Discussion Paper No. 09-087

Does Interdisciplinarity Lead to Higher Employment Growth of Academic Spinoffs?

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Non-Technical Summary

Establishing a new firm is a complex process which comprises many tasks. A common assumption in the theoretical literature on entrepreneurship is therefore that interdisciplinarity is important for successfully running a new firm. Empirically it is still an open question whether interdisciplinarity is a success factor of new firms. In this paper, I analyse whether interdisciplinarity of the founders of academic spinoffs is important for the employment growth of these firms. Academic spinoffs are spinoffs from universities and other research institutes. For these firms interdisciplinarity may be especially important as it is not only relevant for running the firm but also as a basis for the business idea itself.

In detail, the following groups of academic spinoffs are compared with respect to employment growth: a) team foundations versus single entrepreneurs, b) single entrepreneurs who studied several subjects versus single entrepreneurs who studied only one subject, c) team foundations whose members studied different subjects versus team foundations whose members all studied the same subject, and d) team foundations whose members all come from the same type of research institution versus team foundations whose members come from different types of research institutions. These comparisons are made using a data set on academic spinoffs in Germany.

The results of this paper show that employment growth of academic spinoffs is higher when the firm is founded by a team than when it is founded by a single entrepreneur. Team foundations of engineers have higher employment growth when they have a business scientist among them. However, heterogeneity with respect to the subjects studied per se and with respect to the institution of academic origin is irrelevant for the employment growth of academic spinoffs. Thus, interdisciplinarity appears not to be an important success factor of new firms.

Das Wichtigste in Kürze

Die Errichtung eines neuen Unternehmens ist eine vielschichtige Angelegenheit mit vielen Aufgaben. In der theoretischen Literatur zu Entrepreneurship wird deswegen im Allgemeinen angenommen, dass Interdisziplinarität wichtig für den Erfolg neuer Unternehmen ist. Empirisch ist dies aber eine immer noch offene Frage. In diesem Papier untersuche ich deswegen, ob Interdisziplinarität der Gründer von akademischen Spinoffs relevant für das Beschäftigungswachstum dieser Unternehmen ist. Akadamische Spinoffs sind Ausgründungen aus Universitäten und anderen Forschungseinrichtungen. Für diese Unternehmen sollte Interdisziplinarität eine besondere Rolle spielen, da sie nicht nur relevant ist für das Führen des Unternehmens, sondern auch als Basis für die Geschäftsidee selbst.

Im Einzelnen werden folgende Gruppen von akademischen Spinoffs hinsichtlich ihres Beschäftigungswachstums miteinander verglichen: a) Einzelgründungen versus Teamgründungen, b) Einzelgründer, die mehrere Fächer studiert haben versus Einzelgründer, die nur ein Fach studiert haben, c) Teamgründungen, deren Mitglieder unterschiedliche Fächer studiert haben versus Teamgründungen, deren Mitglieder alle dasselbe Fach studiert haben und d) Teamgründungen, deren Mitglieder alle von demselben Typ Forschungseinrichtung kommen versus Teamgründungen, deren Mitglieder von unterschiedlichen Typen von Forschungseinrichtungen kommen. Diese Vergleiche werden mithilfe von Daten über akademische Spinoffs in Deutschland durchgeführt.

Die Ergebnisse dieses Papiers zeigen, dass akademische Spinoffs, die im Team gegründet werden, ein höheres Beschäftigungswachstum haben als akademische Spinoffs, die von Einzelpersonen gegründet werden. Teamgründungen von Ingenieuren sind erfolgreicher, wenn sie einen Wirtschaftswissenschaftler im Team haben. Heterogenität hinsichtlich der studierten Fächer an sich und hinsichtlich der akademischen Herkunft der Gründer hat jedoch keinen Einfluss auf das Beschäftigungswachstum von akadamischen Spinoffs. Interdisziplinarität scheint also kein bedeutender Erfolgsfaktor für neue Unternehmen zu sein.

Does Interdisciplinarity Lead to Higher Employment Growth of Academic Spinoffs?

Bettina Müller*

September 2009

This paper is a completely revised version of the paper
"Human Capital and Successful Academic Spin-Off"
(ZEW Discussion Paper No. 06-081)

Abstract

Does heterogeneity in the educational backgrounds of the founders matter for firm success? Are team foundations more successful than single entrepreneurs? These questions are analysed using data on academic spinoffs in Germany. Firm success is measured by employment growth. I find that team foundations have higher employment growth than single entrepreneurs. Team foundations of engineers perform better when they have a business scientist in the team. However, different subjects per se and heterogeneity in the academic origins of the founders do not play a significant role for the employment growth of academic spinoffs.

Keywords: human capital, entrepreneurship, academic spinoffs, employment growth.
JEL Classification: C12, L25, M13.

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1 Introduction

A common assumption in the theoretical literature on entrepreneurship is that interdisciplinarity is important for successfully running a new firm. Lazear (2005) claims that single entrepreneurs must have knowledge in different areas, and Fabel (2004) uses a model in which firm success depends on the knowledge and abilities of the different individuals in the team that performs the essential tasks of the firm. There is some evidence that interdisciplinarity increases the probability to become an entrepreneur. Lazear (2005) and Wagner (2006) find that individuals are the more likely to found a firm the more diverse their educational background is.

However, it is empirically still an open question whether interdisciplinarity is a success factor of new firms. So far, there is no evidence for firms founded by single entrepreneurs and for firms founded by teams, the results are mixed. Ensley, Carland, and Carland (1998) and Ensley and Amason (1999) find that heterogeneity in the subjects studied has a negative effect on the level of sales, but no effect on sales growth and profitability. Zimmerman (2008) finds a positive effect of the same variable on the amount of capital that the firms obtain at their initial public offering, and Amason, Shrader, and Tompson (2006) report no effect on sales growth, profitability and market performance (net return to shareholders in the 3-year period after initial public offering).

In this paper, I analyse whether interdisciplinarity of the founders of academic spinoffs is important for the employment growth of these firms. Academic spinoffs are spinoffs from universities and other research institutes. They are considered to be important for economic growth because they are a vehicle for spreading new ideas. Often, new ideas emerge by recombining existing knowledge, which could be encouraged by different knowledge backgrounds of the involved persons. Thus, for these firms interdisciplinarity may be especially important as it is not only relevant for running the firm but also as a basis for the business idea itself.

As theoretical basis for the derivation of the hypotheses, the models by Lazear (2005) and Fabel (2004) mentioned above are used. To my knowledge, these are the only formal theories that consider the effects of the composition of human capital for new firms. Lazear focusses on single entrepreneurs whereas Fabel allows for the possibility that firms are founded by teams. These two models suggest to compare the following groups of firms with respect to employment growth: a) team foundations versus single entrepreneurs, b) single entrepreneurs who studied several subjects versus single entrepreneurs who studied only one subject, c) team foundations whose members studied different subjects versus team foundations whose members all studied the same subject, and d) team foundations whose members all have the same level of ability versus team foundations whose members have different levels of ability. The outcome of this analysis is relevant for developing guidelines to set up promising start-ups. But it also concerns education policy as it indicates whether universities should set up interdisciplinary curricula when aiming at fostering academic spinoffs.

One reason for the inconclusive results of the existing studies is that they rely on rather small data sets. The most extensive data set used has just 174 observations, which could lead to imprecise estimates. Furthermore, the existing results are presumably based on selected samples as the authors only observe surviving firms. As firm performance and survival are not independent (Dunne, Roberts, and Samuelson (1989)), estimates based only on surviving firms are potentially biased. In this paper, I use the ZEW spinoff survey, which contains educational information on the founders of roughly 3,000 academic spinoffs in Germany. Additionally, it is possible to use information on non-surviving firms founded in research and knowledge intensive sectors to correct for the bias arising from the fact that the effect of heterogeneity in educations can only be calculated for surviving firms.

The results of this paper show that employment growth of academic spinoffs is higher when the firm is founded by a team than when it is founded by a single entrepreneur. Team foundations of engineers have higher employment growth when they have a business scientist among them. However, heterogeneity with respect to the subjects studied per se and with respect to the institution of academic origin is irrelevant for the employment growth of academic spinoffs. Thus, it is only important that several persons are involved, but it is by and large negligible who matches with whom to set up the firm.

The paper is organized as follows: Section 2 presents the theoretical approaches by Lazear (2005) and Fabel (2004) and develops the hypotheses for the empirical analysis. Section 3 describes the data set and the relevant variables. Section 4 presents the estimation method. Section 5 shows the results, and Section 6 concludes.

2 Theory and Hypotheses

In this section, the hypotheses for the empirical analysis are developed. They are based on the jack-of-all-trades model by Lazear (2005) and the partnership model of entrepreneurship by Fabel (2004). These theories make statements about the probability to become an entrepreneur and about the equilibrium size of firms. The approaches are therefore extended in order to derive hypotheses about employment growth.

2.1 The "Jack-of-all-Trades" Model

Lazear (2005) views entrepreneurs as persons whose primary task is to bring together different factors of production for creating a new product or producing an old product at lower costs. They "must possess the ability to combine talents and manage those of others" (Lazear (2005), p. 650). In order to be able to fulfil such a task, entrepreneurs must have knowledge in different areas. Lazear (2005) therefore assumes that entrepreneurs need the full range of their skills and that income depends on the skill with which the entrepreneurs are least endowed. This is in contrast to employees who can exploit their best skill to generate income. As a consequence, individuals with a balanced skill profile (jack-of-all-trades) choose to become entrepreneurs and individuals with one outstanding skill choose to become employees.

If the jack-of-all-trades argument applies, individuals have different investment strategies in education depending on their skill profile. Individuals with a clear imbalanced skill profile invest in only one of their skills because they will use only one of their skills in future work. In contrast, individuals with a more balanced skill profile either do not invest, invest in the skill with which they are least endowed or invest in more than one skill. This depends on the investment costs in human capital they face. Thus, following Lazear, the two types of individuals can be distinguished empirically by the breadth of their investment in human capital.[1] In this paper, the breadth of investment in human capital is measured by the fact whether or not an individual has studied several subjects.

For analysing who will become an entrepreneur (which is the concern of Lazear), this reasoning straightforwardly transforms into the hypothesis that individuals with a broad human capital investment strategy are more likely to become entrepreneurs. Concerning employment growth, the case is a little bit more complicated as it is not clear who is observed when we look at an individual with only one subject studied given that she founded a firm: someone with an unbalanced skill profile who "wrongly" chose to become an entrepreneur or someone with a balanced skill profile whose investment costs in education are such that she only chose to study one subject. This leads to different hypotheses about the relationship between heterogeneity in educations and employment growth from the jack-of-all-trades model. One is

H1a: Given start-up size, firms founded by single entrepreneurs who studied only one subject have lower employment growth than firms founded by single entrepreneurs who studied more than one subject.

This hypothesis applies if individuals face some uncertainty about their skill profile which makes it necessary that they actually start a firm before they know whether their skill profile is sufficiently balanced. If the actual skill profile is only revealed incrementally, the unsuitable entrepreneur will not shut down overnight but may will first reduce employment in order to reduce costs.[2]

The contrasting hypothesis is

H1b: Given start-up size, firms founded by single entrepreneurs who studied only one subject have equal employment growth as firms founded by single entrepreneurs who studied more than one subject.

[1] A more direct strategy would be to use information on test scores from school. This information is neither available for the paper by Lazear nor for this paper.

[2] This reasoning is similar to Jovanovic (1982) who models the evolution of the size structure of an industry as a process of noisy selection. Firms do not know their efficiency at the outset but become acquainted with it through learning. Efficient firms grow, and inefficient firms decline. Almus (2004) finds empirically that exiting firms indeed shrink before they close down.

This hypothesis applies if the observed entrepreneurs all have a sufficiently balanced skill profile but for some, the investment costs are such that they can invest in more than one skill whereas for others, it is only beneficial to raise their weakest skill to the level of their other skills.

A drawback of the jack-of-all-trades model is that it allows predictions only about single entrepreneurs. In teams, it is possible that the weaknesses of one team member is compensated by the strengths of another. But this is implicitly ruled out in the jack-of-all-trades model. Alternatively, Fabel (2004) presents an approach which also permits team foundations.

2.2 The Partnership Model of Entrepreneurship

In his model, Fabel (2004) adopts the O-ring production function approach of Kremer (1993). According to this theory, the performance of each task in a project is essential.[3] If any member of the team that performs the essential tasks makes a considerable mistake, the project fails. The project success therefore depends crucially on the ability of the team members.

The O-ring theory implies that there is a unique optimal team size for each firm and that team foundations have more employees than single entrepreneurs in equilibrium. This approach therefore allows to formulate a hypothesis with respect to the question whether or not the relevant knowledge should be provided by different persons. If start-up size is equal for both single entrepreneurs and team foundations and if it is below optimal size, team foundations should have higher employment growth than single entrepreneurs. The second hypothesis is therefore

H2: Given start-up size, firms founded by teams experience higher employment growth than firms founded by single entrepreneurs.

Fabel (2004) assumes that each task requires exactly one person. This is a rather strong assumption as it rules out the cases that one individual can perform sev-

[3]The O-ring approach got its name from the accident of the space shuttle Challenger which exploded because of the malfunctioning of only one of its components: the O-rings of the booster. This event is used as a metaphor for production processes in which everything has to work sufficiently well for the project to be a success.

eral tasks and several individuals are assigned to one task. However, with this assumption it can be conjectured that teams whose members have acquired similar types of skills ("specialised teams" in the following) are more likely to split up on the way to equilibrium because the skills of their members are redundant. Teams whose members obtained different skills ("generalistic teams" in the following) can rely on a broader basis which could help them to better run and grow the business. Thus, assuming again that the start-up size of the firms is smaller than their optimal size, the third hypothesis is

H3: Given start-up size, firms founded by generalistic teams experience higher employment growth than firms founded by specialised teams.

A further implication of the O-ring theory is that in competitive labour markets, teams are homogeneous with respect to the ability of their members. The reason is that the abilities of the team members are complementary, i.e. the marginal productivity of the ability of one team member increases in the abilities of the other team members. This implies that a team consisting of individuals with the highest ability level in the population can benefit the most from an equally able team member for a further task and will therefore offer 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.

This sorting mechanism requires that abilities are observable. If, however, abilities are not perfectly observable at the outset, it is possible that also heterogeneous firms are founded. These firms must fail on the way to equilibrium, because for the highest able individual in each team it is always appealing to join a team with equal (or even higher) ability and to leave the lower able individuals. The reason is that having a partner with at least equal ability reduces the probability of firm failure compared to being a member of a heterogeneous team with lower ability individuals. If abilities only become known gradually over time, the employment in firms with heterogenous teams might be reduced before the firm is closed completely. This leads to the fourth hypothesis.

H4: Given start-up size, firms founded by heterogeneous teams experience lower employment growth than firms founded by homogeneous teams.

3 Data and variables

3.1 Data

The data set used in this paper is the ZEW-spinoff survey 2001 (Egeln, Gottschalk, Rammer, and Spielkamp (2002, 2003)). This survey covers firm foundations in research and knowledge intensive sectors in Germany between 1996 and 2000. These sectors are

- high technology: sectors with high R&D intensity, e.g. the chemical and pharmaceutical industry, engineering, and the computer industry,
- technology oriented services: service sectors in which new technologies are particularly relevant for the business, e.g. software consulting, technical offices, and research services,
- knowledge intensive services: sectors in which the qualification of the employees or the use of knowledge is important, e.g. consulting, tax accountancy, and education.

The ZEW-spinoff survey is sampled from the Mannheim Foundation Panel (MFP) of the Centre for European Economic Research (ZEW), which contains almost all firms founded in Germany since 1989 (Almus, Engel, and Prantl (2000)). The information on the firms for this panel is made available to the ZEW by CREDITREFORM, the largest credit rating agency in Germany. In the MFP, only start-ups with at least one full-time job are included. Changes in legal form or addresses, foundations of investment companies, and part-time foundations do not count as firm foundations. For the spinoff survey, a random sample of almost 70,000 firms stratified by the sector groups defined above, foundation year, and region is drawn. The survey was conducted between October and December 2001 using computer-aided telephone interviews (CATI) and led to a total of 20,241 interviews.

Since the focus of this study is on academic spinoffs, all start-ups which are not academic spinoffs are discarded from the set of firms. A start-up is defined as an academic spinoff if at least one of the founders has studied or is currently studying at a university or a technical college and if academic skills, new scientific methods, or new scientific results are essential for the new firm.

By construction of the survey, only firms that survive until 2001 are interviewed. For the sampled firms that do not survive until 2001, the basic information that is provided by CREDITREFORM for all firms is available. This information can be used to correct for the selection bias that arises because employment growth is not independent of survival. In total, a market exit is observed for 10,498 firms. Since the information relevant for identifying spinoffs is collected during the telephone interviews, the set of non-surviving firms can only be restricted to firms which have at least one university graduate among the founders. In the end, there remain 2,906 surviving firms and 1,752 non-surviving firms for the analyses, which makes a total of 4,658 firms.

The data for the surviving firms cover the number of employees at start and the number of employees in 2001. This information can be used to calculate the average rate of employment from the year of start up to 2001. Additionally, the data include information on the subjects studied by the founders, the research institution the founders come from, and facts about the firms, such as the year of foundation, the size of the foundation team, contacts to the scientific world, and whether the firm received subsidies. The basic information provided by CREDITREFORM includes the number of employees at start, the year of foundation, the region in which the firm is located, information about real estate property and the educational degree of the founders.

3.2 Variables

In addition to the variables describing the general characteristics of the firms, a number of additional variables is generated that form the core input to the test of the hypotheses. Due to the character of the information available in the data set, these variables are all dummy variables.

Generalist: This variable captures whether or not a single entrepreneur has a broad investment strategy in human capital. It takes the value one if a single entrepreneur has chosen at least two subjects during her studies. This variable is relevant for H1a and H1b.

With this definition, a single entrepreneur is regarded to have a broad investment strategy if she studied at least two subject regardless of how much related these subject are. E.g., she is termed a generalist if she studied physics and chemistry. A less broad definition is to only consider someone having a broad investment strategy if she studied at least two different subjects from different disciplines, e.g. natural sciences and business sciences. Therefore, an additional dummy is constructed taking the value one if a single entrepreneur obtained skills from at least two different disciplines, which is used alternatively in the regressions. Table 6 in the appendix shows which subjects and disciplines are considered for the analysis.

Team: This variable takes the value one if the size of the foundation team amounts to at least two individuals. This variable is relevant for H2.

Generalistic team: This variable takes the value one if the members of a team have studied different subjects. It is zero if all team members have studied the same subject. This variable is relevant for H3.

As in the case of single entrepreneurs, a further dummy variable is generated which takes the value one only if the team is composed of individuals coming from different disciplines, e.g., if the team is composed of a physicist and a business scientist but not if it is composed of a physicist and a chemist.

Homogeneous teams: This variable takes the value one if the firm is founded by a team and all founders come from the same type of research institution. For the analyses in this paper, the founders can originate from three types of research institutions: universities, technical colleges, and non-university research institutes. The variable takes the value zero if at least two team members come from different research institutions. This variable relates to H4.

Defining the variable this way is only a crude approximation to the homogeneity in abilities of the O-ring model applied by Fabel (2004). In this model, ability corresponds to the probability of performing a task sufficiently well. However, these probabilities are not observable. In this paper, I use the academic origin of the founders as a measure of their ability. This is motivated by the fact that in Germany technical colleges provide more practically oriented and universities more theoretically oriented education. The education or qualification one obtains is therefore likely to be differently demanding in different types of research institutions.

Although the data is quite extensive, it has some limitations. As Table 6 in the appendix shows, the information on the subjects is quite detailed but does not cover the whole variety of study courses in Germany. Especially, study courses which have a wide focus, such as business informatics (*Wirtschaftsinformatik*), cannot be identified. For the analyses, an individual who studied such subjects appears as someone with a narrow investment strategy although she receives a rather broad education.

A further drawback of the data is that it is unknown how many team members studied a given subject. E.g., for a team of three individuals, who studied physics and engineering, it is unknown whether there are two physicists and one engineer or one physicist and two engineers. Thus, for the analyses it can only be determined whether or not a team is generalistic. The Herfindahl- or Blau-Index, which is used as a measure for team heterogeneity in the literature, cannot be calculated.

Table 1 shows descriptive statistics for the variables used in the regressions. The majority of the firms in the data set are founded by teams (62 percent), but a considerable part is also founded by single entrepreneurs (38 percent). The average number of employees at start is higher for team foundations than for single entrepreneurs. This is partly due to the fact that the number of employees is given in full time equivalents including the founders. For the estimations, the founders are not separated from the employees as the relevant comparison is to contrast the employment growth of a team with the hypothetical situation that all team members started as single entrepreneurs. A separation would overestimate the effect of having a team. Furthermore, the new firms also provide employment for the founders. In this sense, the founders are also employees of the firms. On average, a firm founded by a team grows with a higher rate than a firm founded by a single entrepreneur.

Almost all of the single entrepreneurs in the sample (95 percent) have studied only one subject. This fraction becomes 96 percent if "generalist" is defined in terms of disciplines. Among the team foundations, 45 percent have partners with different backgrounds with respect to subjects studied. Considering disciplines,

Table 1: Descriptive statistics

variable	single entrepreneurs		team foundations	
	mean	std.dev.	mean	std.dev.
fraction[1]	0.381		0.619	
employment growth	0.155	0.316	0.204	0.334
generalists (subjects)	0.053	0.224		
generalists (disciplines)	0.036	0.187		
generalistic teams (subjects)			0.449	0.498
generalistic teams (disciplines)			0.372	0.484
homogeneous teams[2]			0.794	0.404
number of employees at start[3]	3.311	5.211	5.339	6.882
firm age	3.094	1.373	2.807	1.369
min. labour market experience	8.453	8.986	5.753	7.480
number of contacts to science	1.304	1.648	1.818	1.829
continuous R&D	0.291	0.455	0.381	0.486
occasional R&D	0.131	0.338	0.150	0.357
public support	0.279	0.449	0.320	0.466
high technology	0.153	0.361	0.172	0.377
technology oriented services	0.423	0.494	0.427	0.495
knowledge intensive services	0.423	0.494	0.401	0.490
number of observations	883		1,618	

Notes: [1]based on 2,620 observations. [2]based on 1,508 observations. [3]full time equivalents including founders.
Source: ZEW-spinoff survey 2001, author's calculations.

the fraction of generalistic teams is 37 percent. Regarding the homogeneity of the ability, 79 percent of the team foundations are set up by partners who originate from the same type of research institution.

4 Estimation Method

The econometric model for estimating employment growth is related to the framework used by Evans (1987). It is assumed that the relationship between initial employment and employment in 2001 for firm i can be described as

$$E_{t_2,i} = [G(x_i'\beta)]^{t_2-t_{1,i}} E_{t_1,i}\epsilon_i, \tag{1}$$

where E denotes employment, $t_{1,i}$ the year of foundation of firm i, t_2 the year of the survey 2001 and ϵ a lognormally distributed error term. The vector x contains the variables which capture the effects of team foundation, generality and homogeneity as well as the control variables including a constant. After taking logs and rearranging the resulting regression equation is

$$\frac{ln(E_{t_2,i}) - ln(E_{t_1,i})}{t_2 - t_{1,i}} = ln[G(x_i'\beta)] + u_i, \tag{2}$$

where $u_i \sim N(0, \sigma_i^2)$ and independent of the observed explanatory variables X. As in Evans (1987), age and initial employment enter the regression equation by the second order logarithmic expansion

$$ln(E_{t_1}) + ln(age) + ln(E_{t_1}) * ln(age) + (ln(E_{t_1}))^2 + (ln(age))^2. \tag{3}$$

As it is possible that the effects of the central variables are different in each sector, the key dummy variables defined above are interacted with the industry dummies. For example, for the hypothesis comparing team foundations with single entrepreneurs, the regression equation for the growth relationship is

$$\begin{aligned} Growth &= \beta_0 + \beta_1 team\ in\ high\ technology \\ &\quad + \beta_2 team\ in\ technology\ oriented\ services \\ &\quad + \beta_3 team\ in\ knowledge\ intensive\ services \\ &\quad + z_i'\gamma + u_i. \end{aligned} \tag{4}$$

The regression equations for the other hypotheses are built equivalently by replacing the variables in the first three rows by the respective dummies for the other hypotheses. The only exception is the estimation of the effect of generalistic single entrepreneurs. For this relationship, the dummy "generalist" is not interacted with the industry dummies since the number of generalists is too small to produce meaningful results at the sectoral level.

The central variables for the analysis in this paper are only available for firms which survive the whole period from their initiation until 2001. This could give rise for selection issues since growth is not independent of survival (Dunne et al. (1989)). Therefore, a sample selection model is estimated.

$$Growth = ln[G(x_i'\beta)] + u_i \tag{5}$$

$$Survival = \mathbb{1}[w_i\delta + \nu_i > 0], \tag{6}$$

where correlation between the error terms u_i and ν_i is permitted. The vector w_i contains variables which influence the survival probability of the firms. These variables are taken from the basic information provided by CREDITREFORM for all firms. The model is estimated by applying the two-step procedure proposed by Heckman (1976, 1979). As exclusion restrictions, the region in which the firms are located (the German federal states) and real estate property are used.

5 Results

The presentation of the results starts with the effects for the hypothesis comparing team foundations with single entrepreneurs (H2), because it uses the full sample and is thus the most encompassing. Then the results concerning the effects of the heterogeneity in educational backgrounds for single entrepreneurs and team foundations (H1, H3, and H4) are shown. In order to save space, the results for the growth regressions are presented in the main text. Table 7 in the appendix shows the results of the selection equation for the regression comparing team foundations with single entrepreneurs. The signs of the coefficients are plausible. Due to the different sample sizes considered, the coefficients in the selection equation differ between regressions, but yield similar results.

Teams vs. single entrepreneurs. The results of the regression for the hypothesis that team foundations have higher employment growth than single entrepreneurs are shown in Table 2. The key coefficients in this case are the ones relating to the dummies *team in high technology*, *team in technology oriented services* and *team in knowledge intensive services*.

Team foundations experience higher employment growth than single entrepreneurs. The coefficient of *team in industry j* is positive and highly significant. Regarding the magnitude of the effect, it turns out that it is not significantly different across industries. Running a regression without the sector differentiation yields that firms founded by a team experience a 7.5 percent higher employment growth than a firm founded by a single entrepreneur. Thus, H2 cannot be rejected.

Concerning the control variables, the results are consistent with what one would expect and what has previously been found in the literature. Employment growth

Table 2: Employment growth of team foundations in comparison to single entrepreneurs

dep. var.: *employment growth*: $\frac{ln(E_{t2,i})-ln(E_{t_1,i})}{t_2-t_{1i}}$		
	coeff.	std. error
team in high technology	0.082***	0.032
team in technology oriented services	0.070***	0.021
team in knowledge intensive services	0.077***	0.020
$ln(E_{t_1})$	-0.169***	0.024
$ln(age)$	-0.108*	0.056
$ln(E_{t_1}) * ln(age)$	0.055***	0.014
$(ln(E_{t_1}))^2$	0.015***	0.006
$(ln(age))^2$	-0.042*	0.024
minimum labour market experience	-0.003***	0.001
number of contacts to science	0.028***	0.004
continuous R&D	0.075***	0.015
occasional R&D	0.023	0.018
public support	0.047***	0.014
ref. cat. high technology		
technology-oriented services	-0.034	0.030
knowledge-intensive services	-0.013	0.031
constant	0.303***	0.038
λ	-0.077	0.048
$\chi^2_{(15)}$	315.93***	
number of observations: uncensored	2,620	
number of observations: censored	1,559	

Notes: ***, **, * depict significance at the 1%, 5% and 10% level respectively.
Source: ZEW-spinoff survey 2001, author's calculations.

is negatively related to both employment at start and age. The number of contacts to science, the conduction of R&D and the attainment of public support have all positive and highly significant effects. Somewhat unexpected is the negative sign of the coefficient for minimum job experience, which is defined as the difference between the year of foundation and the year in which the last founder left academia. A possible explanation is that the variable due to its definition also captures the effect of individuals' age. Older entrepreneurs probably do not tend to expand their firm because they cannot reap the benefits for a sufficiently long time. These two effects cannot be separated since there is no information about the age of the individuals in the data set.

Generalists vs. specialists. H1a and H1b contrast single entrepreneurs who studied several subjects (generalists) and single entrepreneurs who studied only one subject (specialists). The results of this comparison are shown in Table 3. The columns denoted with (1) show the results for the case that a single entrepreneur studied at least two subjects and the columns denoted with (2) for the case that she studied at least two different subjects that are from different disciplines. The crucial coefficient is the one in the first row.

It turns out that single entrepreneurs who studied several subjects do not have higher employment growth than single entrepreneurs who studied only one subject. The coefficient for *generalist* is insignificant. This result persists if generalists with respect to disciplines rather than subjects are considered. This is consistent with H1b but not with H1a.

With respect to the jack-of-all-trades model, there are several explanations for this result. First, individuals who are entrepreneurs are all jack-of-all-trades (have a balanced skill profile) but have different investment costs in education. For some it is worthwhile to invest in more than one skill and for others it is only reasonable to invest in one of their skills. If it is only relevant for the success of new firms that individuals are jack-of-all-trades, we should get no effect because all individuals are in fact equal in the crucial dimension, although we cannot observe it. This is the explanation based on H1b. Second, it is possible that also individuals with an imbalanced skill profile are among the founders but they are able to compensate their disadvantage by, say, a high motivation for being an entrepreneur or having a broad social network they can rely on. Finally, it cannot be ruled out that the jack-of-all-trades theory is wrong and that a balanced skill is not important for successfully running a new firm. In order to determine whether the jack-of-all-trades theory is not only reasonable for the probability to become an entrepreneur but also for the success of new firms founded by single entrepreneurs, more detailed information on the skill profile of the individuals would be necessary.

Table 3: Employment growth of generalists in comparison to specialists

sample: single entrepreneurs				
dep. var.: *employment growth*: $\frac{ln(E_{t2,i})-ln(E_{t_1,i})}{t_2-t_{1i}}$				
	coeff.	std. error	coeff.	std.error
	(1)		(2)	
generalist	0.007	0.045	0.017	0.054
$ln(E_{t_1})$	-0.133***	0.038	-0.133***	0.038
$ln(age)$	-0.102	0.106	-0.103	0.106
$ln(E_{t_1}) * ln(age)$	0.047**	0.022	0.048**	0.022
$(ln(E_{t_1})^2$	0.012	0.011	0.011	0.011
$(ln(age))^2$	-0.026	0.048	-0.026	0.048
minimum labour market experience	-0.004***	0.001	-0.004***	0.001
number of contacts to science	0.034***	0.007	0.034***	0.007
continuous R&D	0.055**	0.025	0.055**	0.025
occasional R&D	-0.011	0.032	-0.011	0.032
public support	0.049**	0.023	0.049**	0.023
ref. cat. high technology				
technology-oriented services	-0.043	0.033	-0.043	0.033
knowledge-intensive services	-0.016	0.034	-0.016	0.034
constant	0.246***	0.048	0.246***	0.048
λ	0.093*	0.054	0.094*	0.054
$\chi^2_{(13)}$	92.31***		92.40***	
number of observations: uncensored	886		886	
number of observations: censored	1,559		1,559	

Notes: ***, **, * depict significance at the 1%, 5% and 10% level respectively. Columns denoted with (1): single entrepreneur studied at least two subjects. Columns denoted with (2): single entrepreneur studied at least two subjects that are from different *disciplines*.
Source: ZEW-spinoff survey 2001, author's calculations.

Generalistic vs. specialised teams. There is also no support for the hypothesis that teams whose members all studied different subjects experience higher employment growth than teams in which all members have studied the same subject (H3, Table 4). The crucial coefficient is insignificant in all sectors both when subjects (columns denoted with (1)) and disciplines (columns denoted with (2)) are considered. Presumably, this is the result of what is called the double-edged sword of heterogeneity in the literature (Hambrick, Cho, and Chen (1996), Ensley and Amason (1999)): Different subjects also represent different ways of interpreting the business environment which could lead to misunderstandings and even to conflict among the team members. This could offset the advantage of having a broader skill basis due to different educational backgrounds.

Homogeneous vs. heterogeneous teams. The fourth hypothesis contrasts homogeneous teams with respect to ability with heterogenous teams. The results of the regression are shown in rows four to six in Table 4. It turns out that the coefficient for homogeneous teams with respect to ability is insignificant in each industry. Thus, it is irrelevant whether team members are graduates from only one type of research institution or whether there is a mix of graduates from different research institutions. This result allows two different conclusions concerning the partnership model of entrepreneurship. Either, there is a measurement problem. It is possible that the sort of qualification one gets in the different research institution does not measure ability differences adequately. Or, the theory is false. In this case, tasks are not as essential as assumed in the partnership model of entrepreneurship so that it is better to have a mixed team with respect to ability. The latter is the case if some tasks can be assigned to rather low ability individuals since these individuals are cheaper. In Müller (2009), I use lifetime wages as a measure of ability in a regression on the determinants of the survival probability of young firms. There is again no effect of the degree of homogeneity with respect to ability detectable. Thus, the evidence suggests that the the second conclusion mentioned above must be drawn.

Table 4: Employment growth of generalistic (homogeneous) teams in comparison to specialised (heterogeneous) teams

sample: team foundations				
dep. var.: *employment growth*: $\frac{ln(E_{t2,i})-ln(E_{t_1,i})}{t_2-t_{1i}}$				
	coeff.	std. error	coeff.	std. error
	(1)		(2)	
generalistic team in high technology	-0.029	0.039	-0.039	0.040
generalistic team in technology oriented services	0.015	0.025	0.010	0.025
generalistic team in knowledge intensive services	-0.005	0.026	-0.004	0.026
homogeneous team in high technology	0.036	0.049	0.038	0.049
homogeneous team in technology oriented services	0.020	0.031	0.021	0.031
homogeneous team in knowledge intensive services	0.024	0.031	0.023	0.030
$ln(E_{t_1})$	-0.267***	0.037	-0.266***	0.037
$ln(age)$	-0.128*	0.073	-0.129*	0.073
$ln(E_{t_1}) * ln(age)$	0.081***	0.021	0.081***	0.021
$(ln(E_{t_1})^2$	0.034***	0.010	0.033***	0.010
$(ln(age))^2$	-0.060**	0.031	-0.059**	0.031
minimum labour market experience	-0.004***	0.001	-0.004***	0.001
number of contacts to science	0.026***	0.005	0.026***	0.005
continuous R&D	0.079***	0.019	0.079***	0.019
occasional R&D	0.039*	0.024	0.039*	0.024
public support	0.044***	0.018	0.044***	0.018
ref. cat. high technology				
technology-oriented services	-0.051	0.059	-0.046	0.056
knowledge-intensive services	0.000	0.060	0.000	0.057
constant	0.478***	0.067	0.477***	0.065
λ	0.033	0.044	0.034	0.044
$\chi^2_{(18)}$	228.20***		228.40***	
number of observations: uncensored	1,504		1,504	
number of observations: censored	1,559		1,559	

Notes: ***, **, * depict significance at the 1%, 5% and 10% level respectively. Columns denoted with (1): at least two team members studied different subjects. Columns denoted with (2): at least two team members studied different subjects that from different *disciplines*.
Source: ZEW-spinoff survey 2001, author's calculations.

Table 5: Employment growth of teams with technical and business skills in comparison to teams with technical but without business skills

sample: team foundations				
dep. var.: *employment growth*: $\frac{ln(E_{t2,i})-ln(E_{t_1,i})}{t_2-t_{1i}}$				
	coeff.	std. error	coeff.	std. error
	(1)		(2)	
team foundations with natural and business scientists	0.039	0.033		
team foundations with engineers and business scientists			0.082***	0.032
$ln(E_{t_1})$	-0.319***	0.068	-0.194***	0.048
$ln(age)$	-0.203*	0.115	-0.218*	0.115
$ln(E_{t_1}) * ln(age)$	0.101***	0.035	0.046*	0.027
$(ln(E_{t_1})^2$	0.030*	0.018	0.027**	0.012
$(ln(age))^2$	-0.034	0.052	0.005	0.049
minimum labour market experience	-0.004*	0.002	-0.003**	0.001
number of contacts to science	0.026***	0.008	0.017***	0.007
continuous R&D	0.107**	0.034	0.039	0.028
occasional R&D	0.058	0.042	0.005	0.034
public support	0.095***	0.030	0.064***	0.026
ref. cat. high technology				
technology-oriented services	-0.047	0.037	-0.060*	0.032
knowledge-intensive services	-0.003	0.046	-0.060	0.039
constant	0.578***	0.080	0.438***	0.068
λ	-0.018	0.051	0.083*	0.051
$\chi^2_{(15)}$	120.55***		80.94***	
number of observations: uncensored	637		614	
number of observations: censored	1,559		1,559	

Notes: ***, **, * depict significance at the 1%, 5% and 10% level respectively.
Source: ZEW-spinoff survey 2001, author's calculations.

Natural scientists and engineers with business scientists. A conjecture often put forward in discussions is that teams whose members attained technical skills perform better if they form a team with someone with commercial skills. Table 5 shows the results for the comparison between teams of natural scientists and engineers with and without business scientists, respectively. For natural scientists, it does not seem to make any difference whether or not they have a business scientist among them, but for engineers it does. Teams of engineers with business scientists experience a 9 percent higher employment growth than teams of engineers without business scientists.

6 Conclusions

In this paper, I analyse how employment growth of academic spin-offs is affected by the degree of heterogeneity in the educational backgrounds of the founders and the size of the founding team. As theoretical basis, the approaches by Lazear (2005) and Fabel (2004) are used. The results show that it is relevant that a firm is founded by a team. Additionally, there is evidence that engineers should choose business scientists as partners for setting up a successful firm. However, different subjects per se do not play a role, neither for single entrepreneurs nor for team foundations. For team foundations, it is also irrelevant whether or not all founders come from the same type of research institution.

For the design of academic curricula, the results suggest that the success of academic spinoffs cannot be fostered by organising curricula interdisciplinary. It is only important that several persons meet each other. This can happen in different ways and does not depend on the concrete design of curricula. University-wide social events or even events outside the university would also serve the purpose.

With respect to the jack-of-all-trades model (Lazear (2005)) and the partnership model of entrepreneurship (Fabel (2004)), the empirical results seem to cast some doubts on the validity of these approaches. But it is possible that the rejection of most of the hypotheses is due to measurement problems. The crucial variables of the models – the skill profile in the jack-of-all-trades model and the ability of the individuals in the partnership model of entrepreneurship – are both not directly observed in the data. It could be the case that the measures used in this paper do not proxy these variables sufficiently well. Definite conclusions can only be drawn if the results of this paper are replicated with other measures of these variables.

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Appendix

Table 6: Subjects and disciplines

subjects	disciplines
biology	natural sciences
chemistry	
computer sciences	
math	
physics	
other natural sciences	
medicine	
mechanical engineering	engineering
electrical engineering	
construction engineering	
other engineering	
business sciences	business sciences
social sciences	social sciences
law/humanities/languages	
other	other

Source: ZEW-spinoff survey 2001.

Table 7: Selection equation

	coeff.	std.err.
E_{t1}	0.103***	0.008
$(E_{t1})^2$	-0.001***	0.000
ref. cat. age: 1 year		
age: 2 years	-1.894***	0.191
age: 3 years	-2.129***	0.190
age: 4 years	-2.256***	0.190
age: 5 years	-2.458***	0.190
ref. cat. thuringia		
schleswig-holstein	-0.628****	0.195
hamburg	0.117	0.190
lower saxony/bremen	-0.307**	0.156
north-rhine westphalia	-0.432***	0.145
hesse	-0.503***	0.156
rhineland-palatinate/saarland	-0.351**	0.167
baden-wurttemberg	-0.252*	0.149
bavaria	-0.443***	0.147
berlin	-0.343**	0.163
brandenburg	-0.308*	0.181
mecklenburg-western pomerania	0.225	0.256
saxony	-0.184	0.166
saxony-anhalt	-0.256	0.191
professor or doctor (PhD) among founders	0.104*	0.055
real estate property	0.046	0.088
real estate property belonging to firm	0.090	0.270
real estate property missing	-0.265	0.166
equity holding by other firm	-0.154**	0.066
ref. cat. high technology		
technology oriented services	-0.178***	0.071
knowledge intensive services	-0.396***	0.070
constant	2.702***	0.239
number of observations	1,559	

Notes: ***, **, * depict significance at the 1%, 5% and 10% level respectively. Values refer to the regression comparing teams with single entrepreneurs.
Source: ZEW-spinoff survey 2001, author's calculations.