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Ability Matching and Survival of Start-Ups

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Non-Technical Summary

New firms are regarded to be of substantial importance for the development of an economy, especially for innovation, growth, and the creation of jobs. However, new firms also face a high risk of failure. Thus, there seem to be high try-out costs connected with the establishment of firms. In order to reduce these try-out costs, policy makers aim at providing general conditions which ensure a higher longevity of young firms.

This paper focusses on the number and the composition of the persons involved in young firms as drivers for the probability of firm survival. As theoretical basis, the O-ring theory is used. This theory assumes that ability is positively and team size is negatively related to firm survival. Moreover, it can be inferred from this theory that a higher level of homogeneity with respect to ability and a higher level of heterogeneity with respect to the field of education leads to higher survival chances of new firms.

Using a rich employer-employee data set on the whole population of Danish firms founded in 1998, I find that the average level of ability in a team and the team size have positive effects on a firms' probability to survive the next year. Most important is founding in a team at all. In contrast, the homogeneity with respect to ability and the heterogeneity with respect to educations do not effect the probability of firm survival. Thus, young firms can be supported by making sure that several persons are involved and the ability of the persons is as high as possible. However, it is not important that the team members have different educations and the same level of ability.

Das Wichtigste in Kürze

Unternehmensgründungen werden insbesondere wegen ihres Beitrags zu Innovationen, Wachstum und Schaffung von Arbeitsplätzen als bedeutsam für eine Volkswirtschaft angesehen. Junge Unternehmen haben jedoch auch eine hohe Wahrscheinlichkeit zu scheitern. Mit der Gründung von Unternehmen scheinen also hohe Kosten des Ausprobierens enthalten zu sein. Ein Ziel der Wirtschaftspolitik ist es daher, diese Kosten des Ausprobierens, ob man am Markt bestehen kann, zu reduzieren und Rahmenbedingungen zu schaffen, die jungen Unternehmen eine längere Lebensdauer ermöglichen.

In diesem Papier wird untersucht, welchen Einfluss die Anzahl und die Zusammensetzung der in jungen Unternehmen involvierten Personen auf die Überlebenswahrscheinlichkeit dieser Unternehmen hat. Als Basis für die Ableitung von Hypothesen wird die O-Ring-Theorie verwendet. Diese Theorie nimmt an, dass die durchschnittliche Fähigkeit der Individuen in einem Team die Überlebenswahrscheinlichkeit eines Unternehmens erhöht, während ein zusätzliches Teammitglied die Überlebenswahrscheinlichkeit senkt. Weiterhin lässt sich aus dieser Theorie ableiten, dass ein höherer Grad an Homogenität in den Fähigkeiten der Teammitglieder und ein höherer Grad an Heterogenität in der fachlichen Ausbildung positiv für die Überlebenswahrscheinlichkeit eines Unternehmens ist.

Für die Analyse steht ein umfangreicher Datensatz zur Verfügung, der sämtliche Unternehmen, die 1998 in Dänemark gegründet wurden, sowie alle in diesen Unternehmen beschäftigten Individuen umfasst. Die Analysen in diesem Papier zeigen, dass sowohl das durchschnittliche Fähigkeitsniveau in einem Team als auch die Teamgröße einen positiven Einfluss auf die Überlebenswahrscheinlichkeit haben. Dabei ist es insbesondere wichtig, überhaupt im Team zu gründen. Der Grad der Homogenität hinsichtlich der Fähigkeiten und der Grad der Heterogenität hinsichtlich der fachlichen Ausbildung der Teammitglieder haben hingegen keinen Einfluss auf die Überlebenswahrscheinlichkeit. Junge Unternehmen können also dadurch unterstützt werden, dass man dafür Sorge trägt, dass mehrere Personen an der Gründung beteiligt sind, und dass die durchschnittliche Fähigkeit dieser Personen so hoch wie möglich ist. Die beteiligten Personen müssen aber nicht unbedingt aus unterschiedlichen Fachrichtungen kommen und dasselbe Fähigkeitsniveau haben.

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Abstract

In this paper, I analyse how the survival of new firms is affected by the average ability level in the founding team, the team size, team members' homogeneity with respect to ability, and team members' heterogeneity with respect to education. As a theoretical basis, I apply the O-ring theory (Kremer (1993)). Using a rich employer-employee data set on the whole population of Danish firms founded in 1998, I find that the average ability level in a team and the team size have positive effects on firm survival. Having a team at all is the most crucial factor for the probability of survival of young firms. The degree of homogeneity with respect to ability and the degree of heterogeneity with respect to educations have no effect on the survival probability.

Keywords: entrepreneurship, firm survival, O-ring theory, start-ups
JEL Classification: D23, L25, L26, M13

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1 Introduction

New firms are regarded to be of substantial importance for the development of an economy, especially for innovation, growth, and the creation of jobs. However, new firms also face a high risk of failure. For example, Mata and Portugal (1994) report that only a good half of the firms in their data set survived the first four years and Audretsch (1991) notices that only a third is still in operation after ten years. Thus, there seem to be high try-out costs connected with the establishment of firms. In order to reduce these try-out costs and to create general conditions which ensure young firms to be in business for longer periods, it is important to know what determines the survival of new firms in the first years of their existence.

As many venture capitalists note, one of the main success factors of young firms is the management team (see e.g. Gompers and Lerner (2001)). This paper therefore focusses on the impact of the involved persons on new firms' survival. In particular, it is analysed how the average ability level, the team size, the degree of homogeneity with respect to ability, and the degree of heterogeneity with respect to education affects firm survival. As theoretical basis, the O-ring theory introduced by Kremer (1993) and applied to young firms by Fabel (2004a,b) and Fabel and Weber (2005) is used. To my knowledge, this theory is the only one which links the size and the composition of teams to firm survival.

The O-ring theory assumes that a project consists of a series of tasks, each of which must be fulfilled at a certain minimum level of quality for the project to have success.[1] The survival probability of a firm is given by the joint probability of each team member performing her task at a certain minimum level of quality. For new firms this seems to be an appropriate description since the whole project can fail if only one task is not performed carefully. For example, the best idea is not worth anything if it is not marketed appropriately to potential costumers.

The O-ring setup implies a positive effect of ability and a negative effect of team size on firm survival. Ability of workers is conceptualized by the probability to perform an assigned task sufficiently well. Higher ability comes along with

[1] Its name originate from the accident of the space shuttle Challenger which exploded in 1986 because of the malfunctioning of only one of its components: the O-rings of the booster.

lower individual failure rates which increases the survival chances of the firm. On the other hand, since tasks are tied to persons, taking on a further person is a further source of risk since another link in the chain of necessary tasks has to be completed. Thus, it should be observed that, given team size, a higher average ability in the team is associated with a higher survival probability and, given ability, a larger team size is associated with a lower survival probability. These are the first two hypotheses tested in this paper.

Besides the effects of team size and ability, the O-ring theory further implies that individuals segregate between firms according to their level of ability. In labour market equilibrium this results in homogeneous workforces within firms. Observing inhomogeneous teams should therefore be a transitory phenomenon caused by imperfect information about each others' abilities. Hence, it is additionally analysed how the degree of homogeneity with respect to team members' ability influences the probability of firm survival. Finally, the fourth variable investigated is the degree of heterogeneity in educations. This is motivated by the assumption that for the different tasks knowledge from different fields is necessary.

For the analyses in this paper, I draw on register data covering the entire population of firms founded in Denmark in 1998 as well as all individuals involved in these new firms. This leaves me with a sample of more than 14,000 firms which are distributed over all sectors of the economy. The data provide rich information on the individuals so that it is possible to control for ability when estimating the effect of size on survival and to determine the degree of homogeneity with respect to ability as well as with respect to educations within firms.

The results show that both team size and ability have a positive effect on the survival of young firms. Most important is founding in a team at all. In contrast, the homogeneity with respect to ability and the heterogeneity with respect to educations do not effect the probability of firm survival.

The paper is structured as follows: In Section 2 the hypotheses for the empirical analysis are derived from the O-ring theory. In Section 3, the data are described. Section 4 presents the estimation method and specification and Section 5 the results. Section 6 concludes.

2 Theoretical Background and Hypotheses

The O-ring theory goes back to Kremer (1993) and applies to production processes which consist of a series of tasks each of which must be performed at a certain minimum level of quality for the output to have positive market value. Individual ability corresponds to the probability that an individual performs her task sufficiently well. The project as a whole only has a positive outcome if all team members perform their tasks at a certain minimum level of quality. Otherwise output is zero. This is modeled by including individual abilities multiplicatively in the production function

$$Y = F(k, n) \left[\prod_{i=1}^{n} q_i \right] n, \tag{1}$$

where k refers to physical capital, n to the number of tasks and $q_i \in (0, 1)$ to the probability that the individual assigned to task i works sufficiently well, which is her ability. Following the literature, it is assumed that each task requires one person, i.e. n is also the number of individuals.[2] Following the exposition above, $[\prod_{i=1}^{n} q_i]$ is the survival probability of the firm.

The survival probability exhibits the following two properties. First, given team size, the survival rate increases in the ability level of each individual in the team

$$\frac{\partial([\prod_{i=1}^{n} q_i])}{\partial q_i} = \prod_{j \neq i} q_j > 0, \tag{2}$$

And second, given ability, the survival rate decreases in the size of the team[3]

$$\frac{\partial([\prod_{i=1}^{n} q_i])}{\partial n} = ln(q)q^n < 0. \tag{3}$$

One can argue that the effect of insufficient task performance on survival depends on the phase of a firm's life cycle. In the conception phase of the business idea the product might have no market value at all if one of the involved team members does not perform her task sufficiently well. Consequently, the firm might have

[2]In his seminal paper, Kremer (1993) explicitly mentions that n indicates the number of tasks and not necessarily the number of employees. But his exposition of the theory uses the assumption of one person per task and Fabel (2004b) follows him in this respect.

[3]In equilibrium these two effects are balanced and there is a unique failure probability for optimally composed firms. It is even possible to give a value for this failure probability: 0.632.

no basis anymore and therefore has to give up. In contrast, if the firm already reached its operation phase, it is no longer inevitable that the firm dissolves if someone makes a mistake. Low-level performance during contract fulfillment for one client can be compensated by normal-level performance for another. The firm can make a loss but this loss is not necessarily threatening for the whole business. Nevertheless, the effects concerning ability level and team size on the survival rate should also be observed in the operation phase of the firm, albeit weaker. Formulated as empirical hypotheses, equation (2) and (3) yield:

H1a: Given team size, the probability of firm survival increases in the ability level of the team members.

H1b: Given the ability level of the team members, the probability of firm survival decreases in team size.

The assumption of the O-ring theory that team size is negatively related to firm survival cannot easily be reconciled with the results already established in the literature.[4] The existing studies almost unanimously come to the conclusion that size is positively related to survival. The positive relationship between size and survival is sometimes even regarded as a stylized fact (Geroski (1995), Sutton (1997), Caves (1998)). However, most of the papers cannot control for ability due to data restrictions. Taking equation 2 and 3 together, it is possible that the effect of size appears to be positive as in most of the previous empirical studies. This is the case when higher able persons build larger teams. As shown by Kremer (1993), the O-ring theory implies that ability and team size are positively correlated. Thus, the positive effect of team size found empirically could result because ability is not controlled for.

Team size also appears to be positively related to survival when human capital variables such as length of education, educational degrees or labor market experience are included in the regressions (Brüderl et al. (1996), Prantl (2003), and Jørgensen (2005)). However, human capital variables only capture part of individuals' ability and may not fully represent the q of the O-ring theory. The

[4]Evans (1987a,b), Dunne, Roberts, and Samuelson (1989), Phillips and Kirchhoff (1989), Mata and Portugal (1994), Mata, Portugal, and Guimarães (1995), Audretsch and Mahmood (1995), Brüderl, Preisendörfer, and Ziegler (1996), Cabral and Mata (2003), Prantl (2003), and Jørgensen (2005).

theory itself suggests using wages as representation of ability. To see this, consider a firm that maximizes expected profits and employs only individuals of one ability level[5]

$$\max_{q,k,n} \pi(q,k,n) = pF(k,n)q^n n - w(q)n - rk \tag{4}$$

For the following, a specific functional form for $F(k,n)$ is needed. Normalising output price p to one and specifying output per team member $F(k,n)$ as $k^\alpha n^{1-\alpha}$ as in Fabel (2004b) the firm does not want to change the ability level of its workers if

$$\frac{\partial \pi(q,k,n)}{\partial q} : k^\alpha n^{1-\alpha} q^{n-1} n = \frac{dw(q)}{dq}, \tag{5}$$

i.e. if marginal revenue of changing the ability level equals marginal costs. The first order condition with respect to capital k is

$$\frac{\partial \pi(q,k,n)}{\partial k} : \alpha k^{\alpha-1} n^{1-\alpha} q^n = r. \tag{6}$$

Solving equation 6 for k, inserting it into equation 5, and integration yields[6]

$$w(q) = (1-\alpha)\left(\frac{\alpha}{r}\right)^{\frac{\alpha}{1-\alpha}} (n)^{\frac{1}{1-\alpha}} q^{\frac{n}{1-\alpha}}. \tag{7}$$

This is a monotonously increasing function of ability, i.e. each ability level is unambiguously reflected in a certain wage and a higher ability level comes along with a higher wage. In the empirical analysis, wages are therefore used as a measure of ability.

Besides insufficient ability, the O-ring theory implies a further reason why a firm can fail: better outside options for at least one team member. These can arise when teams are built with the wrong partners. In the production function (1), the marginal product of ability of the individual assigned to task i is increasing in the average ability levels of the individuals assigned to the other tasks

$$\frac{d^2 Y}{dq_i d\left(\prod_{j\neq i} q_j\right)} = F(k,n)n > 0. \tag{8}$$

[5]As will be explained below, the O-ring theory actually implies the sorting of individuals according to their ability which results in homogeneous workforces within firms.

[6]The constant of integration is zero since an individual with zero ability destroys the product with certainty and therefore cannot receive positive wages.

This means that skills are complementary.[7] If labour markets are competitive, this implies that firms which have started to employ individuals with the highest ability in the population (and still have suboptimal size) can attract other individuals of the highest ability level since they can pay them the highest wage. Firms with medium ability individuals cannot successfully compete for higher able individuals but are successful in attracting medium ability individuals compared to firms with lower average ability level. This leads to homogeneity in the ability levels of all individuals within firms.

As a theory for describing an equilibrium, the O-ring theory implies that heterogenous teams are not formed at all since abilities are publicly observable and heterogeneous teams are unattractive for high-ability individuals. Thus, in equilibrium it is useless to search for an effect of the degree of homogeneity on firm survival. But, as shown in Müller (2008), the ability levels of team members in just established firms exhibit a considerable amount of heterogeneity although not as much as in randomly assembled teams. It is possible that this is partly due to measurement error, since ability always has to be approximated somehow. But it might also be the case that abilities are not perfectly observable so that individuals mistakenly choose the wrong partners. Moreover, each individual might only overlook a small set of potential partners. Thus, teams with similar but not the same level of ability are built. If real abilities and suitable partners become known over time only, better outside options for some team members can arise and a firm can close down because of too much diversity in the abilities. Thus, a further hypothesis is:

H2: Given average ability and team size, the probability of firm survival increases in the degree of homogeneity with respect to the ability of the team members.

As mentioned above, in the literature on the O-ring theory it is assumed that each task requires one person. This is a rather strong assumption as it rules out the cases where one individual can perform several tasks and several individuals are assigned to one task. Nevertheless, it can be expected that individuals are predestined for certain tasks but not for others due to their field of education. Presumably, a firm with a team consisting of individuals with different educa-

[7] This is the same concept of complementarity as applied e.g. in Milgrom and Roberts (1990, 1995) and to explain the joint occurrence of certain technologies.

tional backgrounds can rely on a broader basis of knowledge and therefore has a higher probability of survival. Hence, a third hypothesis is:

H3: Given average ability and team size, a high degree of heterogeneity in educations increases the probability of firm.

With H2 and H3 this paper is also related to the literature of the so called "upper echelons research" in business administration (Hambrick and Mason (1984)), which analyses the impact of team composition on firm performance.[8] However, the focus of the upper echelons research lies mainly on well established and rather big firms. Moreover, none of these studies looks at homogeneity in ability as it is done in this paper and all papers that consider new firms are interested in other outcome variables than survival.[9]

3 Data

The data used in this paper are provided by Statistics Denmark, Denmark's federal statistical office. These are register data, which cover the whole population of firms which were set up in Denmark in 1998 and that were still in operation at the end of that year.[10] The total number of new firms at the end of 1998 amounts to 16,063. On an annual basis, these firms were observed until 2001 or until they shut down.[11] In the start-up year and at the end of each year during the follow-up period, the current number of employees and the current amount of exports, purchases, and sales are recorded. Additionally, industry of business, legal form and location are registered in the start-up year.

[8] For overviews, see Carpenter et al., 2004, Finkelstein and Hambrick, 1996 or Jackson, 1992.

[9] Roure and Madique (1986), Roure and Keeley (1990), Ensley, Carland, and Carland (1998), Ensley and Amason (1999), Ensley and Amason (1999), Beckman, Burton, and O'Reilly (2007), and Zimmerman (2008) look at new firms.

[10] Firms that started in 1998 and shut down within the same year are not contained in the data set.

[11] The same procedure has been applied to all firms founded in 1994. However, for these firms it is only possible to merge individual information for the person who registered the firm with the authorities for the start-up year. Since it is essential for determining the degree of homogeneity between team members to either have information on all individuals or to have at least a representative sample of the individuals, the analysis is restricted to the 1998 cohort.

Table 1: Survival and hazard rates

	surviving firms	number of exits	survival rate	hazard rate
1998	14,171	0	1.000	0
1999	11,822	2,349	0.834	0.166
2000	8,994	2,828	0.635	0.239
2001	7,369	1,625	0.520	0.181

Source: ZEW-spinoff survey 2001, author's calculations.

By a combination of firm and personal identification numbers (ID), it is possible to link the firm-level information to information on individuals stored in the Integrated Database for Labour Market Research (IDA). The IDA database covers a wide range of variables on the total Danish population from 1980 onwards, including the complete education and employment history. The latter can be used to generate the relevant variables for the individuals involved in the new firms in all years. Due to missing information about the employees for some firms 14,171 firms of the original 16,063 firms can be used for the subsequent analysis.

A drawback of the data is that it is not possible to identify the persons who perform the necessary tasks in the firm. However, as the great majority of the new firms are small entities, each person can be considered to be important. [12] In the following, firms with at least two persons involved are referred to as "team foundations".

In Table 1, the distribution of the life duration of the firms in the data set is shown. At the end of the observation period in 2001, only about half of the firms still exist. The largest number of exits occurs in the second year after foundation.

4 Empirical Approach

The effects of the variables relevant for this paper are determined by estimating a duration model. In principle, the exit of a firm can occur at any time during

[12] Figure 1 in the appendix shows the average number of individuals per firm over the whole period of consideration by industry. The total average firm size is 1.7 persons.

the year, i.e. survival time is continuous. However, in the data at hand it is only reported whether the respective firm still exists at the end of the year. Since spell lengths are only observed in intervals, a model for interval censored data is estimated. The relevant hazard rate is the probability of exit during year j given survival up to year $j-1$:

$$h_j(X) = P(j-1 < T \leq j | T > j-1, X), \tag{9}$$

where j denotes the half-open interval $(year_{j-1} - year_j]$. Duration models based on this type of data can be estimated by applying methods for standard binary outcome models (e.g. Sueyoshi (1995), Jenkins (2005)). The dependent variable contains the information whether or not firm i survived year j

$$S_{ij} = \begin{cases} 1 & \text{if firm } i \text{ survives year } j \\ 0 & \text{if firm } i \text{ does not survive year } j \end{cases}. \tag{10}$$

The likelihood function is constructed as follows: The probability that firm i survives year j is given by $P(S_{ij} = 1) = 1 - h_{ij}(X_{ij}, \beta)$. Correspondingly, the probability that firm i does not survive year j is given by $P(S_{ij} = 0) = h_{ij}(X_{ij}, \beta)$. Considering only one firm, the probability for the sequence of outcomes s_{ik} over the whole period of observation amounts to

$$P(S_{i1} = s_{i1}, S_{i2} = s_{i2}, \ldots, S_{ij} = s_{ij}) = \prod_{k=1}^{j} (1 - h_{ik}(X_{ij}))^{s_{ik}} h_{ik}(X_{ij})^{1-s_{ik}}. \tag{11}$$

Since this holds for all firms, the likelihood function for the whole sample is

$$\mathcal{L} = \prod_{i=1}^{n} \left[\prod_{k=1}^{j} (1 - h_{ik}(X_{ij}))^{s_{ik}} h_{ik}(X_{ij}))^{1-s_{ik}} \right]. \tag{12}$$

Taking logs, the loglikelihood function is obtained

$$\log \mathcal{L} = \sum_{i=1}^{n} \sum_{k=1}^{j} [s_{ik} \log(1 - h_{ik}(X_{ij}))) + (1 - s_{ik}) \log(h_{ik}(X_{ij})))]. \tag{13}$$

One observation is a firm-year combination and the probability of surviving the following year is estimated.

To make the model estimable, a functional form for the hazard rate $h_{ik}(X_{ij})$ must be chosen. In principle, any continuous distribution function can be used. As it is known from practical applications of binary choice models, the results are not very sensitive to the functional form of the distribution functions. Therefore, the choice of the functional form for the hazard rate reduces to the question what can be implemented easiest. For this paper, the logistic distribution is chosen which turns equation (13) into a likelihood function of a pooled logit model. In order to allow the hazard rate to vary with survival time (duration dependence) year dummies are added to the list of regressors.

To account for firm heterogeneity which is not captured in the observable variables, a random effects logit is estimated. In this case the hazard rate becomes

$$h_{ik} = \frac{exp(X_i'\beta + c_i)}{1 + exp(X_i'\beta + c_i)}, \tag{14}$$

where c_i reflects the unobservable firm effect. In random effects models for binary variables it is assumed that this effect is sampled along with the dependent variable and observable independent variables and it is removed by integrating it out.[13] Here, the distribution of c_i is assumed to be $N \sim (0, \sigma_c)$ and the removal of this effect is carried out with the default approximation routine implemented in STATA's xtlogit command.

Measurement and Specification

As mentioned in Section 2, wages are used to measure ability. Statistics Denmark provides the average hourly wage once per year for each year the individual was wage employed. For the analyses in this paper, these wages are corrected for inflation, disciplines, and industry effects. The goal of correcting the wages this way is to exclude all components which do not represent ability.[14] After the correction, the average lifetime hourly wage of an individual is calculated, starting with her year of labour market entry until 2001. Thus, for the estimations in this paper, the ability level in a team is the average of the corrected lifetime

[13]For details, see e.g. Wooldridge (2002), pp. 482.

[14]The effects of disciplines and industries were corrected for to take out demand effects: If, for example, engineers are in short supply, their wages rise due to the working of the market forces and not due to an increase in their abilities in the first line . See Müller (2008) for further discussion of the wage correcting procedure.

wages across all team members. The degree of homogeneity of abilities is determined by calculating the standard deviation of the corrected lifetime wages. For easier interpretation, the negative of the standard deviations is included in the regressions.

As a measure of the degree of heterogeneity in education, the Herfindahl-Index of the highest education attained is calculated for each team. The Herfindahl-Index is a measure of concentration. For the purpose of this paper it is computed as

$$H = \sum_{i=1}^{n} s_i^2, \tag{15}$$

where s_i denotes the share of education i in a team.

The range of possible values of the Herfindahl-Index depends on the number of individuals in a team. To correct for this and to make the Herfindahl-Index better comparable between teams of different size, the index is transformed to the $[0, 1]$-interval in the following way

$$H^{tr} = 1 - \left(H - \frac{1}{n}\right)\frac{n}{n-1} \quad \in [0, 1]. \tag{16}$$

As a result, it takes on the value zero if all individuals have the same education and becomes one if each individual attained a different education. With this transformation, teams in different firms are treated as equally diverse if all individuals have different educations, independently of team size.

The variable the Herfindahl-Index is based on can take on more than 1,000 values, i.e. it provides highly detailed information on the education of the individuals. Since the educational degree is only a crude measure for the task actually fulfilled in the firm, there is no obvious level of aggregation for this variable. In this paper, the variable has not been aggregated in any respect for calculating the Herfindahl-Index.

The empirical model is estimated in two different versions: In the first, only characteristics of the start-up year are considered. This takes account of the fact that the conditions at start have a lasting effect on the organisation and the outcome of young firms (e.g. Mata and Portugal (1994) or Baron, Burton, and Hannan (1996)). The second version allows the regressors to take on different values over time. The share of exports in sales and regional as well as industry dummies are used as control variables. Since it is assumed that all relevant observable and unobservable abilities of the individuals are reflected in the wages, no further ability measures are included in the regressions. In order to to account for the conjecture that the marginal effect of the first partner is different from the marginal effect of a second or a third partner, a dummy which takes the value one if at least two persons are involved in the firm is included in addition to the variable "team size".

Table 2 and Table 3 show descriptive statistics of the variables used in the regressions in the next Section. The numbers are based on firm-year combinations. Table 2 shows the figures for characteristics in the start-up year whereas in Table 3 it is allowed that the variables change over time. Surviving firms exhibit a higher average ability, but also have more employees than non-surviving firm. And teams in surviving firms are less homogeneous with respect to ability and less heterogeneous with respect to educations than in non-surviving firms.

5 Results

Table 4 shows the estimation results. The figures are the marginal effects calculated at the mean of the independent variables. For the estimations in columns (1) and (2), only the values of the respective variables in the start-up year are considered. Columns (3) and (4) show the results when the values of the variables are updated each year. As can be seen from the critical value of the LR-test ($\bar{\chi}^2_{01}$), the hypothesis that unobserved effects do not play a role can be rejected for both versions of the empirical model. Therefore, only the results from the RE logit are considered in the following.

Concerning the effect of ability and team size, it turns out that both the average ability in a team and the size of the team have a positive impact on the survival probability. Additionally, having a team at all has a much stronger effect on survival than including a further person in a team. Considering only start-up year characteristics, an increase of the average ability by one standard deviation increases the probability of survival by 1 percentage point. An additional team member yields a 0.5 percentage points higher survival rate but the first partner

Table 2: Descriptive statistics - Start-up year characteristics

variable	**all firms**		**surviving firms**		**non-surviving firms**	
	mean	std.dev.	mean	std.dev.	mean	std.dev.
avg. ability	3.731	0.325	3.735	0.321	3.714	0.340
team size	1.456	1.830	1.511	1.941	1.215	1.189
team (y/n)	0.133	0.340	0.147	0.355	0.069	0.253
homogeneity in abilities	-0.036	0.113	-0.040	0.118	-0.019	0.087
heterogeneity in educations	0.115	0.308	0.127	0.321	0.061	0.232
share of exports in sales	0.020	0.123	0.022	0.126	0.015	0.108
copenhagen	0.429	0.495	0.422	0.494	0.459	0.498
city	0.299	0.458	0.297	0.457	0.306	0.461
rural	0.273	0.445	0.281	0.450	0.234	0.424
low-technology	0.020	0.141	0.022	0.148	0.011	0.106
medium-low technology	0.010	0.099	0.011	0.103	0.007	0.081
medium-high technology	0.002	0.049	0.002	0.049	0.002	0.047
high technology	0.135	0.342	0.146	0.353	0.089	0.284
construction	0.099	0.298	0.100	0.300	0.091	0.288
wholesale trade	0.034	0.180	0.035	0.183	0.030	0.169
retail trade	0.197	0.397	0.184	0.388	0.252	0.434
hotels, restaurants	0.062	0.242	0.057	0.232	0.084	0.278
knowl.-intens. high-tech serv.	0.108	0.310	0.104	0.306	0.124	0.330
knowl.-intens. market serv.	0.199	0.399	0.202	0.402	0.183	0.387
other knowl.-intens. serv.	0.033	0.179	0.035	0.183	0.027	0.163
freight transport	0.101	0.301	0.101	0.302	0.100	0.300
number of observations	31,992		26,129		5,863	

Source: ZEW-spinoff survey 2001, author's calculations.

increases the survival probability by 12 percentage points. Allowing for time varying characteristics the effects remain roughly the same both regarding sign and magnitude. H1a cannot be rejected but H1b can. Thus, I cannot find the countervailing effect of team size and ability in the failure probability suggested by the O-ring theory. Instead, I can corroborate the finding of earlier studies stating that firms founded with a higher number of persons have higher survival chances. Interestingly, this result appears *even when* ability is controlled for.

The effects of homogeneity in abilities and heterogeneity in educations can be found in row three and four of Table 4. Obviously, the degree of homogeneity

Table 3: Descriptive statistics - Time-varying characteristics

variable	**all firms**		**surviving firms**		**non-surviving firms**	
	mean	std.dev.	mean	std.dev.	mean	std.dev.
avg. ability	3.724	0.322	3.727	0.319	3.713	0.337
team size	1.697	2.621	1.804	2.819	1.199	1.230
team (y/n)	0.178	0.382	0.204	0.403	0.055	0.227
homogeneity of ability	-0.051	0.134	-0.059	0.142	-0.016	0.079
heterogeneity in educations	0.153	0.347	0.176	0.366	0.048	0.207
share of exports in sales	0.022	0.126	0.023	0.129	0.014	0.109
number of observations	31,895		26,273		5,622	

Source: ZEW-spinoff survey 2001, author's calculations.

in abilities and the degree of heterogeneity do not have any effect of the survival probability of young firms. This result casts doubt an the assumption that team heterogeneity is an important variable to explain firm performance as put forward in the upper echelons literature. These doubts concern at least new firms. What is striking about the previous studies on new firms is that it is obviously difficult to identify any effect of team heterogeneity at all. However, this could also be a small number-problem as the authors of the previous studies rely on rather few firms and selected industries. In contrast, the analysis in this paper uses a high number of observations but also finds no effect. This suggests that team heterogeneity is rather unimportant for firm performance.

A possible reason for the missing effect of team heterogeneity is that diversity is a double-edged sword. Concerning ability, it is attractive for a high ability individual to look for other high ability individuals because of their lower failure probability. On the other hand, high ability individuals also demand a high compensation for their labour input. Thus, if not all tasks are essential for the success of the project – and it seems that they are not – it could simply be cheaper to employ an individual with low ability. Concerning educations, heterogeneity may provide a broader basis of knowledge. But on the other hand, different educations also represents different modes to interpret the world what could lead to misunderstandings and even to conflict among the team members. Overall, the effects can cancel out.

With the results presented in Table 4, the O-ring theory does not describe the situation in young firms very well. However, one can argue that the theory only applies to a subset of industries. Task complementarity might only be particular for the production environments in certain sectors. However, this is not confirmed in the data. To account for the probable limited applicability of the theory the regressions are performed separately for different industries. This differentiation does not lead to any results systematically different from those found for all firms. However, as can be seen in Table 6 and Table 7 in the appendix, the main results are driven by the firms in the service sectors.

Moreover, it might be the case that firms founded with university graduates are better described by the O-ring theory than firms founded without university graduates. The reason is that firms with university graduates are more likely to deal with innovative products and therefore with more complex technologies which require specialists in different fields. Good matching might therefore be particularly important for these firms. However, as shown in Table 8 in the appendix, regressions run for firms founded with university graduates only, again do not lead to major differences compared to the effects for all firms. The only deviation from the results for all firms is that for team with university graduates it is only important to have a team at all. A further team member has no additional effect. This again confirms the conjecture that the step from a single entrepreneur to a team is the crucial step to increase the probability of survival.

Table 4: Results (marginal effects)

dep. var.: survival of the following year (yes/no)								
	start-up year characteristics				time-varying characteristics			
	pooled logit		RE logit		pooled logit		RE logit	
	coeff.	std.err.	coeff.	std.err.	coeff.	std.err.	coeff.	std.err.
	(1)		(2)		(3)		(4)	
avg. ability	0.031***	0.006	0.033***	0.007	0.028***	0.006	0.030***	0.007
team size	0.004**	0.002	0.005**	0.002	0.002	0.002	0.004***	0.002
team (y/n)	0.114***	0.017	0.118***	0.017	0.149***	0.014	0.118***	0.015
homogeneity in abilities	0.015	0.041	0.016	0.044	-0.022	0.040	-0.021	0.034
heterogeneity in educations	-0.022	0.030	-0.024	0.032	-0.007	0.031	-0.012	0.025
share of exports in sales	0.050**	0.021	0.052***	0.021	0.047**	0.020	0.044**	0.019
regional dummies (ref.cat. copenhagen)								
city	0.012**	0.005	0.013**	0.005	0.009*	0.005	0.011**	0.005
rural	0.038***	0.005	0.041***	0.006	0.036***	0.005	0.039***	0.005
industry dummies (ref.cat. low-technology)								
medium-low technology	0.056***	0.016	0.058***	0.016	0.039**	0.017	0.038***	0.014
medium-high technology	0.040*	0.022	0.043*	0.022	0.035*	0.021	0.036**	0.017
high technology	-0.016	0.047	-0.015	0.053	-0.015	0.045	-0.005	0.052
construction	0.041***	0.012	0.041***	0.012	0.022*	0.012	0.021*	0.012
wholesale trade	-0.011	0.014	-0.013	0.016	-0.014	0.014	-0.018	0.017
retail trade	-0.074***	0.015	-0.083***	0.019	-0.074***	0.015	-0.100***	0.023
hotels, restaurants	-0.130***	0.020	-0.150***	0.029	-0.155***	0.021	-0.230***	0.042
knowl.-intens. high-tech serv.	-0.034***	0.015	-0.037**	0.017	-0.030**	0.014	-0.036**	0.019
knowl.-intens. market serv.	0.002	0.013	0.001	0.014	0.006	0.012	0.004	0.014
other knowl.-intens. serv.	0.026*	0.015	0.027*	0.016	0.031**	0.014	0.029**	0.013
freight transport	-0.015	0.014	-0.016	0.016	-0.025*	0.014	-0.028	0.018
time dummies (ref.cat. 1999)								
2000	-0.091***	0.005	-0.111***	0.018	-0.087***	0.005	-0.173***	0.014
2001	-0.044***	0.006	-0.083**	0.035	-0.044***	0.006	-0.232***	0.036
pseudo-R^2	0.036				0.057			
log likelihood	-14,686.789		-14,685.742		-14,005.661		-13,979.795	
$\bar{\chi}^2_{01}$			2.09*				51.73***	
number of observations	31,992		31,992		31,895		31,895	

Notes: ***, **, * depict significance at the 1%, 5% and 10% level respectively. Marginal effects are calculated at the means of the independent variables. For the calculation of the marginal effects of the RE logit, the random effect is set to its mean value zero. For a detailed description of the combined industries see Table 5 in the appendix.
Source: Statistics Denmark, author's calculations.

6 Conclusions

In this paper, I analyse how the survival of young firms is affected by the level of ability, the team size, team members' homogeneity with respect to ability, and team members' heterogeneity with respect to educations. The O-ring theory of production served as a theoretical basis. It turns out that the average level of ability in a team and the team size have positive effects on a firms' probability to survive the next year. Most important is having a team at all. In contrast, homogeneity with respect to ability and heterogeneity with respect to educations do not have any on the probability of survival. The results of this paper imply that young firms can be supported in their longevity by making sure that several persons are involved and the ability of the persons is as high as possible. However, the degree of diversity in ability and educations can be neglected.

With respect to the O-ring theory, the result that more persons are good for survival even when ability, measured by wages, is controlled for, implies that the O-ring theory does not adequately describe the project "firm foundation". The reason is that the positive effect of team size contradicts the fundamental assumption of the O-ring theory that a further person in a team also constitutes a further risk.

Presumably, the main reason why the O-ring theory is not a good description of young firms is that it does not allow for redundancies. One good worker cannot be substituted by two mediocre workers in the theory. This is an extreme assumption. If tasks are really critical, it might be worthwhile to back up these tasks with a second person who checks the work of the first. A second reason for the inapplicability of the theory is that it probably is always possible to absorb mistakes in the course of the project at least to some extent.

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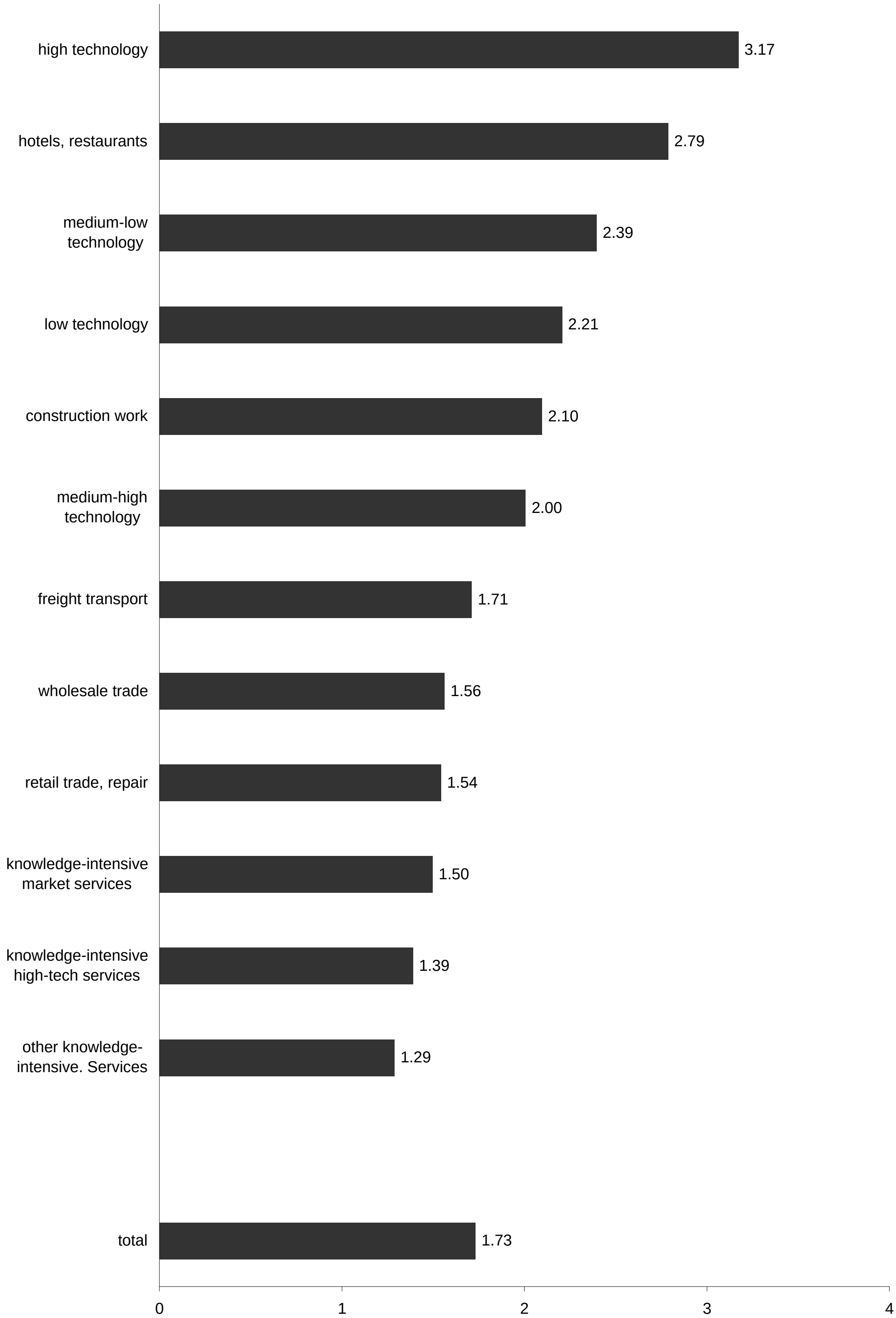
Appendix

Table 5: Definition of Industries

	NACE - Code	Description
Low-technology	15, 16	Food, beverages and tobacco
	17, 18, 19	Textile and clothing
	20, 21, 22	Wood, pulp, paper products, printing and publishing
	36, 37	Other manufacturing and recycling
Medium-low technology	23	Coke, refined petroleum products and nuclear fuel
	25	Rubber and plastic products
	26	Non-metallic mineral products
	27	Basic metals
	28	Fabricated metal products
	351	Shipbuilding
Medium-high technology	24, excl. 24.4	Chemicals excl. pharmaceuticals
	29	Non-electrical machinery
	31	Electric machinery
	34	Motor vehicles
	352, 354, 355	Other transport equipment
High-technology	244	Pharmaceuticals
	30	Computers, office machinery
	32	Electronics, communication
	33	Scientific instruments
	353	Aerospace
Knowledge-intensive high-tech services	64	Post and telecommunications
	72	Computer and related activities
	73	Research and development
Knowledge-intensive market services (excl. financial intermediation)	61	Water transport
	62	Air transport
	70	Real estate activities
	71	Renting of machinery and equipment w/o operator, and of personal and household goods
	74	Other business activities
Other knowledge-intensive services	80	Education
	85	Health and social work
	92	Recreational, cultural and sporting activities

Source: OECD (2003).

Figure 1: Average number of employees during the period 1998 and 2001



Reading aid: Firms in the knowledge-intensive market services have on average 1.50 individuals during the period 1998 to 2001.
A * at the sector names indicates whether firms with university graduates differ significantly from firms without university graduates at the 5% level. For a detailed description of the combined industries, see Table 5.
Source: Statistics Denmark, own calculations.

Table 6: Results (marginal effects) for firms founded in the manufacturing sector

dep. var.: survival of the following year (yes/no)								
	start-up year characteristics				time-varying characteristics			
	pooled logit		RE logit		pooled logit		RE logit	
	coeff.	std.err.	coeff.	std.err.	coeff.	std.err.	coeff.	std.err.
	(1)		(2)		(3)		(4)	
avg. ability	0.035	0.024	0.004*	0.003	0.023	0.023	0.014	0.012
team size	0.004	0.004	0.000	0.000	-0.001	0.003	0.000	0.001
team (y/n)	-0.059	0.078	-0.003	0.012	0.169***	0.064	0.061*	0.034
homogeneity in abilities	-0.095	0.119	-0.010	0.012	0.076	0.128	0.027	0.048
heterogeneity in educations	0.092	0.063	0.007	0.008	-0.126	0.149	-0.047	0.041
share of exports in sales	0.040	0.072	0.003	0.005	0.040	0.060	0.019	0.025
regional dummies (ref.cat. copenhagen)								
city	0.020	0.016	0.002	0.001	0.014	0.016	0.007	0.008
rural	0.035**	0.016	0.003*	0.002	0.026*	0.016	0.014	0.009
industry dummies (ref.cat. low-technology)								
medium-low technology	0.048***	0.015	0.004**	0.002	0.034**	0.015	0.015*	0.009
medium-high technology	0.032*	0.018	0.002*	0.001	0.029*	0.017	0.012	0.008
high technology	-0.014	0.038	-0.001	0.005	-0.008	0.035	0.000	0.017
time dummies (ref.cat. 1999)								
2000	-0.106***	0.021	-0.049***	0.014	-0.095***	0.020	-0.095***	0.022
2001	-0.078***	0.023	-0.180***	0.045	-0.075***	0.022	-0.180***	0.038
pseudo-R^2	0.040				0.049			
log likelihood	-814.614		-811.340		-783.096		-778.218	
$\bar{\chi}^2_{01}$			6.55***				9.76***	
number of observations	2,124		2,124		2,131		2,131	

Notes: ***, **, * depict significance at the 1%, 5% and 10% level respectively. Marginal effects are calculated at the means of the independent variables. For the calculation of the marginal effects of the RE logit, the random effect is set to its mean value zero. For a detailed description of the combined industries see Table 5.
Source: Statistics Denmark, author's calculations.

Table 7: Results (marginal effects) for firms founded in the service sectors

dep. var.: survival of the following year (yes/no)								
	start-up year characteristics				time-varying characteristics			
	pooled logit		RE logit		pooled logit		RE logit	
	coeff.	std.err.	coeff.	std.err.	coeff.	std.err.	coeff.	std.err.
	(1)		(2)		(3)		(4)	
avg. ability	0.036***	0.007	0.039***	0.009	0.032***	0.007	0.038***	0.009
team size	0.003	0.003	0.003	0.003	0.006**	0.003	0.009***	0.003
team (y/n)	0.130***	0.021	0.138***	0.021	0.134***	0.020	0.121***	0.016
homogeneity in abilities	0.045	0.049	0.052	0.054	-0.035	0.048	-0.034	0.045
heterogeneity in educations	-0.009	0.040	-0.011	0.043	0.046	0.038	0.034	0.034
share of exports in sales	0.065***	0.023	0.072***	0.025	0.064***	0.023	0.068***	0.024
regional dummies (ref.cat. copenhagen)								
city	0.011**	0.006	0.013**	0.007	0.009	0.005	0.013*	0.007
rural	0.040***	0.006	0.044***	0.007	0.038***	0.006	0.045***	0.006
industry dummies (ref.cat. retail trade)								
wholesale trade	0.054***	0.007	0.060***	0.009	0.051***	0.007	0.056***	0.007
hotels, restaurants	-0.048***	0.011	-0.056***	0.015	-0.067***	0.011	-0.083***	0.018
knowl.-intens. high-tech serv.	0.035***	0.007	0.041***	0.009	0.038***	0.007	0.046***	0.007
knowl.-intens. market serv.	0.069***	0.006	0.076***	0.008	0.072***	0.006	0.079***	0.007
other knowl.-intens. serv.	0.084***	0.009	0.090***	0.010	0.085***	0.008	0.081***	0.009
freight transport	0.052***	0.007	0.059***	0.009	0.043***	0.007	0.050***	0.007
time dummies (ref.cat. 1999)								
2000	-0.100***	0.006	-0.130***	0.026	-0.095***	0.006	-0.199***	0.023
2001	-0.045***	0.007	-0.103**	0.049	-0.043***	0.007	-0.253***	0.053
pseudo-R^2	0.032				0.054			
log likelihood	-12,297.512		-12,296.266		-11,705.559		-11,688.144	
$\bar{\chi}^2_{01}$			2.49*				34.83***	
number of observations	25,543		25,543		25,434		25,434	

Notes: ***, **, * depict significance at the 1%, 5% and 10% level respectively. Marginal effects are calculated at the means of the independent variables. For the calculation of the marginal effects of the RE logit, the random effect is set to its mean value zero. For a detailed description of the combined industries see Table 5.
Source: Statistics Denmark, author's calculations.

Table 8: Results (marginal effects) for firms founded with university graduates

dep. var.: survival of the following year (yes/no)								
	start-up year characteristics				time-varying characteristics			
	pooled logit		RE logit		pooled logit		RE logit	
	coeff.	std.err.	coeff.	std.err.	coeff.	std.err.	coeff.	std.err.
	(1)		(2)		(3)		(4)	
avg. ability	0.056***	0.015	0.056***	0.015	0.049***	0.015	0.052***	0.016
team size	0.001	0.003	0.001	0.003	0.004	0.003	0.004	0.003
team (y/n)	0.158***	0.054	0.158***	0.045	0.126***	0.046	0.111***	0.037
homogeneity in abilities	0.088	0.085	0.088	0.098	0.028	0.102	0.014	0.092
heterogeneity in educations	-0.037	0.136	-0.037	0.117	0.048	0.097	0.039	0.081
share of exports in sales	0.050	0.035	0.050	0.034	0.043	0.032	0.042	0.031
regional dummies (ref.cat. copenhagen)								
city	0.014	0.011	0.014	0.011	0.009	0.010	0.008	0.011
rural	0.034***	0.013	0.034***	0.012	0.032***	0.012	0.031***	0.012
industry dummies (ref.cat. low-technology)								
medium-low technology	-0.007	0.068	-0.007	0.068	-0.026	0.069	-0.033	0.085
medium-high technology	-0.070	0.082	-0.070	0.096	-0.078	0.079	-0.063	0.117
high technology	-0.215***	0.079	-0.215*	0.125	-0.234***	0.070	-0.267	0.206
construction	-0.046	0.043	-0.046	0.043	-0.046	0.042	-0.058	0.055
wholesale trade	-0.013	0.033	-0.013	0.033	-0.019	0.031	-0.021	0.037
retail trade	-0.041	0.031	-0.041	0.031	-0.034	0.029	-0.043	0.037
hotels, restaurants	-0.161***	0.055	-0.161***	0.057	-0.175***	0.056	-0.223**	0.095
knowl.-intens. high-tech serv.	-0.023	0.028	-0.023	0.029	-0.014	0.027	-0.013	0.031
knowl.-intens. market serv.	-0.009	0.025	-0.009	0.026	-0.006	0.024	-0.010	0.027
other knowl.-intens. serv.	-0.023	0.035	-0.023	0.035	-0.012	0.032	-0.017	0.038
freight transport	-0.037	0.047	-0.037	0.045	-0.055	0.048	-0.077	0.065
time dummies (ref.cat. 1999)								
2000	-0.095***	0.013	-0.095***	0.013	-0.078***	0.012	-0.123***	0.033
2001	-0.071***	0.014	-0.071***	0.014	-0.058***	0.013	-0.160**	0.078
pseudo-R^2	0.038				0.048			
log likelihood	-2,614.543		-2,614.543		-2,484.622		-2,483.193	
$\bar{\chi}^2_{01}$			0.00				2,86**	
number of observations	5,844		5,844		5,825		5,825	

Notes: ***, **, * depict significance at the 1%, 5% and 10% level respectively. Marginal effects are calculated at the means of the independent variables. For the calculation of the marginal effects of the RE logit, the random effect is set to its mean value zero. For a detailed description of the combined industries see Table 5.
Source: Statistics Denmark, author's calculations.