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Empirical Validity of Density Dependence Hypothesis: Unobserved Heterogeneity and Failure Rates*

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Abstract

This study examined whether strong support for density dependence hypothesis in previous studies was due to unobserved inter-firm heterogeneity Using the population of Dutch accounting firms, we compared two models· one without firm heterogeneity variables and the other with those variables Firm heterogeneity variables examined here included the adoption of a partner-associate structure, firm size, the number of domestic offices, firm-level human and social capital, founding type, and organizational changes. Results indicated that regardless of the inclusion of firm heterogeneity variables, density had a strong U-shaped relation with failure rates as predicted by density dependence hypothesis Implications and future research directions were discussed

1. Introduction

During the past two decades, population ecology has contributed to organizational sociology by showing the importance of environmental factors in explaining founding and failure rates of organizations. Among those factors, density —

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number of organizations in a population — has been most emphasized. With some exceptions (e.g., Delacroix, Swaminathan, and Solt (1989), Barnett and Amburgey (1990), Baum and Oliver (1992), and Ranger-Moore (1997)), extant studies on density dependence of founding and failure rates generally produced results consistent with the hypothesis across diverse populations (see Singh and Lumsden (1990) for a review; Hannan and Carroll (1992)).

However, there has been an important debate on whether the strong support for density dependence of failure rates in previous studies is due to unobserved heterogeneity.[1] Unobserved heterogeneity exists when at least one important independent variable that affects dependent variable is omitted. Therefore most empirical studies are susceptible to this unobserved heterogeneity problem. The problem becomes serious especially when the inclusion of omitted variables alters relationships that are found to exist in observed model. Petersen and Koput (1991) raised this question about density dependence hypothesis Using simulation, they showed that unobserved heterogeneity, independent of density dependence, could generate a positive relationship between density and failure rates.[2]

This study empirically tests the density dependence hypothesis while controlling for organizational heterogeneity. The hypothesis is supported if the density has a predicted effect on failure rates even when organizational innovation and firm-specific resources are introduced in the model. If significant influence of density disappears after controlling for organizational heterogeneity, the present study can suggest that strong support for density dependence hypothesis in previous studies may have been due to unobserved heterogeneity. Organizational heterogeneity controlled in this study includes the adoption of a partner-associate structure, a firm's relative size, the number of domestic offices, human and social capital

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1) Lomi (1995) questioned the validity of the density dependence hypothesis in explaining organizational founding rates He reported that regional density rather than national density was a better measure to explain organizational founding rates

2) Additional analysis of Hannan and Carroll (1992) used simulation model provided by Petersen and Koput They showed that results reported in Petersen and Koput (1991) were not typical

that firm has through its members, founding type, and organizational changes. By controlling for fine-grained organizational level variables, this study can expose the strength of density dependence formulation.

2. Density Dependence Hypothesis

Hannan and Freeman (1987, 1988, 1989) proposed the density dependence hypothesis of organizational founding and failure rates The hypothesis posited that the *density will have a U-shaped relation with the failure rates and an inverted U-shaped relation with the founding rates.* Legitimation and competition processes lead to the hypothesis. Initial growth in density increases legitimacy of organizational forms. The enhanced legitimacy lowers failure rates and elevates founding rates. The process leads to rapid growth in density during the early stage of population development. When density grows high enough, additional growth in density does not enhance legitimacy but instead increases competition among organizations. The competition process elevates failure rates and lowers founding rates. As a result, density stabilizes during the late stage of population development. With some exceptions, extant studies produced results that were consistent with the hypothesis over diverse populations from diverse geographical areas (see Singh and Lumsden (1990) for a review, and Hannan and Carroll (1992)).

In population ecology formulation, each organization contributes same degree of legitimation and competition to a population. This assumption of homogeneity receives a great deal of criticism. Winter (1990) for instance claimed that large firms contribute more to competition and industry evolution than do small firms. To deal with the criticism, Hannan and Carroll (1992) introduced the concept of mass and controlled for it in estimating failure rates. The mass is the population density with each organization weighted by its size. Mass dependence interpretations were based on the recognition of size heterogeneity among firms.

Hannan and Carroll (1992) added total mass and firm size in estimating failure rates and reported that density still had a significant and consistent U-shaped relationship with failure rates. They concluded that these findings favored density dependence of failure rates over a mass-dependence explanation. However, they did not have the data for population mass and firm size over much of the long periods studied. They, consequently, could not effectively control the influence of population mass and organizational size on failure rates. In a study of failure rates in the population of Manhattan banks over the two hundred year history, Banaszak-Holl (1991) also reported a U-shaped relationship between density and failure rates even when bank's size and population mass were added in the model as time varying covariates.

3. Criticisms and Inconsistent Findings

Despite the strong empirical support for density dependence hypothesis, the ecological paradigm has been criticized on the bases of its conceptual validity and the precision of measurements. Earlier formulations of population ecology emphasized the importance of heterogeneity in the evolution of population. For instance, Hannan and Freeman's (1977) fitness theory was based on the assumption of firm heterogeneity. Freeman and Hannan's study on the survival of specialists and generalists interacting with environmental characteristics (Freeman and Hannan (1983, 1987)) illustrated the importance of organizational heterogeneity in population ecology. Aldrich's (1979) notion of variation also stressed organizational heterogeneity Under the condition of heterogeneity, the environment-induced negative selection can reinforce organizations with viable characteristics (Hannan and Freeman (1977), Aldrich (1979))

Later development on the density dependence hypothesis (Hannan and Freeman (1987, 1988), Carroll and Hannan (1989a)), however, relies on homogeneity assumption. It assumed that each organization contributes the same degree of population legitimacy and produces same degree of competition with other organizations. With this assumption, Hannan and Freeman's (1977) original ideas of "the maximization by the selection environment" cannot be explored. In empirical studies on density dependence, organizations are heterogeneous only with respect to their age, age cohort, and size.

In contrast with the density dependence hypothesis, evolutionary economics (Nelson and Winter (1982), Winter (1990)) and the resource-based view of the firm (Penrose (1959)) adopted the assumption of organizational heterogeneity rather than homogeneity. Evolutionary economics begins with the assumption that organizations have divergent competencies or technologies. An entrepreneur's entry (Schumpeter (1934)) or an incumbent's innovative search (Nelson and Winter (1982)) are among the events that generate organizational heterogeneity. Under the condition of heterogeneity, selection mechanism can reinforce viable organizations by granting them more resources.

The assumption of organizational heterogeneity and the existence of selection mechanism are consistent with the fitness theory of earlier study of Hannan and Freeman (1977) but inconsistent with their density dependence formulation. In sum, scholars who emphasize organizational heterogeneity are more interested in *what kinds of organizations* perform better, while those who emphasize density dependence in population ecology are more interested in *what conditions* render organizations to be more prone to emerge or fail.

Concern with measurement issues is also related to conceptual developments regarding legitimacy and competition. Zucker (1989) and Delacroix and Rao (1994) claimed that density is not a good legitimacy proxy of organizational forms. Winter (1990) questioned the validity of density in measuring competition and recommended instead firm size and location. Baum and Mezias (1992) and Baum and Singh (1994a, 1994b) acknowledged the importance of organizational heterogeneity and formulated localized competition, under which organizations are more likely to compete with similar organizations than with dissimilar ones. The recognition of organizational heterogeneity itself questioned the validity of density as a measure of the degree of competition

Several studies included organizational-level characteristics in estimating the effect of density on vital rates and reported findings that were discrepant with the density dependence hypothesis. With a population of Pennsylvania telephone companies, Barnett and Amburgey (1990) showed density to have a major effect on founding and failure rates, with the relationship being curvilinear as predicted by the density dependence hypothesis. However, when population mass was included in the equation, only competition was related with founding and failure rates. In other words, the first-order density had a negative effect on founding rates and a positive effect on failure rates, while the effects of density squared term disappeared from the equation. Baum and Oliver (1992) reported similar findings. In an effort to model the effects of external ties on founding and failure rates, they included the number of ties that organizations had with their institutional environments. Whereas they found a strong support for the density dependence hypothesis when the measure of external embeddedness was not included, they reported a pure competition effect of density with the inclusion of embeddedness. The two studies cast some doubts on the empirical validity of density dependence hypothesis.

4. Alternative Explanations: Innovation and Competition

Some scholars provided alternative explanations for a common pattern of density changes — slow initial growth in density with rapid acceleration, followed by a peak, and then decline and stabilization — for which the density dependence model was formulated to explain They claimed that competition among heterogeneous firms can produce the common pattern of density changes and that innovations are major source of firm heterogeneity.

Using simulation, Petersen and Koput (1991) showed that unobserved heterogeneity could generate the first-order effect of density on failure rates. They constructed a single population of 10,500 organizations consisting of five subpopulations with variable mortality rates that are constant over time and hence independent of density In each period, they created equal number of organizations in each subpopulation. With the simulated population, Petersen and Koput found a negative relation between density and failure rates. When they controlled for the previously unobserved heterogeneity, the density did not have any effect on the failure rates. The reason was that organizations with low failure rates increased with density, as organizations with high failure rates were removed from the population. Levinthal (1992) also showed that pure selection forces coupled with rational calculation of economic return of entry and exit could generate the U-shaped relation between density and failure rates.

Scholars in evolutionary economics (e.g., Gort and Klepper (1982), Winter (1984), Klepper and Graddy (1990), and Jovanovic and MacDonald (1994)) provided other logic that can explain similar trajectory of density: initial growth in density, shake-outs, and stabilization.[3] They dealt with competition among organizations *with heterogeneous competencies* Organizational heterogeneity in an industry is a regularity rather than an exception (Lippman and Rumelt (1982), Iwai (1984a)). Rational decisions of entry and exit, innovations and imitations, and competition among heterogeneous organizations can lead to equivalent trajectories of density. Their underlying assumptions are *heterogeneity* among organizations and market selection mechanisms.

Innovative search processes generate organizational heterogeneity in Winter's (1984) model. Uncertain imitability (Lippman and Rumelt (1982)) as well as innovations of new entrants and incumbent organizations (Schumpeter (1934), Nelson and Winter (1982), Iwai (1984b)) contributes to the persistence of heterogeneity among firms that produce a homogeneous product. Gort and Klepper (1982) collected the historical trends of the number of organizations, outputs, and price as well as technological innovations in the industry of 46 new products. They found similar density trajectory as described in population ecology in most of aged industries: slow initial growth in density with rapid acceleration, followed by a peak, and then decline and stabilization. They reported that the frequencies and characteristics of technological innovations could well explain the changes in density

Product life cycle formulations (e.g., Abernathy and Townsend (1975), Utterback and Abernathy (1975), Abernathy (1978), and

3) Winter (1984) did not posit any precise relationship between density and failure rates However, his simulation results demonstrated that under some conditions innovation and imitation coupled with competition can generate a S-shaped density curve

Utterback (1979)) also explained the equivalent historical trajectory of density. In the early stage of industry development, producers have uncertainty over what customers want. Customers also have uncertainty about their needs and desirable characteristics of a product because the product is new to them. Due to the uncertainty, producers use heterogeneous technologies and produce heterogeneous products. Because of the uncertainty and heterogeneity among producers, customers cannot directly compare the products of diverse producers. It means that the selection mechanism is not strong. Because of the initial uncertainty and worry on the entry of more efficient producers, incumbent producers hesitate to increase their scale even though they are most efficient at the time of decision (Porter and Spence (1982)). With increasing demand over time, the period can be characterized by high entry and exit rate as well as increase in density.

As *dominant designs* emerge, organizations capable of producing the dominant designs expel others from the market place. Furthermore, the standardization of product features enables customers to compare prices and qualities of products and thus generates a strong selection environment. The customers' selection drives out organizations that cannot produce dominant design efficiently. The emergence of dominant designs is also related with the emergence of process technology that enables large-scale operation. The introduction of dominant designs and standardized product and process technology results in the emergence of large producers. Since large producers drive out small producers from the market, this period can be characterized as period of "shake-outs."

After the emergence of dominant designs, product and process innovations become incremental (Abernathy and Utterback (1975)). The slowdown of major innovations stabilizes the number of organizations in the industry Studies on automobile and airframe industries (Klein (1977)) as well as on steel, petroleum, and tire industries (Mansfield (1962)) provided suggestive evidences for product life cycle explanations.

Stobaugh (1988) applied the product life cycle formulation to non-assembled products. The number of methanol producers in the US monotonically increased during the period of 1926-1966 from 1 to 15. After 1966, the number monotonically decreased until 1973 when there were 9 producers (Stobaugh (1988: 120-121)). The average annual production per manufacturer grew from 2.8 million gallons in 1930 to 118 million gallons in 1973. The decrease in the number of producers and the sharp increase in the average annual production per methanol manufacturers after 1966 can be attributed to the introduction of a major process innovation: a low-pressure process of producing methanol. The low-pressure process, which Imperial Chemical Industries (ICI) first introduced in 1966, had tremendous cost advantages. The advantages included "higher efficiency, lower energy consumption, longer catalyst life, increased reliability, lower maintenance costs, and *greater economies of scale from large plants*" (Italics: our emphasis, Stobaugh (1988: 116)). ICI's low-pressure technology and an imitative innovation of Lurgi Minerraloltechnik forced existing plants to shut down or to convert to the new process. By 1982, all methanol produced in the US was through the low-pressure process. Stobaugh's study illustrated the importance of technological innovation and competition in shaping industry structure by showing that the introduction and diffusion of a low-pressure process to manufacture methanol determined the industry density — the number of manufacturers.

In sum, evolutionary economics and product life cycle formulations provided an alternative explanation for describing the density trajectory. The common underlying constructs are organizational heterogeneity and selection mechanism rather than legitimation and competition emanating from the density itself. The explanation predicts that the U-shaped relationship between density and failure rates will disappear when organizational heterogeneity variables such as organizational innovation and resources are controlled.

5. Data and Methods

5.1. Data collection

Data for this study cover the entire population of Dutch accounting firms from 1880 to 1990. Firm level data were extracted from the membership directories of accounting associations. During the first eight decades, there were numerous associations, each with its own membership roster until all of them merged into a single association in 1966. The directories provide information about the members of associations and about accounting firms.

Individual level data were collected with one to five year intervals, depending on the availability of directories. For before 1970, there are one four-year (1919-1923) and one five-year intervals (1941-1946). From 1970 to 1974, each year was recorded, while after 1974, every fourth year was recorded. Individual level data included accountant's name, address, education, and status in the firm, if applicable. Also included in the directories was employment affiliation — the name of audit firm, business firm, or governmental agency. The directories also provided the names of cities where each accounting firm had an office.

5.2. Analytic Strategy

Many studies on density dependence used only founding and dissolving dates or years. To replicate the density dependence of failure rates, we assumed that we had information about only founding and failing years. Strong predicted effects of density on failure rates under the assumption would indicate that the sample for this study is not a peculiar one. With the data, we identified a model that has the best goodness of fit. The model was used as a baseline model for additional analysis that included proxies of organizational heterogeneity.

In the second set of models, we introduced organizational characteristics beyond those included in the first set of models. The disappearance of density effect would suggest that strong supports for the density dependence in previous studies might be due to unobserved heterogeneity. Otherwise, the findings may indicate that density dependence formulation is a sound formulation in the population of the present study.

5.3. Measures for the First Set of Equations (Replication of Previous Investigations)

Organizational founding was identified when the organization was first registered in the directory, while organizational failure was indicated by permanent disappearance of its name from the directory. The number of firms at a focal time measured the *density*. To take into account competition level at the time of founding (Carroll and Hannan (1989b)), we controlled for *density at founding*. Carroll and Hannan's density delay hypothesis posited that organizations founded at high density had high failure rates because they were forced to occupy peripheral and non-affluent niches and did not have opportunities to accumulate resources for migrating into affluent niches. The number of firms at the time of a focal firm's founding indicated density at founding.

Also controlled was *organizational age*. The liability of newness argument (Stinchecombe (1965), Hannan and Freeman (1984), Ranger-Moore (1997)) holds that young organizations have higher failure rates due to lack of established rules and of legitimacy in the web of organizational networks. Organizational age was measured by years elapsed after founding. Although the density at founding and organizational age are indicators of organizational heterogeneity, we controlled them to replicate previous studies on density dependence in which those variables were usually controlled for.

We also controlled for *the annual average numbers of foundings and failures during the previous observation period* as time-varying covariates. Delacroix, Swaminathan, and Solt (1989) argued that these two numbers have a negative effect on failure rates. The number of prior foundings indicates the existence of a new niche into which existing organizations could migrate. The possibility of migration renders the association between prior foundings and failure rate negative. They also maintained that prior failures free up resources that can be used by survivors. The availability of resources freed up by failing organizations decreases the failure rates of survivors. Since we had non-uniform observation intervals, we used the annual average numbers of foundings and failures during the previous observation interval

We controlled for proxies of "history", including World War II, Indonesia's independence in 1949, and significant changes in regulations that governed the accounting profession and its clients. The effects of World War II and Indonesia's independence were short-lived. World War II was specified as if it would have effects during the period 1941-1947 and Indonesia's independence during the period of 1949-1951. Government regulations during 1914-1918 and 1929 that dealt with short-term political and economic changes may not have long-lasting effects on failure rates. Government regulations during 1914-1918 and of 1929 were modeled to have its effect during 1914-1920 and during 1929-1931 respectively. Significant changes in regulations such as the mandatory auditing of all listed firms, which changed the demand for audit services, would have persistent effects until its abolition. Because the regulations were still effective in 1990, they were specified as if they had effects during the entire period following the onset of the regulations. Also controlled was the period when only a single powerful accountant association existed in the Netherlands. Since the single association was established in 1966, we used a dummy variable that was set to 1 after 1966, and 0 otherwise.

We also controlled the length of observation intervals. The possibility of failure during time t and time $t+d$ may be positively related with the length of d. Since d ranged from one to five years in this study, we introduced four dummies to handle these non-uniform observation intervals. To obtain a parsimonious model, we also tried the natural logarithm of d. Four dummies to represent the length of *previous* observation interval are introduced, because the observed annual average number of foundings and failures during previous observation interval would depend on its length. When we measured the number of foundings and failures with a five-year interval, for instance, organizations that were both founded and failed during the interval were not counted as foundings or failures. These organizations would be counted as foundings and failures if we observed them with one-year observation interval.

Figure 1 presents historical variation of density and the number of single proprietors. Figure 2 presents the historical variation of foundings and failures Since the data used in this study have non-uniform observation intervals, we presented the annual average number of foundings and failures in Figure 2.

5.4. Measures for the Second Set of Equations: Introducing Organizational Heterogeneity

In the second set of equations, we introduced organizational level characteristics. Data on accountants were aggregated to produce organizational level information. Organizational foundings, failures, and changes were measured by examining changes in accountants' organizational affiliation. Organizational

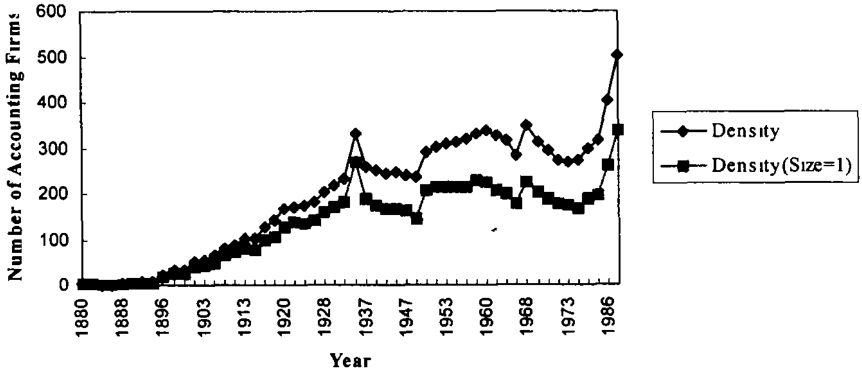

Figure 1. Historical Variations in Density for the Population of Dutch Accounting Firms

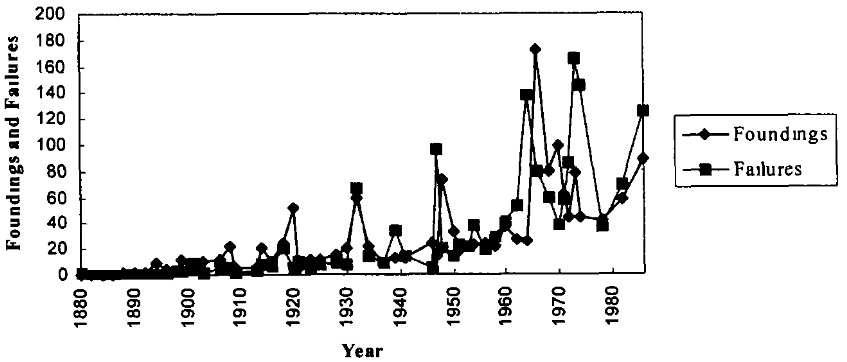

Figure 2. Historical Variations in the Number of Foundings and Failures (Only with Founding and Failing Years: No Organizational Changes)

changes examined in this study included merger, acquisition, split, and name change. Name change was recorded when a firm's name differed from its previous one, provided two-thirds or more of its partners continued their affiliation with the firm. Name change did not include changes due to merger or "cosmetic" name changes such as modifications in the order of named partners, additions of the Dutch equivalents of "Accountants" or "Registered" and "Limited Liability" to the firm's original name.

Organizational split was recorded when at least two partners left and formed a new firm while the remaining partners continued to work for the existing firm. When the defecting partners joined another firm, the departure was not treated as a split but as a lateral movement Holder of the existing firm's name was regarded as a continuation of the existing firm.

When two or more firms joined together and adopted one of the pre-existing names, the event was coded as an acquisition. The firm that maintained its name was coded as an acquirer, and others were coded as the acquired firms. When two or more firms joined together and adopted a new name, the event was coded as a merger. Continuation of the firm was assigned to the largest of the involving firms. Other smaller counterparts were treated as merged firms. When the size of the involved firms was equal, the new firm was treated as the continuation of the firm whose name is alphabetically ahead. In identifying the events, we used the criterion of two-thirds of partners. That is, two-thirds or more of the partners should join a new firm to be considered as a counterpart to merger or acquisition. The decision rule of treating the new firm as a continuation of one of two or more existing firms in these cases is unavoidable, since event history analysis precludes the treatment of an observation as the continuation of two different entities.

Organizational founding was coded when a new name was listed in the directories for the first time without merger or name change. A firm founded by the split of partners from existing firms was also treated as a founding. Failure was flagged when a firm's name was permanently delisted from the directories without merger or name change. Density, density at founding, the number of foundings and failures were constructed based on the new measure of organizational foundings and failures.

Based on the new measure of organizational foundings and failures, we constructed organizational level variables. We controlled the types of foundings by using a dummy that was set to 1 if it was founded by a split, 0 otherwise. We also controlled the number of organizational changes that a focal firm experienced. They included the cumulative number of mergers, acquisitions, splits, and name changes. If organizational changes hampered the reliability of organizations and reseted the liability of newness clock (Hannan and Freeman (1984), Amburgey, Kelley, and Barnett (1993)), they would increase failure rates. Also controlled were the number of a focal organization's domestic offices, and its relative size. The number of accountants associated with a focal firm divided by the total number of accountants in the industry proxied the relative size. To incorporate Winter's (1990) claim that large firms generate more competition than do small firms, we constructed *population mass*. The number of accountants who were affiliated with all accounting firms in each observation period measured population mass. To avoid the pressure of competition from a focal organization itself, we subtracted the focal firm's size from the population mass.

Other heterogeneity factors included human and social capital of organizations. Human and social capital that an organization developed is the most important competitive resources of accounting firms (Pennings, Lee and Witteloostuijn (1998)). Human capital was measured by two indicators — general human capital and firm-specific human capital of the firms. The proportion of CPAs who possessed a Master's or higher degree among all CPAs in the firm measured general human capital. Firm-specific human capital was measured by the average of CPA's firm-specific human capital, which was measured by the natural logarithm of his/her tenure in the focal accounting firm. The speed of firm-specific knowledge accumulation was assumed to decrease over the accountant's tenure.

Social capital was proxied by two measures. One was the proportion of CPAs among all CPAs in the firm who had worked in other industries or government. The other was the proportion of CPAs among quitters who left the firm in the previous 10 years to work for other industries or government but never came back to the accounting industry. A ten-year span was adopted, not only because the strength of network ties decreases with time, but also because the quitters are bound to retire from the business world and would provide no longer any value to the firm. For comparison, 5 and 15 year spans were also tested Sensitivity analysis showed that the results reported here were not significantly different.

We also controlled the adoption of structural innovation — a partner-associate structure. The partner-associate structure enables organizations to accumulate human and social capital and facilitates the emergence of large accounting firms. Rather than using dummy variables for the adopters, we constructed a continuous variable, *leverage ratio*, which was the number of associate accountants divided by the number of partners.

Figure 3 presents the historical variation of foundings and failures. As in Figure 2, we presented annual average number of foundings and failures to handle non-uniform observation intervals. Comparing Figure 2 and Figure 3, we can notice a decrease in the number of foundings and failures in Figure 3 after 1960. The decrease was due to many organizational changes that were counted as organizational foundings and failures in Figure 2. In fact, a great deal of mergers and acquisitions happened and many organizations changed their name after 1960.

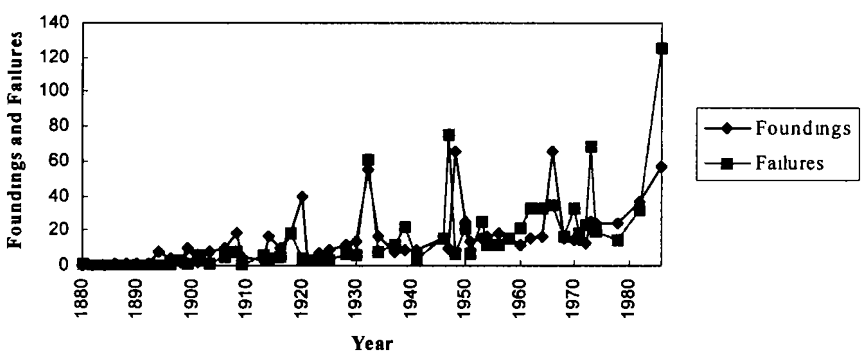

Figure 3. Historical Variations in the Number of Foundings and Failues (Organizational Changes and Linear Interpolation)

5.5. Model and Estimation

Empirical analysis of this study deals with time varying conditions that lead up to the organizational failure. Organizations that were alive in 1990 were treated as right-censored. Since the effect of organizational age was estimated as a time varying covariate, Cox's proportional hazard model could not be used for this study. Following Allison's (1982) recommendation, we employed discrete event history analysis. A discrete-time hazard rate is defined by:

$$P_{it} = Pr\,[T_i = t \mid T_i \geq t,\, X_{it}],$$

where T is the discrete random variable giving the uncensored time of failure (Allison (1982)) P_{it} is the conditional probability that firm i will die at time t, given that it has not already died. Specifically, we used the complementary log-log function, since the model has an advantage over the logit function in handling non-uniform observation intervals. The complementary log-log function assumes that the data are generated by the continuous-time proportional hazard model and thus the coefficient vector is invariant to the length of time intervals (Allison (1982)) The model is expressed as·

$$P_{it} = 1 - \exp\,[-\exp(\alpha_t + X_{it}\beta)],$$

or

$$\log\,[-\log\,(1 - P_{it})] = \alpha_t + X_{it}\,\beta,$$

where α_t is a function of time, X_{it} is a row vector of firm i's state variables at time t, and β is a column vector of coefficients. In estimating the model, we specified $\alpha_t = \alpha_0 + \alpha_1 \log t$. All independent variables except for dummy variables for observational intervals were modeled to have lagging effects by one observation period. In other words, population level variables and firm i's state variables at time t were used to explain failure during time t and $t + d$, where d is the length of observational interval measured in years. A dummy for d was used as an independent variable to explain failure during time t and $t + d$. Procedure with complementary log-log function in SAS was used to estimate the models.

6. Results

6.1. Replication of Previous Investigations

When we assumed that we have information only on the founding and failing years, there have been 3,062 organizations in the history of Dutch accounting industry. Among them, 2,561 accounting firms exited in one way or another before 1990. Episode-splitting resulted in 11,119 firm-intervals.[4]

Table 1 presents results from regression analysis with complementary log-log function. In Model I, density and its squared term did not affect the failure rates. The log of age showed a significant and negative effect on failure rates, as predicted by the liability of newness hypothesis. Density at founding also had a significant and positive effect on failure rates, indicating that organizations founded at high density were more likely to die than organizations founded at low density.

In Model II, we added the numbers of prior foundings and failures and their square terms. The incremental χ^2 test (χ^2 = 339.79, d f.= 4, $p < .001$) showed that the addition significantly enhanced the goodness of fit. When they were controlled, the density had a predicted U-shaped relation with failure rates. The numbers of prior foundings and failures had an inverted U-shaped relation with failure rates. The influence of age and density at founding was not different from Model I. Since the first-order effect of prior failures was not significant, we excluded the variable from Model II to obtain a more parsimonious model to get Model III. Based on Model III, we plotted density against the probability of failure. Figure 4 presents the relationship between the probability of failure and density when all other independent variables were set to zero. The figure shows that the density has a U-shaped relation with

4) Means, standard deviations, and correlation matrix of variables are available from the author

Table 1. Regression Results of Organizational Failure
(Replicating Previous Investigations. 2,708 Firms and 11,119 Firm-Intervals)

Variables	Model I	Model II	Model III
Intercept	-1 976***	-1 837***	-1 848***
	(225)	(230)	(230)
Current Interval 1 Year	-.969***	-.620***	-.598***
	(071)	(100)	(098)
Current Interval 3 Years	894***	853***	792***
	(096)	(116)	(.103)
Current Interval 4 Years	135	779***	841***
	(127)	(146)	(136)
Previous Interval 1 Year	- 302***	096	077
	(072)	(104)	(103)
Previous Interval 3 Years	- 681***	- 305*	-.273
	(169)	(167)	(161)
Previous Interval 4 Years	- 505***	- 955***	-1 059***
	(120)	(160)	(134)
Previous Interval 5 Years	535***	.864***	830***
	(207)	(224)	(221)
Government Regulation 1914-1918	- 449**	- 042	-.077
	(201)	(207)	(205)
Government Regulation 1929	- 158	286	233
	(205)	(216)	(211)
Government Regulation 1971-1973	- 278**	-2 136***	-2.141***
	(112)	(.166)	(166)
Government Regulation 1984-1989	935***	- 210	-.231
	(.141)	(.165)	(164)
World War II 1941-1945	572***	1 173***	1 156***
	(133)	(147)	(147)
Indonesia's Independence 1949	854***	957***	1 019***
	(111)	(.136)	(126)
Single Association (1 if year > 1966)	1 564***	3 338***	3 443***
	(065)	(157)	(131)
Log of Organizational Age	- 108***	- 283***	- 281***
	(021)	(025)	(025)
Density at Founding / 100	480***	167***	176***
	(.042)	(.047)	(047)
Density / 100	**-.142**	**-.730*** **	**-.692*** **
	(.205)	**(.221)**	**(.219)**
Density^2 / 10000	**-.038**	**.180*** **	**.180*** **
	(.040)	**(.045)**	**(.045)**
Prior Foundings / 100		1.980***	2 110***
		(463)	(449)
Prior Foundings^2 / 10000		-1 500***	-1 600***
		(240)	(.240)
Prior Failures/100		620	
		(524)	
Prior Failures^2 / 10000		-1 800***	-1 500***
		(300)	(090)
Log-Likelihood Degrees of Freedom	-4936 74·18	-4768 84·22	-4769 54 21

Note Asymtotic standard errors are in parentheses
* $p < .10$, **. $p < .05$, ***. $p < .01$ (Two-tailed test)

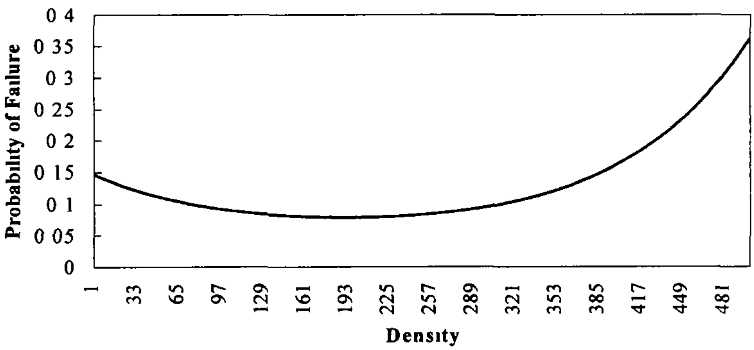

Figure 4. Density and the Probability of Failure

the probability of failure.

As the significance level of prior failures in Model II indicated, the deletion did not significantly change the log-likelihood (χ^2 = 1.34, d.f.=1, not significant). We also ran a model with prior failures instead of its squared term. χ^2 test (χ^2 = 12.35, d.f.=1, p < .01) to compare Model III with Model II revealed that the deletion of the squared term significantly deteriorated the goodness of fit Therefore, we used Model III as a baseline model to investigate the strength of density dependence hypothesis.

6.2. Introducing Organizational Heterogeneity

We constructed another sample of firms when firm heterogeneity variables are considered. The measure of organizational founding and failure, that was explained in the measurement section, generated 1,805 accounting firms in the history of the Dutch accounting industry One hundred sixty three accounting firms disappeared temporarily from the directories. Among 1,642 non-missing accounting firms, 1,141 firms dissolved before 1990. Among 1,141 dissolved firms, 790 firms were terminated, while 351 firms were targets of mergers and acquisitions.

Table 2 presents results from regression analyses with complementary log-log function. Model IV and V were based on the sample that we constructed by excluding temporarily disappeared firms from the population. When a firm disappeared temporarily from the directories, we did not include it in

Table 2. Regression Results of Organizational Failure
(Under Heterogeneity Assumption)

Variables	Model IV (All Types of Exits)		Model V (Termination Only)	
	B	S E	B	S E
Intercept	-2 451***	922	1 872	1.367
Current Interval 1 Year	- 502***	121	- 447***	145
Current Interval 3 Years	1 561***	151	1 639***	181
Current Interval 4 Years	705***	209	975***	.251
Previous Interval 1 Year	-.010	124	- 084	150
Previous Interval 3 Years	013	236	064	.280
Previous Interval 4 Years	- 302	201	- 293	248
Previous Interval 5 Years	426	278	085	381
Government Regulation 1914-1918	298	.252	379	.268
Government Regulation 1929	052	314	- 014	.360
Government Regulation 1971-1973	-.683***	244	-.512	324
Government Regulation 1984-1989	293	.240	- 055	.290
World War II 1941-1945	1 005***	.196	1 242***	222
Indonesia's Independence. 1949	516***	.184	1.040***	204
Single Association (1 if year > 1966)	056	176	074	236
Log of Organizational Age	134	.089	234**	117
Density at Founding / 100	.565***	088	703***	111
Density / 100	**-1.510*** **	**.494**	**-2.480*** **	**.642**
Density2 / 10000	**.160***	**.088**	**.340*** **	**.110**
Prior Foundings / 100	1 080*	632	2 330***	761
Prior Foundings2 / 10000	-1 100**	470	-1 800***	550
Prior Failures2 / 10000	-2 500**	1 230	-5 800***	1 520
Log of Mass	378*	229	- 156	293
Relative Size	- 123*	075	-1 367***	296
Number of Domestic Offices	- 059**	027	- 147***	054
Founded by Split	806***	.150	593**	.267
Cum Number of Mergers	203***	.057	407***	090
Cum Number of Acquisitions	- 046	069	088	121
Cum Number of Splits	122	142	229	257
Cum Number of Name Changes	038	108	035	150
Partners "From" Client Sectors	- 096	.094	- 199*	.105
Partners "To" Client Sectors	066	127	161	177
General Human Capital (Education)	- 147*	083	- 379***	106
Firm-Specific Human Capital	-1 073***	137	-1 317***	168
Firm-Specific Human Capital2	305***	034	377***	040
Associate/Partner Leverage	- 149*	088	- 378**	169
Temporary Disappearance				
Firm-Intervals	7027		6676	
Log-Likelihood Degrees of Freedom	-2821.84. 35		-2083.46. 35	

Note * $p <$ 10, ** $p < .05$, *** $p <$ 01 (Two-tailed test)

Table 2. Regression Results of Organizational Failure(Continued)

Variables	Model IV (All Types of Exits)		Model V (Termination Only)	
	B	S E	B	S.E.
Intercept	-4 792***	851	- 932	1 219
Current Interval 1 Year	- 551***	111	- 498***	133
Current Interval 3 Years	1 500***	.140	1 636***	166
Current Interval 4 Years	523***	.191	700***	227
Previous Interval 1 Year	.028	116	- 005	139
Previous Interval 3 Years	143	213	.256	248
Previous Interval 4 Years	- 457**	191	-.447*	.235
Previous Interval 5 Years	.328	266	-.025	374
Government Regulation 1914-1918	- 034	238	.002	.256
Government Regulation 1929	- 081	307	- 083	352
Government Regulation 1971-1973	- 707***	228	- 465	293
Government Regulation 1984-1989	227	223	- 181	268
World War II: 1941-1945	910***	182	1 149***	.209
Indonesia's Independence 1949	934***	152	1 411***	.172
Single Association (1 if year > 1966)	-.060	.163	- 095	216
Log of Organizational Age	051	062	118	075
Density at Founding / 100	302***	.072	366***	089
Density / 100	**-1.800*** **	**.451**	**-2.820*** **	**.582**
Density2 / 10000	**.220*** **	**.080**	**.420*** **	**.100**
Prior Foundings / 100	1.040*	.587	2 260***	.708
Prior Foundings2 / 10000	-1 000**	.430	-1 600***	500
Prior Failures2 / 10000	-3 400***	1 110	-6.000***	1.350
Log of Mass	.923***	211	486*	265
Relative Size	- 134***	049	-1 244***	257
Number of Domestic Offices	- 052**	.024	- 160***	051
Founded by Split	669***	136	265	244
Cum Number of Mergers	207***	052	381***	.084
Cum Number of Acquisitions	-.033	056	.147	.094
Cum Number of Splits	062	127	- 053	227
Cum Number of Name Changes	.109	092	.111	126
Partners "From" Client Sectors	- 111	.086	-.201**	.096
Partners "To" Client Sectors	-.066	102	022	136
General Human Capital (Education)	-.080	076	- 255***	095
Firm-Specific Human Capital	-1.016***	.108	-1 191***	128
Firm-Specific Human Capital2	308***	028	363***	.034
Associate/Partner Leverage	-.182**	084	- 457***	.161
Temporary Disappearance	- 933***	104	-1 095***	123
Firm-Intervals	11119		10726	
Log-Likelihood. Degrees of Freedom	-3450 36	36	-2590.90	36

Note: *: $p < .10$, **: $p <$ 05; ***. $p < .01$ (Two-tailed test) counting density, relative size, and mass. In Model IV, termination and being a target of merger and acquisition were treated as the same kind of events. Consistent with the density dependence hypothesis, the density had a significant U-shaped relation with failure rates. The density at founding also had a strong and positive effect on failure rates. However, the effect of firm age disappeared in the model. The effects of variables proxying the population dynamics were not changed from Model III.

Among organizational heterogeneity variables, relative size, leverage ratio, and the number of domestic offices had negative effects on failure. The average firm-specific human capital had a U-shaped relation with the failure rates. The cumulative number of mergers in which a focal organization was engaged significantly increased the failure rates. Other organizational changes did not have any significant effect in this model. Log of mass had a marginal positive effect on failure rates, suggesting that the emergence of large firms slightly increased the failure rates of small firms.

In Model V, we treated the last observation interval of organizations that were the target of mergers and acquisitions as right-censored. In the model, density had a significant U-shaped relation with termination rates. Compared with its effect in Model IV, density became more significant in explaining termination. Other major changes in the results from Model IV were the effects of firm age, organization's social capital, and general human capital. Contradicting the liability of newness argument, the log of firm age had a positive effect on termination. The social capital and general human capital that an organization enjoys through its members had significant and negative influences on termination.

Model VI and VII were based on the sample when we took into account the issue of temporarily disappeared firms through interpolation. We interpolated firm size, human and social capital, the number of domestic offices, and leverage ratio. It was based on the assumption that those firms were operating during their missing intervals but were not listed in the directories and that they changed linearly during those intervals. Because of this interpolation, density, relative size, and mass differed from those measured for Model IV and V. Among 1,304 dissolving firms, 911 firms experienced termination while 393 firms were the targets of mergers and acquisitions.

In Model VI, we treated termination and being a target of mergers and acquisitions as the same class of events. Consistent with the density dependence hypothesis, density had a significant U-shaped relation with failure rates. The density at founding also had a strong and positive effect on failure. However, firm age had a positive effect. The effects of other variables did not significantly change from Model IV.

In Model VII, we treated the last observation interval of organizations that were targets of mergers and acquisitions as right-censored. In the model, density had a significant U-shaped relation with termination rates. Other major change from Model V was the effect of firm age. The log of firm age had no effect on termination. The results of Model VI and VII showed that the findings were not sensitive to the specification of temporarily disappeared firms.

We also ran the same models from Model IV to Model VII with the sample that we treated a firm founded by a merger as a new firm, not as a continuation of one of the involving firms. Results were not significantly different from those presented in Table 2. All the results suggested that density had a stable and strong curvilinear effect on organizational failures even when major organizational heterogeneity variables were controlled. In sum, results supported density dependence hypothesis rather than an alternative explanation.

7. Discussion and Conclusions

The present study tested density dependence hypothesis. Alternative explanations for the S-shaped growth curve of density suggested that the addition of organizational innovations and other critical firm heterogeneity indicators would render the effect of density on failure rates insignificant. Strongly supporting Hannan and Freeman's density dependence hypothesis (Hannan and Freeman (1987, 1989)), empirical analysis of the population of Dutch accounting firms showed that the density had a strong and consistent U-shaped association with failure rates even when major organizational level variables were controlled for. The results also indicated a strong support for Carroll and Hannan's density delay hypothesis (Carroll and Hannan (1989b)) even when the organizational characteristics were controlled. The natural logarithm of firm age did not have the predicted negative effect on failure rates when organizational characteristics were controlled.

Delacroix et al. (1989) argued that the effects of prior foundings and failures, instead of the density, can explain the S-shaped growth curve of density. The present study showed that the density did not affect organizational failure when the numbers of prior foundings and failures were not controlled. However, the present study showed that the density had a strong U-shaped relation with the failure rates when those numbers were controlled The number of prior foundings itself had an inverted U-shaped relation with the failure rates. It may suggest that a small number of prior foundings may increase the competition but that the large number of prior foundings may indicate the development of new niches such as increasing demand for accounting and consulting services from small businesses and individuals. The number of prior failures had an accelerating negative influence on the failure rates. The findings favored Hannan and Carroll's (1992) argument that the density dependence hypothesis is not incompatible with the population dynamics argument — the effects of prior foundings and failures.

Since all empirical studies can suffer from unobserved heterogeneity, we cannot reject the possibility that the strong support for density dependence hypothesis in this study is due to other unobserved variables, for example stable network ties with large sized clients or CPA's family background. However, the strong support for the density dependence hypothesis, even with fine-grained organizational level factors controlled, provides suggestive evidence for the hypothesis.

When the literature of innovation and market development was taken into account, the strong support for the density dependence hypothesis is somewhat surprising. The finding may be related to the peculiarity in the accounting industry. Even when some accounting firms adopted an innovation, these firms did not experience instantaneous growth rate and thus did not drive out small accounting firms from the market. The following are the reasons that accounting firms cannot grow instantaneously even with a viable organizational innovation, and that industry shake-out from innovations cannot take place.

First, accounting firms are not able to grow instantaneously due to their partnership arrangement with unlimited liability. Under the arrangement, partners are responsible for the loss that other partners create Accounting firms, consequently, are very conservative in hiring new partners or in promoting associates to partners. The arrangement constrains the instantaneous membership growth, even when a structural innovation that enables a large partnership is adopted.

Second, there is a *relational inertia* independent of intra-organizational inertia. As Levinthal and Fichman (1988) observed, the relationship between accounting firms and their clients is stable rather than volatile. The relational specificity between the service-providers and their clients is responsible for the stable relation (Levinthal and Fichman (1988), Uzzi (1996), and Baker, Faulkner and Fisher (1998)). Difficulty experienced by clients in measuring the quality of accounting services may also be responsible for the stability. The difficulty renders the relational ties central when the clients select their service-providers. The relational inertia prohibits rapid growth of accounting firms.

Third, the development of new market niches enables small firms to survive. As the complexity of tax regulation has increased, the demand for accounting services by small businesses and individuals has also increased. Small businesses and individuals are more price sensitive than large corporate clients are. Premium pricing by large accounting firms forces small price-sensitive clients to choose small accounting firms. Small clients also prefer service providers that are easily accessible. As a result, we can observe a positive relationship between the size of the client's business and the firm size of professional service providers.

In sum, internal and relational inertia that accounting firms have prevent them from growing instantaneously and, thus, driving out small firms from the market. Small accounting firms also may proactively respond to competitive pressure generated by the emergence of large accounting firms by migrating into new market niches. Because of those reasons, we observed steady increase in the number of single proprietors accompanied with the emergence of large accounting firms in the history of the Dutch accounting industry.

The present study showed that the density had a predicted U-shaped relation with failure rates even when fine-grained proxies for organizational heterogeneity were controlled. The findings supported Hannan and Carroll's (1992) argument that the density dependence argument is compatible with innovation literature. Having strong structural inertia forces, organizations investigated here had a limit on instantaneous organizational growth. In other words, the driving force behind the evolution of this industry may not be innovations In addition, accounting industry is not a homogeneous goods industry, which Nelson and Winter's evolutionary model almost always assumes. In a heterogeneous goods industry with multiple niches, Nelson and Winter's argument may not work. The industry characteristics may explain why the addition of innovation and firm heterogeneity variables cannot wash out the effect of density. Future studies on populations in which innovations lead to instantaneous growth may provide more information about the compatibility of density dependence hypothesis and the literature of evolutionary economics.

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