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# Smart people come, smart people go: What spin-off entrepreneurs already know and what they take from their previous employers.

**Dominik Peter Heinisch**
**University of Kassel**
**Economic Policy Research**
**heinisch@uni-kassel.de**

**Guido Buenstorf**
**University of Kassel**
**Economic Policy Research**
**beunstorf@uni-kassel.de**

## Abstract

To what extent do incumbents train or rather attract future spin-off entrepreneurs? Heritage theory predicts higher performance, in terms of growth and firm survival, for firms founded by entrepreneurs with previous work experience at incumbents (Klepper 2002; Klepper 2007; Buenstorf and Klepper 2009). The abilities and the knowledge which founders transfer to the new venture seem to be crucial for entrepreneurial activities and their success. Higher qualified employees are more likely to found their own company if they leave their previous workplace (Klepper and Thompson 2010; Campbell et al. 2012). The standard argument why spin-offs outperform other kinds of start-ups is that entrepreneurs with previous work experience were able to acquire sensitive knowledge about products and processes which makes incumbents "involuntary training grounds for future entrepreneurs" (Agarwal et al. 2015a). Besides knowledge about products and processes, knowledge about whom to hire is another strong predictor of early firm success. Convincing qualified co-workers to leave their previous employer as well seems to be an ability that spin-off entrepreneurs profit greatly from. Knowledge acquired at previous workplaces might play a minor role for spin-off survival even if it had been the most promising explanation before (Dahl and Sorenson 2014). Recruitment, especially of previous colleagues, appears to be a more dominant factor. However, employing former colleagues does not reduce hazard rates of spin-offs alone, while the previous work experience of those employees does. Also, hiring of new workers is not independent of founder abilities (Dahl and Klepper 2015). The assets that founders take from their previous work place are correlated with the founders' abilities, while ability alone might seems not to be sufficient enough to make the new venture a success (Agarwal et al. 2015b). Whatever makes founders with industry work experience perform better there seems to be something "magic" about already established firms which they pass on to their offspring. This "magic" might be visible to graduates and workers with high abilities, or vice versa incumbents' "magic" might lie in the ability to select promising candidates to hire. Whether experience or

(self-) selection of qualified staff causes spin-offs to be more successful remains unclear. Individual abilities and motives matter for firms innovative output (Sauermann and Cohen 2010). A high participation rate in the scientific community seems not only be linked to a higher innovative output, but be driven by a common factor the "motive for intellectual challenge". Employees searching for "intellectual challenge" might find better working conditions at incumbents, however face a higher risk to found their own business. Building on this theoretical background we begin to disentangle the selection of qualified workers by incumbents from other mechanisms. To this purpose we exploit information about the educational and academic achievements of future employees and spin-off entrepreneurs. We suspect spin-off generating incumbents to be more likely to employ PhDs with high research abilities for their R&D departments. However, we also expect those employees to have a higher propensity to establish spin-offs themselves or to follow their entrepreneurial colleagues, on the search for intellectual challenge. The advantage that founders with previous work experience have might partly be explained by this previous selection of incumbents that hire the smarter employees. We expect that differences between start-ups and spin-offs in firm survival are reduced when the founders' research ability, as proxied by their educational and academic performance prior to entering a private-sector employment, is taken into account. Additionally, we investigate the importance of pre-existing relations for recruitment of spin-offs and start-ups. The relations back to academia (i.e. the former adviser or previous PhDs colleagues) might be a fruitful source of employees and collaborations positively influencing the ventures survival. To answer these questions we use a newly created database containing all German PhDs in laser related disciplines combined with their previous publication output and patenting activity. We search for laser source producers among the applicants to identify work experience in R&D departments at the established and newly founded firms. The laser source producers cover the whole firm population in Germany between 1964 and 2005, covering incumbents, diversifiers, spin-offs and start-ups, as well as their founders (Buenstorf 2007). The PhDs' publication output (number of publications and number of citations) is used as a proxy of their research ability and smartness. The data also allows to make some assumptions on the PhDs' adviser which enables us to reconstruct their "academic family". ---------- Agarwal, Rajshree, Guido Buenstorf, Wesley M. Cohen, and Franco Malerba. 2015a. "The Legacy of Steven Klepper: Industry Evolution, Entrepreneurship, and Geography." Industrial and Corporate Change 24 (4): 739–753. Agarwal, Rajshree, Benjamin Campbell, April Franco, and Martin Ganco. 2015b. "What Do I Take with Me?: The Mediating Effect of Spin-Out Team Size and Tenure on the Founder-Firm Performance Relationship." Academy of Management Journal, June (online before print). Buenstorf, Guido. 2007. "Evolution on the Shoulders of Giants: Entrepreneurship and Firm Survival in the German Laser Industry." Review of Industrial Organization 30 (3): 179–202. Buenstorf, Guido, and Steven Klepper. 2009. "Heritage and Agglomeration: The Akron Tyre Cluster Revisited*." The Economic Journal 119 (537): 705–33. Campbell, Benjamin A., Martin Ganco, April M. Franco, and Rajshree Agarwal. 2012. "Who Leaves, Where To, and Why Worry? Employee Mobility, Entrepreneurship and Effects on Source Firm Performance." Strategic Management Journal 33 (1): 65–87. Dahl, Michael S., and Steven Klepper. 2015. "Whom Do New Firms Hire?" Industrial and Corporate Change 24 (4): 819–36. Dahl, Michael S., and Olav Sorenson. 2014. "The Who, Why, and How of Spinoffs." Industrial and Corporate Change 23 (3): 661–88. Klepper, Steven. 2002. "The Capabilities of New Firms and the Evolution of the US Automobile Industry." Industrial and Corporate Change 11 (4): 645–66. ———. 2007. "Disagreements, Spinoffs, and the Evolution of Detroit as the Capital of the U.S. Automobile Industry." Management Science 53 (4): 616–31. Klepper, Steven, and Peter Thompson. 2010. "Disagreements and Intra-Industry Spinoffs." International Journal of Industrial Organization 28 (5): 526–38. Sauermann, Henry, and Wesley M. Cohen. 2010. "What Makes Them Tick? Employee Motives and Firm Innovation." Management Science 56 (12): 2134–53.

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Guido Buenstorf [abc], Dominik Peter Heinisch [ab]

[a] Institute of Economics, University of Kassel, Kassel, Germany
[b] International Centre for Higher Education Research (INCHER-Kassel), Kassel, Germany
[c] IWH Leibniz Institute of Economic Research, Halle, Germany

Corresponding author: Dominik Peter Heinisch, heinisch@uni-kassel.de

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**Motivation**

To what extent do incumbents train or rather attract future spin-off entrepreneurs? Heritage theory predicts higher performance, in terms of growth and firm survival, of firms founded by entrepreneurs with previous work experience at incumbents (Klepper 2002; Klepper 2007; Buenstorf and Klepper 2009). The abilities and the knowledge that founders transfer to the new venture seem to be crucial for entrepreneurial activities and their success. The standard argument why spin-offs outperform other kinds of start-ups is that entrepreneurs with previous work experience were able to acquire sensitive knowledge about products and processes which makes incumbents "involuntary training grounds for future entrepreneurs" (Agarwal et al. 2015a). Knowledge about whom to hire is another strong predictor of early firm success. Convincing qualified co-workers to leave their previous employer as well seems to be an ability that spin-off entrepreneurs profit greatly from. It has even been suggested that recruitment, especially of prior colleagues, may be more important as a driver of spin-off performance than knowledge about products and processes acquired at previous workplaces (Dahl and Sorenson 2014). However, just employing former colleagues does not systematically reduce the hazard rates of spin-offs, whereas the previous work experience of those employees does. In addition, the ability to hire new workers is related to founder abilities (Dahl and Klepper 2015). And while founder ability alone may not be enough to make the new venture successful, how much founders can take with them from their previous work place seems correlated with their abilities (Agarwal et al. 2015b).

Whatever it is that makes entrepreneurs with industry work experience outperform their less experienced peers - in any case there seems to be something "magic" that spin-offs inherit from their parent firms. This "magic" might consist of knowledge and capabilities that workers with high abilities can acquire and transfer to their own venture, or vice versa incumbents' "magic" might lie in the ability to select top-performing employees in the first place. Whether employee learning or (self-) selection of qualified staff causes spin-offs to be more successful remains unclear. One aspect of (self-) selection relates to firms' engagement with basic research. Interacting with the scientific community seems not only linked to a higher innovative output, but may also help attract employees with a pronounced "motive for intellectual challenge" (Sauermann and Cohen 2010). University graduates and job-switching employees searching for "intellectual challenge" may find suitable working conditions at incumbents engaged in basic research. They may also be those employees who face the highest risk to start their own business at a later stage in their careers.

Building on this theoretical background we begin to disentangle the selection of skilled workers by incumbents from other mechanisms underlying spin-off dynamics and performance. To this purpose we exploit information about the educational and academic achievements of employees and spin-off entrepreneurs. We suspect that newly minted PhDs with high research abilities migrating to the private sector are mostly attracted to innovative established firms possessing a strong track record of engaging in basic research and engaging with the scientific community. However, we also expect these employees to subsequently have a higher propensity to establish spin-offs themselves or to follow their entrepreneurial colleagues, on the search for intellectual challenge. The advantage of

founders with industry experience might then reflect that the brightest and most committed graduates of science and engineering programs previously self-selected into jobs at industry incumbents to satisfy their "motive for intellectual challenge", and that the same group of individuals accounts for a large share of founders and/or early hires of spin-offs. If this conjecture were correct, then performance differences between start-ups and spin-offs should be reduced when founders' research ability, as proxied by their educational and academic performance prior to entering into private-sector employment, is taken into account. In addition, we investigate the importance of pre-existing relationships for recruitment of spin-offs and start-ups. Relationships back to academia (i.e. to the former adviser or previous PhDs colleagues) might be a fruitful source of employees and collaborations, which would be expected to boost the performance of new ventures.

To address these issues we use a newly created database containing all German PhDs in laser-related disciplines combined with their previous publication output and patenting activity. We search for laser source producers among the patent applicants to identify work experience in R&D departments at established and newly founded firms. The set of laser source producers cover the whole laser firm population in Germany between 1964 and 2005. For all covered years, incumbents can be distinguished from entrants, and the latter can be distinguished according to their pre-entry experience, including diversifiers, spin-offs and (other) start-ups (Buenstorf 2007). The identity of firm founders and their background in laser research have also been established. For the PhD-holding entrepreneurs, their research ability (or cognitive ability more generally) is proxied by number of publications and citations related to their PhD research. The data also allow us to reconstruct founders' "academic family" and relate their academic "roots" to their entrepreneurial activity and performance.

Currently this study focuses on the question at what type of firms PhD graduates are patenting. The educational background of entrepreneurs and the influence on firm success has not been investigated yet. The chances of PhDs becoming an entrepreneur is also missing at the current state of work. However, some preliminary results on the attractiveness of different firm types on high skilled workers can be presented and some first conclusions concerning the above described questions are drawn.

**Theoretical background**

(to be elaborated)

**Hypotheses**

What firms in an industry attract PhDs, especially those PhDs with high research affinity and abilities? The first part of our empirical exercise takes a closer look on the hiring of R&D personnel. Established firms (including diversifiers from related industries) are expected to provide better

working conditions in terms of higher salaries, larger R&D laboratories and more interesting career prospects for highly qualified researcher compared to newly established ventures.

H1: PhDs are expected to be more likely to patent for established firms than for new ventures.

Over time, (surviving) firms manage to grow and gain reputation. They also become more likely to conduct large scale R&D activities. As a consequence, they have an increasing demand for academically trained employees, while at the same time they enhance their attractiveness as an employer of these individuals.

H2: With increasing age firms are associated with an increasing likelihood to attract PhD-holding inventors.

Employees searching for "intellectual challenges" are particularly likely to might find working conditions at innovative established firms attractive, e.g. because they can expect to find more freedom to focus on their own research interests in the larger labs that only established firms are able to provide.

H3: PhDs with scientific publications face a higher risk to patent for established firms than for new ventures.

Finding and attracting academically trained R&D personnel is a challenging task, particularly for newly established firms. To attract and recruit suitable PhDs, entrepreneurs who hold a PhD themselves might make use of their preexisting personal relationships to their own academic roots.

H4: PhDs are more likely to patent for a firm if they have the same academic roots as the firm's founder(s).

**Data and empirical methods**

For the analysis individual-level data of German laser PhD graduates are matched with patent inventors of laser source producing firms' patents, as well as authors of scientific publications.

We started our data collection effort by extracting all priority patent applications filed by German applicants in IPC H01S from PATSTAT (2014b), a total of 2,922 patents for the time period 1970 to 2010. Laser source producers among the applicants were identified using an extended version of the list of firms analyzed in (Buenstorf 2007), which includes 170 German laser source manufacturers. These firms can be categorized according to their (founders') backgrounds prior to entering the laser industry. Specifically, we distinguish diversifiers from other industries (de alio entrants, which include well-established firms such as Siemens and Carl Zeiss, as well as smaller firms that often integrated from laser sales or laser system manufacturing into the production of laser sources) from newly established ventures (de novo entrants, which predominantly consist of academic startups and employee spin-offs). Names of applicants and firms were standardized[1]. The standardized applicant

[1] The standardization procedure includes removal of punctuations and whitespaces, correcting German umlauts, removing annexes of firm names like "GmbH" and "AG".

and firm names (and where available previous or alternative firm names) were matched using a fuzzy matching algorithm[2]. Positive matches were manually checked to detect false positives. Sixty-nine of the firms included in the list were identified as having at least one patent. The patenting firms account for 1,306 (about 40%) patent applications.

Entrepreneurs might apply for patents before the firm is founded. In these cases the firm name is not listed among the applicants. To cover the whole patent portfolio of a firm the above procedure was repeated for the firm founders as well. For 112 firms information of altogether 179 firm founders is available. Applying the above matching procedure resulted in 34 additional patent applications filed by 18 firm founders.

In the next step we identified PhDs among the inventors in the patent dataset. 3,264 distinct inventor names were listed on the patent applications in the sample. The inventor names were cleaned according to the procedure described above. In addition we retrieved the academic title from the inventor names. Since in Germany the "Dr." is an official part of the name, a high coverage of academic titles is assumed. Our data on PhD graduates is based on the catalog of the German National Library (DNB). Since 1969 the DNB has been obliged by law to collect all German publications and publications of Germans. This provision includes PhD theses. We use a subsample of PhD theses listed in the DNB catalog covering all PhD theses from 1970 to 2010 that were categorized as theses in physics, electrical or mechanical engineering. Dissertations classified as medical theses were excluded. The dataset used contains 152,679 PhD theses and their authors.

The name matching resulted in 2,176 positive PhD inventor pairs. Several filters were applied to distinguish true and false positive matches. The matched theses were classified as "laser dissertation" if the title includes words closely related to laser research[3]. For all matched PhDs homonyms were searched in the full PhD sample. If no homonym (PhD with exactly the same surname first name combination) could be found, the PhD was classified as having a unique name. In the respective cases the PhD is the only person with this specific name combination who graduated in Germany in the relevant disciplines. The unique name in combination with a "Dr." in the inventor name data provides a strong predictor of being a true positive match. In addition, the lag between the year of graduation and the year of the first patent filing was calculated. All positive matched inventor PhD pairs were manually processed to detect wrong name matchings and inconsistencies (e.g., time lag to first patent is negative and inventor has a "Dr." in their name). In cases where no clear decision was possible additional information was used (using the title of the PhD thesis, field classifications of the DNB, keywords, and depatis.net information – the "Dr." is often listed in depatis.net even if it is not available in PATSTAT). After eliminating false positive matched PhD-inventor-pairs, we obtained a full sample of 414 PhDs active in patenting for German laser source producers. By applying the

[2] For all string matchings a 2-gram Jaccard similarity as proposed by (Schoen, Heinisch, and Buenstorf 2014) for German patent data. While the author use a minimum required similarity smaller than 0.9 we use a threshold of 0.8. The smaller sample size allows using a more relax threshold, which is preferable since false negative matches are reduced by keeping the manual data checking effort manageable.

[3] The following words were classified as indicating a laser-science related dissertation: laser, light, spectroscopy, spectral, pulse, optical, induced and the German translation of these words.

same procedure to the 179 laser firm founders 43 entrepreneurs were identified to hold a PhD degree.

For all PhDs information on their publishing activities while conducting the theses was collected from the Web of Science (WoS). The underlying procedure was originally developed for all science and engineering theses contained in the DNB catalog (a working paper detailing the procedure is work in progress). The algorithm developed to match PhD theses with publications in the WoS uses a two-step procedure. In the first step publications in the WoS were clustered in distinct author groups. The used procedure follows in the basic steps the procedure recommended by (Wang et al. 2012). All authors were grouped by their name and affiliation. Other similarities between the authors were searched within the name-affiliation groups (using common co-authors, self-citations, time-lags of publication dates, second names if available and identical keywords). To test whether the matching procedure worked accurately the average number of papers assigned to the 100 most common (German) surnames were tested against all other names. No significant difference was found. This suggests that no bias is introduced by assigning more papers to more frequent names that were poorly disambiguated, indicating that the matching procedure worked with a satisfactory degree of accuracy. After the WoS disambiguation procedure WoS authors were matched with the PhD data by using author names and affiliations (affiliation of the author group and the affiliation the PhD graduated from). The matched pairs were filtered for false positive using (lack of) similarity in titles[4] as well as the time lag between the first paper published and the submission of the PhD thesis. Of the 414 PhD inventors 217 PhDs were found to have published during their PhD time.

The procedure described above provides us with the universe of PhD holding inventors in the German laser industry. Besides characteristics of the firm and their firm founders, characteristics of the PhDs like their alma mater, the year of their graduation and publications related to their thesis are available. More than half of the PhD holding inventors have published at least one paper while conducting their PhD. On average these PhDs hold about 9 publications (median about 5). Their patenting activity ranges from 1 to 28 patents per person, with a mean of 3.15 patents. Numbers of publications and patents are positively correlated with a correlation of 0.18 ($p<0.01$).

Since recruitment is in the focus of our analysis patenting PhDs who are identified as founders of the applicant firm are excluded from the sample. This reduces the dataset by 9 inventors to 405. In addition, professors are identified among the inventors using Kürschners Gelehrtenkalender, which includes all German Professors. Professors often collaborate with several firms and are not directly employed at the patenting firms. They are removed from the sample reducing the dataset to 392 inventors. For the remaining PhD holding inventors a risk set of all potential applicants is constructed. The risk set includes all firms which are active in laser source production after the submission year of the thesis. Firms that newly entered laser source production after graduation are also placed as potential employers in the risk set. In total this leads to 46,759 matched PhD firm pairs with 436 truly realized pairs taking the value 1. This implies that an individual PhD could in

[4] Using a LCS function with minimum string length of 5 characters.

principle have become an inventor for any of about 100 laser source producers. Which firm characteristics either attract or select PhDs is estimated by using a conditional logit model.

**(Preliminary) Results**

Of the 170 laser source producer only 69 patented in IPC H01S (laser sources). However all types of firms in the dataset are represented. 24 of the 55 diversifiers are active in patenting (44%), 25 of the 68 spin-offs (37%; including similar to Buenstorf (2007) integrating distributers), and 18 of the 36 academic startups (50%). Seventeen of the diversifiers list PhDs on their patents, 19 spin-offs, and 14 academic start-ups. The average diversifier lists 5.75 PhDs, academic startups 1.72 and spin-offs 0.87 PhDs. However, with 2.79 the average number of publications per PhDs is higher for the spin-offs than for the diversifiers (1.9 publications on average). Academic start-ups have highest average publications per PhD with 10.53. Differences in the time lag between graduation and the first patent filing are more similar between the distinguished firm types. PhDs patenting for diversifiers do this 8.94 years after graduation on average. PhDs at spin-offs and academic start-ups are slightly faster with 7.89 and 7.62 years.

**conditional logit regression: PhD patenting for laser source producer**

| | model 1 | | | model 2 | | | model 3 | | | model 4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| firm age at submission | 0.0321 | *(0.008)* | *** | 0.0394 | *(0.0082)* | *** | 0.0323 | *(0.0081)* | *** | 0.0421 | *(0.0083)* | *** |
| years till entry | -0.1427 | *(0.0138)* | *** | -0.1438 | *(0.0142)* | *** | -0.1464 | *(0.0139)* | *** | -0.1475 | *(0.0142)* | *** |
| # firm patents at submission | 0.0188 | *(0.0012)* | *** | 0.0183 | *(0.0012)* | *** | 0.0194 | *(0.0012)* | *** | 0.0187 | *(0.0012)* | *** |
| academic startup | | | | | | | -0.7478 | *(0.2308)* | *** | -0.9302 | *(0.2374)* | *** |
| spin-off | | | | | | | -0.9151 | *(0.2231)* | *** | -0.8146 | *(0.2256)* | *** |
| diversifier | 1.0958 | *(0.176)* | *** | 1.1307 | *(0.1792)* | *** | | | | | | |
| acad.*pub | | | | | | | 0.4910 | *(0.3754)* | | 0.5817 | *(0.3819)* | |
| acad.*pub5 | | | | | | | 1.1074 | *(0.3504)* | *** | 0.9132 | *(0.3609)* | ** |
| spin-off*pub | | | | | | | 0.6367 | *(0.345)* | * | 0.5791 | *(0.3477)* | * |
| spin-off*pub5 | | | | | | | 0.3822 | *(0.3881)* | | 0.3517 | *(0.3891)* | |
| div.*pub | -0.5694 | *(0.2815)* | ** | -0.6125 | *(0.2853)* | ** | | | | | | |
| dib.*pub5 | -0.7784 | *(0.2882)* | *** | -0.6430 | *(0.2935)* | ** | | | | | | |
| same region (firm) | | | | 2.0826 | *(0.166)* | *** | | | | 2.0733 | *(0.1664)* | *** |
| same origin (founder) | | | | 2.7304 | *(0.3469)* | *** | | | | 2.6403 | *(0.3563)* | *** |
| n | 46759 | | | 46759 | | | 46759 | | | 46759 | | |
| events | 436 | | | 436 | | | 436 | | | 436 | | |

*: p < 0.1 regression coefficient
**: p < 0.05 (standard errors in brackets)
***: p < 0.01

Table 1: selection on firms and PhD-inventors (conditional logit regression)

We use a conditional logit regression to test the hypotheses formulated above. The dependent variable takes the value 1 if the PhD is actually found patenting for respective firm included in the risk set of potential applicants. As main explanatory variables use the firm background in interaction with the PhDs publishing behavior. In the Models 1 and 2 the variable "diversifier" classifies firms as existing firms which diversified into laser source production. In the Models 3 and 4 the variable "academic startup" classifies firms with founders having a public research organization as previous

working background. The variable "spin-off" unifies firms found by a previous employee of another laser source producer and distributers integrating into laser source production. Eleven firms with unknown background were included into the counterfactual. We also include a control variable for firm R&D size by including the patent stock at the time the PhD submitted the thesis.

In Hypothesis 1a we proposed that PhDs are more likely to invent for established firms. Models 1 to 4 confirm our expectation. Coefficients are positive and significant for diversifiers (Models 1 and 2); they are negative for academic startups and spin-offs (Models 3 and 4). The variables "firm age at submission" and "years before entry" account for the firm age proposed in Hypothesis 2 to be a selection criterion in PhDs job searches. Firm age at submission measures the age of the firms included in the risk set in the year of the PhDs thesis submission. If a firm is not active in laser source production at the time of the graduation the variable takes the value zero. Similar "years before entry" measures for each firm in the risk set how many years after graduation a firm enters laser source production if the firm has not been active in this industry before. "Firm age at submission" is positively associated with PhDs' inventive activities. The coefficient estimate implies that each additional year of firm age increases the likelihood of a PhD to invent for this firm by about 3 per cent. Not surprisingly, the longer the time gap between the graduation date and the founding year, the less likely a firm is to be associated with a PhD-holding inventor.

By interacting firm backgrounds with "pub" and "pub5" we test whether publishing PhDs are more likely to be associated with specific types of firm backgrounds. The variable "pub" takes the value one whenever a PhD has 1 to 5 thesis-related publications. Similarly the variable "pub5" assumes the value 1 whenever a PhD has more than 5 publications. As can be seen in Models 1 and 2, diversifiers are negatively associated with both groups of publishing PhDs. This is contradictory to Hypothesis 3. Looking into the de novo entrants in more detail, we find positive effects in interaction with publication outcomes for both academic startups (highly significant for the most prolific authors) and spin-offs (marginally significant for the authors of 1 to 5 papers). That academic start-ups are associated with PhDs who have a higher publication output is perhaps not too surprising. That spin-offs also attract (modestly) publishing PhDs may reflect that these individuals search for "intellectual challenge" which may be found in new ventures.

Based on information about the university and the year of graduation we can analyzed whether (PhD-holding) founders tend to attract (PhD-holding) inventors who graduated from the same university and who they may know personally. In Models 2 and 4 we include the variable "same_origin" which takes the value one if the PhD graduated from the same university at approximately same time (+/- 5 years) as the firm's founder. The coefficients is positive and significant leading us to accept Hypothesis 4 on PhDs with having identical academic roots as the firm founder being a strong selection criterion. In these models we also control for regional effects on the NUTS-3 level, assuming that PhDs might prefer to work close to the university they graduated from. This is indeed found, as firms in the university regions are much more likely to attract inventors than firms located elsewhere. The other results are hardly affected by including these extra variables.

## Conclusions

We constructed a new dataset on scientifically trained inventors in the German laser industry. So far our analysis focused on the question at which types of firms skilled researchers are patenting. Spin-off performance caused by founders' research capabilities and by hiring of skilled researchers as discussed in the outline of the paper is remaining yet. While we find a high share of PhDs being active in entrepreneurial and inventive activities, we find only a few PhDs patenting for more than one firm. In general PhD-holding private-sector inventors are more likely to work for established firms (diversifiers from other industries) than for entrepreneurial startups. However, new ventures are attracting more of the PhDs with stronger academic records, possibly because they provide a richer environment in terms of "intellectual challenges". We find PhDs with modest publication output to be associated with spin-offs, and those with high publication output to be associated with academic startups. In addition, having the same academic origins as the entrepreneur is a strong predictor for patenting activities at the same firm. The link back to the academic origins seems to be an important source for labor recruitment, providing PhD-holding entrepreneurs with an advantage in recruiting R&D personnel.

## Outlook

The presented work will be continued by focusing on the intellectual capacities firms obtain in early years and the effect of firm survival. Entrepreneurs' academic background might provide additional insights on early recruitment of capital inventors.

Agarwal, Rajshree, Guido Buenstorf, Wesley M. Cohen, and Franco Malerba. 2015. "The Legacy of Steven Klepper: Industry Evolution, Entrepreneurship, and Geography." *Industrial and Corporate Change* 24 (4): 739–53. doi:10.1093/icc/dtv030.

Agarwal, Rajshree, Benjamin Campbell, April Franco, and Martin Ganco. 2015. "What Do I Take with Me?: The Mediating Effect of Spin-Out Team Size and Tenure on the Founder-Firm Performance Relationship." *Academy of Management Journal*, June, amj.2012.0853. doi:10.5465/amj.2012.0853.

Buenstorf, Guido. 2007. "Evolution on the Shoulders of Giants: Entrepreneurship and Firm Survival in the German Laser Industry." *Review of Industrial Organization* 30 (3): 179–202. doi:10.1007/s11151-007-9132-1.

Buenstorf, Guido, and Steven Klepper. 2009. "Heritage and Agglomeration: The Akron Tyre Cluster Revisited*." *The Economic Journal* 119 (537): 705–33. doi:10.1111/j.1468-0297.2009.02216.x.

Campbell, Benjamin A., Martin Ganco, April M. Franco, and Rajshree Agarwal. 2012. "Who Leaves, Where To, and Why Worry? Employee Mobility, Entrepreneurship and Effects on Source Firm Performance." *Strategic Management Journal* 33 (1): 65–87. doi:10.1002/smj.943.

Dahl, Michael S., and Steven Klepper. 2015. "Whom Do New Firms Hire?" *Industrial and Corporate Change* 24 (4): 819–36. doi:10.1093/icc/dtv026.

Dahl, Michael S., and Olav Sorenson. 2014. "The Who, Why, and How of Spinoffs." *Industrial and Corporate Change* 23 (3): 661–88. doi:10.1093/icc/dtt032.

Klepper, Steven. 2002. "The Capabilities of New Firms and the Evolution of the US Automobile Industry." *Industrial and Corporate Change* 11 (4): 645–66. doi:10.1093/icc/11.4.645.

———. 2007. "Disagreements, Spinoffs, and the Evolution of Detroit as the Capital of the U.S. Automobile Industry." *Management Science* 53 (4): 616–31.

Sauermann, Henry, and Wesley M. Cohen. 2010. "What Makes Them Tick? Employee Motives and Firm Innovation." *Management Science* 56 (12): 2134–53. doi:10.1287/mnsc.1100.1241.

Schoen, Anja, Dominik Heinisch, and Guido Buenstorf. 2014. "Playing the 'Name Game' to Identify Academic Patents in Germany." *Scientometrics* 101 (1): 527–45. doi:10.1007/s11192-014-1400-x.

Wang, Jian, Kaspars Berzins, Diana Hicks, Julia Melkers, Fang Xiao, and Diogo Pinheiro. 2012. "A Boosted-Trees Method for Name Disambiguation." *Scientometrics* 93 (2): 391–411. doi:10.1007/s11192-012-0681-1.