Survival of New Plants in Different Industry Environments in Norwegian Manufacturing: A Semi-Proportional Cox Model Approach

Ragnar Tveterås
Geir Egil Eide

ABSTRACT. Using a rich plant level data set from Norwegian manufacturing we analyse possible determinants of survival for ten plant cohorts during the period 1977–92. By specifying a semi-proportional hazards model of plant exit, we are able to accommodate for structural differences between entrepreneurial entrants and new plants of existing firms. Industry heterogeneity in terms of plant size, capital intensity and productivity is also accounted for in the model. According to our estimated models, there are significant structural differences between new small firms and new plants of existing firms. For example, the size of the plant relative to the industry average had less influence on the survival probability for entrepreneurial entrants. Hence, the empirical results suggest that the two types of entrants establish themselves in different market niches with distinct technological characteristics. The results underscore the necessity of adjusting for the dissimilar environments facing plants which enter different industries.

Final version accepted on November 3, 1999

Ragnar Tveteras
Stavanger University College & Foundation for Research in Economics and Business Administration
P.O. Box 2557 Ullandhaug
N-4091 Stavanger
Norway
E-mail: Ragnar.Tveteras@oks.his.no

and

Geir Egil Eide
Section of Mathematics and Statistics
Norwegian School of Economics and Business Administration
Helleveien 30
N-5035 Bergen-Sandviken
Norway
E-mail: Geir.Eide@nhh.no

1. Introduction

The purpose of this paper is to analyse the survival of new establishments (or plants) in Norwegian manufacturing.[1] Specifically, an aim is to investigate the findings of several studies of the small business literature that entrepreneurial entry is structurally different from new plant entry by larger existing firms. This study also recognises that new plants which enter various industries face very different environments, and that these environments may be more or less disadvantageous to new small firms compared to larger firms. We account for this industry heterogeneity by adjusting plant level explanatory variables of survival by industry level measures of optimal minimum efficient scale, capital intensity, etc.

Our study also contributes to the empirical literature on post-entry performance by providing results for a country representing the Scandinavian welfare state, where new establishments face a socio-economic regime which in many respects must be considered structurally different from economies for which analyses have already been undertaken, e.g. U.S.A. (Agarwal, 1998; Agarwal and Audretsch, 1999; Audretsch and Mahmood, 1994; 1995), Canada (Baldwin and Rafiquzzaman, 1995), Germany (Boeri and Bellmann, 1995; Brüderl, Preisendorfer, P. and Ziegler, R., 1992; Harhoff, Stahl and Woywode, 1998; Wagner, 1994), and Portugal (Mata, Portugal and Guimaraes, 1995).

We utilise a data set with annual observations on Norwegian manufacturing plants from 1977 to 1992. This means that we can observe new plants for a longer time period than other studies of new plant survival cited in this paper. This period

Small Business Economics **14**: 65–82, 2000.

covers a mild recession (1982–83), a boom (1985–86), and a major recession (from 1988). Another distinguishing factor compared with other studies is the number of cohorts we are able to follow. We study ten cohorts (1977–86), which entered in different phases of the business cycle, thus allowing us to analyse the effect of different macroeconomic conditions on the rate of failure during the first critical years. We have plant level data on employment, sales, costs, capital and ownership, which allows us to account for plant-specific factors in the analysis.

We estimate semi-proportional Cox hazard models for the 1977–86 cohorts (Dabrowska, Doksum, Feduska, Husing and Neville, 1992). Time-varying covariates at the plant level are employed to account for the possibility of "active" learning (Ericson and Pakes 1992). Previous studies have to a large extent used time-constant covariates, measured at the time of entry, which implies that entrants are subject to "passive" learning (Jovanovic, 1982). If the ability to learn after entry is more important than the inferiority at the time of entry, then time-varying covariates should be included in the model.

The structure of this paper is as follows: Section two discusses theories and some empirical observations on entry, in particular whether there exist structural differences between new firms and new plants established by existing firms. Section three attempts to summarise the empirical research on post-entry survival and growth utilising longitudinal data sets. Section four provides the methodological framework for our analysis of plant duration, and discusses the methodological approaches of earlier studies. The longitudinal data set on Norwegian manufacturing plants is presented in section five. In section six, the empirical results for Norwegian manufacturing are provided. Finally, summary and conclusions are presented in section seven.

2. Theories and some empirical observations on entry

The traditional view in industrial organisation was that the main role of new entrants was to act as an equilibrating force by restoring the levels of profitability and price to their long-run competitive levels. The assumptions of homogeneity of production technologies and products played a central part in this view of the world. However, it is difficult to reconcile the theories of entry in standard textbooks with the empirical findings (Geroski and Schwalbach, 1991). Only modest effects of entry on market performance in terms of prices and profit rates were found. Another view of the role of entry is based on the empirical observation that production technologies and products are subject to a more or less continuous evolution over time. The process of evolution can be regarded as a search process. New firms probably play an important role in these evolution processes, because new entrants are often vehicles for introducing new production technologies or products (Audretsch, 1995, pp. 447–450; Geroski, 1995, pp. 436–437; Agarwal, 1998; Agarwal and Audretsch, 1999). Geroski (1995, p. 437) reconciles the two views of entry by stating that "not only is entry an (imperfect) mechanism for getting prices right in markets, it is a mechanism for getting product and process specifications right".

Geroski (1995) presents some stylised facts and stylised results that summarises the findings of empirical studies of entry. Econometric studies of entry have mainly been concerned with the level of entry and industry characteristics that constitute barriers or inducements to entry. However, econometric models of entry have not been very successful in explaining entry rates using conventional measures of profitability and entry barriers. Geroski (1995) attempts to provide an explanation by suggesting that what has traditionally been considered to constitute a barrier to entry may pose less of a barrier to entry and more of a barrier to survival. It is easier to enter an industry than to survive for a longer time period in that industry. In recognition of this, the research effort has shifted from entry itself to post-entry performance of infant plants and firms.

Before going further, a digression on terminology is required. In the following, we have adopted the term "SPF entry" to represent the similar terms "entrepreneurial entry", "single plant firm entry", "independent firm entry" or "de novo entry" commonly found in the literature.[2] Likewise, we adopt the term "MPF entry" to represent "new plants of existing firms", "new plants of diversifying firms", "new plants of incumbent firms" and "new plants of multi-plant firms" throughout the paper.

Although large numbers of firms enter most markets in most years, entry rates are far higher than the immediate market penetration rates of entrants, because entrants are usually very small. The fact that cumulative market penetration rates of consecutive cohorts of surviving entrants over time are much larger, as shown in Figure 1 for Norwegian manufacturing, has contributed to shifting the attention towards survival and growth rates of new entrants. Establishment of new firms is an important vehicle for new job creation in Norway. Figure 1 shows the job creation of SPFs and plants of MPFs established 1977–86 in Norwegian manufacturing industries measured as relative share of total manufacturing employment. For example, at the end of 1981 new SPFs established from 1977 to 1981 employed 3.0% of manufacturing labour in 1981, and new MPF plants established 1977–81 employed 2.8% of manufacturing labour. The figure reveals that the total cumulative employment share of the 1977–86 cohorts of new plants adds up to a substantial fraction; the total share is 12% by the end of the ten-year period. Furthermore, in 1986 the cumulative job creation of the 1977–86 cohorts was 7.15% and 4.8% of total manufacturing work force. In other words, SPF plants had created roughly 50% more jobs than MPF plants.[4]

2.1. *Structural differences between plant entry of new firms and existing firms*

There are strong reasons to believe that different behavioural models explain the entry decision of the two entrant types, and that they face different environments. According to the small business literature, there are at least four reasons for distinguishing between plant entry of new small firms and existing (larger) firms:

(i) *Decision-makers in new independent firms and existing firms may have different motives for establishing a plant.*

It is reasonable to assume that pure monetary profitability considerations are a more important element in entry decisions of existing firms than for small entrepreneurs.

Empirical studies suggest that many individuals would prefer to be self-employed, i.e. that for a given wage, self-employment would provide a higher utility than dependent employment (Blanchflower and Oswald, 1992b).[5] If this is the case, individuals would not merely look at expected monetary compensation when deciding whether to establish a business or not. They would also incorporate the higher level of well-being associated with self-employment.

Empirical evidence also suggests that unemployment may explain some of the new small firm

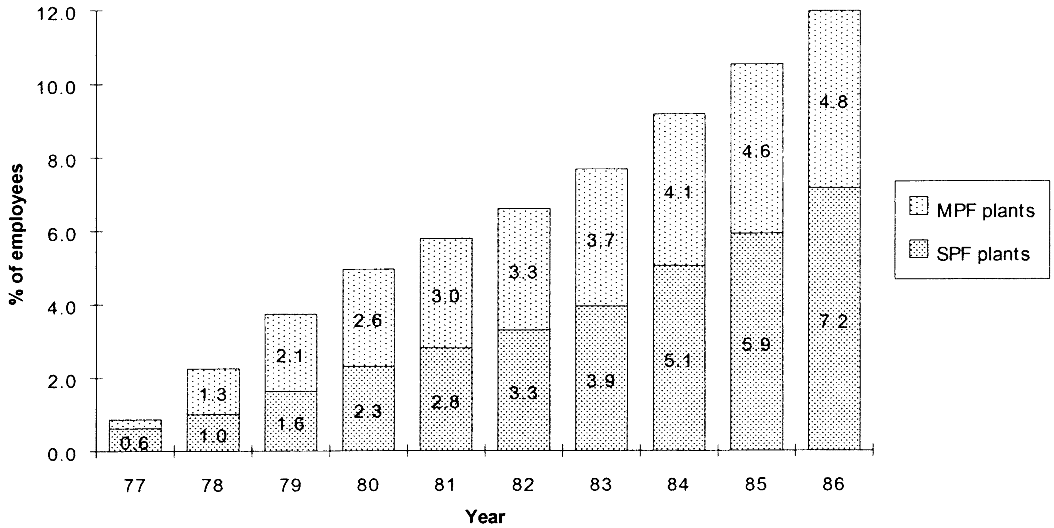

Figure 1. Cumulative employment share of SPF and MPF plants established in 1977–86 relative to total employment in Norwegian manufacturing.

formations.[6] It has been argued that individuals, faced with unemployment and little prospect of gaining work as an employee, would be more likely to work for themselves than an otherwise similar individual who is in employment. A survey by Boye and Kinserdal (1992, p. 183) suggests that 1/3 of new firms in Norwegian manufacturing were established by unemployed persons in 1988 and 1990. Studies in the U.K. and U.S. provide similar results (Storey, 1991). On the other hand, a high unemployment rate may be associated with depressed demand conditions, which would have a negative effect on the probability to found a firm (Evans and Leighton, 1989, 1990).

(ii) *New small firms and existing firms in general face very different restrictions with regard to the scale of entry and their post-entry behaviour.*

Empirical evidence clearly indicates the existence of imperfect capital markets and suggests that capital constraints play a significant role in the establishment of small independent businesses. New firms must to a large extent get the required capital from the entrepreneur's own purses, while existing firms finance new plants by a combination of retained earnings and loans.[7] The existence of imperfect capital markets may undermine the competitiveness of entrepreneurial entry in two ways: Firstly, lack of capital may force the entrepreneur(s) to invest in a plant of sub-optimal scale, i.e. a sub-MES scale plant. Secondly, entrepreneurs may have to pay a higher interest rate than existing firms on the external capital due to higher perceived risk.[8] Furthermore, since existing firms in general have a greater financial strength than new small firms, they can allow new plants to accumulate negative profits for a longer period before they are eventually closed down.

On the other hand, existing firms may to a greater extent be constrained by labour market legislation, agreements with unions and environmental legislation than new small firms. A new plant established by an existing firm will in general inherit many of the prevalent institutions of the firm. The probability that the employees are organised in a union from the date of establishment or soon after establishment, increases if the labour force of the existing plants owned by the firm is organised. New firms do not inherit a union structure, and the employees are therefore less likely to be organised. In addition, new small firms may have a more relaxed attitude to laws and public regulations than large corporations, which are often very concerned about their relationship with public authorities and unions. All in all, this may imply that new firms are more flexible than existing firms with regard to organisational and technological changes, hiring and firing of labour, use of part-time labour, wage setting and working environment.

(iii) *Plants of new firms and existing firms have unequal access to internal and external human, technological and marketing resources.*

New independent establishments are often not able to employ persons with particular skills, because they are unable to pay the high salaries or provide the level of job security demanded by these persons. Usually a new establishment does not have all necessary functions or resources internally, e.g., R&D, marketing or accounting department. New establishments may also have weaknesses in certain areas, for example, lack of marketing skills and established customer relationships. On average, a new establishment of an existing firm probably has better access to external resources than a *de novo* entrant.

(iv) *Plants of new firms and existing firms to a certain extent establish themselves in different market segments.*

New firms establish themselves in market niches which require small-scale, specialised, flexible production and marketing, and which large firms find too small or unprofitable to be of any interest (Julien, 1993). To some extent, entrepreneurs may choose such market niches because of their inability to compete in markets which require large-scale production and large investments in R&D and capital equipment. In addition, there are differences with respect to the scope of markets which may be candidates for entry: Diversified firms will have more options with regard to which market to enter than entrepreneurs, who are generally limited to enter a market where they can exploit their personal education and skills.

3. The empirical research on post-entry performance

Empirical studies of post-entry performance have recently been undertaken on large longitudinal data sets for countries such as the U.S. (Agarwal, 1998; Agarwal and Audretsch, 1999; Audretsch, 1995; Audretsch and Mahmood, 1994; 1995; Doms, Dunne and Roberts, 1995), Canada (Baldwin and Rafiquzzaman, 1995), Germany (Boeri and Bellmann, 1995; Brüderl, Preisendorfer, P. and Ziegler, R., 1992; Harhoff, Stahl and Woywode, 1998; Wagner, 1994), and Portugal (Mata, Portugal and Guimaraes, 1995).[9] Although these studies differ in scope and methodology they are in general concerned with the relationship between establishment/firm characteristics, industry characteristics and macroeconomic conditions, and post-entry performance in terms of growth and survival.

One of the stylised facts established by Geroski (1995) is that "the survival rate of most entrants is low, and even successful entrants may take more than a decade to achieve a size comparable to the average incumbent." In the above cited studies, it is typically found that only 30% to 50% of new establishments survive the first few years.

Another stylised result presented by Geroski (1995) is that both firm size and age are correlated with the survival and growth of entrants. Several empirical studies find a clear positive correlation between survival rates and both age and firm size for small firms (Sutton, 1997; Caves, 1998). The age effect is consistent with the view that learning-by-doing may be an important determinant of survival.

An interesting question is whether there are differences in survival and growth rates across industries. Studies have found that the height of barriers to entry varies considerably across industries (Geroski, 1995, pp. 429–430). These barriers can also be viewed as barriers to survival. Dunne, Roberts and Samuelson (1988, 1989) find that survival and growth rates of entrants vary systematically across U.S. manufacturing industries.

Audretsch and Mahmood (1994, 1995) and Audretsch (1995) focus on differences in innovative regime across U.S. manufacturing industries as a determinant of differences in survival rates. Since new firms are often vehicles for innovation, industries with a high level of innovative activity should have high entry rates, *ceteris paribus*. An entrant that successfully innovates will have a greater likelihood of survival. However, it can be argued that, on average, the typical entrant in a highly innovative industry faces a higher risk of offering a product which will not be viable. Hence, the likelihood that entrants in such an industry successfully innovate and survive may be lower. The results from Audretsch and Mahmood and Audretsch's empirical models support this hypothesis. Boeri and Bellmann (1995), on the other hand, found a negative relationship between their measure of innovative activity in German manufacturing industries and the hazard rate of entrants.

Little attention has been devoted to the relationship between aggregate economic fluctuations and new firm survival and growth. This can probably partly be explained by the lack of panel data that cover at least one business cycle. Audretsch and Mahmood (1995) and Boeri and Bellmann (1995) analyse the influence of the business cycle on firm survival rates. The latter study also examines cyclical sensitivity of new firm growth. Audretsch and Mahmood find that the hazard rate of new firms increases with the unemployment rate, which is used as a proxy for the business cycle. In other words, new firms are more likely to fail during macroeconomic downturns. Boeri and Bellmann, who employ the growth rate of unemployment, find that hazard rates of new firms are not responsive to the business cycle. Furthermore, they find that the growth of surviving entrants exhibit little cyclical sensitivity.

Baldwin and Rafiquzzaman (1995) examine if the entry process follows a selection process or an evolutionary learning process in Canadian manufacturing.[10] They find that labour costs of new firms, relative to incumbents, far exceed relative labour productivity. However, the relative productivity of surviving entrants grows at a much faster rate than relative labour costs, resulting in an increase in relative profitability over time. Overall, a somewhat mixed picture emerges: Both selection and evolutionary learning are found to affect post entry-performance.

Doms et al. (1995) focus on the relationship between capital intensity, use of advanced manufacturing technologies, and plant growth rates and exit probabilities. Capital inputs are usually considered fixed in the short run. Through its effect on variable costs, the capital usage may thus affect the plant's shutdown decision. Among otherwise similar plants, those with higher capital intensity may be less likely to shut down. Furthermore, if capital investments have a substantial sunk cost component the more capital-intensive plants should exhibit more persistence. Doms et al. use a data set with information on each plant's usage of different advanced production technologies. They find that the capital-labour rate is negatively correlated with plant failure and positively correlated with plant growth. They also find that plants that have adopted a larger number of advanced manufacturing technologies have lower exit rates and higher growth rates.

Among the studies that have examined the performance of entrepreneurial entry versus that of new plants by incumbent firms are Audretsch and Mahmood (1994, 1995) and Mata et al. (1995). Audretsch and Mahmood (1994) estimate separate Cox (1972) hazard rate models for new firms and new plants of existing firms. They find that the hazard rate of new firms is more sensitive to start-up size, industry growth and R&D intensity of the industry. On the basis of estimated t-values they conclude that "new-firm start-ups are much more influenced from the external environment, and in particular, from the extent of scale economies and from the technological environment than are new branches and subsidiaries of existing firms". However, it should be taken into account that the number of observations on new plants of existing firms is much smaller than for new firms. This may explain the lack of significance of parameters in the estimated Cox model.

Audretsch and Mahmood (1995) only account for structural differences between new firms and new plants by existing firms by implementing an ownership type variable in their Cox hazard rate model. Somewhat surprisingly, they find that new plants of existing firms have a significantly higher exit hazard rate than new firms.

Mata et al. (1995) obtain similar results for Portuguese manufacturing. Plants of new firms are initially smaller than those of existing firms, but they compensate by growing at a faster rate. Mata et al. estimate a Cox hazard rate model with dummy variables for ownership type. Both in the Cox analysis and the descriptive analysis they find that new firms have the lowest hazard rate. Next, they estimate separate Cox models for new firms and existing firms. According to the estimated parameters there are no structural differences between new firms and existing firms with respect to the relationship between hazard rates and start-up size, current size, industry growth and industry entry rate.

Empirical studies of post-entry performance have undoubtedly provided important insight into the determinants of growth and survival of new establishments. However, as pointed out by Audretsch and Mahmood (1995), the lack of detailed information at the plant and firm level is a general weakness of these studies.

4. Considerations in model specification and estimation

Three different approaches can be distinguished in empirical studies of firm survival: (1) Binary choice models, i.e., probit models (Wagner, 1994) and logit models (Audretsch, 1995; Boeri and Bellmann, 1995), (2) tobit models of firm age (Wagner, 1994), and (3) duration models, or more specifically, Cox (1972) proportional hazards models.

Unlike the model by Cox, the probit, logit and tobit model all make distributional assumptions. This fact seems to make the Cox proportional hazards model more attractive, since there exists no strong theoretical or empirical arguments for a particular distributional form for the probability of plant exit (probit and logit) or plant age (tobit). For the tobit model, it has been shown that if the underlying disturbances are not normally distributed, then the usual estimator is inconsistent. Alternative estimators are available, but these also make specific distributional assumptions.

In the Cox proportional hazards model the hazard rate is given by

$$r(t, \mathbf{x}; \alpha) = h(t) \exp(\alpha_1 x_1 + \alpha_2 x_2 + \ldots + \alpha_n x_n),$$

where $h(t)$ is an unspecified baseline hazard rate and the second factor specifies the possible influence of the covariate vector $\mathbf{x}$ on the hazard rate. The partial-likelihood approach suggested by Cox can be used to estimate α in the proportional hazards model without specifying the form of the baseline hazard function $h(t)$.

In the Cox-model, the relationship between the hazard rates r and r' corresponding to the values of the kth covariate, x_k and x_k', is given by

$$\frac{r}{r'} = \frac{r(t, \mathbf{x}; \alpha)}{r(t, \mathbf{x}'; \alpha)} = \exp\{(x_k - x_k')\alpha_k\},$$

where all the elements in the vectors $\mathbf{x}$ and $\mathbf{x}'$ are equal, except the kth element. The Cox model formulation implies that the hazard rates r and r' have a constant factor of proportionality over time. However, the assumptions may be considerably relaxed by allowing *time-varying* covariates, $x_{k,\,t}$, *time-varying effects* of covariates, and *stratum-specific baseline* hazard rates, $h_s(t)$.

The previously mentioned studies of Audretsch and Mahmood (1994; 1995) and Mata et al. (1995) employ the ordinary proportional Cox hazards model in their analyses, but differ with respect to the time variation of covariates. Audretsch and Mahmood (1994) only use time-constant covariates. Except for plant start-up size, the covariates are all measured at the industry level. In their 1995-study, Audretsch and Mahmood also employ time-constant plant level covariates, but now introduce time-varying covariates at the industry level. Finally, Mata et al. (1995) use both time-constant and time-varying covariates.

The proportionality and baseline hazard restrictions in the Cox model is handled to different degrees in the above mentioned papers. One strategy used by both Audretsch and Mahmood (1994) and Mata et al. (1995) is to include ownership type dummy variables in the model. However, this strategy does not take care of the proportionality and baseline hazard restrictions. Another strategy employed by both Audretsch and Mahmood (1994) and Mata et al. (1995) that completely remove these restrictions, is to estimate separate Cox models for different types of plant entrants. A potential problem associated with this approach is the small number of observations for some types of plant entrants, which may be an explanation for more insignificant parameter estimates for these entrants. Furthermore, direct testing of parameter inequalities (i.e. structural differences between entrant types) is not possible with separate regressions.

Due to the lack of strong theoretical and empirical justifications for a particular parametric form we choose to estimate a Cox model for our empirical application. Furthermore, as the first study of plant survival, we have chosen to estimate a *semi*-proportional Cox model, where the baseline hazard rate is stratified by the firm ownership type and interaction terms between the stratification variable and covariates are implemented (Eide, Omenaas and Gulsvik, 1996). The model preserves proportionality of hazards functions within each stratum (indexed by s) while letting the hazard ratio vary between strata as well as introducing non-proportionality between hazards functions of plants from different strata. Testing the interaction terms corresponds to testing structural differences between plants from the two strata in a very general framework. This model is given by

$$\begin{aligned} r(t, x_t, s; \alpha) = h_s(t) \exp\{&\alpha_{1,\,0}x_{1,\,t} + \alpha_{2,\,0}x_{2,\,t} \\ &+ \ldots + \alpha_{n,\,0}x_{n,\,t} + s \cdot (\alpha_{1,\,1}x_{1,\,t} \\ &+ \alpha_{2,\,1}x_{2,\,t} + \ldots + \alpha_{n,\,1}x_{n,\,t})\}, \end{aligned}$$

where $s = 0$ for new plants of MPFs and $s = 1$ for new plants of SPFs (i.e. new firms). The model preserves proportionality of hazard functions within the strata s while letting the hazard ratio vary between strata as well as introducing non-proportionality of hazard functions for plants from different strata. Furthermore, it allows testing of structural differences between plants in the two strata.

New plants enter different industries which provide very different environments in terms of economies of scale, capital intensity, technology use, demand conditions etc. This industry heterogeneity has not been properly accounted for in previous empirical models of plant survival. The specification of firm or plant level explanatory variables in previous studies can be interpreted as an implicit assumption of industry homogeneity. One example is plant size, which is typically represented by the number of employees. If industries are heterogeneous with respect to minimum efficient scale (MES), then a measure of plant size which adjusts for the industry MES is more appropriate than the absolute size from a theoretical viewpoint. The same argument applies to other explanatory variables such as capital intensity. The optimal capital-labour ratio varies significantly from industry to industry in the manufacturing sector. By not using a measure of capital intensity which adjusts for the optimal capital-labour ratio in the industry one implicitly assumes homogeneity across industries. The empirical models estimated here account for industry heterogeneity by measuring several of the plant level covariates as logarithmic deviations from the industry mean (at the 4 or 5 digit SIC level), which is an approximation to the optimal scale, capital intensity, etc. in the industry.

5. Data

This study uses a data set that allows us to follow more cohorts for a longer time period than in the previously cited empirical studies of plant survival. Ten cohorts are observed for a period of 5–15 years. Furthermore, our data set includes a large number of variables measured each year at the plant level, while other studies mostly rely on variables measured at fewer time points (e.g., only at time of entry) or at a more aggregate level (e.g., industry level).

We have access to a plant level data set for Norwegian manufacturing industries from Statistics Norway, with annual observations which stretches from 1976 to 1992.[11] The data set allows us to identify plants owned by single-plant firms (SPFs) and multi-plant firms (MPFs), and for the years 1977–86 entering plants. For all plants, the number of employees, sales revenues, industry affiliation (SIC code), plant type (producing or ancillary plant) are supposed to be reported each year. In addition, plants with five or more employees report costs (wages, materials), gross real investments, and gross real capital each year. Thus, when employing variables which depend on cost or capital figures, plants with less than five employees have to be dropped from the sample.

We included only plants which the Statistics Norway defined as "producing units" in each year for estimation, thus dropping headquarters and plants under construction. For some of the plants, data were missing for one or more of the years the plant was in operation. These plants were dropped from the estimating sample. Some plants in the data set also reported zero employees or sales in one or more years, and these were also dropped from the estimating sample. Based on a tentative study of the data, we conclude that for our models the selection bias associated with elimination of plants due to missing observations or zero values is probably not very large. The selection bias is likely to diminish the observed structural differences between SPF entrants and MPF entrants.

According to Table I the removal of plants with less than five employees each year leads to a dramatic reduction in the number of plants; in the year of entry, the relative reduction in the number of plants varies from 74% (1978 cohort) to 84% (1981 cohort). Furthermore, the survival rates also change dramatically, being in the range from 23.0% (1981 cohort) to 31.9% (1984 cohort) for the full sample, and in the range 32.9% (1977

TABLE I
Sample characteristics before/after dropping plants with less than five employees

Cohort	Year of entry			1992		
	Plants (1)	% SPF plants (2)	Avg. empl. (3)	Plants (4)	% SPF plants (5)	Avg. empl. (6)
1977	361 / 79	88% / 76%	7.9 / 26.2	92 / 26	75% / 50%	24.4 / 69.0
1978	377 / 98	80% / 54%	12.1 / 38.2	104 / 41	68% / 37%	37.1 / 85.4
1979	428 / 99	85% / 67%	10.3 / 36.0	101 / 36	78% / 61%	42.0 / 104.0
1980	425 / 77	89% / 69%	5.4 / 17.4	114 / 32	73% / 47%	16.7 / 41.4
1981	421 / 67	89% / 63%	7.3 / 32.9	97 / 19	84% / 47%	16.4 / 52.1
1982	389 / 73	92% / 81%	5.4 / 18.2	90 / 32	81% / 72%	12.0 / 22.8
1983	508 / 107	89% / 66%	6.6 / 21.7	137 / 44	78% / 55%	16.8 / 38.0
1984	611 / 135	87% / 67%	6.0 / 18.7	195 / 62	76% / 63%	16.8 / 39.5
1985	656 / 107	93% / 79%	4.5 / 15.0	204 / 41	86% / 66%	10.0 / 23.8
1986	828 / 158	93% / 80%	4.8 / 33.0	258 / 67	86% / 73%	13.0 / 35.9

Source: Statistics Norway.

cohort) to 45.9% (1984 cohort) after dropping the smallest plants. According to column (3) the initial average number of employees increases from 12.1 to 38.2 persons for the 1978 cohort when small plants are dropped, while the increase is from 4.8 to 33.0 employees for the 1986 cohort. However, the employment growth rate is considerably smaller after the plant elimination, which can be verified from Table I by comparing average employment in the year of entry with average employment in 1992, columns (3) and (6), respectively.

The ratio of SPF-owned plants to MPF-owned plants also changes significantly as a result of the plant elimination, cf. column (2). Before the elimination, the share of SPF plants in the year of entry were in the range 80–93%, depending on the cohort, while after the elimination the shares dropped to 54–81%. Since small and SPF-owned plants are underrepresented in the sample we conclude that there is probably a selection problem associated with excluding plants with less than five employees. There may be important structural differences between the smallest plants which are dropped and the larger plants which remain in the sample, as suggested by the discussion in section two. Caution should therefore be used when drawing inferences to the entire population of new plants. We will return to this problem in the next section.

6. Empirical analysis

Two model specification sets are estimated. Model set A does not include cost- and capital-based measures, and thus allows estimation over the full sample. Model set B, on the other hand, includes cost- and capital-based measures, and can therefore only be estimated for plants which have five or more employees in each observation year, hereafter called "large" plants. Table II presents the variables used in the estimation of the models. The data set allows us to employ plant level time-varying covariates in the Cox models to account for the possibility of "active" learning. All variables, except *INDUGROW* and *MANGROW*, are measured at the plant level. The expected signs of the associated coefficients of the hazard rate models are also presented in the table.

The firm-type (or ownership type) dummy variable *F* and the interaction term with other variables account for the structural differences between plants of new firms and plants of existing firms (SPF- and MPF-owned plants, respectively) with respect to survival not captured for by other variables.

To investigate the effect of plant size on the hazard we have included both the logarithm of the number of employees as well as the squared logarithm of the number of employees to account for a possible nonlinear effect.

To test for the importance of industry heterogeneity, as discussed earlier, we use logarithmic ratios between plant level observations and

TABLE II
Variable definitions and *a priori* expected sign of regression coefficient in hazard models

Variable	Exp. sign	Model*	Definition
F_i	+	A, B	Dummy variable with value one for plants owned by SPFs and zero for plants owned by MPFs
$LNEMPL_{i,t}$	–	A, B	ln(Number of employees)
$LNEMPL2_{i,t}$	+	A, B	ln(Number of employees)^2
$DEMPL_{i,t}$	–	A, B	ln(Number of employees / Industry average number of employees)
$INDUGROW_{i,t}$	–	A, B	4 or 5 digit SIC industry percentage sales growth from previous year
$MANGROW_{i,t}$	–	A	Percentage growth in Norwegian manufacturing sector value added
$DSALEMPL_{i,t}$	–	A, B	ln((Sales / Number of employees) / (Industry average sales / Number of employees))
$DKL_{i,t}$	–	B	ln(Capital-labour ratio / Industry average capital-labour ratio)
$PROFEMPL_{i,t}$	–	B	Profitability / Employees = (Sales – Wages – Materials) / Employees
$LNBINCAP_{i,t}$	–	B	ln(Gross real investments / Gross real capital)

* Variable included in models estimated on the full sample (A) or the sample of large plants (B).
Note: All industry averages are measured at the 4 or 5 digit SIC level.

industry average values (at the 4 or 5 SIC level). The logarithmic ratio between plant level employment and the average employment level in the industry (*DEMPL*) is a proxy for the importance of scale economies. The logarithmic ratio between sales/employees ratio at the plant and the industry average sales/employees ratio (*DSALEMPL*) is supposed to capture the effects of deviations from the industry average productivity on plant survival. To assess the effect of deviations from the industry average capital-labour ratio we use the logarithmic ratio variable *DKL*.

To test for the effect of changes in industry-specific market conditions on the hazard rate we use the percentage growth of the industry's sales from the previous year (*INDUGROW*), where the industry is defined at the 4 or 5 digit SIC level. The effect of the business cycle on the hazard rate is proxied by the lagged percentage growth in manufacturing value added (*MANGROW*).[12]

6.1. *Empirical results for the full sample*

First, we estimate a stratified Cox model, which is presented in Table III as Model A1. The ownership dummy *F* is used as stratification variable, to account for structural differences in the baseline hazard rate for new firms and new plants of existing firms.

Simple correlation coefficients were calculated for the variables in model A1 in order to tentatively assess whether multicollinearity is a problem. The correlation coefficient between most variables was rather low, and only for a few pairs it was above 0.8. For (*LNEMPL*, *LNEMPL2*) the correlation coefficient is 0.93.

All coefficients of model A1 have the expected signs stated in Table I, and with the exception of *MANGROW* they are all statistically different from zero at conventional confidence levels, i.e., 1%, 5% or 10% level. Note in particular that productivity relative to the industry average, as measured by *DSALEMPL*, is an important determinant of survival.

Next, we introduce model A2, which adds to model A1 interaction variables between the plant ownership type dummy *F* and the other covariates. Since we maintain the *F* stratification for the baseline hazard rate, this model is a so-called semi-proportional Cox model. Table IV presents the empirical results from the estimation of this model.

A likelihood ratio test can be used to compare models A1 and A2. The likelihood ratio test statistic is 21.4, which is above the critical value of 16.8 at the 1% level (6 df). On the basis of this test, model A2 must be considered the more appropriate specification of the two.

The coefficients of the first-order covariates in model A2 provide estimates of the sensitivity of the hazard rate of MPF-owned plants. Two of the coefficients of first-order covariates are significant

TABLE III
Model A1: Cox model stratified on ownership type estimated on all plants

Covariate	Coefficient	Standard error	*t*-value
DEMPL	–0.0546**	0.0226	–2.42
DSALEMPL	–0.3579***	0.0198	–18.04
INDUGROW	–1.0562***	0.1402	–7.53
MANGROW	–0.0021	0.0037	–0.58
LNEMPL	–0.4291***	0.0488	–8.79
LNEMPL2	0.0269**	0.0120	2.24

Significant at *** 1%, ** 5%, * 10% level of significance.
No. of observations = 29183.
Log likelihood = –27252.5.

TABLE IV
Model A2: Semi-proportional Cox model with interaction terms between ownership type and other covariates estimated on all plants

Covariate	Coefficient	Standard error	*t*-value
DEMPL	–0.2816***	0.0604	–4.66
DSALEMPL	–0.2933***	0.0558	–5.26
INDUGROW	–0.4217	0.4413	–0.96
MANGROW	–0.0110	0.0112	–0.98
LNEMPL	–0.2080	0.1290	–1.61
LNEMPL2	0.0096	0.0246	0.39
F·DEMPL	0.2643***	0.0651	4.06
F·DSALEMPL	–0.0787	0.0597	–1.32
F·INDUGROW	–0.7184	0.4653	–1.54
F·MANGROW	0.0099	0.0118	0.84
F·LNEMPL	–0.2622*	0.1404	–1.87
F·LNEMPL2	0.0224	0.0289	0.77

Significant at *** 1%, ** 5%, * 10% level of significance.
No. of observations = 29183.
Log likelihood = –27241.7846.

and have the expected signs, while four coefficients are not significant. The most important determinants of plant survival for MPF-owned plants seem to be relative plant size compared to the industry average (*DEMPL*), and relative sales compared to the industry average (*DSALEMPL*).

The coefficients of the interaction terms between the firm-type dummy *F* and other covariates in model A2 suggest that there are structural differences between SPF plant entry and new plants of MPFs. For new SPF plants, the exit hazard seems to be more sensitive to the absolute size of the plant, but less sensitive to the relative size of the plant, according to the coefficients of $F \cdot LNEMPL$ and $F \cdot DEMPL$. In other words, an increase in the absolute plant size has a stronger positive effect on the likelihood of survival for SPF plants than for MPF plants. On the other hand, for SPF plants size relative to the industry average has almost no effect on survival, while it increases the survival probability for MPF plants. The explanation for these results may be that the two measures of plant size represent other unobserved underlying factors which influence the likelihood of survival. Absolute plant size may, among other things, be correlated with the plant's ability to obtain capital to invest in production equipment or to cover operating expenses when sales revenues are not sufficient to cover expenses. It may also capture benefits from increasing plant size which apply to all manufacturing industries, e.g. the ability to hire specialised accounting and administrative personnel. The finding that the survival of SPF plants is less sensitive to changes in relative plant size may suggest that SPF plants operate in other market niches within an 4 or 5 digit SIC industry than MPF plants, for example, niches which are characterised by small-scale production.

There is no significant difference with respect to changes in the relative labour productivity measure between SPF and MPF, according to the coefficient of $F \cdot DSALEMPL$.

The above results rely on the correctness of the model specification. If important determinants of plant survival have been omitted, such as the stock of capital or investments in capital equipment, then these findings can be questioned. In the following we will control for such factors, but the cost of this is that we have to omit plants from the estimating sample.

6.2. *Testing for structural differences between samples*

We now introduce capital intensity, investment rate and profitability as determinants of the hazard rate of new plants. As mentioned earlier, since only plants with five or more employees report capital figures, we have to drop plants with less than five employees in one of the observation years. This reduces the sample significantly, from 5,004 plants to 1,000 plants, and from almost 30,000 observations to approximately 6,000 observations.

Before we turn to the new model specifications, we would like to investigate if there are any structural differences between the full sample and the sample with only large plants. First, we plot life table estimates for the full sample and the sample of plants with five or more employees in all observation years in Figure 2.

Omitting plants with less than five employees has a profound effect on hazard rates. The first two years, the hazard rate is slightly higher for the sample of large plants, but in the remaining years the sample of large plants has a significantly lower hazard rate than the full sample.

We cannot preclude that the differences in hazard rates are due to different values of important determinants of plant survival. The plants with five or more employees in all years may also be over-represented in certain industries compared with the full sample. Plants owned by SPFs are underrepresented in the sample with large plants; in the full sample, 84.9% of the observations are SPF-owned plants, while in the large plant sample the share has been reduced to 63.7%. We tested for structural differences between the plants in the two samples by introducing into model A1 a dummy variable and interaction terms for plants with five or more employees in all years. For model A1 versus its unrestricted counterparts the likelihood ratio test statistic is 174.46, which is well above the critical value of 16.8 at the 1% level (6 df). These tests support the hypothesis that the plants which have five or more employees in all years are structurally different from the remaining plants. Hence, we should be careful to

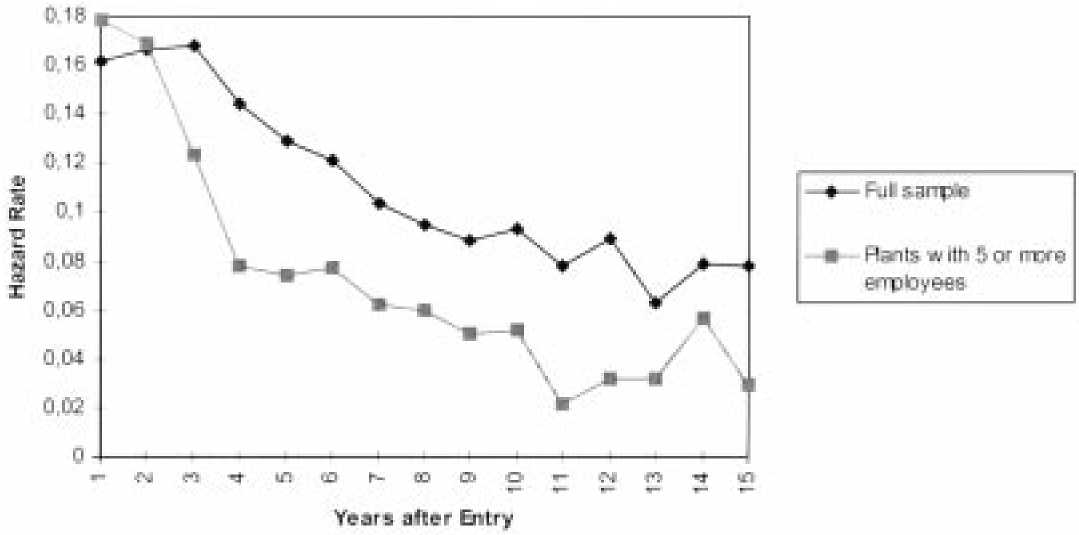

Figure 2. Life table estimates of plant exit hazard rates.

generalise the following results to the entire population of new plants.

6.3. *Empirical results for plants with five or more employees*

In the following, we present two Cox hazards model specifications with cost and capital measures included as covariates; model B1 and B2 (Tables 5 and 6, respectively). Both models are stratified by the ownership type, but model B2 also involves interaction terms between the ownership type dummy *F* and other covariates.

The coefficients of Model B1 all have the *a priori* expected signs. All coefficients are significant, except for *DEMPL*. The discussion of the individual determinants of plant survival is postponed to model B2, which provides the same signs for the coefficients.

The likelihood ratio test statistic for the unrestricted model B2 versus the restricted model B1 is 13.2, which means that model B2 is not supported at the 10% confidence level (critical chi-square value of 13.36 with 8 df). However, one of the interaction terms involving ownership type and other covariates have a coefficient which is statistically significant from zero, namely *F·DEMPL*. When we compare model B2 with model A2 estimated on the full sample, we see that the differences between SPF and MPF plants are

TABLE V
Model B1: Cox model stratified on ownership type estimated on large plants

Covariate	Coefficient	Standard error	*t*-value
DEMPL	–0.0666	0.0545	–1.22
DKL	–0.0700***	0.0208	–3.37
DSALEMPL	–0.2763***	0.0578	–4.78
INDUGROW	–0.7079*	0.3637	–1.95
PROFEMPL	–1.7131***	0.3367	–5.09
LNBINCAP	–0.0593***	0.0052	–11.34
LNEMPL	–1.6486***	0.2716	–6.07
LNEMPL2	0.2029***	0.0421	4.82

Significant at *** 1%, ** 5%, * 10% level of significance.
No. of observations = 6090.
Log likelihood: –3166.0992.

smaller for the sample of large plants. This may suggest that larger entrepreneurial entrants are less different from diversifying firms than smaller entrepreneurs.

It is also interesting to compare the parameter estimates from the models estimated on the full data set with the estimates from the model estimated only on plants with five or more employees, to see if the omission of small plants and introduction of new covariates have any effects on the signs of coefficients. A comparison of the coefficients of covariates which are included both in

TABLE VI
Model B2: Semi-proportional Cox model with interaction terms between ownership type and other variables estimated on large plants

Covariate	Coefficient	Standard error	*t*-value
DEMPL	–0.3237***	0.0995	–3.25
DKL	–0.0813***	0.0308	–2.64
DSALEMPL	–0.1869*	0.1034	–1.81
INDUGROW	–0.7018	0.6935	–1.01
PROFEMPL	–1.4766***	0.4659	–3.17
LNBINCAP	–0.0614***	0.0123	–4.99
LNEMPL	–1.5704***	0.4832	–3.25
LNEMPL2	0.2213***	0.0698	3.17
F·DEMPL	0.3667***	0.1195	3.07
F·DKL	0.0274	0.0418	0.65
F·DSALEMPL	–0.1181	0.1260	–0.94
F·INDUGROW	0.0032	0.8148	0.00
F·PROFEMPL	–0.5844	0.6916	–0.84
F·LNBINCAP	0.0028	0.0136	0.21
F·LNEMPL	–0.0291	0.6005	–0.05
F·LNEMPL2	–0.0450	0.0915	–0.49

Significant at *** 1%, ** 5%, * 10% level of significance.
No. of observations = 6090.
Log likelihood: –3159.4889.

model A2 and model B2 reveals that there are no important changes in sign.

Plant size, as measured by the covariates *LNEMPL* and *LNEMPL2*, is still an important determinant of the hazard rate of new plants. The results indicate that the hazard rate of plants owned by new firms is somewhat more sensitive to increases in plant size, although the difference between new firms and plants of existing firms is not statistically significant.

An increase in the relative plant size as measured by *DEMPL* decreases the exit hazard rate for MPF plants. However, according to the coefficient of *F·DEMPL* relative plant size has no significant negative effect on the exit hazard of SPF plants. The estimated coefficient is slightly positive for SPF plants, with a value of –0.323 + 0.367 = 0.044. This result is similar to what we found for the model estimated on the full sample, and reinforces our assertion that new firms to a larger extent operate in specialised market niches which are somewhat distinct from the main bulk of the industry.

According to the coefficient of *PROFEMPL*, the exit hazard rate of new plants decreases significantly in profit. But there are no significant differences between SPF and MPF plants.

The empirical results strongly support the importance of investments in capital equipment on plant survival. The hazard rate is negatively correlated with both the deviation of the capital-labour ratio from the industry average (*DKL*) and the investment rate of the plant (*LNBINCAP*). Plants with a high capital intensity and plants which add or replace capital equipment at a high rate are less likely to shut down.

7. Conclusions

In this paper, we have analysed the survival of new plants in Norwegian manufacturing, with an emphasis on the importance of industry heterogeneity and the structural differences between entrepreneurial entrants and expanding firms.

New establishments play an important role in job creation in Norwegian manufacturing. Plants established during the 1977–86 period represented 12% of manufacturing employment in 1986, despite high mortality rates. The hazard rates of new plants were found to be around 16% the first three years after entry, and then declined gradually until it stabilised around 7–9% ten years after entry. In a period when the manufacturing sector had a net loss of 51,000 jobs, new establishments created a total of 39,800 jobs. The job creation statistics also reveal that SPF entrants were the most important source of job creation, creating 60% of the new jobs associated with plant entry.

In the analysis of the determinants of new plant survival, we estimated Cox hazard models on a plant level data set. This study emphasises industry heterogeneity in terms of minimum efficient scale of operation, capital intensity and productivity. We have argued that there are substantial structural differences between manufacturing industries, and it is therefore more appropriate to use plant level covariates represented as deviations from the industry mean than unadjusted plant level covariates.

We found that both unadjusted and industry-adjusted plant level covariates explained plant hazard rates. For example, both the absolute size of the plant and the difference between plant size and industry mean plant size were important determinants of plant survival.

Capital intensity and investment in capital equipment seem to play an important role for plant survival. The hazard rate was significantly lower for plants with a high capital-labour ratio and high investment rate. It may also be the case that the capital-labour ratio and investment rate are proxies for the plant's access to external financial capital. The only other study we have found which examines the relationship between survival and capital intensity is Doms et al. (1995), which also find that the capital-labour ratio is negatively related to plant failure. However, our study is the only one which documents the important relationship between the plants' investment rates and their likelihood of failure.

We found significant structural differences between new firms and new plants established by existing firms, which suggest that entrepreneurial entrants and diversifying entrants operate in different market niches and may follow other behavioural rules. However, when we omit the smallest plants from the sample the differences became less significant, suggesting that the smallest entrepreneurs may be the most distinct class of entrants.

One should also be careful with respect to drawing policy implications directly on the basis of this study. For example, the estimated models do not tell why firms with capital-labour ratio below the industry average have higher hazard rates. It may be due to sub-optimal investments in capital equipment because of capital market imperfections that precluded the entrant from obtaining the necessary external capital. Moreover, it may be that the most turbulent market niches also are characterised by below-average capital intensities.

Although several questions remain to be answered on the behavioural rules of different types of entrants and how different industry environments create different conditions for entrants, we believe that the approach presented here may represent one fruitful direction for future research.

Notes

[1] An establishment or plant is defined as a distinct physical production unit. If a firm owns only one plant, the firm and plant coincide.

[2] In this paper, the term "entrepreneur" is used for individuals who establish a wholly new firm.

[3] An incumbent firm is often more strictly defined as a firm that already has one or more plants in the industry, while a diversifying firm owns plants in other industries only.

[4] See Salvanes and Tveterås (1995) for more details on the job creation in Norwegian manufacturing.

[5] Storey (1991) has defined self-employed as "those who in their main employment work on their own account, whether or not they have employees".

[6] Storey (1991) has reviewed the most significant recent empirical literature on the relationship between new-firm births and unemployment.

[7] See Boye and Kinserdal (1992, p. 188) for an analysis of the financing of small firms in Norway, Dunkelberg and Cooper (1990, p. 126) and Carpenter and Petersen (1998) for the U.S., and Blanchflower and Oswald (1992a) for the U.K.

[8] See Høegh-Krohn and Knivsflå (1996) for empirical evidence on interest rate premiums paid by small Norwegian firms.

[9] Caves (1998) provides a survey of the empirical literature on firm turnover.

[10] Ericson and Pakes (1992) classify these two types of learning into "passive learning" and "active learning", respectively. In the first case, the entrepreneurs have to physically enter the market to learn if their concept is viable in terms of costs, product demand and profits, and after entry there is little they can do to adjust if it turns out that the concept is not viable. In the second case, inferiority of entrants at the time of birth is less important than their ability to learn after entry in order to reduce the gap between themselves and incumbents. It is reasonable to believe that industries differ with respect to the importance of learning by selection and evolutionary adaption; in some industries initial decisions are crucial, while in other industries it is the entrants' ability to learn and adjust that decide their fate. Jovanovic (1982) presents a model of passive learning, while Ericson and Pakes (1992) presents a model of active learning.

[11] A detailed description of data sources, coverage and definitions have been provided by Statistics Norway (several years), and von der Fehr (1990).

[12] We use this measure of the business cycle instead of GDP growth, because it can be argued that with the large oil extraction sector and a large public sector, GDP growth is not a good indicator for the aggregate business cycle of the mainland private sector in Norway.

Appendix 1: Covariate correlation coefficients for all plant observations (n = 29183)

Covariates	F	DEMPL	DSAL-EMPL	INDU-GROW	MAN-GROW	LNEMPL	LNEMPL2	F·DEMPL	F·DSAL-EMPL	F·INDU-GROW	F·MAN-GROW	F·LNEMPL	F·LNEMPL2
F	1.00												
DEMPL	–0.23	1.00											
DSALEMPL	–0.05	0.14	1.00										
INDUGROW	0.02	–0.04	–0.04	1.00									
MANGROW	0.03	–0.01	0.00	0.10	1.00								
LNEMPL	–0.35	0.76	0.11	–0.02	–0.03	1.00							
LNEMPL2	–0.36	0.65	0.08	0.00	–0.03	0.93	1.00						
F·DEMPL	–0.40	0.90	0.15	–0.04	–0.02	0.70	0.57	1.00					
F·DSALEMPL	–0.16	0.17	0.90	–0.04	0.00	0.15	0.12	0.21	1.00				
F·INDUGROW	0.25	–0.09	–0.05	0.89	0.10	–0.11	–0.10	–0.13	–0.08	1.00			
F·MANGROW	0.13	–0.04	0.00	0.09	0.92	–0.06	–0.06	–0.06	–0.02	0.13	1.00		
F·LNEMPL	0.46	0.48	0.07	–0.02	0.00	0.56	0.41	0.42	0.03	0.09	0.04	1.00	
F·LNEMPL2	0.27	0.49	0.06	–0.01	–0.01	0.63	0.58	0.46	0.04	0.05	0.02	0.91	1.00

Appendix 2: Covariate Correlation Coefficients for Sample of Large Plants (n=6090)

Covariates	F	DEMPL	DKL	DSALEMPL	INDUGROW	PROFEMPL	LNBINCAP	LNEMPL
F	1.00							
DEMPL	–0.05	1.00						
DKL	–0.13	0.06	1.00					
DSALEMPL	0.02	0.11	0.02	1.00				
INDUGROW	0.02	–0.02	–0.01	–0.01	1.00			
PROFEMPL	–0.04	0.09	0.01	0.37	0.03	1.00		
LNBINCAP	0.09	0.00	0.08	0.15	0.04	0.06	1.00	
LNEMPL	–0.26	0.03	0.62	0.05	0.01	0.09	0.14	1.00
LNEMPL2	–0.24	0.05	0.59	0.06	0.03	0.10	0.15	0.98
F·DEMPL	–0.10	0.04	0.79	0.03	–0.01	0.04	0.03	0.48
F·DKL	–0.27	0.72	0.06	0.08	–0.04	0.09	–0.07	0.07
F·DSALEMPL	–0.16	0.10	0.06	0.72	–0.03	0.24	0.03	0.06
F·INDUGROW	0.35	–0.04	–0.05	–0.01	0.77	0.00	0.07	–0.08
F·PROFEMPL	0.17	0.09	0.03	0.29	0.02	0.58	0.06	0.05
F·LNBINCAP	–0.53	–0.02	0.10	0.02	0.03	0.05	0.62	0.20
F·LNEMPL	0.89	–0.04	0.10	0.03	0.02	0.00	0.12	0.10
F·LNEMPL2	0.67	–0.02	0.25	0.03	0.03	0.04	0.12	0.36

	LNEMPL2	F·DEMPL	F·DKL	F·DSALEMPL	F·INDUGROW	F·PROFEMPL	F·LNBINCAP	F·LNEMPL	F·LNEMPL2
LNEMPL2	1.00								
F·DEMPL	0.44	1.00							
F·DKL	0.08	0.07	1.00						
F·DSALEMPL	0.06	0.07	0.16	1.00					
F·INDUGROW	–0.07	–0.04	–0.13	–0.08	1.00				
F·PROFEMPL	0.07	0.05	0.09	0.36	0.08	1.00			
F·LNBINCAP	0.19	0.09	0.09	0.13	–0.14	–0.04	1.00		
F·LNEMPL	0.10	0.19	–0.24	–0.13	0.32	0.20	–0.43	1.00	
F·LNEMPL2	0.36	0.36	–0.16	–0.08	0.26	0.22	–0.29	0.93	1.00

References

Agarwal, R., 1998, 'Small Firm Survival and Technological Activity', *Small Business Economics* **11**(3), 215–224.

Agarwal, R. and D. B. Audretsch, 1999, 'The Two Views of Small Firms in Industry Dynamics: A Reconciliation', *Economics Letters* **62**(2), 245–251.

Audretsch, D. B., 1995, 'Innovation, Growth and Survival', *International Journal of Industrial Organisation* **13**, 441–457.

Audretsch, D. B. and T. Mahmood, 1994, 'The Rate of Hazard Confronting New Firms and Plants in U.S. Manufacturing', *Review of Industrial Organisation* **9**, 41–56.

Audretsch, D. B. and T. Mahmood, 1995, 'New Firm Survival: New Results Using A Hazard Function', *Review of Economics and Statistics* **77**, 97–103.

Baldwin, J. R. and M. Rafiquzzaman, 1995, 'Selection Versus Evolutionary Adaption: Learning and Post-Entry Performance', *International Journal of Industrial Organisation* **13**(4), 501–522.

Blanchflower, D. G. and A. J. Oswald, 1992a, 'Does Access to Capital Help Make an Entrepreneur?', Report No. 106, Trade Union Institute for Economic Research, Sweden.

Blanchflower, D. G. and A. J. Oswald, 1992b, 'Entrepreneurship and Supernormal Returns: Evidence from Britain and the U.S', (Report No. 104), Trade Union Institute for Economic Research, Sweden.

Boeri, T. and L. Bellmann, 1995, 'Post-Entry Behaviour and the Cycle: Evidence from Germany', *International Journal of Industrial Organisation* **13**, 483–500.

Boye, K. and A. Kinserdal, 1992, 'Small and Medium-Sized Firms in Norway – An Analysis of Profitability and Capital. Part II'. (In Norwegian: 'Små og mellomstore bedrifter i Norge – en analyse av betydning, lønnsomhetsforhold og kapitalforhold. Utfordringer. Forslag til tiltak. Del II. Rapport'), Report No. 87/92, Foundation for Research in Economics and Business Administration.

Brüderl, J., P. Preisendorfer and R. Ziegler, 1992, 'Survival Chances of Newly Founded Business Organizations', *American Sociological Review* **57**(2), 227–242.

Carpenter, R. E. and B. C. Petersen, 1998, 'Small Firm Growth and Internal Finance', Paper presented at 25th Annual E.A.R.I.E. Conference, Copenhagen, August 27–30, 1998.

Caves, R. E., 1998, 'Industrial Organisation and New Findings on the Turnover and Mobility of Firms', *Journal of Economic Literature* **36**(4), 1947–1982.

CBS, *Industrial Statistics*, annual report, Oslo: Statistics Norway.

Cox, D. R., 1972, 'Regression Models and Life Tables', *Journal of the Royal Statistical Society, Series B* **34**(2), 187–202.

Dabrowska, D. M., K. A. Doksum, N. J. Feduska, R. Husing, and P. Neville, 1992, 'Methods for Comparing Hazards Functions in a Semi-Proportional Hazard Model', *Statistics in Medicine* **11**, 1465–1476.

Doms, M., T. Dunne and M. J. Roberts, 1995, 'The Role of Technology Use in the Survival and Growth of Manufacturing Plants', *International Journal of Industrial Organisation* **13**(4), 523–542.

Dunkelberg, W. C. and A. C. Cooper, 1990, 'Investment and Capital Diversity in the Small Enterprise', in Z. J. Acs and D. B. Audretsch (eds.), *The Economics of Small Firms. A European Challenge*, Dordrecht: Kluwer Academic Publishers, pp. 119–134.

Dunne, T., M. J. Roberts and L. Samuelson, 1988, 'Patterns of Firm Entry and Exit in U.S. Manufacturing Industries', *RAND Journal of Economics* **19**(4), 495–515.

Dunne, T., M. J. Roberts and L. Samuelson, 1989, 'The Growth and Failure of U.S. Manufacturing Plants', *Quarterly Journal of Economics* **104**, 671–698.

Eide, G. E., E. Omenaas and A. Gulsvik, 1996, 'The Semi-Proportional Hazards Model Revisited: Practical Reparametrizations', *Statistics in Medicine* **15**, 1771–1777.

Ericson, R. and A. Pakes, 1992, 'An Alternative Theory of Firm and Industry Dynamics', Cowles Foundation Discussion Paper No. 1041, Yale University, New Haven, Connecticut.

Evans, D. S. and L. S. Leighton, 1989, 'Some Empirical Aspects of Entrepreneurship', *American Economic Review* **79**(3), 519–535.

Evans, D. S. and L. S. Leighton, 1990, 'Small Business Formation by Unemployed and Employed Workers', *Small Business Economics* **2**(4), 319–330.

Geroski, P. A., 1991, *Market Dynamics and Entry*, 1st ed., Oxford: Basil Blackwell.

Geroski, P. A., 1995, 'What Do We Know about Entry?', *International Journal of Industrial Organisation* **13**, 421–440.

Geroski, P. A. and J. Schwalbach (ed.)., 1991, *Entry and Market Contestability. An International Comparison*, Oxford: Basil Blackwell Ltd.

Harhoff, D., K. Stahl and M. Woywode, 1998, 'Legal Form, Growth and Exit of West German Firms – Empirical Results for Manufacturing, Construction Trade and Service Industries', *Journal of Industrial Economics* **46**(4), 453–488.

Høegh-Krohn, N. E. J. and K. H. Knivsflå, 1996, 'Do Smaller Firms Pay Higher Interest Rates, and Why?', Working Paper No. 58/96, Foundation for Research in Economics and Business Administration.

Jovanovic, B., 1982, 'Selection and the Evolution of industry', *Econometrica* **50**(3), 649–670.

Julien, P.-A., 1993, 'Small Businesses as a Research Subject: Some Reflections on Knowledge of Small Businesses and Its Effects on Economic Theory', *Small Business Economics* **5**, 157–166.

Mata, J., P. Portugal and P. Guimaraes, 1995, 'The Survival of New Plants: Start-Up Conditions and Post-Entry Evolution', *International Journal of Industrial Organisation* **13**, 459–481.

Salvanes, K. G. and R. Tveterås, 1995, 'Job Turnover in Norwegian Manufacturing 1976–86', Report No. 53/95, Foundation for Research in Economics and Business Administration.

Storey, D. J., 1991, 'The Birth of New Firms – Does Unemployment Matter? A Review of the Evidence', *Small Business Economics* **4**, 167–178.

Sutton, J., 1997, 'Gibrat's Legacy', *Journal of Economic Literature* **35**(1), 40–59.

von der Fehr, N.-H. M., 1990, ‘A Micro Establishment Database for Norwegian Manufacturing Industries’, Working paper No. 3/90, SAF (Centre for Applied Research).

Wagner, J., 1994, ‘The Post-Entry Performance of New Small Firms in German Manufacturing Industries’, *Journal of Industrial Economics* **XLII**(2), 141–154.