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Human Capital and Successful Academic Spin-Off

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Abstract

Academic spin-offs are one way in which employability of university graduates is reflected. Using the ZEW spinoff-survey, this paper studies empirically the impact of human capital on the success of academic spin-offs founding in knowledge and technology intensive sectors. The focus is thereby on the composition of human capital which is described according to whether or not the founders have studied several subjects and whether or not they all come from the same research establishment. Additionally the impact of having founded as a team is analyzed. Success is measured by employment growth. The findings suggest that it is advantageous to found within a team, but that the human capital composition both for single entrepreneurs and team foundations is rather irrelevant.

Keywords: Higher Education, Human Capital, Entrepreneurship, Spin-off.
JEL Classification: C12, L25, M13.

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Non-technical summary

Universities are increasingly required to train their students in order to qualify them for a job, i.e. to make them employable. One way in which employability is reflected is through the capability of graduates to found an own firm. In this paper I focus on the question, which kind of human capital students should get during their university education for successfully founding a new firm. Should potential entrepreneurs rather be educated interdisciplinary and found a firm alone or should they specialize in one discipline and found together with other specialists? Should one bring together people from theory-oriented institutions (like universities) and practically-oriented institutions (like technical colleges)? Based on the model by Lazear (2005), who puts forward that entrepreneurs should be interdisciplinary-oriented jacks-of-all-trades, and on the model by Fabel (2004), who suggests that successful firm foundations occur within teams composed of specialists, four hypotheses are developed and tested empirically for academic spin-offs: 1) Teams are more successful than single entrepreneurs, 2) Single entrepreneurs who are generalists are more successful than single entrepreneurs who are specialists, 3) Teams whose members have studied different subjects are more successful than teams whose members have all studied the same subject, and 4) Teams whose members have the same institutional background are more successful than heterogeneous teams. Success is thereby measured in terms of average employment growth since the date of foundation.

The empirical analysis is carried out using the ZEW spinoff-survey, a data set on almost 3,000 academic spin-offs founded in knowledge and technology intensive sectors in Germany between 1996 and 2001. The results indicate that teams indeed are more successful than single entrepreneurs, but that the human capital composition both for teams and for single entrepreneurs is rather irrelevant for the success. Only teams operating in technology-oriented services with engineers and business administrators among their founders are more successful than teams which do not exhibit such a combination in this sector.

1 Introduction

One of the recent claims demanded on universities is to train their students in order to qualify them for a job. "Employability" is the keyword often used in this context. For Europe, this demand is manifested for example in the Bologna Declaration of the European Ministers of Education in 1999. Employability of university graduates is reflected in two ways: First, in the capability of graduates to find a job as an employee and second, in their ability to set up an own firm. The focus of this paper is on spin-offs of entrepreneurial firms out of academia. These start-ups are seen as substantial for the development of knowledge-based economies because they transfer recently explored technologies and knowledge into marketable products. Furthermore, they provide an alternative to wage employment for graduates. The "German Rectors' Conference" actually calls upon universities to sensitize their students for entrepreneurship because it conjectures that traditional dependent employment will recede in a knowledge-based economy (HRK 1998).

It has been widely recognized that human capital is essential to build up a firm and keep it running.[1] Moreover, some authors have pointed out that human capital can even explain the financial structure of new firms and its role on new firms' success.[2] In the literature, human capital is measured by means of variables that capture mostly the level of human capital. The most common include the years of education attained by the founder(s) of the firm, the age of the proprietors, the years of previous experience and previous employment status. In contrast, this paper considers the *composition* of human capital employed in the foundation of new firms and its potential role in the firms' performance. In particular I ask: What kind of human capital is relevant for the success of new firms built up by university graduates? Is it rather that interdisciplinary educated individuals are more successful or is it more favorable to have teams consisting of disciplinary educated specialists? The answer to these questions could give an advice for the current restructuring of the curricula of higher education.

[1] See Bates (1990), Bruderl, Preisendorfer and Ziegler (1992), Almus and Nerlinger (1999), Taylor (1999), Moog, Backes-Gellner (2003), Fabel (2004), Lazear (2005).

[2] Cressy (1996) argues that for the particular case of the UK "the influence of finance on performance is nil and the correlation between finance and survival vanishes once human capital is controlled for".

There are two theoretical approaches that link the composition of human capital to firm foundations. The first is the jack-of-all-trades view (Lazear, 2005) which states that individuals with a broad range of skills are more likely to become entrepreneurs. And the second is the team production approach by Fabel (2004) which suggests that individuals should specialize in one task in order to avoid mistakes while setting up a firm. Different specialized individuals should then form a team in order to conduct the different tasks related to a firm foundation. These two papers form the starting point of my analysis. While both approaches consider the role of the human capital composition mainly for the probability of founding a firm I am interested in the impact of the human capital composition on the subsequent success of new firms started by academic graduates. The ideas of Lazear and Fabel are therefore extended to generate hypotheses about the relation of human capital structure to success.

By using the ZEW spinoff-survey which contains information on firm foundations by university graduates in Germany and their study profiles, I pursue two main objectives in this paper. First, I want to evaluate the empirical relevance of the mentioned theoretical approaches by Lazear and Fabel. As will become clear below, these two approaches are not really contradictory but rely on different sets of assumptions thereby highlighting different aspects of the relation between the composition of human capital and firm foundation. The most outstanding is that Lazear assumes that only one person is responsible for the foundation while Fabel suggests that there should be a team to undertake the firm foundation. This paper tests the relevance of both ideas by comparing academic spin-offs by teams and foundations by single entrepreneurs with respect to their success. Second, I attempt to evaluate the impact of the particular composition of human capital on the success of academic spin-offs. The composition of human capital is thereby characterized according to two dimensions: a) subjects studied by the founders, and b) the type of research establishment the founders come from (i.e. whether they come from a university or a technical college or elsewhere).

The results show that it is beneficial to found within a team but that the composition of the team is rather irrelevant. Also for the single entrepreneurs it seems to be negligible whether or not they have a broad range of skills.

The paper is organized as follows: Section 2 presents the theoretical approaches by Lazear and Fabel and develops the hypotheses for the empirical analysis.

Section 3 describes the data set at hand and tests the hypotheses presented in the previous section. Finally, section 4 concludes.

2 Theoretical Background

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

In Lazear's model individuals are endowed with a range of skills, but have different skill profiles. There are individuals that can perform several things on a similar quality level and individuals that have one outstanding skill compared to their other skills. Individuals have two different possibilities to generate income: They can work for another person as an employee or they can become entrepreneurs. When working as an employee individuals exploit their best skill for income generation, that is, they specialize in one of their skills. When deciding to become an entrepreneur they have to use the full range of their skills. However, income generation as an entrepreneur is restricted by the skill with which the individuals are least endowed. According to Lazear entrepreneurs are persons whose primary job is to bring together different factors of production for creating a new product or producing an old product at lower costs. Primarily, they have "to combine talents and manage those of others". For this they must have knowledge in different areas, that is: they have to be jack-of-all-trades, and cannot specialize in a certain subject. Lazear then shows that having an evenly distributed skill profile increases the probability of becoming an entrepreneur.

Additionally, Lazear proves that individuals who plan to become specialists only invest in one of their skills. This is because it would be a wasting of resources to invest in a skill that is not used later on. In contrast, future entrepreneurs invest in the skill with which they are least endowed or they invest in more than one skill. This depends on the relationship between marginal costs of investment in education as a function of the innate skills and marginal returns to entrepreneurship. However, Lazear argues that on average one should observe that future entrepreneurs have a more balanced investment strategy than future employees because they are the only individuals who invest in more than one skill.

Lazear also provides an empirical test for his approach. Using a data set comprising alumni from the Stanford Graduate School of Business he finds a positive relationship between the number of different roles, described by occupational titles an individual has held, and the probability that this individual founds his own firm. Also, individuals who become entrepreneurs have taken a broader range of courses while studying at Stanford. Wagner (2003) tests Lazear's view with a more representative sample than graduates from one special university. He uses a 0.1% sample of the working population in Germany and also finds evidence supporting Lazear's approach. The result of his analysis is that the probability of becoming self-employed rises both with the number of different kinds of professional training (e.g. apprenticeships, degrees as master craftsmen or university degrees) an individual completes after school and the number of changes of profession. The effects are partly quite big. For example, the probability of becoming self-employed rises by more than three percentage points if an individual has one instead of zero different kinds of professional training.

2.2 The partnership model of entrepreneurship by Fabel

One special feature of the model by Lazear, described above, is that he focuses on single entrepreneurs. The firms of these single entrepreneurs produce output with three factors of production: managerial talent, which is the minimum of the skills of the entrepreneur, and two skills which are provided by dependently employed specialists. Lazear implicitly assumes that it is not possible to compensate the weaknesses of the entrepreneur by employing specialists who can take over the task the entrepreneur is weak in. For example: One could imagine an entrepreneur with relatively weak quantitative skills but relatively strong communicative skills. This entrepreneur could employ a worker with strong quantitative skills to compensate his weakness in the quantitative area. But this is not allowed for in the model.

Alternatively, Fabel (2004) presents a partnership view of entrepreneurship. He reasons that the project "firm foundation" shall be carried out by a team of specialists. In his model he adapts the O-ring production function approach developed by Kremer (1993). According to this theory, each task of the production process is important for the value of the final product in such a way that the market value of the product is reduced considerably when the tasks at any stage are not performed sufficiently well.[3] For setting up a firm this means that if any member of the founding team makes a considerable mistake while performing his task, the foundation will fail. The probability to make a failure of each team member is a function of his ability. The project success therefore depends crucially on the ability of the team members.

In this setting Fabel shows that optimization behavior results in teams that are homogeneous with respect to their ability. This is because within the O-ring production approach the marginal productivity of the skill of one team member depends positively on the abilities of the other team members. That is, the abilities of the team members are complementary and one team member performs better the more able the other team members are. This implies that a team consisting of high ability individuals places the highest value on having an equally able team member for a further task and will therefore offer the highest wage. Equivalent arguments hold for teams with initially medium ability level or low ability level team members.

Although the possibility that a firm is founded by only one person is not completely ruled out, Fabel shows that only individuals above a certain threshold ability take on a firm foundation. The reason is that the project risk decreases with ability, which is also due to the underlying production function. Together with the result that group size increases in members' ability, on average we should observe that firms are founded by teams.

2.3 Hypotheses for the success of spin-offs

The above presented theoretical ideas mainly make statements about the probability to take the chance of a firm foundation. In Lazear's model the probability to become an entrepreneur is enhanced if the respective individual has a balanced skill profile. By contrast, in Fabel's model high ability individuals have

[3] This type of production function is called O-Ring production function backing to the accident of the space shuttle Challenger. The Challenger exploded because tiny components of its construction malfunctioned: the O-rings. So, the message deduced from this event is: Everything has to function sufficiently well to lead a project to success.

the highest probability to take up a foundation. However, the aim of the paper at hand is to evaluate empirically the impact of the composition of human capital on the subsequent success of entrepreneurial firms founded by academic graduates. Additionally, the relevance of the two theoretical ideas for the success of academic spin-offs is evaluated. Fabel's model indeed makes some prediction about the success of a new firm where success is measured by the survival of the firm.[4] However, in the empirical part of this paper survival cannot be applied as performance measure since there are only surviving firms in the data set. Instead, average employment growth since the year of foundation is used. The approaches by Lazear and Fabel therefore have to be extended to derive hypotheses about the human capital composition and employment growth.

As already mentioned, the most striking difference between the two models is that Lazear implicitly assumes that there are only single entrepreneurs whereas Fabel conjectures that firms are founded primarily by teams. This point allows the test of the empirical relevance of the two approaches. But what are the implications of the models for employment growth? A result of the analysis of Fabel is that firm size rises with quality and that there is a unique optimal team size. Team foundations are greater than foundations by single entrepreneurs in equilibrium. Assuming that all firms start with a small firm size team foundations should have a greater potential for growth than single entrepreneurs. The related hypothesis is:

> **Hypothesis 1:** Team foundations are more successful than foundations by single entrepreneurs.

One might conjecture that it is already a well known fact that team foundations are more successful than single entrepreneurs. However, surveying the literature it turns out that existing studies are mostly descriptive, rely partly on small numbers of observations (Mellewigt and Spaeth, 2005) and the results are not as clear as expected. For example, Cooper and Bruno (1977) report that in their sample of 250 high technology firms founded in the area of San Francisco in the 1960s 83 percent of the high growth firms (firms with annual sales of more than $5

[4]For example, the model predicts that teams with a low average ability are more likely to fail and shut down.

million) were set up by teams. But also more than half of the unsuccessful firms (firms with less than annual sales of $5 million or firms which ceases to exist) were founded by teams. Stam and Schutjens (2006) find for the Netherlands that among a group of start-up firms which were registered in the Dutch Chamber of Commerce the share of team start-ups that shut down during the first six years is lower than the share of single entrepreneur firms. Moreover, 4.5 percent of the team foundations have more than 10 employees and 3.3 percent have more than 20 employees after six years, compared to 0.4 percent and 1.3 percent among the firms started by a single person.

Among the studies that aim at figuring out the causal effect of having founded as a team on the subsequent success the results are also mixed. Cooper et al. (1994) conduct multinomial logit-analysis with the categories "failure", "survival without or low employment growth" and "high employment growth". They find that having one more full-time partner increases the probability of being among the firms with an employment growth of at least two persons (high employment growth) instead of being among the failing firms by 25 percent. But, having founded as a team has no effect on the probability of survival without or low employment growth compared to the probability of failing. Bruederl et al. (1996) apply bivariate Probit analyses and find that having a partner has no effect on survival, employment growth and sales growth among firms founded in the area of Upper Bavaria once seed capital and number of employees at foundation time is controlled for. Almus and Nerlinger (1999) ran a bivariate Tobit of average employment growth of young innovative firms in West-Germany on a dummy that indicates whether or not the firm was founded by a team (and additional explanatory variables). Their result is that having founded as a team has no significant effect on average employment growth for innovative firms. However, non-innovative firms, which are included in the analysis for comparison reasons, experience a higher employment growth if they are founded by a team. Schutjens and Wever (2000) find for Dutch entrepreneurs who registered their new firm in the Chamber of Commerce in the first quarter of 1994 that team foundations are 1.7 times as likely to hire employees within three years than single entrepreneurs. And also, Egeln et al. (2003) arrive at the conclusion that teams have a positive impact on employment growth. Their objects of investigation are new firms in research- and knowledge-intensive sectors.

Thus, the results of the impact of having founded as a team in the existing literature are not as clear-cut as one might assume. Additionally, to my knowledge no research has been conducted that is especially focussing on the situation of team foundations in comparison with foundations by single entrepreneurs of academic spin-offs.

Regarding Lazear's model, it is assumed that a single entrepreneur is in charge of the founding. As mentioned, Lazear claims that only people with a sufficiently balanced skill profile will become an entrepreneur and employ other individuals as factors of production. This implies that all individuals with an imbalanced skill profile who try themselves as entrepreneurs will vanish over time. The reason is that specialists realize after a while that they can earn more money if they are employed by others. Clearly, this presupposes some kind of uncertainty at the outset. If a specialist is fully aware of his type and knows all employment opportunities at the beginning he will never start up a firm. But if this awareness is a result of a learning process he may start a firm first and then switch to dependent employment.[5] And, if the learning process has several stages then the unsuitable entrepreneur will not shut down overnight but may at first reduce employment in order to reduce costs. Thus, the hypothesis that can be deduced about employment growth from Lazear's model is:

> **Hypothesis 2:** Generalistic single entrepreneurs found more successful firms in terms of employment growth than specialized single entrepreneurs.

In Fabel's model teams have to conduct a certain number of different tasks which are each carried out by one person. Teams whose members have acquired similar types of skills (in the following called "specialized teams") must fall apart on the way to equilibrium because the team members represent perfect substitutes for each other. On the other hand, teams whose members obtained different skills ("generalistic teams") but did not receive their optimal team size grow while reaching the equilibrium (assuming that firms tend to be founded smaller

[5]This goes in the direction of Jovanovic (1982) who models the evolution of the industry structure as a process of noisy selection. Firms do not know their efficiency at the outset but get to know it through learning. Efficient firms then grow, and insufficient firms decline.

than their optimal size). Thus, a similar hypothesis to the one about single entrepreneurs can be formulated for teams:

> **Hypothesis 3:** Generalistic teams found more successful firms in terms of employment growth than specialized teams.

Further, in the model by Fabel there are only teams which are homogeneous with respect to their ability in equilibrium. Hence, heterogeneous teams must break up on the way to equilibrium. This will happen because net profits of heterogeneous teams will be negative. Why? Individuals are paid according to their ability. Higher quality individuals get higher wages. In mixed teams the expected revenue will not suffice to pay all individuals the wage according to their quality, since with given average abilities of the team members (i.e. given output) the wage costs are higher in mixed than in homogeneous teams. Thus, individuals running a firm with a heterogeneous team either have to take on payments below their market wage to secure the existence of the firm or will leave in order to join another team that can provide a wage appropriate to their quality. Clearly, rational individuals will choose the latter option. Again, for the formation of heterogeneous teams there is some incomplete information in the beginning necessary. In terms of employment growth this would mean that firms with a heterogeneous team will shrink. Thus, the hypothesis about employment growth of homogeneous respectively heterogeneous teams from the model by Fabel is:

> **Hypothesis 4:** Teams which are homogeneous in regard to their ability are more successful in founding firms than heterogeneous teams.

3 Empirical Implementation

This section ties up to the theoretical considerations and empirically evaluates the two ideas by Lazear and Fabel with respect to their relevance concerning the success of academic spin-offs. In the following, the data base is described, then the estimation strategy is presented, and finally the results are shown.

3.1 Data

The data set used is the ZEW spin-off survey raised in 2001 (Egeln et al., 2002 and 2003). The population for this survey are all firm foundations in research- and knowledge-intensive sectors in Germany between 1996 and 2001. These sectors are divided into three groups:

> *High-tech Industry*: These are branches with a high effort in R&D. For example: the chemical and pharmaceutical industry, construction, or the computer industry.
>
> *Technology-oriented services*: In these sectors the use of new technologies is particularly relevant. For example: software and computing consulting, technical offices, or research services.
>
> *Knowledge-intensive services*: Here, the qualification of the employees or the use of knowledge is important. For example: consulting, tax accountancy, or education.

Information about firm foundations in research- and knowledge intensive sectors are made available to the ZEW by CREDITREFORM. CREDITREFORM is the largest credit rating agency in Germany. It provides a broad amount of information about almost all German companies covered by the commercial register, or for which a request concerning its creditworthiness is posed. For the spinoff-survey 20,241 interviews were conducted. The survey was undertaken between October and December 2001 using computer-aided telephone interviews (CATI). Unlike other investigations about firm foundations, which often focus on research institutes or start-up centers, the firm founders themselves were interviewed. "Firm foundations" are defined as the take up of an entrepreneurial activity which was not performed before and which suffices as occupation for at least one person. Thus, refoundations, investments in other firms, and part time foundations do not count as firm foundations.

Foundations are identified as academic spin-offs if at least one of the founders has studied or is currently studying at a university or a technical college, and additionally, if academic skills, new scientific methods, or new scientific results have been essential for the foundation. That is, only a subset of foundations with graduates among the founders have been regarded as spinoff, namely the foundations with which a transfer of technology is assumed. Foundations with graduates for which new scientific methods or new scientific results have not been essential or have not been important at all are not considered as spin-offs. Since questions concerning the human capital have only been posed to spin-offs the analysis has to be confined to these firms. The number of observations used in the analyses comprises then 2,975 firms.

The most relevant information for this paper comprise the subjects studied by the founders and the research establishment the founders come from. Further information contained in the data set cover general facts about the firms, such as the year of foundation, the size of the foundation team, the number of employees in the year of foundation, the number of employees in 2001, the connection between the firms and the scientific world and whether the firm received public support.

One property of the data set is that it contains only surviving firms which could give rise to selection issues. This would be the case when the different foundation types (team foundations, single foundations, foundations with a generalist, foundations with a specialist, foundations with a generalistic team, foundations with a specialistic team, foundations with a homogeneous team and foundations with a heterogeneous team) are affected systematically differently by firm closure. For example, if single foundations are more likely to shut down the effect of having founded as a team will be overestimated. Given the information in the data set it cannot be controlled for the potential bias. But from the existing evidence comparing the probability of survival between team and single foundations it cannot be inferred that it is a severe problem in any case. Prantl (2003) shows that team foundations are less likely to go bankrupt but they are more likely to close their firms voluntarily, since team members may trigger the liquidation because of internal conflicts between the team members.

3.2 Estimation Strategy

The indicator of success used in the analyses is employment growth. This measure is chosen mainly for two reasons. Information on employment is usually not confidential and easy to collect so that it can be regarded as reliable. Further, I argue that it is indeed a good indicator for the performance of young firms the management of a firm only decides to employ people if the firm faces good prospects. Schutjens and Wever (2000) conjecture that success in young firms is almost always accompanied with employment growth.

For the econometric model it is assumed that employment grows exponentially:

$$E_{2002,i} \quad = \quad [e^{F(X_i\beta, Z_i\gamma)} H(A_{2002,i}, E_{t,i})^{\delta}]^{2002-t_i} E_{t,i}\epsilon_i,$$

where E denotes employment, A firm age and t the year of foundation. The parameters β, γ and δ will be estimated. The term in the square brackets is the growth factor. It depends on variables X which capture the interesting effects of team foundation, generality and homogeneity. These variables will be described in more detail below. The vector Z contains relevant control variables including a constant term. Finally, the function H, relates age and employment in the foundation year to employment growth. It will take on a second-order logarithmic expansion in the regressions. The error term ϵ is assumed to be lognormally distributed.

Taking logs the resulting regression equation is then:

$$ln(GF) \equiv \frac{ln(E_{2002,i}) - ln(E_{t,i})}{2002 - t_i} \quad = \quad X_i\beta + Z_i\gamma + lnH(A_{2002,i}, E_{t,i})\delta + u_i,$$

where $u_i \sim N(0, \sigma^2)$ and independent of the observed explanatory variables X, Z, A, and E. The dependent variable is the (geometric) average employment growth of firm i. It is the log of the growth *factor*, therefore indicated by GF. This proceeding is equivalent to the framework by Evans (1987) developed to figure out the relation between firm size, age and growth. Subsequently it has been repeatedly used in the literature (e.g. Almus and Nerlinger, 1999 or Moog and Backes-Gellner, 2003).

The central variables used for the estimation are defined as follows:

Team: This variable is a dummy taking the value one if the size of the foundation team comprises two ore more persons. It is the relevant variable for hypothesis 1.

Generalist: This variable captures whether or not a single entrepreneur is a generalist. It relates to hypothesis 2. It takes the value one if a single entrepreneur has studied several subjects during academic education.

This definition of generalization is rather wide. A single entrepreneur is seen as a generalist if he studied any further subject regardless of how much related this subject is to his first subject (e.g. a single entrepreneur is termed a generalist if he studied physics and chemistry). But, from a different perspective a single entrepreneur may only be regarded as a generalist if he studied a subject from another discipline, e.g. natural sciences and business sciences. Therefore an additional dummy is constructed taking the value one if the single entrepreneur obtained skills from at least two different disciplines and used alternatively in the regressions.

Generalistic Team: This is the relevant variable for hypothesis 3. It takes the value one for teams whose members have studied different subjects and zero otherwise.

As in the case of single entrepreneurs the definition of "generalization" is strengthened in a further step by assigning this variable to be only one if the team is composed of members coming from different disciplines (e.g., if it is composed of a physicist, an economist and an engineer, but not if it is composed of a physicist, a chemist and a biologist).

Teams with the same institutional background (Homogeneous Teams): The O-ring model predicts that in equilibrium all teams should be homogeneous in regard to the probability of making a failure in the production process. However, the probability of failing in task performance cannot be calculated with the data set at hand. Nevertheless, a measure of the quality of the team members can be constructed. In the data set there is information about which type of research establishment (university, technical college, Max-Planck-Society,...) the founders have attended. Under the assumption that the quality of education one obtains is sufficiently comparable within one type of research establishment and sufficiently different across different types of research establishments, the origination of the founders from a certain research establishment can be used as a measure of the founders' quality. Therefore, a dummy variable was generated that takes the value one if the foundation was a team foundation and all founders come from the same type of research establishment. This dummy relates then to hypothesis 4.

All the dummy variables defined above are interacted with industry dummies to capture industry-specific effects of these variables. For all hypotheses, the expectation concerning the sign of the coefficients of these interacted variables is positive.[6]

The estimations are carried out applying OLS with robust standard errors with employment growth being the dependent variable. The precise regression equations for the first hypothesis is:

$$\begin{aligned} ln(GF) \;=\; & \beta_0 + \beta_1\, \textit{Team in high tech industry} \\ & + \beta_2\, \textit{Team in technology oriented services} \\ & + \beta_3\, \textit{Team in knowledge intensive services} \\ & + \delta_1 ln(E_{t,i}) + \delta_2 ln(A_{2002,i}) + \delta_3 ln(E_{t,i}) * ln(A_{2002,i}) + \\ & + \delta_4 ln(E_{t,i})^2 + \delta_5 ln(A_{2002,i})^2 + (\textit{control variables})\gamma + \epsilon_i \end{aligned}$$

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

[6]Regression results without industry specific effects are shown in Table 8 in the appendix. Qualitatively they do not differ from the results in the main text.

other hypotheses. The control variables include contacts to science (number different types of contacts), continuous R&D (yes/no), occasional R&D (yes/no), public promotion (yes/no), dummies for two of the three sectors high-tech industry, technology oriented services and knowledge intensive services, and a proxy for former job experience gathered in the firm. The latter variable is constructed by calculating the difference between the year of foundation and the year in which the last founder left academia. It therefore measures the minimum job experience brought in the firm.

3.3 Descriptive Statistics

Descriptive statistics are given in Table 1. The respective information for the control variables can be found in the appendix (Table 7).

The majority of the firms in the data set were founded by teams (62 percent) but a considerable part is also founded by single entrepreneurs (39 percent). On average, a firm founded by a team grows with a higher rate than a firm founded by a single entrepreneur: Single foundations exhibit an average annual employment growth of 13 percent during their lifespan, while team foundations grow with an average rate of 16 percent. This difference is statistically significant at the 1 percent level. Also, the expansion rate of the highest-growing firm among the team foundations is much higher than the expansion rate of the highest-growing firm among the single foundations: While the team foundation with the strongest employment growth more than quadruplet its employment the highest-growing single foundation increases its employment only by a factor of 2.6 per year. However, the distribution of the employment growth between the two extreme values does not differ between the two firm types.

Most of the single foundations start with at most 3 full-time equivalent jobs, and also the average number of employees in the foundation year amounts to roughly 3 full-time equivalent jobs.[7] Only a minority of 5 percent start with more than 10 employees. The team foundations tend to start with more employees. Their average number of full-time equivalent jobs amounts to 5.5, and also the values of the denoted percentiles are greater than those of the single foundations.

[7]These numbers include the founding persons.

Table 1: Descriptive Statistics

Variable:	Fraction	Mean	Std. Dev.	Min	Max	Percentiles 5%	25%	50%	75%	95%
Single entrepreneurs:	38.62									
Employment growth (growth factor)		1.13	0.24	0.26	2.59	0.89	1.00	1.00	1.22	1.59
Number of employees in foundation year[1]		3.32	5.48	0.50	60.00	1.00	1.00	2.00	3.00	10.00
Firm age		3.98	1.46	1.00	6.00	2.00	3.00	4.00	5.00	6.00
Generalists	5.93									
Generalists (disciplines)	4.47									
Team foundations:	61.38									
Employment growth (growth factor)		1.16	0.27	0.32	4.36	0.88	1.00	1.10	1.26	1.58
Number of employees in foundation year[1]		5.51	7.25	0.50	85.00	1.50	2.00	4.00	6.00	15.00
Firm age		3.71	1.43	1.00	6.00	2.00	3.00	4.00	5.00	6.00
Generalistic team	43.74									
Generalistic team (disciplines)	36.15									
Homogeneous	70.98									

Notes: [1] Full-time equivalent jobs. Number of observations: 1,149 (single entrepreneurs), 1,826 (team foundations). Firms founded between 1996 and 2001.
Descriptive statistics of the control variables can be found in Table 7 in the appendix.

Source: ZEW spinoff-survey 2001.

The age of the foundations is evenly distributed for both foundation types with an average age of 3.98 years of the single foundations and 3.71 years of the team foundations. The foundations by single entrepreneurs are therewith somewhat older.

Almost all of the single entrepreneurs in the sample are specialists, i.e. they have studied only one subject. Only about 6 percent of the single entrepreneurs have broadened their skill profile by learning a second subject and are therefore regarded as generalists. This number declines to 4.5 percent if generalists with respect to disciplines are considered. That is, if an individual decides to study a further subject he chooses a subject from another discipline in most of the cases. Among the team foundations the fraction of generalized teams is lower than the fraction of specialized teams: About 44 percent of the team foundations consist of partners with different backgrounds. Looking on disciplines the fraction of generalistic teams declines to 36 percent. Regarding the homogeneity of the quality, 71 percent of the team foundations are erected by partners who originate from the same research establishment.

As can be seen from Table 7 in the appendix, the foundation types hardly differ concerning their distribution over the sectors. Most of the foundations are established in the technology-oriented services (42 percent for both types). In the second place range the knowledge-intensive services: 42 percent of the firms with a single entrepreneur and 40 percent of the team foundations are established in this sector. Only 16 percent of the single foundations and about 18 percent of the team foundations occur in the high-tech industry.

3.4 Results

In the following the estimation results are presented.

Teams vs. Single Entrepreneurs. At first the hypothesis that team foundations are more successful than single foundations is analyzed (hypothesis 1). The results of the respective regression are shown in Table 2. The interesting coefficients in this case are the ones relating to the dummies *Team in high-tech industry*, *Team in technology-oriented services* and *Team in knowledge-intensive services.*

Table 2: Employment Growth and Team Foundation

Dependent Variable: *Employment Growth*: $\frac{ln(E_{2002,i})-ln(E_{t,i})}{2002-t_i}$	Coeff. (Std. Error)
Team in high-tech industry	0.047 (0.020)**
Team in technology-oriented services	0.046 (0.011)***
Team in knowledge-intensive services	0.047 (0.013)***
$ln(E_t)$	-0.092 (0.018)***
$ln(A)$	0.212 (0.023)***
$ln(E_t) * ln(A)$	0.012 (0.009)
$(ln(E_t))^2$	0.009 (0.004)**
$(ln(A))^2$	-0.100 (0.010)***
Job experience	-0.002 (0.000)***
Number of contacts to science	0.018 (0.002)***
Continuous R&D	0.051 (0.009)***
Occasional R&D	0.016 (0.010)
Public support	0.028 (0.008)***
Technology-oriented services[1]	-0.021 (0.018)
Knowledge-intensive services[1]	-0.002 (0.019)
Constant	0.037 (0.027)
R^2	0.120
F(15, 2703)	29.08***
Number of observations	2,719

Notes: [1]reference category: high-tech-industry.
***, ** depict significance at the 1% and 5% level respectively.
Source: ZEW spinoff-survey 2001, own calculations.

Obviously, team foundations are more successful than single foundations in terms of employment growth. The coefficient of *Team in industry j* is significant and has positive values across the industries. A firm which is founded by a team in the high-tech industry experiences an employment growth that is about 4.8 percent higher than a firm that is founded by one person alone in the same sector.[8] Equivalently, team foundations in technology-oriented services have an employment growth that is roughly 4.7 percent above the employment growth by single foundations in this industry. And team foundations in the knowledge-intensive services experience a roughly 4.8 percent higher employment growth than their counterpart founded by a single person in the knowledge-intensive services.

Concerning the control variables the results are virtually consistent with what one would expect and what is previously found in the literature. It turns out that there is a U-shaped relationship between firm size at market entry (measured in terms of the number of employees including the founders at foundation time) and employment growth. In addition, the speed of growth is higher when the firms are in their first year of existence. These patterns coincide with the results of e.g. Evans (1987) and Almus and Nerlinger (1999). Additionally, the number of contacts to science, the conduction of R&D and public support have all positive and highly significant effects on employment growth. Somewhat unexpected is the negative sign of the coefficient of job experience. The reason for this could be that with this variable not only the effect of job experience is captured but also the effect of age. If older entrepreneurs do not tend to set up an expanding firm - because they cannot reap the benefits for a sufficiently long time - then the sign of the variable measuring job experience can be explained. However, this effect cannot be controlled for since there is no information about age in the data set.

Generalists vs. Specialists. Hypothesis 2 contrasts generalists against specialists on the level of single entrepreneurs. The impact of having a generalist rather than a specialist as a firm leader is shown in Table 3. The interesting coefficients in this case are the ones relating to the variables in the first three rows.

[8] The impact of the interesting variables on the average employment growth factor is calculated according to e^{β_k}.

Table 3: Employment Growth and Generalists

Sample: single entrepreneurs Dependent Variable: *Employment Growth*: $\frac{ln(E_{2002,i})-ln(E_{t,i})}{2002-t_i}$	Subjects Coeff. (Std. Error)	Disciplines Coeff. (Std. Error)
Generalist in high-tech industry	-0.105 (0.051)**	-0.105 (0.051)**
Generalist in technology-oriented services	0.034 (0.039)	0.042 (0.057)
Generalist in knowledge-intensive services	-0.022 (0.051)	0.004 (0.056)
$ln(E_t)$	-0.065 (0.030)**	-0.066 (0.030)**
$ln(A)$	0.204 (0.038)***	0.204 (0.038)***
$ln(E_t) * ln(A)$	0.006 (0.016)	0.007 (0.016)
$(ln(E_t))^2$	0.007 (0.006)	0.007 (0.006)
$(ln(A))^2$	-0.087 (0.018)***	-0.087 (0.018)***
Job experience	-0.002 (0.001)***	-0.002 (0.001)***
Number of contacts to science	0.023 (0.004)***	0.023 (0.004)***
Continuous R&D	0.042 (0.015)***	0.042 (0.015)***
Occasional R&D	-0.008 (0.017)	-0.007 (0.017)
Public support	0.032 (0.016)**	0.032 (0.016)**
Technology oriented services[1]	-0.027 (0.021)	-0.026 (0.021)
Knowledge intensive services[1]	0.001 (0.022)	-0.000 (0.022)
Constant	0.022 (0.035)	0.021 (0.035)
R^2	0.119	0.119
F(15, 905)	9.61***	9.48***
Number of observations	921	921

Notes: [1]reference category: high-tech-industry.
***, ** depict significance at the 1% and 5% level respectively.

Source: ZEW spinoff-survey 2001, own calculations.

It turns out that generalized single entrepreneurs are not more successful than their specialized colleagues. The coefficients for *Generalist in technology-oriented services* and *Generalist in knowledge-intensive services* are insignificant. Though there appears to be an effect for generalists in the high-tech industry this result is presumably not valid since the respective data cell contains only three observations. If one omits the distinction between the industries to increase the number of observations in the cell the respective coefficient is also insignificant (see Table 8 in the appendix.) This result persists if generalists in regard to disciplines rather than single subjects are considered (i.e. defining an individual as generalist if he studied e.g. biology and business administration but not if he studied biology and chemistry). Thus, it seems that although generalists are more likely to found a firm, as shown by Lazear and others, they are not supportive for the subsequent growth of their firm. However, it cannot be obviated that the result is driven by the data restrictions, since having studied more than one subject is a rather rare event so that the effect of this group cannot be identified correctly. Additionally, since the information about the subjects is not very detailed, individuals who studied subjects which are inherently generalistic, such as Business Computer Science (*Wirtschaftsinformatik*), cannot be made up. For the analyses they are defined as specialists though they are actually generalists.

Generalistic Teams vs. Specialized Teams. Regarding the third hypothesis there is also no support for the conjecture that teams with a mixed composition concerning the subjects studied are more successful in terms of employment growth (see Table 4). All coefficients of the three relevant variables (*Generalistic team in high-tech-industry*, *Generalistic team in technology-oriented services* and *Generalistic team in knowledge-intensive services*) are insignificant both on the subject and discipline level.

This also holds for combinations between natural scientists and business administrators (see upper half of Table 5). Hunsdiek and Albach (1985) argue that it is necessary for high-technology companies to be successful to have natural sciences respectively technical skills and managerial skills or technical and managerial skills represented among the founders. The reason mentioned by the authors is that because of the rapid technology change and the necessity to be on the front edge of the development a single entrepreneur cannot do both: developing new

Table 4: Employment Growth and Generalistic Teams

Sample: team foundations		
Dependent Variable:	Subjects	Disciplines
Employment Growth: $\frac{ln(E_{2002,i})-ln(E_{t,i})}{2002-t_i}$	Coeff. (Std. Error)	Coeff. (Std. Error)
Generalistic team in high-tech industry	-0.031 (0.024)	-0.036 (0.024)
Generalistic team in technology-oriented services	0.019 (0.014)	0.019 (0.015)
Generalistic team in knowledge-intensive services	-0.006 (0.015)	-0.002 (0.015)
$ln(E_t)$	-0.149 (0.027)***	-0.149 (0.027)***
$ln(A)$	0.236 (0.032)***	0.237 (0.032)***
$ln(E_t) * ln(A)$	0.023 (0.013)*	0.023 (0.013)*
$(ln(E_t))^2$	0.020 (0.005)***	0.019 (0.005)***
$(ln(A))^2$	-0.122 (0.013)***	-0.123 (0.013)***
Job experience	-0.002 (0.001)***	-0.002 (0.001)***
Number of contacts to science	0.015 (0.003)***	0.015 (0.003)***
Continuous R&D	0.053 (0.011)***	0.053 (0.011)***
Occasional R&D	0.028 (0.013)**	0.028 (0.013)**
Public support	0.025 (0.010)**	0.025 (0.01)**
Technology-oriented services[1]	-0.048 (0.020)**	-0.045 (0.018)**
Knowledge-intensive services[1]	-0.015 (0.021)	-0.016 (0.019)
Constant	0.146 (0.042)***	0.146 (0.041)***
R^2	0.132	0.133
F(15, 1661)	20.89***	20.98***
Number of observations	1,677	1,677

Notes: [1]reference category: high-tech-industry.

***, **,* depict significance at the 1%, 5%, and 10% level respectively.

Source: ZEW spinoff-survey 2001, own calculations.

products and managing the firm. However, at least for the success of academic spin-offs in Germany which have natural scientists and business administrators among their founders it does not seem to be relevant whether the founding team comprises both of these skills. Teams with natural scientists and business administrators in the three sectors are not more successful than firms whose founding teams do not show this combination. The picture becomes somewhat different if one considers the combination of engineers and business administrators. In the technology-oriented services this combination seems to be beneficial. A team foundation that has engineers and business administrators among their founders grows by 4.9 percent more than a team in this sector that does not exhibit this combination. In the two other sectors no effect appears. If one restricts the coefficient to be the same across industries then a team with engineers and natural scientist experience an employment growth that is 4.3 percent higher than a team with other combinations of the studied subjects (see Table 8 in the appendix).

Homogeneous vs. Heterogeneous. The fourth hypothesis contrasts homogeneous teams in regard to the quality to heterogenous teams. The results of the regression are shown in Table 6. It turns out that the coefficient for homogeneous teams in regard to the quality (measured in terms of the research establishment its members come from) are insignificant across all industries and model specifications. Thus, the human capital composition of teams does not seem to play any role for the success of the newly founded firms.

Table 5: Employment Growth and Generalistic Teams

Sample: team foundations Dependent Variable: *Employment Growth*: $\frac{ln(E_{2002,i})-ln(E_{t,i})}{2002-t_i}$	Coeff. (Std. Error)	R^2	F(15, 1661)
Team with natural scientists and business administrators		0.130	20.70***
in high-tech industry	0.005 (0.038)		
in technology oriented services	0.015 (0.028)		
in knowledge-intensive services	0.010 (0.026)		
Technology oriented services[a]	-0.026 (0.014)*		
Knowledge intensive services[a]	-0.003 (0.015)		
Constant	0.129 (0.039)***		
Team with engineers and business administrators		0.133	20.58***
in high-tech industry	0.064 (0.049)		
in technology oriented services	0.048 (0.024)**		
in knowledge-intensive services	0.025 (0.028)		
Technology-oriented services[1]	-0.023 (0.014)		
Knowledge-intensive services[1]	0.000 (0.015)		
Constant	0.097 (0.037)***		

Notes: [1] reference category: high-tech-industry. Additional control variables included.
***,**,* depict significance at the 1%, 5% and 10% level respectively; number of observations: 1,677.
Source: ZEW spinoff-survey 2001, own calculations.

Table 6: Employment Growth and Homogeneous Teams

Sample: team foundations Dependent Variable: *Employment Growth*: $\frac{ln(E_{2002,i})-ln(E_{t,i})}{2002-t_i}$	Coeff. (Std. Error)
Homogeneous team in high-tech industry	0.020 (0.028)
Homogeneous team in technology-oriented services	0.003 (0.016)
Homogeneous team in knowledge-intensive services	0.015 (0.015)
$ln(E_t)$	-0.152 (0.029)***
$ln(A)$	0.238 (0.034)***
$ln(E_t) * ln(A)$	0.022 (0.014)
$(ln(E_t))^2$	0.021 (0.005)***
$(ln(A))^2$	-0.121 (0.013)***
Job experience	-0.002 (0.001)***
Number of contacts to science	0.016 (0.003)***
Continuous R&D	0.052 (0.012)***
Occasional R&D	0.026 (0.014)*
Public support	0.026 (0.011)**
Technology-oriented services[1]	-0.019 (0.028)
Knowledge-intensive services[1]	0.015 (0.028)
Constant	0.114 (0.043)***
R^2	0.141
F(15, 1546)	20.03***
Number of observations	1,562

Notes: [1]reference category: high-tech-industry.
***, **,* depict significance at the 1%, 5%, and 10% level respectively.

Source: ZEW spinoff-survey 2001, own calculations.

4 Conclusion

The starting question of this paper has been how the composition of human capital is related to the success of academic spin-off. The ulterior motive has been to figure out indications for the adjustment of academic curricula towards the job qualification of students for a job. To this end the models of Lazear (2005) and Fabel (2004) have been interpreted with regard to this question and tested subsequently by using a firm level data set including information on the educational background of the founders. In summary, the results are:

- Team foundations are more successful (i.e. exhibit higher employment growth) in founding firms than single entrepreneurs.
- Single entrepreneurs who have studied several subjects are equally successful than single entrepreneurs who have studied only one subject. However, this result may be driven by the fact that studying more than one subject is a rather rare event and inherently generalistic study courses cannot be specified in the data.
- Teams in technology-oriented services which have engineers and business administrators among their founders, experience higher employment growth than teams who do not have this combination in this sector. Otherwise it seems to be irrelevant whether a team consists of members who have studied different subjects.
- It does not seem to be beneficial to combine people from different types of research establishments.

The results slightly indicate that the approach of Fabel is more relevant for graduates founding an own firm out of academia, since the results show teams that are more successful. However, for the design of academic curricula the outcome is not very helpful since the constitution of teams is clearly not necessarily a topic of the design of curricula on the content level. Here, the relevant point is that individuals are matched. Naturally, this can happen in different ways. Individuals with the will to found a firm can meet in special courses on entrepreneurship. However, a university-wide social gathering or even a gathering outside the university would also suit for this purpose.

A question that comes up from this analysis for further research is why there are single entrepreneurs at all, if teams come out to be more successful. Some authors suggest that it depends on the industry whether a firm is founded by a team or not (e.g. Gartner, 1985). However, running a probit of the dependent dummy variable "Team" on the industry dummies as a first try it turns out that the different industries do not have any effect on the probability of founding as a team. Thus, the question remains and does not seem to be addressed in the literature yet.

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Table 7: Descriptive Statistics of control variables

	Single Entrepreneurs					Team Foundations				
Variable:	Mean	Std. Dev.	Min	Max	Obs.	Mean	Std. Dev.	Min	Max	Obs.
Job experience	8.14	8.89	0	45	1,036	5.80	7.53	0	37	1,683
Number of contacts to science	1.23	1.61	0	6	1,149	1.75	1.82	0	6	1,826
Continuous R&D	0.27	0.44	0	1	1,149	0.37	0.48	0	1	1,826
Occasional R&D	0.13	0.34	0	1	1,149	0.15	0.35	0	1	1,826
Public support	0.27	0.45	0	1	1,149	0.31	0.46	0	1	1,826
High-tech industry	0.16	0.36	0	1	1,149	0.17	0.38	0	1	1,826
Technology oriented services	0.42	0.49	0	1	1,149	0.42	0.49	0	1	1,826
Knowledge intensive services	0.42	0.49	0	1	1,149	0.41	0.49	0	1	1,826

Source: ZEW spinoff-survey 2001, own calculations.

Table 8: Results for the four hypothesis without differentiation between industries

Dependent Variable: *Employment Growth*: $\frac{ln(E_{2002,i})-ln(E_{t,i})}{2002-t_i}$	Coeff. (Std. Error)	R^2	Obs.	Sample
Hypothesis 1:				
Team	0.046 (0.009)***	0.120	2,719	all firms
Hypothesis 2:				
Generalist with respect to subjects	0.004 (0.030)	0.117	921	single entrepreneurs
Generalist with respect to disciplines	0.012 (0.037)	0.117	921	single entrepreneurs
Hypothesis 3:				
Generalistic team with respect to subjects	0.000 (0.009)	0.130	1,677	team foundations
Generalistic team with respect to disciplines	0.001 (0.010)	0.130	1,677	team foundations
Team with natural scientists and business administrators	0.012 (0.018)	0.131	1,667	team foundations
Team with engineers and business administrators	0.042 (0.017)**	0.133	1,677	team foundations
Hypothesis 4:				
Homogeneous team	0.011 (0.011)	0.140	1,562	team foundations

Notes: ***, ** depict significance at the 1% and 5% level respectively. Same control variables included as in the respective regressions in the main text.

Source: ZEW spinoff-survey 2001, own calculations.