146)
Age	0.075 (0.155)		
Density at birth time	0.082 (0.145)		
Dummy for size replacement	0.188 (1.424)		
Metal can firms born west	0.063 (0.612)		
Metal can firms died west	-0.167 (0.447)		
Yearly change in metal can cost index	-8.228 (10.833)		
Metal can firms total sales	0.000 (0.000)		
Density of metal can firms west	0.224 (0.223)		
Size	0.000 (0.000)		
Unemployment rate	-0.470 (0.377)		
Large breweries born west (plants)		-0.613 (0.558)	-0.625 (0.599)
Large Breweries died west (plants)		-0.158 (0.348)	-0.029 (0.397)
Large breweries sales		0.000 (0.000)	0.000 (0.000)
Density of large breweries west (plants)		0.172 (0.308)	0.306 (0.341)
Density of small breweries west			0.046 (0.038)
Small breweries born west			-0.009 (0.060)
Small breweries died west			-0.335 (0.280)
Small breweries total sales			-0.006 (0.005)
Number of spells	233	233	233
Number of events	13	13	13
Log likelihood	-74.565	-77.112	-76.009

* P<0.05
**P<0.01
*** Covariates were dropped due to collinearity problems.

Table 10- Piece-rate mortality models for decades
(Standard errors in parentheses)

Covariates	**1. Metal can**	**2. Metal can and large breweries**	**3. Metal can plus large and small breweries**
Period 1 (1962-1971):	-1.328	14.011	7.556
	(6.573)	(32.636)	(30.719)
Age	-0.301**	-0.295**	-0.306**
	(0.105)	(0.110)	(0.110)
Metal can firms born	-0.045	0.038	0.024
	(0.106)	(0.150)	(0.147)
Metal can firms died	-0.034	-0.132	-0.154
	(0.132)	(0.158)	(0.162)
Metal can firms total sales	-0.000	0.000	-0.001
	(0.000)	(0.002)	(0.002)
Density of metal can firms	0.112	-0.045	0.038
	(0.116)	(0.347)	(0.328)
Unemployment rate	-0.527		
	(0.308)		
Large breweries born (plants)		-0.119	-0.165
		(0.182)	(0.179)
Large Breweries died (plants)		0.091	0.101
		(0.066)	(0.060)
Large breweries sales		-0.000	-0.000
		(0.000)	(0.000)
Density of large breweries (plants)		-0.039	-0.038
		(0.035)	(0.032)
Density of small breweries			***
Small breweries born			0.473
			(0.391)
Small breweries died			-7.647
			(9.928)
Small breweries total sales			***
Period 2 (1972-1981):	-17.991**	-21.087	4.015
	(5.824)	(18.393)	(50.141)
Age	-0.119**	-0.117**	-0.117**
	(0.039)	(0.038)	(0.039)
Metal can firms born	-0.206	-0.320	-0.189
	(0.126)	(0.169)	(0.311)
Metal can firms died	-0.548**	-0.617**	-1.129
	(0.184)	(0.235)	(0.630)
Metal can firms total sales	-0.000	-0.001	0.000
	(0.000)	(0.001)	(0.002)
Density of metal can firms	0.233*	0.198	-0.255
	(0.112)	(0.182)	(0.722)
Unemployment rate	0.298		
	(0.212)		
Large breweries born (plants)		0.016	0.519
		(0.257)	(0.659)
Large Breweries died (plants)		0.116	0.333
		(0.109)	(0.325)
Large breweries sales		0.000	0.000
		(0.000)	(0.000)
Density of large breweries (plants)		-0.018	-0.055
		(0.047)	(0.085)

Table 10- Piece-rate mortality models for decades (continued)
(Standard errors in parentheses)

Covariates	**1. Metal can**	**2. Metal can and large breweries**	**3. Metal can plus large and small breweries**
Density of small breweries			***
Small breweries born			-2.717
			(2.477)
Small breweries died			1.891
			(1.725)
Small breweries total sales			***
Period 3 (1982-1996):	-13.662**	-26.986**	-18.377
	(2.494)	(9.899)	(11.512)
Age	-0.037**	-0.037**	-0.037**
	(0.011)	(0.011)	(0.011)
Metal can firms born	-0.062	-0.063	-0.004
	(0.056)	(0.090)	(0.104)
Metal can firms died	-0.090	-0.067	-0.127*
	(0.051)	(0.047)	(0.059)
Metal can firms total sales	0.000**	0.001	0.001*
	(0.000)	(0.000)	(0.000)
Density of metal can firms	0.043	0.035	0.024
	(0.033)	(0.041)	(0.059)
Unemployment rate	-0.090		
	(0.155)		
Large breweries born (plants)		-0.095	-0.172
		(0.096)	(0.109)
Large Breweries died (plants)		-0.005	-0.051
		(0.053)	(0.078)
Large breweries sales		0.000	0.000
		(0.000)	(0.000)
Density of large breweries (plants)		0.045	0.026
		(0.046)	(0.055)
Density of small breweries			***
Small breweries born			0.007
			(0.006)
Small breweries died			-0.076
			(0.047)
Small breweries total sales			***
Number of spells	2227	2227	2227
Number of events	140	140	140
Log likelihood	-845.885	-836.784	-833.372

* P<0.05
**P<0.01
*** Covariates were dropped due to collinearity problems.

Table 11- Piece-rate mortality models for metal can cost index stress
(Standard errors in parentheses)

Covariates	**1. Metal can**	**2. Metal can and large breweries**	**3. Metal can plus large and small breweries**
Period 1, no stress (1962-1970):	-7.576 (8.724)	23.172 (99.261)	23.669 (116.185)
Age	-0.244 (0.134)	-0.269 (0.140)	-0.269 (0.140)
Metal can firms born	-0.223 (0.145)	0.292 (0.831)	0.362 (1.835)
Metal can firms died	0.037 (0.143)	0.043 (0.994)	0.037 (1.129)
Metal can firms total sales	-0.001 (0.001)	-0.002 (0.013)	-0.001 (0.018)
Density of metal can firms	0.162 (0.151)	-0.330 (1.133)	-0.391 (1.907)
Unemployment rate	-0.312 (0.418)	-4.066 (12.745)	-4.607 (19.286)
Large breweries born (plants)		-0.4825 (0.918)	-0.541 (1.697)
Large Breweries died (plants)		0.293 (0.815)	0.282 (0.944)
Large breweries sales		***	***
Density of large breweries (plants)		0.065 (0.210)	0.086 (0.533)
Density of small breweries			0.544 (25.520)
Small breweries born			-0.753 (16.302)
Small breweries died			0.473 (134.999)
Small breweries total sales			-0.116 (9.031)
Period 2, stress (1971-1986):	-13.036** (3.098)	-10.905* (5.318)	22.540 (20.123)
Age	-0.107** (0.024)	-0.108** (0.024)	-0.104** (0.024)
Metal can firms born	0.015 (0.078)	-0.028 (0.084)	0.007 (0.121)
Metal can firms died	-0.351** (0.090)	-0.251** (0.096)	-0.323* (0.155)
Metal can firms total sales	0.000 (0.000)	-0.000 (0.000)	-0.000 (0.001)
Density of metal can firms	0.105 (0.056)	0.148* (0.071)	-0.190 (0.323)
Unemployment rate	0.255* (0.129)	0.347* (0.158)	-0.300 (0.329)
Large breweries born (plants)		-0.270* (0.121)	-0.264 (0.294)
Large Breweries died (plants)		-0.086 (0.065)	0.156 (0.144)
Large breweries sales		***	***
Density of large breweries (plants)		-0.019 (0.020)	-0.117 (0.075)
Density of small breweries			-0.578 (0.410)

Table 11- Piece-rate mortality models for metal can cost index stress (continued) (Standard errors in parentheses)

Covariates	**1. Metal can**	**2. Metal can and large breweries**	**3. Metal can plus large and small breweries**
Small breweries born			0.636 (0.627)
Small breweries died			0.576 (1.329)
Small breweries total sales			0.084* (0.043)
Period 3, no stress (1987-1996):	-27.856** (6.143)	-37.109** (9.800)	-1.671 (24.227)
Age	-0.030** (0.011)	-0.030** (0.011)	-0.029* (0.011)
Metal can firms born	-0.205** (0.068)	-0.333* (0.138)	-2.332 (3.588)
Metal can firms died	-0.227** (0.085)	-0.294** (0.097)	-0.044 (0.749)
Metal can firms total sales	0.002** (0.000)	0.002** (0.001)	0.001 (0.005)
Density of metal can firms	0.269** (0.081)	0.440** (0.134)	1.248 (1.685)
Unemployment rate	-1.880** (0.552)	-2.408** (0.664)	-5.979 (10.737)
Large breweries born (plants)		-0.161 (0.119)	1.161 (2.563)
Large Breweries died (plants)		0.096 (0.087)	0.617 (1.134)
Large breweries sales		***	***
Density of large breweries (plants)		-0.046 (0.055)	-1.046 (1.833)
Density of small breweries			-0.121 (0.296)
Small breweries born			0.151 (0.251)
Small breweries died			0.576 (1.329)
Small breweries total sales			0.013 (0.053)
Number of spells	2227	2227	2227
Number of events	140	140	140
Log likelihood	-836.716	-828.230	-810.957

* P<0.05
**P<0.01
*** Covariates were dropped due to collinearity problems.

Figure 1- Density of the brewing and metal can populations 1962-1996