Discussion Paper No. 13-004

University Spinoffs and the "Performance Premium"

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and Andrew A. Toole

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Das Wichtigste in Kürze

Spinoff-Gründungen aus der Wissenschaft werden häufig als ein effektiver Weg des Wissens- und Technologietransfers angesehen, um Forschungsergebnisse wirtschaftlich anzuwenden zu und erfolgreich zu kommerzialisieren. Dabei wird selten beachtet, dass Spinoff-Gründungen durch Wissenschaftler höhere soziale Kosten verursachen als Neugründungen durch Ausbildungsabgänger oder in der Privatwirtschaft Beschäftigte. Denn bei Unternehmensgründungen durch Wissenschaftler kann das in der Wissenschaft akkumulierte Wissen verloren gehen, und anstelle einer Veröffentlichung von erzielten Forschungsergebnisse mit positiven Spillover-Effekten tritt die rein private Nutzung. Um diese höheren sozialen Kosten auszugleichen, sollten Spinoff-Gründungen durch Wissenschaftler höhere soziale Erträge erzielen, indem sie eine bessere Performance aufweisen.

Auf Basis eines repräsentativen Datensatzes zu Unternehmensgründungen in wissensintensiven Wirtschaftszweigen in Deutschland zeigt der vorliegende Aufsatz, dass Spinoff-Gründungen aus der Wissenschaft - d.h. Unternehmensgründungen, an denen zumindest eine Person beteiligt ist, die zuvor in einer Wissenschaftseinrichtung gearbeitet haben oder dies während der Unternehmensgründung noch tun - ein höheres Beschäftigungswachstum um durchschnittlich 3,4 Prozentpunkte aufweisen. Der Performanceunterschied ist größer, wenn die Gründer selbst in der wissenschaftlichen Forschung (z.B. als Professoren oder wissenschaftliche Mitarbeiter) tätig waren. Spinoff-Gründungen, an denen Gründer aus den Rechts- und Sozialwissenschaften oder den Naturwissenschaften beteiligt sind, weisen ebenfalls ein höheres Wachstum auf.

Executive Summary

The creation of spinoff companies is often promoted as a desirable mechanism for transferring knowledge and technologies from research organizations to the private sector for commercialization. However, when university spinoffs involve an employment transition by a researcher out of the not-for-profit sector, the creation of a university spinoff is likely to impose a higher social cost than the creation of an industry startup. To offset this higher social cost which arise from the lost knowledge accumulation and disclosure in the not-for-profit research sector, university spinoffs must produce a larger stream of social benefits than industry startups, a performance premium.

Using data on new ventures founded in knowledge intensive industries in Germany and controlling for survivor bias, this paper finds that university spinoffs generally show greater employment growth than industry startups. For the overall group of university spinoffs, which are defined as new companies started by former or current university employees, the performance premium is 3.4 percentage points higher employment growth. This premium is higher for research academic entrepreneurs than non-research academic entrepreneurs. We also find performance differences by academic discipline, with higher employment growth for spinoffs with academic founders from law & social science or natural sciences. By creating more new jobs than industry startups, university spinoffs are offsetting their higher social cost, at least to some degree.

University Spinoffs and the "Performance Premium"[1][2]

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Abstract

The creation of spinoff companies is often promoted as a desirable mechanism for transferring knowledge and technologies from research organizations to the private sector for commercialization. In the promotion process, policymakers typically treat these "university" spinoffs like industry startups. However, when university spinoffs involve an employment transition by a researcher out of the not-for-profit sector, the creation of a university spinoff is likely to impose a higher social cost than the creation of an industry startup. To offset this higher social cost, university spinoffs must produce a larger stream of social benefits than industry startups, a performance premium. This paper outlines the arguments why the social costs of entrepreneurship are likely to be higher for academic entrepreneurs and empirically investigates the existence of a performance premium using a sample of German startup companies. We find that university spinoffs exhibit a performance premium of 3.4 percentage points higher employment growth over industry startups. The analysis also shows that the performance premium varies across types of academic entrepreneurs and founders' academic disciplines.

Keywords: Academic Entrepreneurship, Startups, Firm performance, Technology Transfer, Open Science, University Spinoff Policy, Human Capital, Social Capital

JEL-Classification: L25, L26, J24

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1 Introduction

Many national governments and public research organizations have implemented policies to promote the formation of university spinoff companies, reflecting a shift in the culture and mission of public research organizations toward an entrepreneurial paradigm (Etzkowitz 2004, Etzkowitz et al. 2000, OECD 2000, Lockett and Wright 2005, O'Shea et al. 2005, Mustar and Wright 2010). For instance, university administrators are expanding the practice of accepting equity in lieu of licensing fees and choosing to invest directly in spinoff companies (Desruisseaux 2000, Feldman et al. 2002, Di Gregorio and Shane 2003, Shane 2004). When combined with the growing use of venture capital and small firm financing programs, university researchers are increasingly involved in the most extreme form of entrepreneurial behavior – working part-time or full-time on commercialization in a spinoff company.[3]

Fostering technology transfer by incenting university researchers to form spinoff companies involves a potentially costly trade-off that is seldom (if ever) considered in policy discussions. Unlike startups formed by individuals already working in the private sector, university researchers must undertake an employment transition out of the not-for-profit research sector. As these academic entrepreneurs pursue commercialization, less time and cognitive effort is devoted to university research and their contribution to knowledge accumulation and disclosure decreases. The sacrifice of public research to pursue commercialization, especially when it involves the most productive university researchers, imposes a costly "brain drain" on the not-for-profit research sector (Toole and Czarnitzki 2010).

From a societal perspective, university spinoff policies are effective when they create incentives that produce a net gain in social welfare. This can be achieved when the social costs from lost knowledge accumulation and disclosure in the not-for-profit research sector are more than offset by the social benefits created through successful performance of

[3] Throughout the paper we will use "university" as shorthand for all public research organizations (PROs) in the not-for-profit sector.

university spinoffs in the private sector. Because the social costs of undertaking entrepreneurship are likely to be higher for academic entrepreneurs relative to industry entrepreneurs (since the contributions to "open science" by industry entrepreneurs are unlikely to change much when undertaking employment transitions within the private sector), university spinoffs must create a larger stream of social benefits than industry startups to produce an equivalent net gain in social welfare. In this sense, university spinoffs must achieve a "performance premium" relative to industry startups in order justify the adoption of university spinoff policies as a mechanism for technology transfer.

In light of the definitional inconsistencies found in the literature, it is important to be clear about the type of university spinoffs that necessitate a performance premium. There are two important elements. First, a university employee must undertake a partial or complete employment transition from the not-for-profit sector to the private sector. We refer to these individuals as academic entrepreneurs.[3] Second, the new company employing the academic entrepreneur must be based largely on the research results generated during his/her activity at the university. This second element restricts attention to university research staff such as professors, research scientists, and other employees who participate and contribute to open science. The transition to the private sector by these individuals is likely to involve some sacrifice of knowledge accumulation and disclosure which generates the social cost necessitating a performance premium for their spinoffs. We refer to these individuals as "research academic entrepreneurs" and their companies as "research spinoffs". All other academic entrepreneurs are referred to as "non-research academic entrepreneurs" and their companies are called "non-research spinoffs".

There is a small but growing literature that examines whether university spinoffs involving academic entrepreneurs perform better or worse than industry startups or spinoffs. Several studies find that university spinoffs are less likely to fail than industry startups (Nerkar and

[3] In our definition, a new company is a university spinoff when it involves an academic entrepreneur. New companies that were formed to commercialize a university technology (e.g. through the technology transfer office) or that received some kind of support from the university do not qualify as university spinoffs under our definition unless they also have an academic entrepreneur in the founding team.

Shane 2003, Rothaermel and Thursby 2005, Zhang 2009, Cantner and Goethner 2011). Toole and Czarnitzki (2007, 2009) find that firms with an academic entrepreneur perform better in terms of proof of concept research, patenting, and the receipt of follow-on venture capital investment. However, the results are mixed when considering other indicators of performance such as sales and employment. Zahra et al. (2007) find that university spinoffs performed better in terms of revenue growth, but worse in terms of return on assets and sales per employee. Ensley and Hmieleski (2005) and Wennberg et al. (2011) also find lower sales growth for university spinoffs. For employment growth, Wennberg et al. (2011) and Colombo and Piva (2005) find no significant differences, but Cantner and Goethner (2011) find that university spinoffs exhibit significantly lower employment growth.

This paper makes two contributions to the literature. First, we outline the reasons why the social costs of entrepreneurship are likely to be larger for academic entrepreneurs. From this conceptual development, it is clear that the required performance premium is not constant across all types of university spinoffs, but depends on the foregone contributions of the academic entrepreneurs to knowledge accumulation and disclosure in the not-for-profit research sector at the time the spinoff is founded. Second, we undertake an empirical analysis to investigate the existence of a performance premium for university spinoffs using a representative sample of German startup companies while controlling for potential survival bias that would otherwise lead to an overestimate of any performance premium. Our data, which represent knowledge intensive industries, allow us to differentiate between research and non-research academic entrepreneurs and control for the academic discipline of the founders.

The paper is organized as follows. In Section 2 we describe the reasons why the social costs of university spinoffs are likely to be larger and define the performance premium. This section also reviews recent studies on firm performance of university spinoffs. Section 3 describes the empirical model and the data. Section 4 presents the empirical results, and section 5 concludes with some reflections on the main findings and policy implications.

2 Theory and Hypotheses

The social costs of university spinoffs and the performance premium

The existence of a performance premium for university spinoffs relative to industry startups stems from the change in knowledge production and disclosure practices that take place when university researchers transition out of the not-for-profit research sector. Prior to this transition, university researchers contribute to knowledge production in an “open science” institutional environment. Their choices about research projects and disclosure are largely governed by the “priority reward” system of incentives (Dasgupta and David 1994, Stephan 1996). As Dasgupta and David (1994) describe, the priority reward system serves to direct research toward socially valuable outcomes (at least as interpreted by the community of scientific peers), speed up knowledge discovery, and promote rapid public dissemination. After transitioning to a spinoff in the private sector, however, academic entrepreneurs are subject to a new set of incentives and rewards that favor the pursuit of commercial opportunities and the exploitation of rents from new knowledge by restricting public disclosure.

One part of the potential social cost of university spinoffs is the subsequent decrease in the production of academic research. The literature on the economics of science and technological change offers a substantial body of evidence supporting the idea that academic research is important for innovation and productivity growth. For instance, Jaffe (1989) presents evidence that university research contributes to state-level corporate patenting. Adams (1990) shows that cumulative stocks of academic research stimulate productivity growth in manufacturing industries. Toole (2012) finds that university research makes a significant contribution to drug innovation in the pharmaceutical industry.[4] Unlike university spinoffs involving academic researchers, industry startups do not adversely affect the productive capacity for academic research.

Another part of the potential social cost of university spinoffs is the subsequent decrease in the disclosure of knowledge. Disclosure permits the stock of public knowledge to be

[4] See Salter and Martin (2001) for an overview.

cumulative, accessible, and reliable. It limits duplication of research efforts, allows new knowledge to be replicated and verified by professional peers, and permits access and use by other researchers which enhances opportunities for complementary research (Dasgupta and David 1994). In recent work, Murray et al. (2009) find that greater access to ideas and materials in academic research not only increased incentives for direct follow-on research, but led to an increase in the diversity of research by increasing the number of experimental research lines. Mukherjee and Stern (2009), who examined the theoretical conditions supporting “open science” versus “secrecy”, stress that maintaining and growing the stock of public knowledge requires a limit on the private financial returns obtained through secrecy. Relative to a secrecy system, open science is considered to be an efficient and welfare enhancing system for the production of scientific and technical knowledge (Dasgupta and David 1994, Mukherjee and Stern 2009).

The literature contains a handful of studies that examine how research productivity is affected when university researchers become involved in spinoff companies.[5] For academic entrepreneurs who remain full-time at their research institutions, the findings are mixed. Lowe and Gonzalez-Brambila (2007) find an increase in publication output for engineering faculty, but for science faculty, their publication output is not significantly different from the control group. Analyzing Max Planck scholars, Buenstorf (2009) shows that both publications and citations decrease significantly. When academic researchers work part-time or full-time at the for-profit company the emerging evidence is stronger that research productivity falls. For a sample of biomedical scientists supported by the U.S. National Institutes of Health (NIH), Toole and Czarnitzki (2010) find significant decreases in publications, journal impact factor weighted publications, and grantsmanship. Their most conservative estimate shows a 26% drop in average publication output per year for each academic entrepreneur (also see Czarnitzki and Toole 2010).

[5] There is a much broader literature studying the influence of patenting and industry sponsorship on academic research (see, for instance, Agrawal and Henderson 2002, Azoulay et al. 2009, Breschi et al. 2007, Czarnitzki et al. 2009, 2012, Rosenberg 1998).

Most of these studies find that spinoff involvement by university researchers is associated with a reduction in academic research productivity.[6] The stream of benefits that would have resulted from this lost research represents a social cost attributable to the employment transition of university researchers out of the not-for-profit research environment. Because industry entrepreneurs do not transition across sectors to start a new company, industry startups do not impose a social cost from lost knowledge accumulation or disclosure. While employment transitions within the private sector also involve trade-offs, the mobility of labor across industries through mechanisms such as entrepreneurship are usually seen as welfare enhancing when consumer preferences are expressed through market signals. This suggests that the social costs from private sector entrepreneurship are likely to be low. From a societal perspective, university spinoffs that involve an academic entrepreneur must create a larger stream of social benefits than industry startups to offset their higher social cost. That is, university spinoffs must achieve a performance premium relative to industry startups to produce an equivalent gain in social welfare. Policies that promote university spinoffs involving academic entrepreneurs implicitly assume a performance premium exists. This leads to our first hypothesis:

(H1) University spinoffs involving an academic entrepreneur will show a performance premium relative to industry startups, ceteris paribus.

It is important to recognize that the size of the performance premium is not constant across all types of university spinoffs.[7] Its size will depend on the identity of the academic entrepreneur. For instance, the performance premium will need to be near its maximum size in order to outweigh social costs when "star" scientists are involved in spinoffs. At the other extreme, no performance premium would be necessary for an academic entrepreneur who

[6] The current body of empirical evidence on changes in research productivity is limited to samples drawn from science and engineering fields. Importantly, the theoretical argument about the potential social costs of university spinoffs is not limited to any particular field of study. For instance, academic researchers in law and social science fields may reduce their contributions to open science when pursuing entrepreneurship. Given the stage of research in the literature, there is no information available that would suggest one field of study is more socially valuable than another.

[7] The stream of benefits that would have been derived from a university researcher's future contributions to academic research and disclosure is an unobservable counterfactual since the academic entrepreneur cannot be observed as both a full-time university researcher and a spinoff entrepreneur at the same time. This complicates any attempt to directly estimate of the necessary size of the performance premium.

does not contribute (or is not expected to contribute) to knowledge accumulation and disclosure. From a societal perspective, the performance premium implicit in university spinoff policies is larger when the expected loss in academic research productivity is larger. This leads to our second hypothesis:

(H2) University spinoffs involving a research academic entrepreneur will show a larger performance premium than university spinoffs with a non-research academic entrepreneur, ceteris paribus.

University spinoff performance: Might we expect a performance premium?

The hypotheses stated above specify what we would like to see from a policy perspective, but based on the existing literature, is it reasonable to expect university spinoffs to perform better than industry startups? Scholars highlight differences in market opportunities, the human and social capital of the founder(s), and connections to universities as determinants of performance. Looking at the literature, however, one finds different theoretical perspectives as well conflicting empirical results.[8]

Some scholars suggest that university spinoffs will perform better due to a competitive advantage in selecting and/or exploiting market opportunities. Using a theoretical model, Lacetera (2009) argues that university researchers face higher opportunity costs of undertaking entrepreneurship than do industry entrepreneurs. For a given set of market opportunities, academic entrepreneurs select those opportunities with greater expected revenues and this leads university spinoffs to perform better than industry startups. Another source of better performance could be access to radical technologies that provide a competitive advantage for exploiting market opportunities (Shane 2001, Nerkar and Shane 2003). Researchers who participate in the discovery of new technologies may enter the market early with a first-mover advantage leading to better growth opportunities. For example, the method of recombinant DNA was a radical technology that allowed the founders

[8] See Rothaermel et al. (2007) and Helm and Mauroner (2007) for recent reviews of the literature.

of Genentech to gain a significant competitive advantage over traditional pharmaceutical manufacturers (Kenney 1986, Zucker and Darby 1998).

Against these arguments, other scholars suggest that university researchers are not able to identify the most profitable market opportunities or stress that university technologies are often too early-stage to be exploited effectively. Shane (2000) argues that differences between entrepreneurs in their prior knowledge of markets, how to serve markets, and how to identify customer needs lead to the discovery of different market opportunities, even with the same technology. In this sense, industry entrepreneurs may be able to identify more valuable market opportunities leading to better startup performance (also see Druilhe and Garnsey 2004, Vohora et al. 2004, Wennberg et al. 2011). Given the early-stage nature of many university-based discoveries, university spinoffs are likely to face more technological and market uncertainty. Higher uncertainty exacerbates information asymmetries that may limit access to human and financial resources needed for spinoff growth (Shane 2004, Toole and Czarnitzki 2007, Wright et al. 2004b, Lockett and Wright, 2003).

The literature also suggests different growth prospects for university spinoffs based on the human and social capital of the academic entrepreneurs. The specialized human capital of academic entrepreneurs can be a source of firm-specific capabilities and superior performance. Looking at "star" scientists, Zucker et al. (2002) find that various measures of success for biotechnology firms such as patents and products in development significantly increase with the degree of involvement by university scientists. For a sample of companies in the U.S. Small Business Innovation Research (SBIR) Program, Toole and Czarnitzki (2007, 2009) show that firms with an academic entrepreneur perform better in terms of patents, proof of concept research, and raising venture capital investment. Colombo and Piva (2005) also find that university spinoffs are more innovative than industry startups, but this difference did not carry over to their results on growth. With respect to social capital, several studies suggest that academic entrepreneurs are more embedded in the scientific community which may facilitate establishing and exploiting collaborative relationships with universities and help to attract venture capital investment (Nicolaou and Birley 2003a,b, Murray 2004). Using data on MIT start-ups, Shane and Stuart (2002) find that social network ties to investors (angel funding or venture capital) decrease the probability of failure and increase the likelihood of venture capital funding, although they did not explicitly identify those firms with an academic entrepreneur on the founding team.

Other scholars posit that university spinoffs are likely to perform worse than industry startups because the human capital of academic entrepreneurs is too academic. The nature of the human capital scientists develop over the course of their careers is shaped by the institutional incentive systems characterizing their work environments as well as the evolution of opportunities (Dasgupta and David 1994, Stephan 1996, Nelson 2004). University scientists who are particularly adept at pursing "academic goals," who we think of as individuals with a specialized form of human capital that is honed for identifying and exploring academic opportunities, may not be well suited for advancing invention in an industrial research environment. This suggests that academic entrepreneurs may lack the commercial skills, market knowledge or the ability to balance between timeliness and scientific accuracy of research activities, which together may result in a worse business performance compared to industry startups. Toole and Czarnitzki (2009) find that academic entrepreneurs contribute to patenting, but this contribution falls as their science-oriented human capital increases – a form of diminishing returns to science-oriented human capital. Ensley and Hmieleski (2005) expect university spinoffs to perform worse because the top management team is more homogeneous and has less developed working dynamics. Wennberg et al. (2011) find that university spinoffs exhibit lower survival and slower sales growth than corporate spinoffs. They attribute the superior performance of corporate spinoffs to more exposure to market knowledge during the industry entrepreneurs' careers outside academia.

Connections to universities could benefit both spinoffs and industry startups by allowing access to new knowledge, students, training, and other resources. The overall literature studying the effects of such "science linkages" on firm performance is quite broad and diverse. Spinoffs or industry startups could be connected to universities through a wide range of channels such as joint research projects, performing contract research for the university, contracting research out to the university, sending employees to the university for training, accepting student interns at the company, or maintaining informal contacts. In the empirical analysis, a dummy variable is used to control for university connections.

3 Empirical Model and Data

Model

To investigate our hypotheses about the performance premium, we analyze the relative growth of university spinoffs and industry startups in knowledge intensive industries. Spinoff performance can be viewed from a number of different perspectives such as innovation in products or services, sales, market value, or employment. For the performance premium, we require an indicator that captures a socially valuable outcome that can be interpreted as offsetting the social cost of lost knowledge accumulation and disclosure in the not-for-profit research sector. Innovation indicators such as patents are probably poor candidates since the economic value of most patents is extremely low. In this paper, we focus on employment growth. The creation of new jobs is arguably one of the most important outcomes of entrepreneurship (World Bank 2012). In the empirical analysis, employment growth is measured in terms of the annualized logarithmic change in the number of employees between the first year of commercial operation of a new venture (*s*), and a reference year (*t*).

Heckman selection models are used to control for potential survivor bias in the population of new ventures over time.[9] The outcome equation models employment growth as a function of the characteristics of the founding team, resource endowments of the new venture at the time of entering the market, and aspects of its external environment (see Storey 1994). A dummy variable, called *AE*, identifies university spinoffs as new venture(s) with an academic entrepreneur(s) as part of the founding team. To examine hypothesis #1, the outcome equation in the Heckman model has the following form:

$$\mathrm{EMP}_{\mathrm{Growth}_i} = \beta_0 + \beta_1 \mathrm{AE}_i + \beta_2 \mathit{Control\ Variables}_i + \beta_3 \lambda_i + \varepsilon_i$$

Where the subscript i represents new ventures and “Control Variables” is shorthand for all other covariates in the regression specification. The coefficient on *AE* captures the difference in employment growth between university spinoffs and industry startups. If university spinoffs exhibit a performance premium for employment growth, the coefficient β_1 will be

[9] See e.g. Heckman (1976), (1979), or Verbeek (2012: 248-252) for details on the Heckman selection model.

positive and statistically significant. λ_i denotes the selection term also known as Heckman's lambda or inverse mills ratio.

For hypothesis #2, we define two additional dummy variables in order to split university spinoffs into subgroups. *Research_AE* takes the value of one for university spinoffs with a research academic entrepreneur(s) as part of the founding team. Similarly, *Non_Research _AE* is defined to be one when the university spinoff has a non-research academic entrepreneur(s) on the founding team. In this case, the outcome equation in the Heckman model has the following form:

$$EMP_{Growth_i} = \beta_0 + \beta_1 Research_{AE_i} + \beta_2 Non_{Research\_AE_i} \#$$

$$+ \beta_3 Control\ Variables_i + \beta_4 \lambda_i + \varepsilon_i$$

Once again the coefficients β_1 and β_2 capture the performance premiums for university spinoffs. However, because research academic entrepreneurs are likely to be associated with a larger social cost, we would like to observe $\beta_1 > \beta_2$ in order to find support for university spinoff policies from a societal perspective.

Sample and Survey Method

Our empirical analysis is based on a survey of German firms that were founded in the five years 1996 to 2000 in "knowledge intensive industries", i.e. in high-tech manufacturing and in those service sectors where new technologies and human capital are important for competitiveness (see Appendix 1 for a definition of the sectors used). The new ventures were surveyed by telephone interviews, using stratified random sampling combined with quota sampling. For each stratum in the gross sample, new ventures were ordered randomly and interviews were conducted until a target figure of successful interviews in each stratum was reached. We used sector groups (high-tech manufacturing, technology-oriented services, knowledge-intensive consulting), year of foundation (1996-2000), and region (separating three types of regions according to the existence of research universities in the region, and their entrepreneurial orientation) as stratification criteria and applied a disproportional weighting, oversampling high-tech manufacturing and regions with research universities. Interviews were conducted with a person that was part of the founding team. The interviews took place from late October to early December 2001. The new ventures were between one year (for start-ups founded at the end of 2000) and almost 6 years (for start-ups founded at the beginning of 1996) old at the time of the interviews.

The sample was drawn from the Mannheim Foundation Panel (MFP) of the Centre for European Economic Research (ZEW). This data set contains almost all firms founded in Germany since 1989 and rests on information from Germany's largest credit rating agency, *Creditreform*. In principle, only firms meeting a minimum threshold of economic activity enter the database. *Creditreform* transmits information twice a year on newly founded firms to ZEW where it is transformed into a panel data structure (see Almus et al. 2000). Among others, the MFP contains data on founding date, personal characteristics of founders, description of economic activity, credit rating and employment.

The total number of new ventures surveyed is 20,241. In order to realize this number of interviews, a total of 57,022 firms had to be contacted. Those firms that were contacted but with whom no interview could be performed fell into two groups: (1) firms that refused to participate in the survey or could not be contacted during the interview period because the interviewee was not available (n=25,359) and (2) firms for which the existing contact details turned out to be incorrect and no better contact information could be identified (n=11,422). The response rate of surveyed firms to the total number of successfully contacted firms at the time of survey was 44.2%.

It turned out that 19.4% of the surveyed firms were actually founded prior to 1996. In most of these cases, the founding data contained in the MFP indicated a change in legal form of the company, while the real market entry took place earlier. A further 3.0% of the surveyed firms were founded as subsidiaries by other companies and are thus regarded as non-original new ventures. After omitting these firms, we also filtered out extreme observations by trimming the top and bottom of the employment distribution growth at the 99.5 and 0.5 percentiles, respectively. The net sample we use for further analysis consists of 14,844 new ventures.

These represent about 5% of the total estimated number of new ventures in Germany within the 5 year period and in the sectors covered by the survey.

Due to budget constraints, a smaller telephone questionnaire was given to industry startups than was given to university spinoff companies. The smaller questionnaire still included many items. For instance, it asked about the number of firm founders, the education of the founders, the employment at the new venture at founding and at the time of the interview, in-house R&D activities, and ongoing collaboration with universities.[10] New ventures involving an academic entrepreneur (e.g. university spinoffs) were asked additional questions such as the academic background of the university founder(s), their university employment status, the name of the parent institutions, and the use of university knowledge (see Egeln et al. 2003 for more details on the questionnaire and descriptive results).

For those new ventures in the gross sample that could not be successfully contacted due to incorrect contact details (e.g. invalid phone number), we analyzed whether these firms have indeed exited the market prior to the time of interviews. We use information contained in the MFP on bankruptcy, insolvency, deregistration from company registers, voluntary closures and other rating-related information for this purpose. About ninety-seven percent (11,100 out of the 11,422 not successfully contacted) were identified as non-surviving firms. This is equal to an exit ratio of 19.5% of all contacted new ventures. This high exit ratio demonstrates that the sample of surveyed new ventures may be a distorted sample of the population of all newly started businesses in the knowledge intensive sectors of the German economy that entered the market between 1996 and 2000 since many of these new ventures ceased business soon after start. Since the variables that explain why a new venture ceased business may be correlated with the variables that explain growth of surviving new ventures, we control for a likely survival bias by using a Heckman selection model.

[10] Recall that we will use the term "university" when referring to any type of science institution. With respect to the German situation, science institutions primarily comprise state-funded universities and other publicly funded research organisations (such as Max Planck Institutes, Fraunhofer Institutes and governmental laboratories and research centres) as well as a few private universities.

Data and variables in the Selection (Survival) Model

The selection model for the Heckman procedure uses data from the Mannheim Foundation Panel (MFP) to model the probability of survival for new ventures in knowledge intensive industries. MFP information on the population of new ventures includes the founding year, industry (NACE 5-digit), location, equity ownership by other firms, credit rating, number of firm founders, family status, real estate property of firm founders, and the highest level of formal educational attainment. The endogenous variable in the survival model is a dummy variable that takes the value of one if the startup was active in 2001 and zero if (1) a startup could not be successfully contacted during the telephone interview due to incorrect contact details or (2) the startup was identified as not economically active at the end of 2001 from MFP. The covariates in the selection equation include the following: founding year dummy variables, industry dummy variables, regional dummy variables, startup equity held by another firm, formal educational attainment, real estate property owned by firm founders.

Variables in Growth Model

The endogenous variable, employment growth, is measured by the annualized logarithmic change in the number of employees in the first year of firm activity to the end of 2001. The explanatory variables fall into three categories. The first category includes characteristics of the founding team. The following founding team covariates are used:

AE	A dummy variable equal to one if the new venture had at least one university employee (former or current) on the founding team. These individuals are called academic entrepreneurs and their firms are categorized as university spinoffs.
Research_AE	A dummy variable that is equal to one if the university spinoff had at least one academic entrepreneur that was involved in university research. To make this distinction, we asked the university spinoffs whether new research results generated during their activity at the university were essential or at least very important for starting the business. Research results include scientific discoveries or methods, techniques and technologies developed at university.

Non_Research_AE	A dummy variable that is equal to one if the university spinoff had at least one academic entrepreneur that was not a university researcher. This group is identified from the difference between the total number of university spinoffs and the number of spinoffs with a research academic entrepreneur.
% Academic Degree	This variable captures the general human capital of the founding team. It is measured as the percentage of founding team members with an academic degree. Academic degree refers to any tertiary education level.
Team Size	The number of people on the founding team.

The second category includes characteristics of new the venture at the time of founding. The following covariates are used:

Science	A dummy variable indicating that the university spinoff had at least one academic entrepreneur from the natural or life science disciplines. Natural and life science include physics, chemistry, biology, medicine, pharmacology, geology and mathematics.
Engineering	A dummy variable indicating that the university spinoff had at least one academic entrepreneur from engineering. Engineering fields include mechanical and electrical engineering, civil engineering, architecture and planning and other engineering.
Other Field	A dummy variable indicating that the university spinoff had at least one academic entrepreneur whose field of study was law or social science disciplines such as business administration, economics, psychology and so forth.
Firm Patent	A dummy variable indicating the new venture had at least one patent.
Firm R&D (cont)	A dummy variable indicating that the new venture conducts in-house research and development (R&D) activities on a continuous basis. The survey used the same definition and phrasing as the Community Innovation Surveys of Eurostat.

Firm R&D (occ) A dummy variable indicating that the new venture conducts in-house research and development (R&D) activities on an occasional basis. The survey used the same definition and phrasing as the Community Innovation Surveys of Eurostat.

Employees at founding The number of employees at the new venture in the first year of economic activity. The number of employees is measured in full time equivalents and includes the founders themselves (as long as they actively contribute labor), salaried employees, trainees, student apprentices and freelancers.

Credit rating The credit rating of the new venture was obtained from *Creditreform*. This covariate controls for access to external financial capital. *Creditreform* uses a scale from 100 to 600 with 100 representing the best and 600 representing the worst rating. We normalize the scale to be between 1 and 6.

Limited liability Comp A dummy variable indicating that the new venture was founded under a legal form that limits the founders liability. For instance, one legal form limits the founders' liability to the amount of equity invested at the start of the business. However, it requires a higher minimum equity for starting the business and may complicate access to external capital.

The third category includes characteristics related to the new venture's external environment which includes any connections to universities. The covariates in this category include:

Connections A dummy variable indicating that the new venture maintains any connection to a university in the post-foundation period. For the regression models in Table 2, any connection includes joint research, contracting in, contracting out, employee training, student interns, and regular informal contact.

Industry A set of eight dummy variables controlling for the industry in which the new venture is active. The list of industries appears in Appendix 1.

Cohort This is a set of year dummy variables that indicate the year the new venture was founded. It controls for annual cohort effects for new ventures founded in different years, 1996-2000, which may result, among others, from differences in business climate.

4 Empirical Results

Table 1 presents the descriptive statistics for the sample of new ventures in Germany's knowledge intensive industries. The top panel reports the variables for industry startups and the bottom panel reports the information for university spinoffs. Based on the number of new ventures, university spinoffs are a relatively small proportion of total new ventures in knowledge intensive industries, representing only 7.8% of the surviving firms in 2001, the date of the survey. Slightly more than half of these university spinoffs, 52%, involve a research academic entrepreneur(s). Other founding team characteristics are also different between industry startups and university spinoffs. The average size of the founding team is larger for university spinoffs, an average of 2.3 FTEs versus 1.6 FTEs, but they also show a higher standard deviation than industry startups. About 90% of the founding team members of spinoffs have academic degrees whereas this percentage is only 45.6% for industry startups.

Among the characteristics of the new venture companies, university spinoffs are larger and appear to focus more on innovation than industry startups. Spinoffs have an average of 4.5 FTEs at founding while industry startups have an average of 3.5 FTEs. University spinoffs show larger average values across all the innovation indicators such as patents, R&D conducted continuously, and R&D conducted occasionally. For access to external financial capital, however, both spinoffs and industry startups have very similar average credit ratings, with only a slightly higher standard deviation for industry startups. Fewer industry startups are organized as legal forms involving some type of limit on liability. Among the science disciplines of the academic entrepreneurs, forty-one percent of university spinoffs have at least one founder from a science discipline (477 spinoffs), while thirty-two percent have at least one founder from an engineering discipline (371 spinoffs). Table 1 also shows that a much larger proportion of university spinoffs maintain connections to universities, 67.9% 28.9% respectively.

To investigate whether there is a performance premium for university spinoffs we analyzed both descriptive statistics and multivariate regression results based on Heckman models correcting for potential survivor bias. The unconditional descriptive results in Table 1 show an employment performance premium of 5.6 percentage points, which is statistically significant at the 1% level. The multivariate Heckman selection model results are reported in Table 2.[11] The Heckman procedure shows that correcting for survival is important. The Inverse Mills Ratio given at the bottom of the table is statistically significant at the 1% level. (This correction remains important for all models estimated in our analysis.) In the first column of regression results, conditional on all the covariates except external connections to universities, Model 1 shows the dummy variable identifying university spinoffs (*AE*) is positive and statistically significant at the 1% level. The magnitude of 0.034 indicates an employment performance premium for university spinoffs relative to industry startups of 3.4 percentage points, which is 2.2 percentage points smaller than the unconditional results. When post-foundation university connections are held constant, as shown in Model 2, the performance premium is still positive and significant, although its magnitude falls to 2.7 percentage points. These results support hypothesis #1. While policies that incent university spinoffs induce a larger social cost than policies incenting industry startups, this larger social cost is offset to some degree by producing a larger stream of social benefits, as measured by employment growth.

Model 3 in Table 2 splits university spinoffs into those with a research academic entrepreneur and those with a non-research academic entrepreneur. Because the social costs of lost knowledge accumulation and disclosure depend of whether the academic entrepreneur performs research, from a policy perspective, it is desirable to observe a larger performance premium for spinoffs started by research academic entrepreneurs. This is exactly what the results in Model 3 show. Both types of spinoffs have positive and significant performance premiums, but the performance for those with a research academic entrepreneur is 1.5 percentage points higher.

[11] As a robustness check, all the models were re-estimated using sampling weights from the survey. These results are reported in Table 3. There are no significant differences between weighted and non-weighted results.

The field of the academic founder(s) of university spinoffs may also be relevant for understanding differences in the performance premium. In terms of the social cost, future research may show that the nature and impact of open science norms vary across academic disciplines. In this case, the necessary performance premium will vary within the group of research academic entrepreneurs and not only between research and non-research AEs. Whether the social impact of open science is greater in some academic fields or not is unknown at this time, but the regression results in Table 2 suggests the performance premium disappears for those university spinoffs with at least one academic founder from the engineering disciplines. In all models, the engineering covariate shows a negative and significant coefficient. From Model 3, university spinoffs associated with research academic entrepreneurs from the engineering disciplines have a positive point estimate for the performance premium of 1.2 percentage points (3.5 minus 2.3), but it is not statistically different from zero. Similarly, for spinoffs with non-research AEs from the engineering disciplines, the performance premium is not significantly different from zero. None of the models in Table 2 show a significant offset for spinoffs with at least one founder whose knowledge contribution derives from the life and natural science disciplines.

There are some interesting results for the other explanatory variables in Models 1 and 2. First, Model 1 suggests that intellectual property in the form of patents, the size of the founding team, and the general human capital of the founding team, measured as the percentage of the founders with an academic degree, are associated with more employment growth. However, once university connections are held constant in Model 2, all of these factors become insignificant for all new ventures, whether it is a university spinoff or an industry startup. This suggests that these covariates act as proxy variables for university connections. Having university connections is associated with a 4.1 percentage point increase in employment growth for all new ventures, spinoffs and industry startups. Among the other covariates, the results are as one would expect. New ventures that perform R&D, those with better credit ratings, and those organized as limited liability companies show better employment growth. The initial size of the new venture is negatively related to employment growth.

5 Conclusion

Using data on new ventures founded in knowledge intensive industries in Germany and controlling for survivor bias, this paper finds that university spinoffs generally show greater employment growth than industry startups. For the overall group of university spinoffs, the performance premium is 3.4 percentage points higher employment growth. By creating more new jobs than industry startups, university spinoffs are offsetting their higher social cost, at least to some degree. It is important to remember, however, that achieving a performance premium is only a necessary condition to justify spinoff promotion policies. To calculate net social welfare, one needs to weigh the social cost of knowledge accumulation and disclosure against the social benefits of new job creation. Needless to say, this "bottom line" social welfare statement is not possible given the state of research in the field. As research progresses, scholars will be able to state the tradeoff between additions to the stock of public knowledge and new jobs (or some other performance measure) in terms of quantities, but ultimately these quantities will need to be valued to allow a net social gain calculation.

In this paper, university spinoffs are defined as new companies started by former or current university employees. The involvement of the university employee is a critical part of whether there is a need for a spinoff performance premium or not. If university spinoffs are defined in terms of a licensed technology or other arms-length transactions, then there is no reason to expect any sacrifice of knowledge accumulation or disclosure in the not-for-profit research sector. In this case, a sufficient standard to justify spinoff policies may be that spinoffs perform as well as industry startups, on average.[12] In other words, no performance premium needs to be observed. Similar reasoning applies when the university employee who founds the spinoff is a non-research academic entrepreneur. The movement of these individuals out of the research sector to the private sector would not involve a foregone knowledge accumulation and disclosure. This is the basis of Hypothesis #2 that says the

[12] In our empirical analysis, we compared university spinoffs to industry startups based on a random sample that was stratified by industry (in particular, knowledge intensive industries), year of company foundation, and region. Other scholars such as Wennberg et al. (2011) compare university spinoffs to corporate spinoffs. This is a subgroup of industry startups that is likely to perform better than average and thereby serves as higher standard of comparison for university spinoffs. For general policy justification, we believe the overall population of industry startups (properly stratified) is the relevant control group.

performance premium should be larger for research academic entrepreneurs than non-research academic entrepreneurs. Our empirical results show a performance premium for both types, but the premium is larger for research academic entrepreneurs, 3.5 and 2.0 percentage points respectively.

The analysis also shows that the performance premium varies by the academic composition of the university spinoff, which is determined by the academic discipline(s) of the university founder(s). University spinoffs show a performance premium when they have at least one academic founder from law & social science or from science-oriented disciplines. However, the results do not show any performance premium for spinoffs that have at least one academic entrepreneur from the engineering fields. These spinoffs experience the same employment growth as industry startups.

For policymakers, our research suggests a new perspective on the design and evaluation of spinoff policies. The conventional assumption that university spinoffs are equivalent to industry startups is too simplistic. Both types of new companies may produce similar benefits in the private sector, such as new jobs that fuel economic growth, but the social costs of creating university startups are larger when these spinoffs result in lost knowledge accumulation and disclosure. At the present time policy designs do not incorporate these differences. Our research also highlights the importance of the individuals who found spinoff companies. Spinoff policies are typically designed to maximize the number of spinoffs without understanding how the policy influences the mix of academic founders. Our research suggests that policy designs can be improved by anticipating the mix of academic founders who are likely to be influenced by the policy. Similarly, impact evaluations of spinoff policies could be improved by incorporating information on lost knowledge accumulation and disclosure.

While our research advances the literature, more research is needed on university spinoffs and associated policies. At the present time, very few studies connect university spinoffs to the individual academic researchers who found these firms. For instance, the literature characterizing changes in academic research productivity as a result of entrepreneurial behaviors such as spinoff creation is too narrowly focused on science and engineering fields. Academic researchers in law, social sciences, and other fields make contributions to open science. A better characterization of the potential losses to open science from spinoff activity will require this additional work. For the spinoffs, moving beyond employment growth to include multiple firm-level performance indicators will allow a more complete understanding of the spectrum of benefits created by spinoffs. Future research could also expand the types of spinoffs and industry startups used in the analysis. For instance, Wennberg et al. (2011) compare university spinoffs to corporate spinoffs.

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Appendix I: Definition of Technology Sectors

High-tech manufacturing: This sector comprises manufacturing activities characterized by high R&D inputs and includes the following NACE rev. 1.1 codes: 24, 29, 30, 31, 32, 33, 34, 35 (chemicals and pharmaceuticals, machinery and equipment, computer and office machinery, electrical equipment, electronics, medical and measurement instruments, automotive and other vehicles).

Technology-oriented services: This sector covers services that are heavily relying on the use of new technology, particularly information and communication technology, and includes the NACE rev. 1.1 codes: 62.3, 72, 73, 74.2, 74.3, 92.11 (telecommunication, computer services and software, R&D services, engineering, testing, film making).

Knowledge-intensive consulting: This sector represents services that are largely based on high qualified labor while relying less on new technology and includes NACE rev. 1.1 codes: 74.1, 74.4, 74.85.1, 74.85.2, 74.87.2, 74.87.4, (business consulting, advertising, design activities, etc.)

Appendix II: Tables

Table 1: Descriptive Statistics by Industry Startups and University Spinoffs

Industry Startups (non-USOs) = 13693	Mean	Std. Dev.	Min	Max
Employment growth (average annual)	0.092	0.162	-0.448	0.805
Founding team characteristics				
Size of founding team	1.579	1.045	1	15
Percent founding team members with academic degrees	0.456	0.466	0	1
New venture characteristics				
Employees at founding (FTE)	3.487	4.684	0.5	50
Patent	0.018	0.134	0	1
R&D (continuous)	0.165	0.371	0	1
R&D (occasional)	0.101	0.301	0	1
Credit rating at founding	2.670	0.464	1.46	6
Limited liability company	0.375	0.484	0	1
External environment characteristics				
University connections (any type)	0.288	0.453	0	1

University Spinoffs (USOs) = 1151	Mean	Std. Dev.	Min	Max
Employment growth (average annual)	0.148	0.186	-0.418	0.805
Founding team characteristics				
Research AEs	0.520	0.500	0	1
Non-research AEs	0.480	0.500	0	1
Size of founding team	2.333	1.384	1	15
Percentage of founding team with academic degrees	0.901	0.200	0.067	1
New venture characteristics				
Founders' discipline: Science	0.414	0.493	0	1
Founders' discipline: Engineering	0.322	0.468	0	1
Employees at founding (FTE)	4.453	4.981	0.5	50
Patent	0.071	0.257	0	1
R&D (continuous)	0.400	0.490	0	1
R&D (occasional)	0.170	0.376	0	1
Credit rating at founding	2.654	0.385	1.77	6
Limited liability company	0.615	0.487	0	1
External environment characteristics				
University connections (any type)	0.679	0.467	0	1

Note: Eight industry dummy variables and five founding year cohort dummy variables are not reported.

Table 2: Startup employment growth (1996-2000), Heckman selection models

Variable	Model 1	Model 2	Model 3
Academic Entrepreneur (AE)	0.034***	0.027***	
	(0.008)	(0.008)	
Research AE			0.035***
			(0.009)
Non-Research AE			0.020**
			(0.009)
Founders' discipline: Sciences	0.004	0.001	-0.001
	(0.010)	(0.010)	(0.010)
Founders' discipline: Engineering	-0.022**	-0.023**	-0.023**
	(0.010)	(0.010)	(0.010)
University Connections		0.041***	0.041***
		(0.003)	(0.003)
Firm Patent (yes/no)	0.016*	0.012	0.011
	(0.009)	(0.009)	(0.009)
Firm R&D (continuous)	0.055***	0.046***	0.046***
	(0.004)	(0.004)	(0.004)
Firm R&D (occasional)	0.033***	0.026***	0.026***
	(0.004)	(0.004)	(0.004)
Percentage of Founding Team with Academic degrees	0.009***	0.002	0.002
	(0.003)	(0.003)	(0.003)
Size of Founding Team	0.002*	0.001	0.001
	(0.001)	(0.001)	(0.001)
Employees at Founding	-0.004***	-0.004***	-0.004***
	(0.0003)	(0.0003)	(0.0003)
Credit rating at Founding	-0.009***	-0.009***	-0.009***
	(0.003)	(0.003)	(0.003)
Limited Liability Comp.	0.033***	0.030***	0.030***
	(0.003)	(0.003)	(0.003)
Intercept	0.092***	0.088***	0.088***
	(0.011)	(0.010)	(0.010)
Founding year dummy variables	Y	Y	Y
Industry dummy variables	Y	Y	Y
Inverse Mills Ratio	-0.050***	-0.047***	-0.046***
Total Observations	23803	23803	23803
Censored Observations	8959	8959	8959

Note: Standard errors in parentheses. *** (**,*) indicate a significance level of 1% (5%, 10%). All second stage regressions include industry and founding year dummy variables.

Table 3: Startup employment growth (1996-2000),
Heckman selection models using sampling weights

Variable	Model 1	Model 2	Model 3
Academic Entrepreneur (AE)	0.036***	0.029***	
	(0.009)	(0.009)	
Research AE			0.034***
			(0.011)
Non-Research AE			0.025**
			(0.010)
Founders' discipline: Sciences	-0.002	-0.004	-0.005
	(0.012)	(0.012)	(0.012)
Founders' discipline: Engineering	-0.025**	-0.025**	-0.026**
	(0.012)	(0.012)	(0.012)
University Connections		0.044***	0.044***
		(0.003)	(0.003)
Firm Patent (yes/no)	0.024**	0.021*	0.020
	(0.011)	(0.012)	(0.012)
Firm R&D (continuous)	0.056***	0.047***	0.047***
	(0.004)	(0.004)	(0.004)
Firm R&D (occasional)	0.035***	0.028***	0.028***
	(0.005)	(0.005)	(0.005)
Percentage of Founding Team with Academic degrees	0.011***	0.004	0.004
	(0.003)	(0.003)	(0.003)
Size of Founding Team	0.002	0.001	0.001
	(0.001)	(0.002)	(0.002)
Employees at Founding	-0.003***	-0.003***	-0.003***
	(0.0004)	(0.0004)	(0.0004)
Credit rating at Founding	-0.007***	-0.007***	-0.007***
	(0.003)	(0.003)	(0.003)
Limited Liability Comp.	0.038***	0.035***	0.035***
	(0.003)	(0.003)	(0.003)
Intercept	0.069***	0.066***	0.066***
	(0.010)	(0.010)	(0.010)
Founding year dummy variables	Y	Y	Y
Industry dummy variables	Y	Y	Y
Inverse Mills Ratio	-0.034***	-0.033***	-0.033***
Total Observations	23803	23803	23803
Censored Observations	8959	8959	8959

Note: Standard errors in parentheses. *** (**,*) indicate a significance level of 1% (5%, 10%). All second stage regressions include industry and founding year dummy variables.

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